Much of the research and extension information contained in this publication was funded by the grower-supported North Carolina Tobacco Research Commission. Funding is awarded annually to tobacco faculty at NC State University based on the present and future needs of the tobacco industry. Tobacco growers have the opportunity to continue their support of this important program through a referendum every six years. The last referendum, held in November 2003, was approved by 93 percent of the voters. For more information, contact the North Carolina Agricultural Research Service, NC State University, Box 7643, Raleigh, NC 27695-7643, or call 919-515-2717.

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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 November 1, 2008.

County	*Name*	*Telephone*
Alamance	Roger Cobb	336-570-6740
Alexander	Allison Brown	828-632-4451
Anson	Janine Rywak	828-694-2915
Beaufort	Gaylon Ambrose	252-946-0111
Bertie	Jacob Searcy	252-794-5317
Bladen	Ryan Harrelson	910-862-4591
Brunswick	Al Hight	910-253-2610
Caldwell	Seth Nagy	828-757-1290
Carteret	Ray Harris	252-728-8421
Caswell	Rickey Williams	336-694-4158
Chatham	Sam Groce	919-542-8202
Chowan	Mike Williams	252-482-6585
Columbus	Michael Shaw	910-640-6605
Craven	Mike Carroll	252-633-1477
Cumberland	Colby Lambert	910-484-7156
Davidson	Troy Coggins	336-242-2083
Davie	Greg Hoover	336-751-6297
Duplin	Curtis Fountain	910-296-2143
Durham	Karen McAdams	919-560-0526
Edgecombe	Art Bradley	252-641-7815
Forsyth	Tim Hambrick	336-767-8213
Franklin	Cedric Jones	919-496-3344
Gates	Reba Green-Holley	252-357-1400
Granville	Tommy Brooks	919-603-1350
Greene	Louie Johnson	252-747-5831
Guilford	Wick Wickliffe	336-375-5876
Halifax	Arthur Whitehead	252-583-5161
Harnett	James Choate	910-893-7530
Hertford	Jacob Searcy	252-358-7822
Hoke	Keith Walters	910-875-3461

County	*Name*	*Telephone*
Iredell	Mike Miller	704-878-3153
Johnston	Bryant Spivey	919-989-5380
Jones	Jacob Morgan	252-448-9621
Lee	Carrie Enyart	919-775-5624
Lenoir	Mark Keene	252-527-2191
Martin	Al Cochran	252-792-1621
Montgomery	Roger Galloway	910-576-6011
Moore	Taylor Williams	910-947-3188
Nash	Charlie Tyson	252-459-9810
Northampton	Craig Ellison	252-534-2711
Onslow	Melissa Evans	910-455-5873
Orange	Karen McAdams	919-245-2050
Pamlico	Bill Ellers	252-745-4121
Pender	Wayne Batten	910-259-1235
Person	Derek Day	336-599-1195
Pitt	Mitch Smith	252-902-1702
Randolph	Troy Coggins	336-318-6002
Richmond	Tiffanee Conrad-Acuna	910-997-8255
Robeson	Rodney McLaurin	910-671-3276
Rockingham	Scott Shoulars	336-342-8230
Sampson	Tray Bridgers	910-592-7161
Scotland	David Morrison	910-277-2422
Stokes	Tim Hambrick	336-593-8179
Surry	JoAnna Radford	336-401-8025
Vance	Cedric Jones	252-438-8188
Wake	Vacant	919-250-1107
Warren	Vacant	252-257-3640
Washington	Frank C. Winslow	252-793-2163
Wayne	Kevin Johnson	919-731-1520
Wilkes	Matt Miller	336-651-7331
Wilson	Norman Harrell	252-237-0111
Yadkin	Nancy Keith	336-679-2061

1. Considering the Economic Situation and Outlook

A. Blake Brown
Extension Economist—Agricultural and Resource Economics

Production and Use

According to the USDA's October crop report, U.S. flue-cured tobacco acreage was estimated at 227,000 in 2008, up 1.8 percent from 2007. As of September 1, estimated average yield per acre was 2,245 pounds, down slightly from 2,259 in 2007. The 2008 flue-cured tobacco crop production estimate was 508.5 million pounds, up 1 percent from 503.8 million pounds in 2007. Within North Carolina, the largest flue-cured producing state, acreage was 172,000 acres, up 6,000 acres from 2007. Production in North Carolina was estimated at 387 million pounds, up 3 percent from 2007.

Global flue-cured tobacco production is expected to be 9.20 billion pounds in 2008, up about 7.8 percent from 2007, according to Universal Tobacco Company's October 2008 issue of "World Leaf Production Summary." Production was up in China and estimated to be about 5.07 billion pounds. Brazilian flue-cured production declined from 1.417 billion pounds in 2007 to 1.340 billion pounds in 2008. Zimbabwean flue-cured production declined from 161 million pounds in 2007 to 123 million pounds in 2008.

Domestic use of U.S. flue-cured tobacco declined from 338 million pounds in 2004 to a low of 246 million pounds in the 2006 market-

Table 1-1. U.S. flue-cured tobacco production, 2004 to 2008, in millions of pounds.

	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*	*36.3*	*387.0*	*42.0*	*43.2*	*508.5*

Source: USDA, NASS, Crop Production Report, September 2008 ing year. Domestic use then increased to 337 million pounds in 2007. Exports of U.S. flue-cured rose from 189 million pounds in 2004 to 305 million pounds in the 2007 marketing year. Total disappearance has increased from 526 million pounds in 2004 to 631 million pounds in 2007. Imports of flue-cured tobacco to the U.S. decreased initially after prices fell with deregulation, but increased some in 2006. Production of U.S. flue-cured has been lower than total use since 1999 as manufacturers continue to pull down inventories.

Prices and Input Costs

Tobacco market prices are difficult to estimate because official market reporting was eliminated with the buyout. Flue-cured tobacco prices likely averaged $1.80 to $1.85 per pound for the 2008 crop, up about 30 cents from 2007. While the 2007 to 2008 price increase was up about 20 percent for some producers, production costs have increased by a similar level due to increased fuel and fertilizer costs. Increased production costs dampened anticipated increases in production despite higher prices.

Fertilizer and LP gas prices, the major input costs besides labor, reached record levels in 2008. Nitrogen prices in spring 2008 were up about 75 percent from spring 2005, the first season after the tobacco buyout. Phosphate and potash prices were up over 143% in spring 2008 from their levels in spring 2005. Fertilizer prices continued to rise in summer 2008 before declining in the fall. The Food and Agriculture Organization of the United Nations forecasts world fertil-

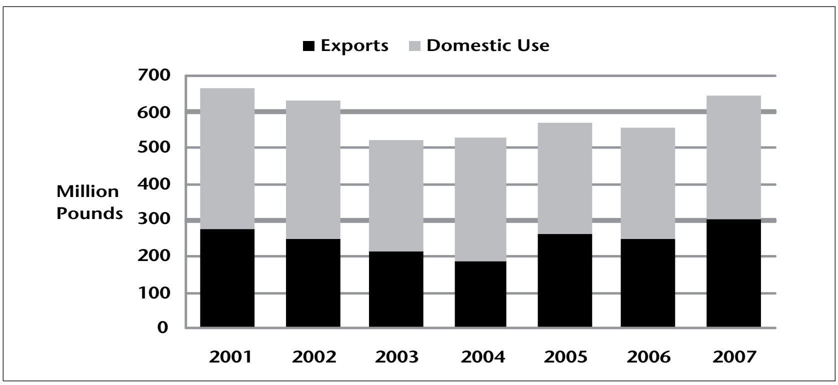

Figure 1-1. U.S. flue-cured disappearance (use). *Source: USDA–AMIS, USDA–ERS*

izer production (N, P, and K) to outstrip demand over the next five years, allowing prices to decline. With declining corn and soybean prices, declining petroleum prices, and increasing supplies of fertilizer, most analysts expect fertilizer prices to be lower in 2009.

The record high 2008 fertilizer prices were blamed on soaring demand for fertilizer due to high corn, soybean, and wheat prices, plus high petroleum prices. LP gas prices rose to more than $2 per gallon in 2008, but declined in the fall with declining petroleum prices. By mid-November 2008, futures prices for LP gas for summer 2009 had declined to nearly $1 per gallon, but remain volatile and uncertain for next year. Although much uncertainty exists for both fertilizer and LP gas prices in 2009, flue-cured tobacco producers may experience some relief in input prices for the 2009 crop.

U.S. Cigarette Industry

U.S. cigarette production has declined over 30 percent in the last decade. This decline is, in part, due to continued declines in U.S. cigarette consumption. U.S. cigarette consumption has declined at a rate of 2 to 3 percent per year for more than two decades. Another factor causing declines in U.S. cigarette production is declining cigarette exports. Exports reached a peak in 1996 of 243.9 billion cigarettes, but had declined to 89 billion cigarettes by 2007. Multi-national manufac-

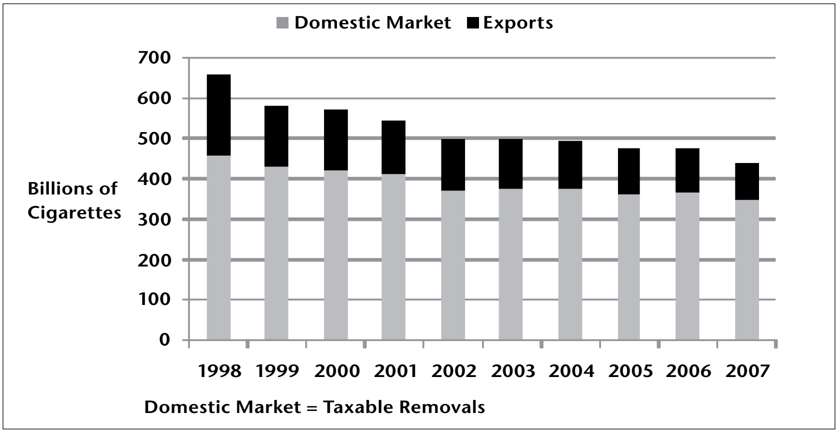

Figure 1-2. U.S. cigarette production. *Source: TMA Tobacco USA, cigarettes August 1, 2008*

turers continue to move production of cigarettes for foreign markets to countries other than the U.S.

The U.S. cigarette market is increasingly focused on harm reduction technologies. FDA regulation of cigarettes is likely to become law in the near future, further increasing the focus of U.S. manufacturers on harm reduction. Changes in cigarette production will likely lead to less tobacco used per cigarette, particularly for traditional cigarette tobaccos such as flue-cured and burley. This, coupled with continued erosion of cigarette consumption, will result in lower domestic demand for U.S. flue-cured and burley tobacco. At the same time, global cigarette production using traditional technologies continues to increase. Lower prices of U.S. tobacco combined with robust international cigarette production have increased demand for exports of U.S. tobacco.

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Universal Leaf Tobacco Company. 2008, October 16. World leaf production summary. Richmond, Va.: Universal Corporation. Online: http://www.universalcorp.com/Reports/SelectReport.asp?ID=725&Menu=Tob

Table 1-1. Flue-cured tobacco—machine harvest—eastern North Carolina: 2009 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	6.20	$40.00	$248.00	
Multipurpose fumigation	gal	10.50	$13.00	$136.50	
Fertilizer					
8-16-24	lb	7.00	$40.75	$285.25	
15.5-0-0	lb	300.00	$0.28	$84.00	
Lime (prorated)	ton	0.33	$43.00	$14.19	
Herbicides	acre	1.00	$43.11	$43.11	
Insecticides	acre	1.00	$33.03	$33.03	
Fungicides	acre	1.00	15.83	15.83	
Sucker control	acre	1.00	$113.67	$113.67	
Hauling	lb	2,400.00	$0.04	$96.00	
Cover crop	acre	0.00	$15.00	$0.00	
Curing fuel	gal	275.00	$1.60	$440.00	
Electricity	kwh	1,580.00	$0.10	$158.00	
Crop insurance	$	1.00	$65.00	$65.00	
Baling supplies	$	2,400.00	$0.003	$7.20	
Tractor/machinery	acre	1.00	$294.92	$294.92	
Labor					
Preharvest	hr	29.00	$8.85	$256.65	
Harvest	hr	51.00	$8.85	$451.35	
Machinery preharvest	hr	3.82	$8.85	$33.81	
Machinery harvest	hr	18.25	$8.85	$161.51	
Interest on op. capital	$	$486.79	9.25%	$45.03	
Total variable costs				$2,983.05	
3. Income above variable costs					
4. Fixed costs					
Tractor/machinery	acre	1.00	$328.12	$328.12	
Bulk barn	acre	1.00	$173.33	$173.33	
Total fixed costs:				$501.45	
5. Total costs				**$3,484.50**	
6. Net returns to land, risk, and management					

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

* *Producers who employ guest workers should also include other expenses (such as housing, and transportation) associated with labor.*

* *Please note: This budget is for planning purposes only.*
Prepared by Gary Bullen, David Smith, Loren Fisher, and Emily Weddington, N.C. State University, Department of Agricultural and Resource Economics.

* *May need two applications of Ridomil for black shank @ $40/application.*

Table 1-2. Flue-cured tobacco—machine harvest—piedmont North Carolina: 2009 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.	6.20	$40.00	$248.00	
Multipurpose fumigation	gal	10.50	$13.00	$136.50	
Fertilizer					
8-16-24	lb	7.00	$40.75	$285.25	
15.5-0-0	lb	300.00	$0.28	$84.00	
Lime (prorated)	ton	0.33	$43.00	$14.19	
Herbicides	acre	1.00	$43.11	$43.11	
Insecticides	acre	1.00	$33.03	$33.03	
Sucker control	acre	1.00	$113.67	$113.67	
Hauling	lb	2,500.00	$0.04	$100.00	
Irrigation	times	3.00	$26.47	$79.41	
Cover crop	acre	0.00	$15.00	$0.00	
Curing fuel	gal	275.00	$1.60	$440.00	
Electricity	kwh	1,580.00	$0.10	$158.00	
Crop insurance	$	1.00	$65.00	$65.00	
Baling supplies	$	2,500.00	$0.003	$7.50	
Tractor/machinery	acre	1.00	$294.92	$294.92	
Labor					
Preharvest	hrs	29.00	$8.85	$256.65	
Harvest	hrs	51.00	$8.85	$451.35	
Machinery preharvest	hrs	3.82	$8.85	$33.81	
Machinery harvest	hrs	18.25	$8.85	$161.51	
Interest on op. capital	$	$351.53	9.25%	$44.30	
Total variable costs				$3,050.20	
3. Income above variable costs:					
4. Fixed costs					
Tractor/machinery	acre	1.00	$328.12	$328.12	
Irrigation	acre	1.00	$79.42	$79.42	
Bulk barn	acre	1.00	$173.33	$173.33	
Total fixed costs				$580.87	
5. Total costs				**$3,631.07**	
6. Net returns to land, risk, and management					

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

* Producers who employ guest workers should also include other expenses (housing, transportation, etc.) associated with labor.

* Please note: This budget is for planning purposes only.
Prepared by: Gary Bullen, Loren Fisher, and Emily Weddington, NC State University, Department of Agricultural and Resource Economics

2. Complying with North Carolina Farm Labor Regulations

Jonathan Phillips
Collegiate Lecturer, Agricultural and Resource Economics

Tobacco growers who employ workers must comply with the ever-changing federal and state farm labor laws. This includes laws pertaining to migrant labor, tax withholdings, minimum wage rates, and insurance. Please note that 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 (IRCA) 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 3 days of employment or on the first day of employment if the length of employment is less then 3 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**.

Employment Discrimination

Employers must consider all qualified applicants if they employ 15 or more workers. All employees, including part-time and temporary workers, are counted for this purpose. The Civil Rights Act of 1964 prevents employment discrimination against individuals because of their membership in a protected class. Employment includes, but is not limited to, the employment application, hiring, promotion, pay, and termination. 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, or spouses) and meet either of these two requirements:

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

The Social Security rate is 6.2 percent for both employee and employer portions. The maximum annual wage on which Social Security taxes must be paid is $102,000 for 2008 and $106,800 in 2009. Medicare tax remains at 1.45 percent 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 Web site: **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 Tax

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 6.2 percent, but a credit of up to 5.4 percent is usually granted, depending on the situation, making the effective tax rate 0.8 percent. North Carolina unemployment tax is paid only on the first $18,600 of each employee's wages in 2008. The state tax rate is between 0 and 6.84 percent, depending on the credit or debt ratio. The new-business starting rate is 1.2 percent. For detailed information about income-based taxes, contact the appropriate agency:

U.S. Internal Revenue Service
The IRS has 10 local offices in North Carolina. To find the nearest office, phone 1-800-829-4933 or visit
www.irs.gov

N.C. Department of Revenue
501 North Wilmington Street, Raleigh, NC 27604, 1-877-252-3052
www.dor.state.nc.us

Employment Security Commission of North Carolina
700 Wade Avenue, Raleigh, NC 27605, (919) 707-1170
The ESC has many regional offices:
http: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 is available from the North Carolina Industrial Commission, (919) 807-2500, **www.comp.state.nc.us**.

Minimum Wage

Beginning July 24, 2008, the federal minimum wage became $6.55 per hour. This increase makes the federal wage law stricter than North Carolina law. Therefore, federal laws must be followed by both agricultural and nonagricultural businesses that are not exempt. The federal minimum wage will increase again on July 24, 2009, to $7.25.

Agricultural employers are exempt from paying the minimum wage if they employed fewer than 500 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 1 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, 1-866-4-US-WAGE, or visit the division's Web site: **www.dol.gov/esa/whd/**.

Overtime

The United States 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 exempt. (See U.S. Department of Labor versus N.C. 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, a nonexempt employee is paid every two weeks and works for 46 hours one week and 34 the next in the same pay period. The employer owes the employee 74 hours standard pay and 6 hours overtime. For more information, Contact the U.S. Department of Labor's Wage and Hour Division at the address noted above for additional information.

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 anytime in any occupation on a farm owned and operated by their parents.

In North Carolina it is illegal to hire any youth under 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 for accusations of some child-labor violations. To obtain a youth employment certificate or further information, contact the N.C. Department of Labor, 1-800-NC-LABOR, or visit the department's Web site: **www.dol.state.nc.us**.

No child under 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 particular circumstances, such as when an adult is present in the bed or cargo area of the vehicle and is supervising the child. For detailed information about vehicle safety laws, contact the Governor's Highway Safety Program, N.C. Department of Transportation,1-800-999-9676, or visit the program's Web site: **www.ncdot.org/secretary/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 500 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, 1-866-4-USA-DOL, or visit the department's MSPA compliance site: **www.dol.gov/dol/compliance/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 the transportation. Under the joint employment laws, if a farm labor contractor is not certified in a function and performs it, then 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 or from any office of the North Carolina Employment Securities Commission.

N.C. Department of Labor
Wage and Hour Bureau
1-800-NC-LABOR
www.nclabor.com/wh/wh.htm

N.C. Employment Securities Commission offices are located across the state. 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 the following:

- 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 employee's 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 Web site 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 Web site to determine which poster you are required to display:
http://www.dol.gov/osbp/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 **www.ncnewhires.com**. For more information, call 1-888-514-4568.

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 at 1-800-NCLABOR, **www.dol.state.nc.us**.

New Laws and Regulations

Many changes in labor law are being proposed at this writing in November 2008. 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, K 326 was the most popular variety of flue-cured tobacco planted in North Carolina during 2008. K 326 was grown on 29 percent of the tobacco acres in the state. Other popular varieties were NC 71 (20 percent), CC 27 (15 percent), NC 196 (8 percent), K 346 (6 percent), CC 37 (3 percent), NC 297 (3 percent), NC 72 (3 percent), and NC 299 (3 percent). Figure 3-1 shows the five most popular varieties planted since 2004. 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 insure 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 11 locations. Six 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:

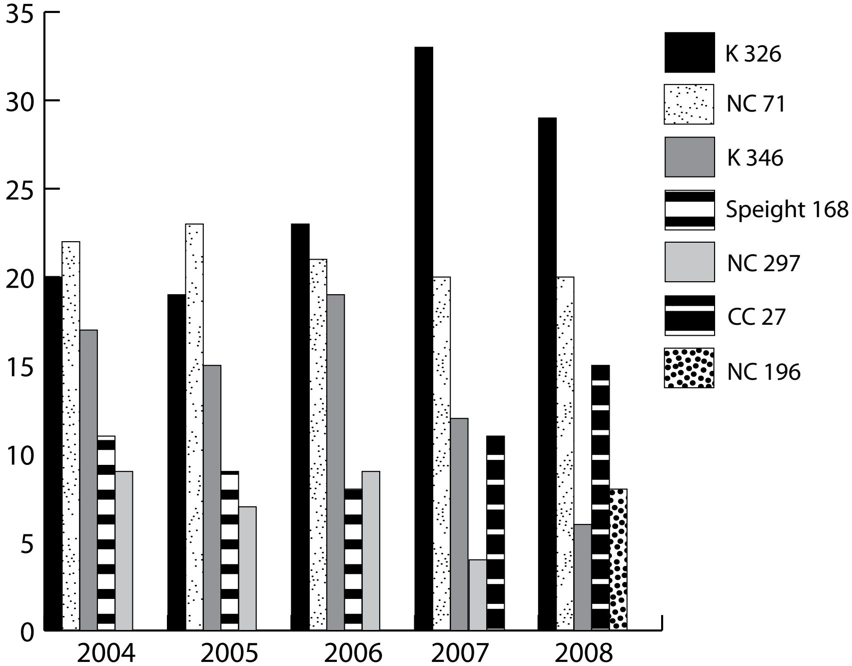

Figure 3-1. Plantings of several popular varieties, 2004 to 2008

Border Belt Research Station—Whiteville
Central Crops Research Station—Clayton
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 black shank and Granville wilt pressure.

Variety Selection

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

Consider disease resistance first. Tables 9-4a and 9-4b in Chapter 9, “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. Determine the level of disease resistance that you need based on field history, length of rotation, and crops grown in rotation with tobacco.

Consider agronomic characteristics, such as yield, quality, and holding ability, after you determine the necessary level of disease resistance. Multi-year 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 3-8) are helpful when you wish to see data collected from a specific growing region and under certain climatic conditions. The pedigrees of varieties in the 2008 OVT are shown in Table 3-9.

Consider holding ability—the ability of a variety to hold its ripeness during the harvest period. Figures 3-2 through 3-5 in this chapter compare the value of the last priming for several popular varieties based on harvest schedule.

New Varieties

CC 35, CC 700, and Speight 236 are new varieties available from Cross Creek Seeds. PVH 2110 is new variety available from Gold Leaf Seeds. Agronomic data for all new varieties can be found in Tables 3-3 through 3-7. Disease resistance information can be found in Chapter 9, “Managing Diseases.”

Table 3-1. Performance of commercial varieties in the N.C. Official Variety Test, three-year average, 2006-2008

Variety	Yield (lb/a)	Value $/a	Price Index ($/cwt)	Grade Index	Days to Flower	Leaves per Plant	Plant Height (in)	Leaf Spacing (in)	Cured Leaf Analysis		
									Sol. Sug. (%)	Tot. Alk. (%)	Ratio Sug. to Alk.
CC 13	2,938	4,501	151.85	85	70	18.4	40	2.20	15.22	2.50	6.81
CC 27	3,116	4,705	150.65	84	69	18.4	40	2.18	16.06	2.62	7.05
CC 700	2,919	4,377	149.89	84	67	17.8	40	2.23	15.69	2.60	6.84
GL 939	2,692	4,021	148.48	84	66	17.8	38	2.13	16.54	2.88	6.46
K 149	2,781	4,170	149.04	84	68	18.6	40	2.17	15.61	2.61	6.83
K 326	3,080	4,734	153.53	85	68	18.0	40	2.21	15.66	2.54	6.88
K 346	2,667	3,981	148.10	84	67	17.9	40	2.23	15.67	2.60	6.94
NC 102	2,744	4,120	149.93	84	68	18.0	38	2.09	15.41	2.73	6.46
NC 196	2,944	4,500	152.45	85	70	18.3	41	2.27	15.32	2.58	6.67
NC 291	2,978	4,485	150.16	85	68	17.5	38	2.18	15.44	2.81	6.03
NC 297	2,909	4,378	149.86	84	69	18.0	39	2.19	15.92	2.80	6.41
NC 299	2,981	4,583	153.25	85	69	18.7	40	2.16	16.00	2.64	6.63
NC 471	2,532	3,822	149.66	84	70	18.7	42	2.23	15.14	2.80	5.98
NC 55	2,886	4,420	152.46	85	69	18.0	38	2.14	15.52	2.80	6.27
NC 606	2,774	4,209	150.53	84	68	18.3	42	2.28	15.85	2.73	6.59
NC 71	3,153	4,757	150.57	85	69	17.8	39	2.20	16.25	2.70	6.76

Table 3-1. (continued)

Variety	*Yield (lb/a)*	*Value $/a*	*Price Index ($/cwt)*	*Grade Index*	*Days to Flower*	*Leaves per Plant*	*Plant Height (in)*	*Leaf Spacing (in)*	*Cured Leaf Analysis*		
									Sol. Sug. (%)	*Tot. Alk. (%)*	*Ratio Sug. to Alk.*
NC 72	*2,902*	*4,419*	*151.91*	*85*	*68*	*18.0*	*42*	*2.32*	*14.99*	*2.59*	*6.56*
PVH 1118	*2,827*	*4,279*	*149.85*	*84*	*67*	*18.4*	*41*	*2.25*	*15.69*	*2.70*	*6.53*
RG 17	*2,846*	*4,341*	*151.67*	*85*	*67*	*18.1*	*39*	*2.15*	*15.38*	*2.65*	*6.63*
RGH4	*2,769*	*4,161*	*149.65*	*84*	*68*	*18.1*	*42*	*2.33*	*15.36*	*3.00*	*5.81*
RGH51	*2,929*	*4,451*	*150.77*	*84*	*67*	*17.7*	*40*	*2.29*	*15.48*	*2.73*	*6.53*
SPEIGHT 168	*2,782*	*4,173*	*149.09*	*84*	*68*	*17.7*	*39*	*2.22*	*15.69*	*2.61*	*6.63*
SPEIGHT 210	*2,488*	*3,734*	*149.41*	*84*	*67*	*17.8*	*40*	*2.26*	*16.06*	*2.67*	*6.97*
SPEIGHT 220	*2,715*	*4,140*	*151.13*	*85*	*70*	*18.2*	*40*	*2.19*	*15.20*	*2.95*	*5.73*
SPEIGHT 225	*2,511*	*3,778*	*150.06*	*84*	*67*	*16.9*	*39*	*2.33*	*14.65*	*2.67*	*6.17*
SPEIGHT 227	*2,772*	*4,093*	*146.12*	*83*	*70*	*18.3*	*40*	*2.18*	*15.32*	*2.60*	*6.77*
SPEIGHT 234	*2,666*	*3,970*	*148.08*	*84*	*69*	*17.3*	*39*	*2.27*	*14.62*	*2.60*	*6.27*
SPEIGHT 236	*2,742*	*4,070*	*147.80*	*83*	*70*	*17.9*	*39*	*2.19*	*14.38*	*2.71*	*6.01*
SPEIGHT H-20	*2,626*	*3,912*	*147.10*	*83*	*67*	*18.1*	*42*	*2.30*	*15.32*	*2.69*	*6.41*
SPEIGHT NF3	*2,613*	*4,044*	*153.06*	*85*	*73*	*19.0*	*41*	*2.19*	*14.32*	*2.65*	*6.19*
Test Average	*2,809*	*4,244*	*150.20*	*84*	*68*	*18.1*	*40*	*2.22*	*15.46*	*2.69*	*6.49*

Table 3-2. Performance of commercial varieties in the N.C. Official Variety Test, two-year average, 2007-2008

									Cured Leaf Analysis		
Variety	Yield (lb/a)	Value $/a	Price Index ($cwt)	Grade Index	Days to Flower	Leaves per Plant	Plant Height (in)	Leaf Spacing (in)	Sol. Sug. (%)	Tot. Alk. (%)	Ratio Sug. to Alk.
CC 13	3,116	5,001	160.45	84	72	18.4	39	2.10	14.66	2.79	5.64
CC 27	3,270	5,228	159.97	84	71	18.4	38	2.06	15.04	3.04	5.34
CC 37	3,111	4,994	161.01	85	71	18.6	39	2.10	15.30	2.84	5.89
CC 700	3,066	4,875	159.67	84	69	18	38	2.09	14.88	2.93	5.58
GL 939	2,877	4,536	158.40	84	68	17.9	36	2.00	15.85	3.29	5.09
K 149	2,927	4,615	157.49	84	70	18.4	38	2.06	15.01	2.96	5.56
K 326	3,153	5,078	161.30	85	71	18.1	37	2.06	14.80	2.88	5.48
K 346	2,830	4,463	157.76	84	69	17.9	38	2.11	14.98	2.95	5.59
NC 102	2,789	4,427	159.39	84	69	17.8	36	2.00	14.30	3.13	4.99
NC 196	3,029	4,851	160.12	84	72	18.6	40	2.14	14.18	2.91	5.30
NC 291	3,095	4,930	159.71	84	70	17.8	36	2.01	14.44	3.14	4.99
NC 297	3,056	4,935	161.39	85	72	18.1	37	2.06	15.03	3.16	5.16
NC 299	3,108	5,025	161.85	85	71	18.8	38	2.04	14.90	2.94	5.27
NC 471	2,693	4,324	160.92	85	73	19.1	40	2.10	14.66	3.13	5.09
NC 55	3,087	5,017	162.62	85	71	18.2	37	2.01	14.42	3.21	4.82
NC 606	2,943	4,724	160.40	84	71	18.4	40	2.18	15.51	3.07	5.39
NC 71	3,266	5,209	159.70	84	71	17.8	37	2.09	15.51	3.05	5.45

Table 3-2. (continued)

Variety	Yield (lb/a)	Value $/a	Price Index ($cwt)	Grade Index	Days to Flower	Leaves per Plant	Plant Height (in)	Leaf Spacing (in)	Cured Leaf Analysis		
									Sol. Sug. (%)	Tot. Alk. (%)	Ratio Sug. to Alk.
NC 72	3,061	4,959	162.18	85	70	18.1	40	2.20	13.71	2.95	4.99
PVH 1118	3,010	4,801	159.25	84	69	18.1	39	2.17	14.79	3.05	5.27
RG 17	2,999	4,823	160.77	85	68	18.1	37	2.03	14.24	3.06	5.08
RGH4	2,951	4,636	157.31	83	69	18.4	40	2.20	14.49	3.40	4.63
RGH51	3,126	5,051	161.83	85	68	17.7	38	2.15	14.40	3.11	5.14
SPEIGHT 168	2,943	4,643	157.90	84	70	17.9	38	2.11	15.02	2.86	5.62
SPEIGHT 210	2,612	4,133	158.80	84	69	17.9	38	2.11	15.50	3.02	5.54
SPEIGHT 220	2,890	4,636	160.36	85	72	18.5	38	2.05	14.85	3.35	4.72
SPEIGHT 225	2,622	4,185	160.08	85	69	17.1	37	2.19	13.96	2.97	5.08
SPEIGHT 227	2,968	4,602	154.91	82	73	18.2	38	2.08	14.68	2.88	5.67
SPEIGHT 234	2,870	4,498	157.20	83	70	17.6	38	2.13	13.79	2.90	5.20
SPEIGHT 236	2,864	4,459	156.57	83	72	18.1	37	2.06	13.84	3.08	5.02
SPEIGHT H-20	2,843	4,513	158.71	84	69	18.3	39	2.13	15.01	2.99	5.57
SPEIGHT NF3	2,788	4,530	161.95	85	74	18.6	40	2.13	13.80	2.98	5.10
Test Average	2,967	4,732	159.67	84	70	18.2	38	2.09	14.69	3.03	5.26

Table 3-3. Performance of commercial varieties in the N.C. Official Variety Test, combined over four locations, 2008

Variety	Yield (lb/a)	Value $/a	Price Index ($/cwt)	Grade Index	Days to Flower	Leaves per Plant	Plant Height (in)	Leaf Spacing (in)	Cured Leaf Analysis: Sol. Sug. (%)	Cured Leaf Analysis: Total Alk. (%)	Cured Leaf Analysis: Ratio Sug. to Alk.
CC 13	3,058	5,330	173.93	84	71	18.7	37	1.97	13.35	2.86	5.07
CC 27	3,194	5,552	173.41	84	71	18.8	36	1.93	14.45	2.98	5.46
CC 35	3,328	5,807	174.08	85	73	17.0	38	2.21	14.55	2.88	5.74
CC 37	2,944	5,143	174.63	85	71	18.7	37	1.99	15.15	2.70	6.32
CC 65	3,215	5,621	174.48	85	73	17.1	38	2.26	14.06	3.11	4.89
CC 700	2,943	5,102	173.52	85	69	18.6	35	1.91	14.04	2.96	5.40
GF 52	3,009	5,175	171.72	84	70	18.1	37	2.02	14.88	3.07	5.27
GL 939	2,669	4,596	172.09	84	69	18.2	34	1.86	14.38	3.24	4.72
K 149	2,788	4,748	169.40	84	71	19.1	36	1.90	14.93	2.65	6.35
K 326	3,064	5,420	176.69	86	71	18.6	36	1.92	13.55	2.95	4.99
K 346	2,709	4,644	170.69	84	70	18.4	36	1.94	14.07	2.95	5.46
K 394	3,023	5,133	169.98	84	71	19.2	36	1.88	15.30	2.62	6.22
K 399	2,680	4,611	171.04	84	70	18.3	34	1.85	14.10	2.95	5.28
NC 102	2,618	4,541	173.27	85	69	17.6	33	1.86	13.04	3.11	4.62
NC 196	2,978	5,191	173.95	84	72	19.3	39	2.01	13.61	2.82	5.37
NC 291	2,932	5,064	172.37	84	70	17.8	33	1.84	13.60	3.25	4.71
NC 297	3,009	5,260	174.69	85	72	18.3	35	1.91	13.72	3.14	5.04
NC 299	3,063	5,341	174.35	85	71	19.4	36	1.86	14.07	2.86	5.18
NC 471	2,548	4,449	174.21	85	73	19.6	38	1.95	13.90	3.06	5.02
NC 55	2,982	5,200	174.08	85	70	18.1	34	1.85	14.25	3.09	5.00

Table 3-3. (continued)

Variety	Yield (lb/a)	Value $/a	Price Index ($/cwt)	Grade Index	Days to Flower	Leaves per Plant	Plant Height (in)	Leaf Spacing (in)	Cured Leaf Analysis		
									Sol. Sug. (%)	Total Alk. (%)	Ratio Sug. to Alk.
NC 606	2,895	5,008	172.71	85	71	17.9	38	2.11	15.48	2.99	5.62
NC 71	3,151	5,424	171.84	84	71	18.4	35	1.89	14.33	3.13	5.06
NC 72	2,991	5,268	176.01	85	70	18.2	37	2.04	12.59	2.86	4.92
NC 810	2,864	4,854	169.79	84	75	19.9	35	1.78	14.08	2.93	5.17
NC92	3,069	5,323	173.38	85	71	18.7	38	2.01	13.73	3.52	4.16
PVH 1118	2,919	5,134	174.98	86	69	18.5	37	1.99	14.14	2.96	5.31
PVH 2110	3,142	5,541	175.82	85	75	20.0	38	1.90	13.01	2.97	4.93
RG 17	2,897	5,049	173.39	85	68	18.5	34	1.87	13.09	3.11	4.79
RGH 51	2,999	5,249	174.66	85	69	18.4	37	2.00	14.36	2.97	5.54
RGH4	2,871	4,917	171.14	84	70	18.3	38	2.07	13.52	3.41	4.56
SPEIGHT 168	2,847	4,892	171.54	84	69	18.2	36	1.95	14.37	2.73	5.88
SPEIGHT 210	2,417	4,173	172.14	84	70	18.3	35	1.92	15.30	2.88	5.74
SPEIGHT 220	2,882	4,971	172.43	84	73	19.2	36	1.87	14.28	3.22	4.85
SPEIGHT 225	2,496	4,316	172.82	85	68	17.6	35	2.01	13.49	2.86	5.10
SPEIGHT 227	2,951	5,115	172.93	85	73	18.5	37	1.98	13.85	2.70	5.92
SPEIGHT 234	2,731	4,749	173.49	85	70	17.4	34	1.98	12.41	2.89	5.05
SPEIGHT 236	2,632	4,515	171.01	84	72	17.9	35	1.94	13.49	2.98	5.31
SPEIGHT H-20	2,802	4,820	171.71	84	68	18.6	37	2.00	14.85	2.79	5.78
SPEIGHT NF 3	2,824	4,991	176.21	86	73	19.5	39	1.97	12.42	2.97	4.82
Test Average	2,901	5,032	173.09	85	71	18.5	36	1.95	13.99	2.98	5.25

Table 3-4. Performance of commercial varieties in the N.C. Official Variety Test at Kinston, N.C., 2008

Variety	Yield (lb/a)	Value $/a	Price Index ($/cwt)	Grade Index	Days to Flower	Leaves per Plant	Plant Height (in)	Leaf Spacing (in)	Cured Leaf Analysis		
									Sol. Sug. (%)	Tot. Alk. (%)	Ratio Sug. to Alk.
CC 13	3,228	5,773	178.85	87	59	18.5	35	1.90	13.53	3.13	4.36
CC 27	3,047	5,451	178.82	87	59	18.3	35	1.90	16.00	2.93	5.52
CC 35	3,827	6,904	180.48	87	67	17.6	36	2.05	13.87	3.29	4.25
CC 37	2,643	4,746	179.45	87	64	18.4	37	2.00	14.43	3.23	4.57
CC 65	3,600	6,522	180.93	87	72	15.8	36	2.26	15.33	3.07	5.18
CC 700	2,590	4,648	179.43	87	59	17.7	32	1.80	13.17	3.28	4.09
GF 52	2,960	5,364	181.19	88	60	17.9	34	1.92	13.27	3.54	3.85
GL 939	2,331	4,163	178.62	87	58	17.6	30	1.74	15.67	3.39	4.63
K 149	2,805	4,995	178.09	86	62	18.5	34	1.84	16.77	2.35	7.27
K 326	3,001	5,468	182.21	88	59	18.1	32	1.77	14.03	3.15	4.54
K 346	2,893	5,148	177.96	87	63	18.3	34	1.87	13.67	3.10	4.43
K 394	2,948	5,217	176.95	86	60	17.1	32	1.87	18.77	2.79	6.86
K 399	2,471	4,380	177.23	86	60	17.1	31	1.82	13.1	3.31	3.99
NC 102	2,659	4,803	180.71	88	60	17.9	30	1.70	13.23	3.54	3.82
NC 196	2,796	4,989	178.42	86	63	18.8	36	1.91	14.6	2.66	6.18
NC 291	3,195	5,669	177.40	86	59	17.4	29	1.66	12.87	3.47	3.71
NC 297	2,788	4,930	176.86	86	62	18.2	32	1.76	12.6	3.76	3.44
NC 299	2,821	5,064	179.67	87	61	19.0	35	1.86	16.00	2.82	5.72
NC 471	2,398	4,161	173.14	85	62	19.1	36	1.88	14.77	3.07	4.93
NC 55	2,989	5,347	178.83	87	61	17.4	31	1.77	15.00	3.21	4.70

Table 3-4. (continued)

Variety	Yield (lb/a)	Value $/a	Price Index ($/cwt)	Grade Index	Days to Flower	Leaves per Plant	Plant Height (in)	Leaf Spacing (in)	Cured Leaf Analysis Sol. Sug. (%)	Cured Leaf Analysis Tot. Alk. (%)	Cured Leaf Analysis Ratio Sug. to Alk.
NC 606	2,838	4,886	170.84	84	60	17.6	35	2.01	17.97	2.84	6.34
NC 71	2,912	4,965	170.44	85	62	18.5	33	1.79	15.23	3.43	4.63
NC 72	2,500	4,453	178.23	87	61	17.9	35	1.97	14.43	2.85	5.19
NC 810	2,493	4,404	176.60	86	64	18.9	32	1.67	12.97	3.31	3.93
NC92	3,012	5,170	172.11	85	61	18.4	36	1.97	15.20	3.47	4.39
PVH 1118	3,204	5,771	179.39	87	60	18.8	35	1.88	13.03	3.38	3.86
PVH 2110	3,273	5,898	180.07	87	63	20.2	38	1.86	12.13	3.38	3.60
RG 17	3,292	5,831	177.21	86	60	17.2	31	1.83	12.83	3.49	3.71
RGH 51	2,780	4,949	178.03	86	58	18.3	33	1.83	13.53	3.35	4.28
RGH4	2,872	5,166	179.91	88	59	17.5	35	1.99	14.40	3.76	3.90
SPEIGHT 168	2,742	4,869	177.59	86	60	18.3	33	1.83	14.83	2.58	5.76
SPEIGHT 210	2,453	4,365	177.95	86	60	18.8	35	1.84	12.63	3.37	3.75
SPEIGHT 220	2,903	5,149	177.39	86	64	17.9	34	1.90	12.07	3.56	3.40
SPEIGHT 225	2,233	3,931	176.00	86	57	16.8	32	1.92	12.93	3.12	4.23
SPEIGHT 227	2,920	5,207	178.34	86	65	17.5	34	1.92	14.57	2.86	5.11
SPEIGHT 234	2,430	4,312	177.44	86	61	16.3	32	1.94	14.80	2.76	5.46
SPEIGHT 236	2,656	4,705	177.13	86	62	17.5	31	1.79	15.80	2.77	5.78
SPEIGHT H-20	3,118	5,552	177.97	86	60	17.6	35	1.99	13.63	3.07	4.45
SPEIGHT NF 3	3,097	5,576	179.94	87	66	17.9	35	1.99	13.47	2.60	5.25
Test Average	2,865	5,100	177.89	86	61	18.0	34	1.88	14.29	3.15	4.69
Waller L.S.D.	653	1,216	11.18	3.17	5.22	1.86	2.65	0.17	4.59	0.64	2.55

Table 3-5. Performance of commercial varieties in the N.C. Official Variety Test at Rocky Mount, N.C., 2008

Variety	Yield (lb/a)	Value $/a	Price Index ($/cwt)	Grade Index	Days to Flower	Leaves per Plant	Plant Height (in)	Leaf Spacing (in)	Cured Leaf Analysis: Sol. Sug. (%)	Cured Leaf Analysis: Tot. Alk. (%)	Cured Leaf Analysis: Ratio Sug. to Alk.
CC 13	2,878	4,774	165.75	80	67	16.9	33	1.93	7.96	2.86	3.01
CC 27	3,043	5,173	169.37	83	69	18.1	33	1.80	9.81	3.11	3.50
CC 35	2,889	4,743	164.58	82	70	16.7	35	2.09	12.00	2.82	4.58
CC 37	2,762	4,691	169.43	84	64	16.4	32	1.94	11.93	2.71	4.45
CC 65	2,735	4,581	167.28	83	68	18.7	36	1.91	11.25	3.11	3.92
CC 700	2,691	4,623	171.71	85	64	15.9	31	1.93	9.31	3.25	2.90
GF 52	2,665	4,374	163.33	82	62	16.8	32	1.90	11.66	3.16	3.67
GL 939	2,151	3,570	165.43	83	63	15.9	30	1.87	10.58	3.44	3.26
K 149	2,183	3,566	163.00	83	65	18.0	32	1.76	13.16	2.93	4.80
K 326	3,055	5,219	170.82	84	66	17.0	30	1.77	10.63	3.04	3.63
K 346	2,249	3,697	163.32	83	62	15.7	31	1.95	9.94	2.94	3.69
K 394	2,741	4,619	168.08	84	66	17.3	31	1.77	10.60	2.93	3.72
K 399	2,048	3,273	160.21	82	63	15.9	28	1.79	11.83	3.00	4.35
NC 102	2,451	4,146	169.22	84	62	15.3	26	1.73	10.07	2.90	3.84
NC 196	2,779	4,697	168.52	82	67	18.3	35	1.90	10.22	2.99	3.60
NC 291	2,616	4,456	170.35	85	65	15.5	28	1.80	10.24	3.62	2.90
NC 297	2,805	4,722	168.48	83	65	17.1	31	1.82	11.76	3.04	4.00
NC 299	3,037	5,142	169.43	83	69	17.7	31	1.73	8.64	3.13	2.78
NC 471	2,398	4,089	170.46	84	67	17.7	34	1.91	10.71	3.33	3.27
NC 55	2,728	4,562	167.24	82	63	15.7	28	1.80	11.74	3.09	4.02

Table 3-5. (continued)

Variety	Yield (lb/a)	Value $/a	Price Index ($/cwt)	Grade Index	Days to Flower	Leaves per Plant	Plant Height (in)	Leaf Spacing (in)	Cured Leaf Analysis Sol. Sug. (%)	Tot. Alk. (%)	Ratio Sug. to Alk.
NC 606	2,732	4,626	169.25	84	65	15.6	32	2.03	9.33	3.39	2.84
NC 71	2,706	4,618	170.72	84	66	15.1	27	1.77	8.35	3.41	2.43
NC 72	2,966	5,028	169.35	83	66	15.8	31	1.98	8.99	2.94	3.24
NC 810	2,853	4,758	166.84	84	75	19.5	35	1.78	10.50	2.96	3.82
NC92	3,037	5,136	168.96	83	68	18.0	33	1.83	10.25	3.52	3.06
PVH 1118	2,288	3,853	168.38	84	62	17.3	34	1.95	10.46	2.92	3.88
PVH 2110	2,896	4,963	171.34	83	69	18.1	33	1.80	10.45	3.03	3.70
RG 17	2,268	3,721	163.52	84	62	16.5	32	1.92	9.49	2.90	3.40
RGH 51	2,653	4,485	168.99	84	63	16.7	33	1.99	13.37	2.88	4.93
RGH4	2,806	4,772	170.07	85	65	17.8	35	1.95	8.24	3.71	2.36
SPEIGHT 168	2,273	3,668	162.71	83	64	15.1	28	1.89	11.23	2.99	4.13
SPEIGHT 210	2,056	3,469	168.58	85	64	16.9	30	1.81	13.47	2.77	4.85
SPEIGHT 220	2,635	4,520	171.51	84	69	17.7	32	1.81	14.10	3.16	4.58
SPEIGHT 225	2,235	3,802	170.17	85	64	15.8	32	1.99	10.99	2.83	4.02
SPEIGHT 227	2,437	4,092	167.86	85	69	17.0	32	1.86	12.05	2.97	4.33
SPEIGHT 234	2,469	4,173	169.00	83	65	15.1	29	1.92	6.92	3.53	1.97
SPEIGHT 236	2,144	3,576	166.58	85	64	17.1	32	1.87	9.33	3.12	3.29
SPEIGHT H-20	2,466	3,937	161.31	82	64	16.8	32	1.90	9.00	3.01	3.01
SPEIGHT NF 3	2,345	4,008	170.95	84	69	19.3	36	1.87	7.79	3.23	2.43
Test Average	2,594	4,357	167.75	83	66	16.9	32	1.87	10.47	3.09	3.59
Waller L.S.D.	605	1,068	22.99	11.52	4.44	1.74	3.41	0.21	7.80	1.21	1.24

Table 3-6. Performance of commercial varieties in the N.C. Official Variety Test at Oxford, N.C., 2008

Variety	Yield (lb/a)	Value $/a	Price Index ($/cwt)	Grade Index	Days to Flower	Leaves per Plant	Plant Height (in)	Leaf Spacing (in)	Cured Leaf Analysis Sol. Sug. (%)	Tot. Alk. (%)	Ratio Sug. to Alk.
CC 13	3,311	5,992	180.96	87	75	18.7	39	2.09	13.53	3.35	4.07
CC 27	3,318	5,955	179.47	87	75	19.5	38	1.94	12.97	3.84	3.40
CC 35	3,808	6,647	174.72	84	73	16.5	38	2.29	13.77	3.58	3.86
CC 37	3,112	5,366	172.72	84	74	19.7	39	2.02	15.87	3.13	5.06
CC 65	3,205	5,774	180.31	87	73	16.7	41	2.49	13.10	3.75	3.50
CC 700	3,381	5,926	175.22	85	72	19.1	37	1.93	15.10	3.50	4.33
GF 52	3,304	5,697	172.58	85	75	18.2	39	2.13	16.40	3.51	4.68
GL 939	3,152	5,636	178.83	86	72	18.4	36	1.98	14.33	3.69	3.95
K 149	3,155	5,457	171.94	84	72	20.6	39	1.88	11.55	3.38	3.62
K 326	3,441	6,136	178.54	86	75	19.3	40	2.09	12.44	3.38	3.75
K 346	3,139	5,391	171.18	83	72	19.3	37	1.92	13.97	3.87	3.61
K 394	3,442	5,594	163.03	81	73	21.2	41	1.95	15.07	2.82	5.54
K 399	3,089	5,510	178.09	86	74	18.8	37	1.98	13.06	3.31	4.09
NC 102	2,759	4,944	179.25	86	72	17.3	35	2.02	12.11	3.73	3.30
NC 196	3,339	5,915	176.98	85	74	18.9	40	2.12	13.67	3.52	3.98
NC 291	3,312	5,817	175.43	85	73	19.2	37	1.93	12.63	3.78	3.43
NC 297	3,289	5,833	177.18	86	75	18.0	37	2.05	12.24	3.82	3.27
NC 299	3,477	6,159	176.90	85	72	20.0	39	1.95	14.73	3.05	4.88
NC 471	2,811	5,035	178.91	86	75	21.3	40	1.91	12.36	3.73	3.40
NC 55	3,352	5,990	178.64	86	73	18.5	37	2.03	12.12	3.76	3.27

Table 3-6. (continued)

Variety	Yield (lb/a)	Value $/a	Price Index ($/cwt)	Grade Index	Days to Flower	Leaves per Plant	Plant Height (in)	Leaf Spacing (in)	Cured Leaf Analysis		
									Sol. Sug. (%)	Tot. Alk. (%)	Ratio Sug. to Alk.
NC 606	2,839	5,029	177.29	86	76	18.9	41	2.16	16.27	3.48	4.69
NC 71	3,564	6,352	178.11	86	75	19.4	39	1.99	15.47	3.55	4.35
NC 72	3,309	5,940	179.38	86	70	19.5	41	2.09	10.97	3.69	2.97
NC 810	3,299	5,444	165.55	82	76	21.4	39	1.84	14.57	3.24	4.51
NC92	3,190	5,788	181.18	87	74	17.9	39	2.19	13.00	4.34	3.01
PVH 1118	3,309	5,884	178.05	86	72	18.7	39	2.08	15.43	3.47	4.59
PVH 2110	3,488	6,281	179.95	87	78	21.0	41	1.98	11.81	3.50	3.47
RG 17	3,060	5,449	177.76	86	71	18.8	35	1.89	11.53	4.03	2.89
RGH 51	3,528	6,334	179.49	86	72	18.5	39	2.12	13.60	3.76	3.69
RGH4	3,005	5,161	171.60	83	73	17.7	39	2.22	13.83	3.90	3.56
SPEIGHT 168	3,068	5,485	178.45	86	73	19.6	39	1.99	13.67	3.48	3.93
SPEIGHT 210	2,865	5,060	176.43	85	71	18.3	38	2.09	15.93	3.36	4.78
SPEIGHT 220	3,219	5,602	174.44	84	75	20.6	38	1.85	14.33	3.89	3.79
SPEIGHT 225	3,109	5,425	174.42	85	71	18.5	38	2.08	13.03	3.44	3.79
SPEIGHT 227	3,125	5,449	174.36	84	74	18.3	39	2.16	11.72	3.37	3.53
SPEIGHT 234	3,210	5,679	175.94	85	74	18.8	37	1.95	11.29	3.53	3.28
SPEIGHT 236	3,163	5,552	175.55	85	75	18.4	38	2.05	10.86	4.11	2.69
SPEIGHT H-20	2,881	5,095	176.72	85	68	19.3	40	2.09	16.17	3.08	5.26
SPEIGHT NF 3	3,146	5,621	178.39	87	75	20.9	42	2.04	10.56	4.01	2.71
Test Average	3,220	5,677	176.25	85	73	19.1	39	2.04	13.46	3.58	3.86
Waller L.S.D.	936	2,190	18.73	7	4.2	3.22	4.93	0.25	7.45	0.66	2.54

Table 3-7. Performance of commercial varieties in the N.C. Official Variety Test at Clayton, N.C., 2008

Variety	Yield (lb/a)	Value $/a	Price Index ($/cwt)	Grade Index	Days to Flower	Leaves per Plant	Plant Height (in)	Leaf Spacing (in)	Cured Leaf Analysis		
									Sol. Sug. (%)	Tot. Alk. (%)	Ratio Sug. to Alk.
CC 13	2,815	4,781	170.15	83	83	20.5	40	1.96	18.37	2.11	8.86
CC 27	3,368	5,629	165.99	81	81	19.1	40	2.07	19.03	2.02	9.43
CC 35	2,787	4,934	176.54	86	80	17.0	41	2.42	18.57	1.83	10.29
CC 37	3,258	5,770	176.92	86	84	20.3	41	2.00	18.37	1.73	11.18
CC 65	3,322	5,606	169.41	82	77	17.2	41	2.38	16.57	2.50	6.96
CC 700	3,110	5,213	167.73	83	81	21.5	42	1.97	18.60	1.83	10.30
GF 52	3,107	5,263	169.79	83	83	19.6	42	2.12	18.20	2.08	8.90
GL 939	3,042	5,017	165.48	81	82	20.9	39	1.85	16.93	2.43	7.05
K 149	3,007	4,972	164.56	81	83	19.5	40	2.13	18.23	1.93	9.70
K 326	2,759	4,855	175.18	85	85	19.9	41	2.06	17.10	2.22	8.05
K 346	2,553	4,342	170.30	83	83	20.1	41	2.03	18.70	1.90	10.12
K 394	2,960	5,102	171.86	84	84	21.1	40	1.93	16.77	1.95	8.77
K 399	3,113	5,280	168.63	83	83	21.4	39	1.83	18.40	2.19	8.71
NC 102	2,602	4,271	163.92	81	82	20.0	40	1.99	16.77	2.25	7.54
NC 196	2,999	5,164	171.90	84	84	21.1	44	2.10	15.97	2.11	7.72
NC 291	2,605	4,313	166.28	82	85	19.1	38	1.97	18.67	2.14	8.78
NC 297	3,152	5,557	176.24	86	85	19.8	39	1.99	18.30	1.94	9.47
NC 299	2,918	5,000	171.40	84	83	20.8	40	1.91	16.90	2.43	7.33
NC 471	2,587	4,509	174.34	85	86	20.4	43	2.09	17.77	2.13	8.49
NC 55	2,860	4,901	171.61	84	85	20.9	38	1.82	18.13	2.30	7.99

Table 3-7. (continued)

Variety	Yield (lb/a)	Value $/a	Price Index ($/cwt)	Grade Index	Days to Flower	Leaves per Plant	Plant Height (in)	Leaf Spacing (in)	Cured Leaf Analysis Sol. Sug. (%)	Cured Leaf Analysis Tot. Alk. (%)	Cured Leaf Analysis Ratio Sug. to Alk.
NC 606	3,169	5,491	173.48	85	82	19.5	44	2.24	18.37	2.26	8.60
NC 71	3,421	5,762	168.08	82	82	20.6	41	1.98	18.27	2.15	8.84
NC 72	3,190	5,651	177.08	86	82	19.5	41	2.12	15.97	1.97	8.28
NC 810	2,811	4,812	170.17	83	86	19.9	36	1.83	18.30	2.23	8.43
NC92	3,038	5,198	171.26	84	82	20.5	42	2.05	16.47	2.73	6.19
PVH 1118	2,874	5,027	174.10	85	83	19.0	39	2.06	17.63	2.07	8.92
PVH 2110	2,912	5,021	171.92	84	89	20.7	40	1.96	17.67	1.98	8.95
RG 17	2,967	5,193	175.09	85	77	21.3	39	1.83	18.50	2.03	9.14
RGH 51	3,037	5,229	172.13	84	83	19.9	41	2.04	16.93	1.89	9.26
RGH4	2,802	4,569	162.99	80	82	20.4	43	2.13	17.60	2.27	8.44
SPEIGHT 168	3,308	5,544	167.41	82	79	19.8	41	2.09	17.73	1.85	9.73
SPEIGHT 210	2,296	3,798	165.60	81	83	19.2	37	1.95	19.17	2.01	9.56
SPEIGHT 220	2,771	4,611	166.37	82	84	20.5	39	1.91	16.6	2.25	7.63
SPEIGHT 225	2,406	4,107	170.71	84	81	19.1	39	2.04	17.0	2.05	8.36
SPEIGHT 227	3,323	5,712	171.17	84	85	21.1	42	1.98	17.07	1.60	10.72
SPEIGHT 234	2,814	4,831	171.58	84	81	19.5	41	2.09	16.63	1.75	9.49
SPEIGHT 236	2,567	4,225	164.80	81	86	18.8	38	2.05	17.97	1.93	9.47
SPEIGHT H-20	2,744	4,695	170.85	84	82	20.7	42	2.02	20.60	1.98	10.39
SPEIGHT NF 3	2,708	4,757	175.56	85	83	20.1	40	2.00	17.87	2.05	8.89
Test Average	2,925	4,993	170.48	83	83	20.0	40	2.03	17.76	2.08	8.84
Waller L.S.D.	653	1,550	34.10	15.38	5.38	3.5	3.32	0.19	4.06	0.77	5.16

Table 3-8. Pedigree information for commercial varieties in the N.C. Official Variety Test, 2008

Variety or Line	Year of Release	Pedigree	Disease Resistance[1] BS	GW	FW	RK	BN SP	Virus	Sponsor
CC 13	2005	Hybrid	R	R					Cross Creek Seeds
CC 27	2003	Hybrid	R	R		TCN/R		TMV	Cross Creek Seeds
CC 35	2007	Hybrid	R	R		M.j/R			Cross Creek Seeds
CC 37	2006	Hybrid	R	R		TCN/RM.j/R		TMV	Cross Creek Seeds
CC 65	2007	Hybrid	R	R		M.j/R			Cross Creek Seeds
CC 700	2005	Hybrid	R	R		TCN/R			Cross Creek Seeds
GF 52	2007	Hybrid	R	R		R		TMV	Gwynn Farms
GL 939	1992	McN 926 × 80241	R	R		R			Gold Leaf Seeds
K 149	1988	([G-28 × 354] × [CB-139 × F-105] ×[G-28 × 354]) McNair 399	M	H		R			Gold Leaf Seeds
K 326	1981	McNair 225 (McNair 30 × NC 95)	L	L		R			Gold Leaf Seeds, Raynor Seed Company, Cross Creek Seeds
K 346	1988	McNair 926 × 80241	H	H		R			Gold Leaf Seeds
K 394	1983	Speight G-28 × McNair 944	H	M					Gold Leaf Seeds
K 399	1979	(C-139 × C-319) × NC 95							Gold Leaf Seeds
NC 102	2001	Hybrid	R	R				TMV/PVY	F. W. Rickard Seeds
NC 196	2002	Hybrid	R	L		R			Gold Leaf Seeds
NC 291	1997	Hybrid	R	R		TCN/R		PVY/TEV	Cross Creek Seeds
NC 297	1998	Hybrid	R	R		R		TMV	Gold Leaf Seeds
NC 299	2001	Hybrid	R	R		TCN/R			Cross Creek Seeds

[1]Resistance; H—High; M—Moderate; L—Low; R- Resistant; T—Tolerant; Su—Susceptible Diseases: BS—Black shank; GW—Granville wilt; FW—Fusarium wilt; RK—Root knot; BN SP—Brown spot; TMV—Tobacco mosaic virus; PVY—Potato virus 'y'; TSWV—Tomato spotted wilt virus; TCN—Tobacco cyst nematode; TEV—Tobacco etch virus; M.j—Meloidogyne javanica

[2]Nonflowering genotypes: Should be topped at 18 harvestable leaves.

Table 3-8. (continued)

Variety or Line	Year of Release	Pedigree	Disease Resistance[1] BS	GW	FW	RK	BN SP	Virus	Sponsor
NC 471	2003	Hybrid	R	R				TMV	Raynor Seed Company
NC 55	1994	(K 326 × DH 1220) × (K 326 × Coker 371-Gold)	L	L		R		PVY/TEV	Gold Leaf Seeds
NC 606	1998	NC 729 × NC 82	R	R		R			Raynor Seed Company
NC 71	1995	Hybrid	H	M		R			F. W. Rickard Seeds
NC 72	1996	Hybrid	H	L		R			F. W. Rickard Seeds
NC 810	2000	OX 2101 × NC 729	R	R		R			Cross Creek Seeds
NC92	2007	Hybrid	R	R		TCN/R			NC State University
PVH 1118	2004	Hybrid	R	R		TCN/R			F. W. Rickard Seeds
PVH 2110	2005	Hybrid							Profigen
RG 17	1993	K 326 × K 399	L	M		R			F. W. Rickard Seeds
RGH 51	1998	Hybrid	R	R		R			F. W. Rickard Seeds
RGH4	1994	Hybrid	M	H		R		TMV	F. W. Rickard Seeds
Speight 168	1996	Coker 371G × Spt. G 118	H	H		R			Speight Seed Farms
Speight 210	2000	(SP 116 × G-126((K 346 × G-28)	R	R		R			Speight Seed Farms
Speight 220	2002	(K 346 × SP 117) (SP 116 × K 346)	R	R		R			Speight Seed Farms
Speight 225	2003	(SP 168 × K 346)(SPA 95 × SP 168)	R	R		R			Speight Seed Farms
Speight 227	2003	(Sp 151 × K 346)(SP 202 × K 346)	R	R		R			Speight Seed Farms
Speight 234	2004	(SP 168 × K 346)	R	R		R			Speight Seed Farms
Speight 236	2005	(SP 168 × SP 196)(SP 179 × SP 177)	R	R		R			Speight Seed Farms
Speight H-20	1999	Hybrid	R	R		R		TMV	Speight Seed Farms
Speight NF 3[2]	1996	Speight NF 1 × NC 0007	H	H		R			Speight Seed Farms

[1] Resistance; H—High; M—Moderate; L—Low; R- Resistant; T—Tolerant; Su—Susceptible Diseases: BS—Black shank; GW—Granville wilt; FW—Fusarium wilt; RK—Root knot; BN SP—Brown spot; TMV—Tobacco mosaic virus; PVY—Potato virus 'y'; TSWV—Tomato spotted wilt virus; TCN—Tobacco cyst nematode; TEV—Tobacco etch virus; M.j—Meloidogyne javanica
[2] Nonflowering genotypes: Should be topped at 18 harvestable leaves.

Table 3-9. NC State University post-buyout grade index and 2008 price index

Company Buying Grade	USDA Grade	Post-Buyout Grade Index (1-100)	2008 Price Index ($/cwt)
P1	P2F, P3F	75	162
P2	P2L, P3L, P4F	70	156
P3	P4L	65	146
P4	P5L, P5F	50	123
P5	P4G, P5G, N1L, N1GL	30	86
X1	X1F, X2F	85	162
X2, X1H	X1L, X2L, X3F, X4F	80	155
X3, X2H, X3H	X3L, X4L, X3KM, X3KR, X5F	75	143
X4	X5L, X4KR, X3V, X4V, X4KL, X4KF, X4KM, X3S	60	119
X5	X4KV, X4GK, X4G, X5G, N1XL, N1XO	40	72
C1	C1F, C2F	90	178
C2, C1H	C1L, C2L, C3F, C4F, C3L	85	170
C3, C2H, C3H	C5F, C4L	80	160
C4	C5L, C4KM, C4KR, C4KL, C4KF, C4V, C4S	70	139
C5	C4G, C4GK, N1GF	40	72
B1, B1X, B2X	B1L, B2L, B1F, B2F, B1FR, B2FR	95	197
B2, B1H	B3F, B3K, B3FR, B4FR	90	191
B3, B2H, B3H	B3L, B4F, B4K	85	180
B4	B4L, B3KM, B3KR, B4KM	75	161
B5	B4KR, B3V, B4V, B3KF, B3KL, B3S, B5L	70	144
B6	B4KL, B4KF, B5V, B5KL, B5KF, B4KV, B5KV, B4GK, B5GK, B4G, B5G,B4S	60	120
BT	N1BO, N1R, N1GR, N1GG, N2	25	50
T1, T1X	H3F, H4F, H4FR, H4K,	100	198
T2, T2X	H5F, H5FR, H5K, B5FR	98	192
T3, T1H, T2H	B5F, B5K	95	184
T4, T3H	B5KR, B5KM	80	164
T5	B6K, H6K, N1K	70	140
T6	B5KF, B6KV, N1KV	60	120

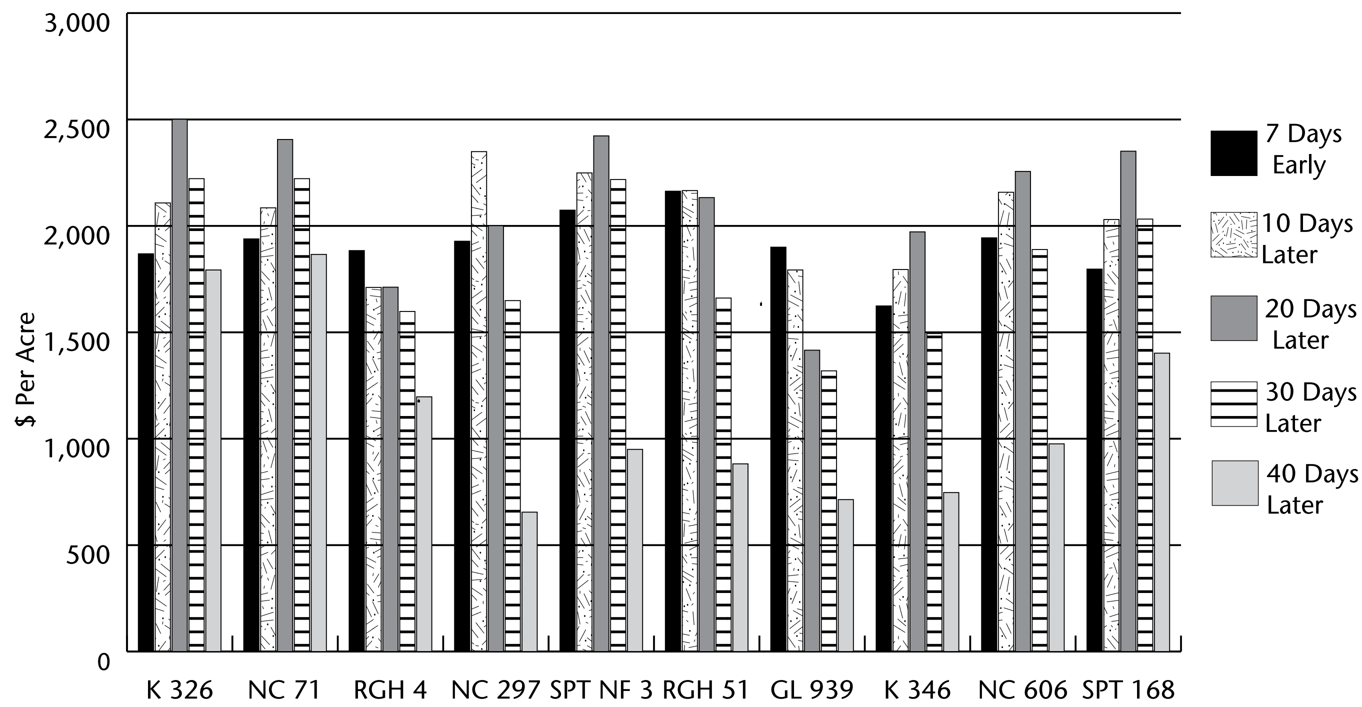

Figure 3-2. Effect of harvest schedule on the value of last priming, 2003

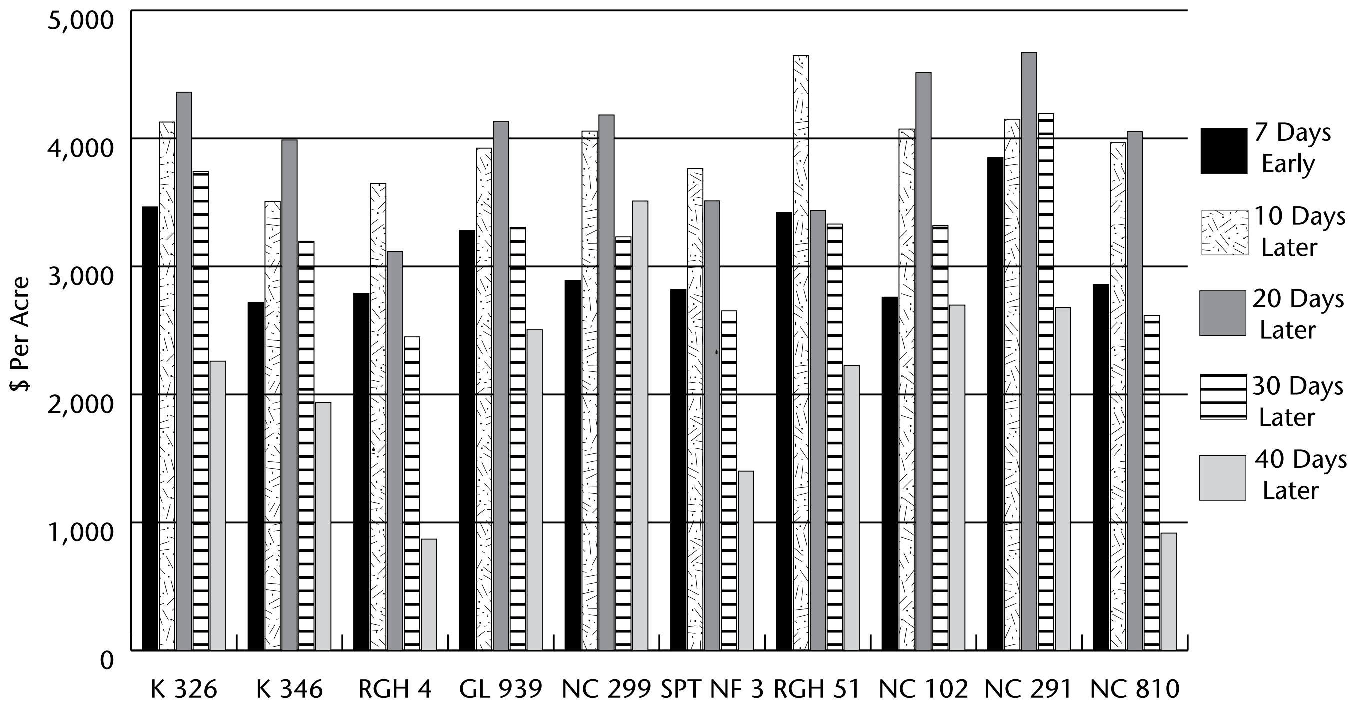

Figure 3-3. Effect of harvest schedule on the value of last priming, 2004

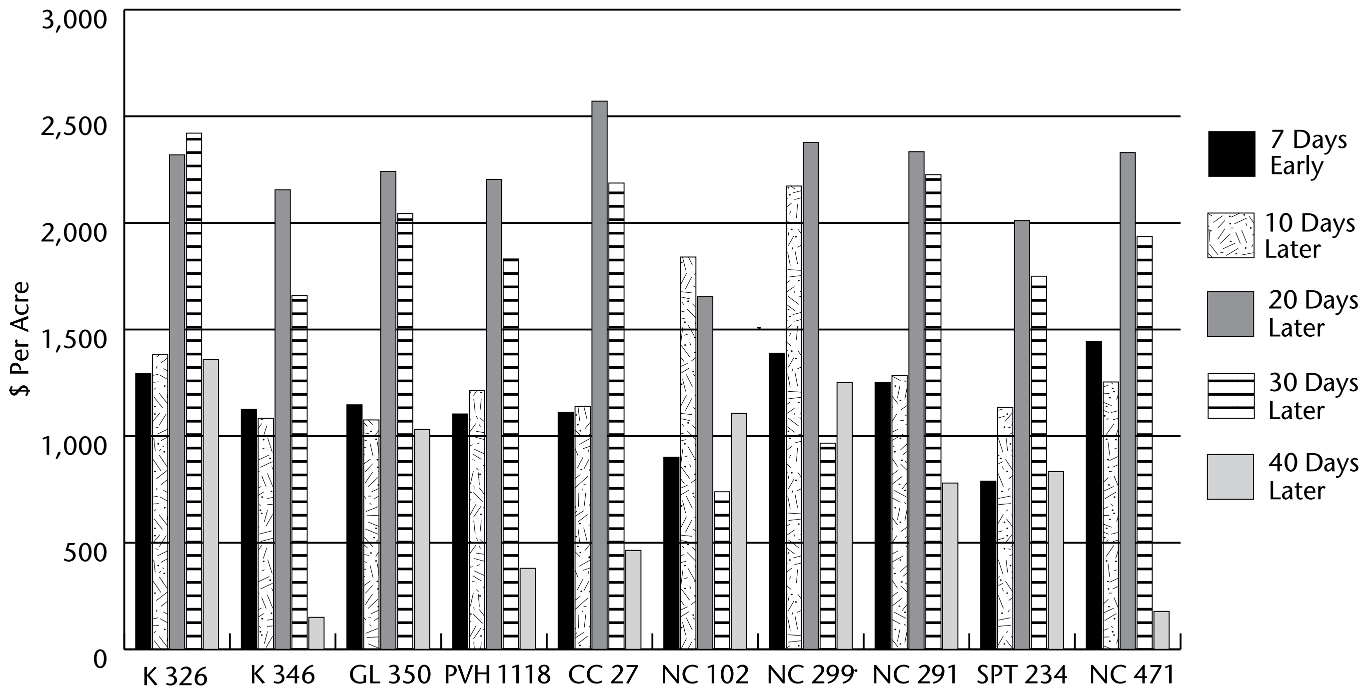

Figure 3-4. Effect of harvest schedule on the value of last priming, 2006

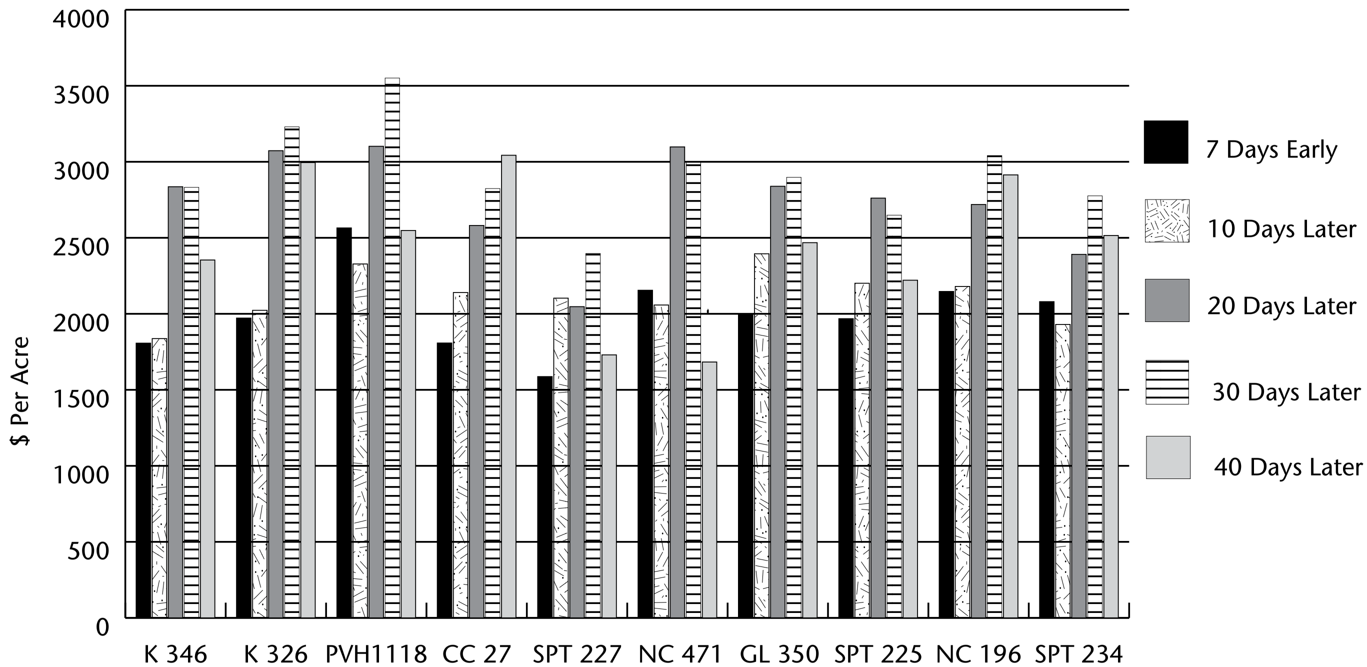

Figure 3-5. Effect of harvest schedule on the value of last priming, 2007

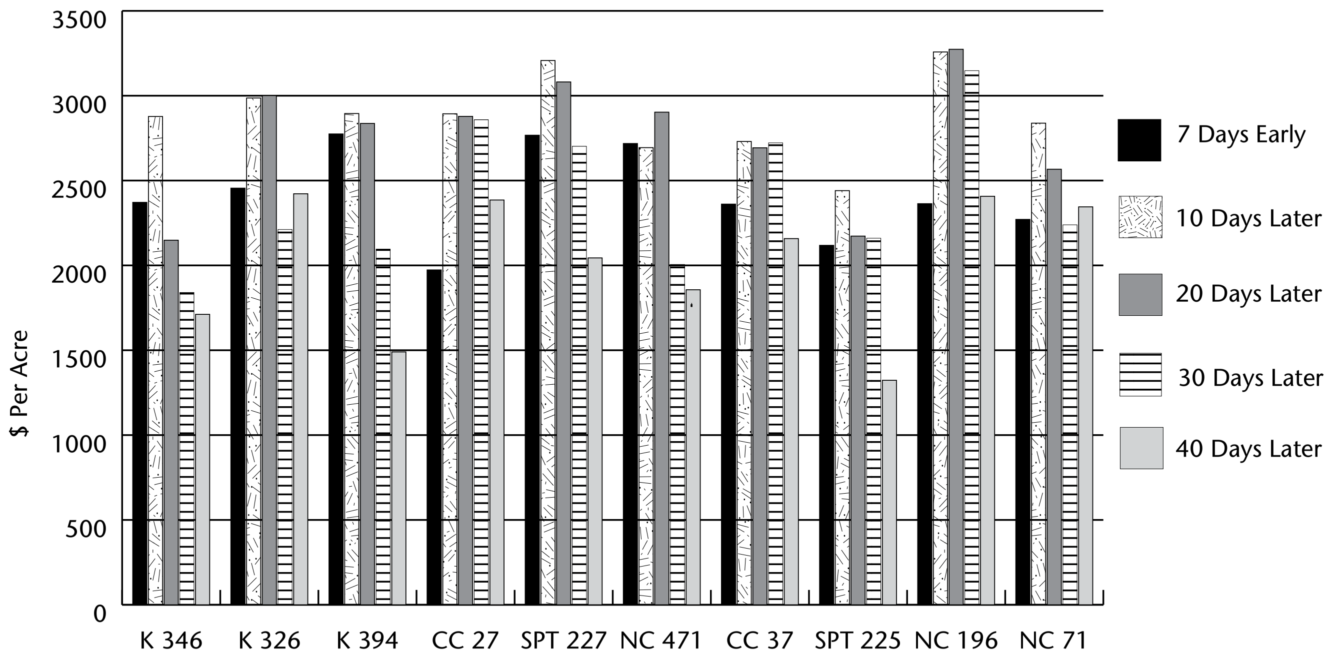

Figure 3-6. Effect of harvest schedule on the value of last priming, 2008

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. So it will be very important in 2009 to maintain yield and minimize 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 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 20-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 soil-less 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.

Studies conducted in 2004 and 2005 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 200-cell tray with a cell volume of 27 cubic centimeters and cell density of 85 cells per square foot.
4. A shallow 200-cell tray with a cell volume of 8.6 cubic centimeters and a cell density of 85 cells per square foot.

Results indicate that 200-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. There were minor differences in usability among media in 2005. However, there were no interactions between media and tray type in 2004 or 2005. Thus, all of these media would be suitable for shallow trays.

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 Diam. (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 Diam. (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.

Promote Uniform Emergence

Uniform emergence and growth are necessary to produce a high percentage of usable transplants. Research conducted in 1999 and 2000 showed that even a three-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 not been shown to speed seedling emergence. However, the use of a premoistened medium decreases the amount of medium that falls

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.

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 5-degree reduction in temperature. Therefore, after maximum seedling emergence is obtained, nighttime temperatures should be reduced to a range of 55 to 60°F to conserve fuel usage. Daytime temperatures of 80 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 be greater because delayed germination makes the plants more susceptible to salt injury and disease.

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

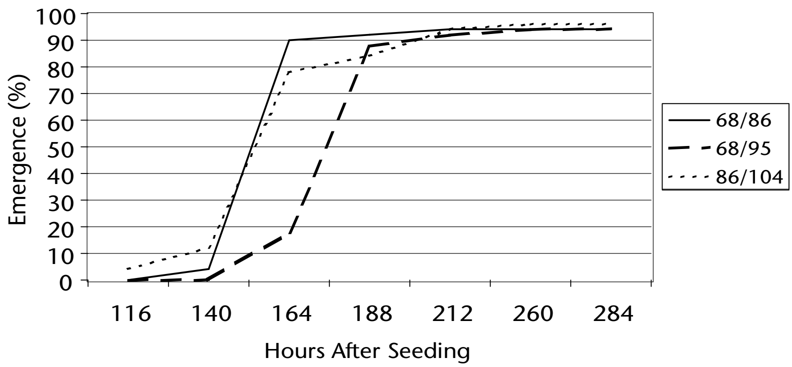


Figure 4-2. Effect of temperature on the germination of K 326 (2004)

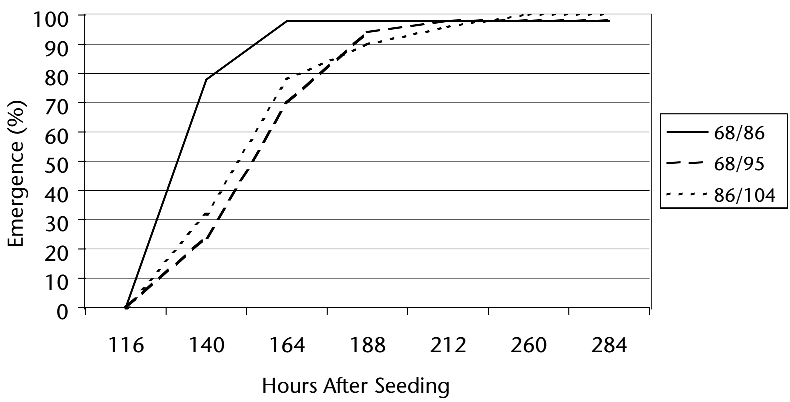


Figure 4-3. Effect of temperature on the germination of NC 71 (2003)

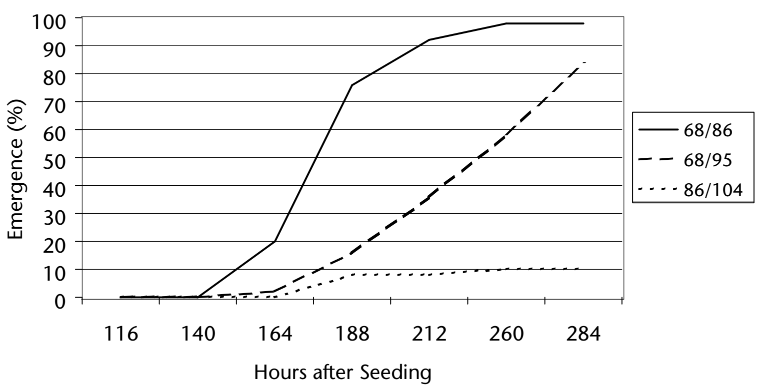


Figure 4-4. Effect of temperature on the germination of NC 71 (2004)

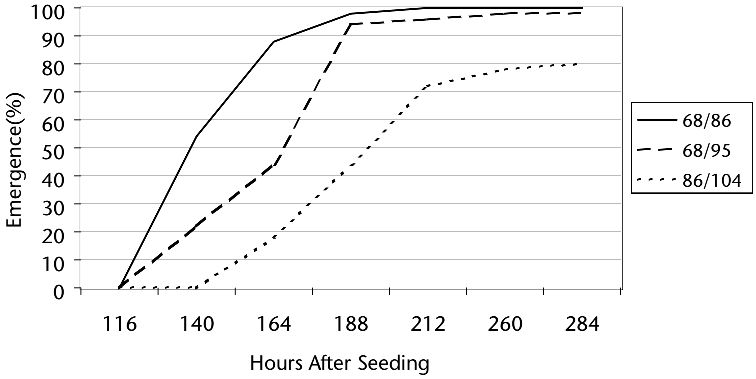


Figure 4-5. Effect of temperature on the germination of NC 297 (2003)

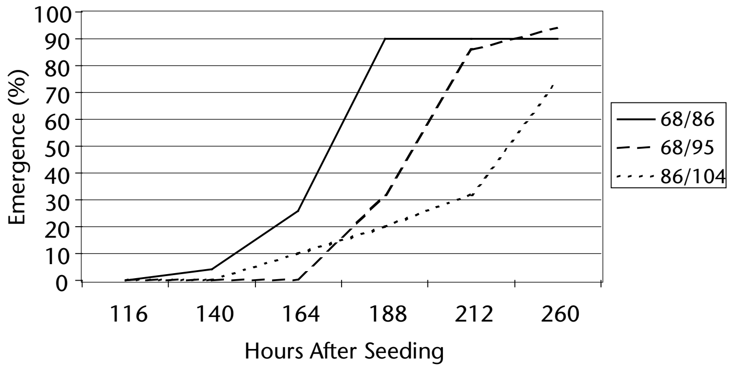
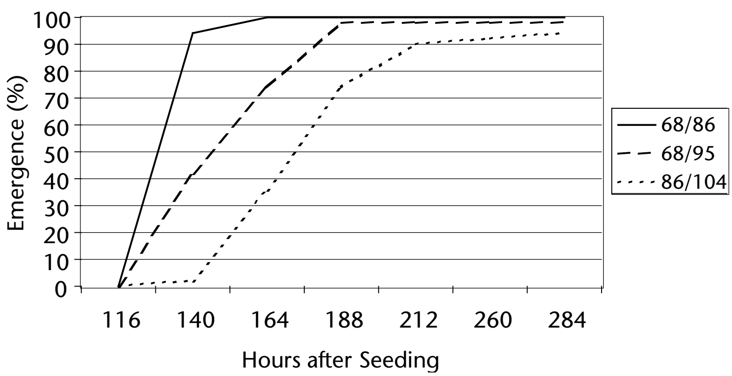


Figure 4-6. Effect of temperature on the germination of NC 297 (2004)



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 7 to 8 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

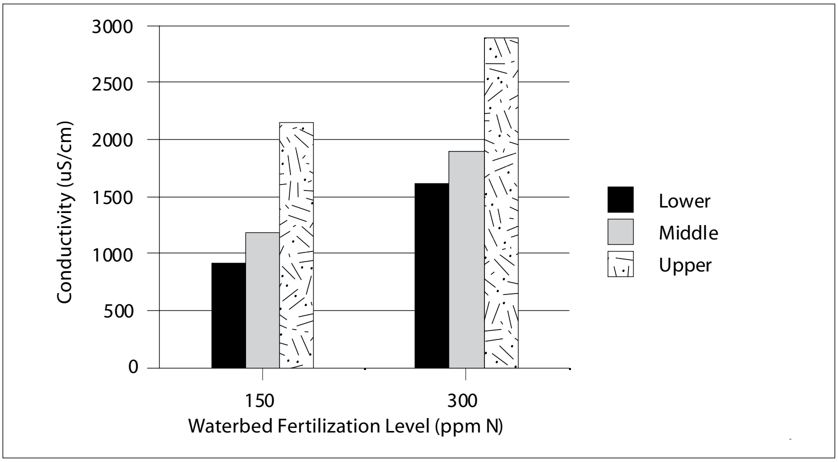
Fertilizer salts injury is the most common nutritional problem in float systems. Fertilizers supply nutrients in the form of salts. When fertilizer is added to the waterbed, these salts dissolve in the water. Then the nutrients move into the growing medium as water is absorbed from the waterbed.

High temperatures, low humidity, and excessive air movement promote water evaporation from the surface of the growing medium, which results in the 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 ½-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 ½-inch of the cell from several trays, then add twice as much distilled water as growing medium on a volume basis (a 2:1 water-to-growing-medium dilution). Shake or stir the sample and wait 2 to 3 minutes before

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



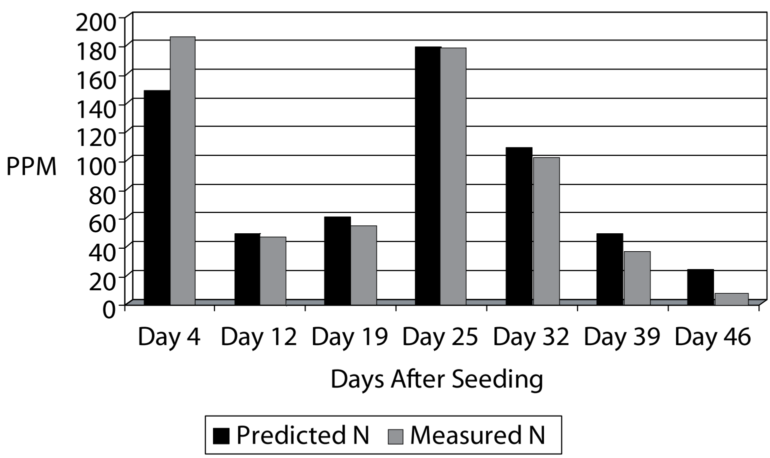
measuring the conductivity. Normal levels range from 500 to 1,000 microseimens (0.5 to 1 millimhos). Readings of 1,000 to 1,500 microseimens (1 to 1.5 millimhos) are moderately high, and readings above 1,500 microseimens are very high. Apply water from overhead to leach and dilute salts when: (1) conductivity 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 seven days after seeding plus a second application to supply 100 ppm nitrogen four 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 ½-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 conducted in 1994 showed 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 4 ounces per 100 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 in 2002 and 2003 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 in 2002 and 2003. In 2003, 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.

In 2003, both organic products produced smaller seedlings and a lower percentage of usable seedlings than 16-5-16. In 2002, the seabird guano and 16-5-16 produced similar percentages of usable

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*

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 3 to 5 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 2 to 2.5 inches above the tray and to set the blade height at 1 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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The 2008 growing season was characterized by the highest sales prices since the buyout, but also the highest production costs for at least the last 30 years. Thus, profit margin was marginal for many growers in 2008. Even though production costs are expected to moderate some, profitability will be an issue again in 2009.

Fuel and fertilizer are responsible for much of the increase in production costs. The cost of fertilizing tobacco using traditional complete fertilizers and sidedressers has more than tripled since 2004. Much of this increase occurred in the last year as nitrogen, phosphorus, and potassium costs have soared. For example, the cost of diammonium phosphate increased from $433 to $1,192 per metric ton. Murate of potash (not used in tobacco but an indicator of world potash prices) increased from $209 to $635 per metric ton, and urea (which is not used as the sole source on nitrogen on tobacco but is a component in 30 percent and 24S UAN products) increased from $284 to $745 per metric ton (Figure 5-1). In October 2008, potassium

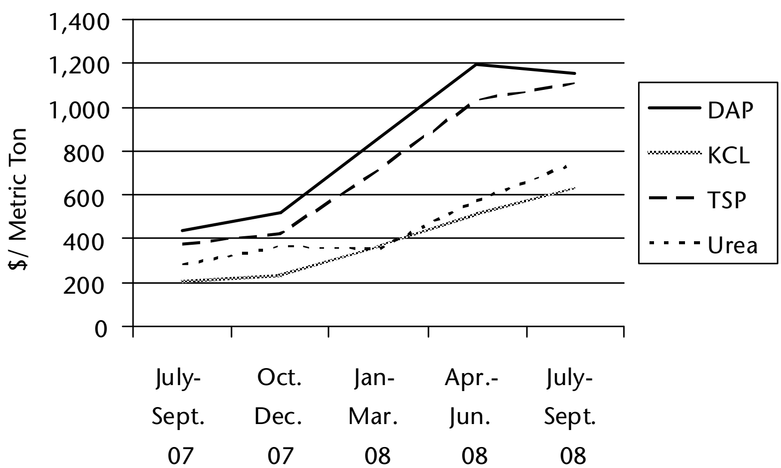

Figure 5-1. World prices of selected fertilizer materials (Source: World Bank). *Note: DAP= diammonium phosphate, KCL= murate of potash, and TSP= triple super phosphate.*

magnesium sulfate cost $1.25 per pound of potash and potassium sulfate cost $1.40 per pound of potash.

Even though the cost of fertilizing a tobacco crop 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. For example, in October 2008, calcium nitrate cost about $2.34 per pound of nitrogen and 30 percent UAN cost $0.72 per pound of nitrogen. Research conducted for the last decade 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, N.C., 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 the ammonium versus nitrate issue is that under our conditions, nitrification rate is rapid enough that UAN products, such as 30 percent and 24S, that contain 75 percent of the nitrogen as ammonium, are equally acceptable nitrogen sources as all nitrate products, such as calcium nitrate. Growers should feel comfortable using any of these products, with the decision based on factors such as application technology and cost, because crop response is not an issue.

A recent survey of county Extension agents estimated that 37 percent of the tobacco acreage received at least a portion of the nitrogen from UAN products and 20 percent of the acreage received all of the nitrogen from a UAN product in 2008. 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.** Over 90 percent of the soil test reports from tobacco fields in the coastal plain and 50 percent from fields in the piedmont recommended that fertilizer phosphorus not be applied. Growers reluctant to not apply any phosphorus can apply 5 pounds of phosphorus in the transplant water, which

Table 5-1. Effect of fertilizer treatment on tobacco yield, value, and grade index at three 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/a + 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

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

has been shown to equal the growth response of 40 pounds of phosphorus banded in the complete fertilizer (Figure 5-2).

- **Based on 2008 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.
- **Avoid products that add cost without improving profitability.** For example the product Avail has been shown—under limited soil phosphorus conditions 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).

Figure 5-2. Effect of phosphorus application on flowering rate at the Upper Coastal Plain Research Station, 2005

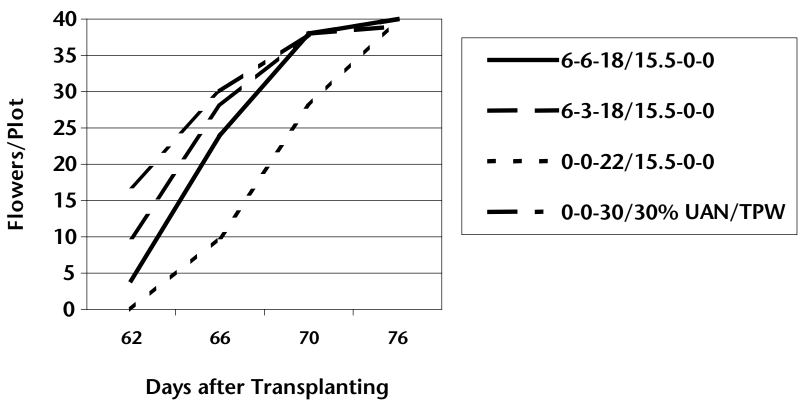

Table 5-2. Effect of fertilizer treatment on tobacco yield, grade index, price and value at two locations, 2008

Treatment	Cunningham Research Station			Oxford Tobacco Research Station		
	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	2,974 a	5,138 a	84 a	2,496 a	4,198 a	80 a
8-8-28 + Avail 500 lb/A + 15.5-0-0 226 lb/A	2,895 a	5,002 a	84 a	2,491 a	4,338 a	83 a

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

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 NCDA&CS. 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!
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*, such as the *bands at transplanting* or *bands within 10 days after transplantin*g 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.

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

Nitrogen Rate (lb/acre)	*Yield, lb/acre*	
	Lime Used—No	*Lime Used—Yes*
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*

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 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

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 1 pound of potassium (K_20) for each pound of nitrogen used as a leaching adjustment if the topsoil is deeper than 10 inches.*

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 lower cost and just as effectively by using 13-0-14 or an 8-0-24 that guarantees sulfur and magnesium but does not contain 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 100 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.

Adding 10 to 15 pounds of extra nitrogen in most drowning situations 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 and frequent rains may cause drowning (root injury). Deep rooting is limited as long as the soil remains saturated, confining root development to the upper 6 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 evaluate 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, while 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 than the 16-0-0 and 30 percent liquid nitrogen fertilizers that supplied only nitrogen. Compared to the control, none of the fertilizers improved grade index or average market price.

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 fertilizers 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.

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

Fertilizer Treatment[a]	*Application Method*	*Yield lb/acre*	*Grade Index*	*Price $/cwt*	*Value $/acre*
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 and 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/acre	*Yield lb/acre*	*Grade Index*	*Price $/cwt*	*Value $/acre*
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.

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.

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

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

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

[a] *Does not include leaching adjustments.*

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

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.*

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.

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 (over 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 often mistaken for those 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 100 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.

Micronutrients

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 3 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 2008 or if your soil test indicates that a problem might occur in 2009. 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 10 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 and Poast).

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

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 and Tillam are both labeled for nutsedge control. Spartan provides excellent control of both nutsedge species (although slightly better control of yellow than purple), and Tillam provides good control (Table 6-1). Studies in 1998 and 1999 found that labeled and below-labeled rates of Spartan provided good to excellent control of yellow nutsedge at three of four locations (Table 6-4). Control was poor at one location with pretransplanting (PRE-T) applications of Spartan at labeled and below-labeled rates, which was likely due to low soil moisture at and immediately following transplanting (Table 6-4).

Yellow nutsedge control from Tillam and Spartan is similar for the first two to three 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 provides season-long control of nutsedge and better grass control than Tillam. However, there are significant rotational restrictions on the Spartan 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 is the only herbicide labeled for tobacco that will control morningglries (Tables 6-1 and 6-5). Although control of morningglories is more consistent when Spartan is incorporated before transplanting (PPI) (Table 6-5), injury to tobacco is less likely with PRE-T applications of Spartan than with PPI applications (Table 6-2).

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 or Tillam for improved grass control (compared to Spartan or Tillam alone).

In past studies, pretransplant-incorporated treatments of Spartan/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, broadcast and incorporate the Prowl before bedding to comply with the current label. Then apply the Spartan 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 a 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 and Prowl provide the best control, and

Tillam and Devrinol provide good control. Table 6-3 shows the effect of labeled and below-labeled rates of Spartan on redroot pigweed and Palmer amaranth control. Based on this limited data, it appears that control of redroot pigweed is good to excellent at lower than labeled rates of Spartan, but that Palmer amaranth control is poor with lower than labeled rates.

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, 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 seven days after transplanting, or at lay-by (Table 6-8). 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 a herbicide to see whether the product controls the problem weed, to determine the proper rate, and to be aware of rotational restrictions.

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 does not affect root growth directly; however, foliar symptoms and stunting have been observed. Foliar symptoms include browning along the lateral and mid-veins 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 is critical. The activity of Spartan is strongly related to soil texture and organic matter, with injury most likely on coarse-textured, low-organic-matter soils.

Studies in 1998 and 1999 found few differences in stunting between labeled and below-labeled rates of Spartan (Table 6-2). This is important to note since using Spartan 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 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 is that early season weed control may be limited when soil moisture is low at, or immediately following, transplanting (Tables 6-2 to 6-5). 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 were used.

Spartan 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 can reduce Spartan injury. In some cases, when Spartan injury was severe, plots treated with a Spartan and Command tank mix had half as much early season stunting as those treated with Spartan 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 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 one-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. Re-bedding fields treated with a surface application of Spartan can cause significant plant injury. This is because the re-bedding operation concentrates the herbicide in the root zone of tobacco.

Research conducted in 1999 and 2000 found no consistent differences in Spartan 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 (Table 6-6).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 shows that uptake, translocation, and metabolism in tobacco is very rapid and that metabolism of Spartan by tobacco is likely the source of crop tolerance. Therefore, crop injury can occur because of poor incorporation of Spartan, 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 pretransplant-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 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 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 manner 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 to the time of transplanting as possible (keeping in mind the 12-hour worker reentry restriction on the Spartan 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 Spartan applied PRE-T in some fields (Tables 6-3 to 6-5).

Spartan has excellent activity on nutsedge, morningglories, and pigweeds (Tables 6-1, 6-3 to 6-5). It is the only herbicide labeled for tobacco that controls morningglories, and it controls nutsedge better than Tillam. Spartan 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 or Prowl/Spartan provide better control than Spartan alone (Table 6-1).

Studies in 2004 showed that tank-mixing Spartan with below-labeled rates of Command can enhance control of large crabgrass when compared to equivalent rates of Command alone (Table 6-7). Spartan tank-mixed with one-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/Command reduce injury to tobacco from Spartan, you can use a reduced rate of Command and still obtain excellent control of large crabgrass. Spartan 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, 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 is applied.

Herbicide Application Overtop within Seven 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 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 lay-by 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.

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 1 to 1.5 pints per acre, depending upon the size of grass weeds. Grasses must be fully covered by spray to ensure control. Add 2 pints of crop oil concentrate or 1 pint of Dash HC spray adjuvant according to label directions. Apply Poast overtop (OT) 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.

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 *2009 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 1 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).

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

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

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 300 gallons. To determine how much herbicide to add to 300 gallons of water:

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

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

4F over the bed before transplanting, be especially sure to calibrate properly. Serious crop injury will occur if the 8.0 or 10.0 ounces 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 4 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 1 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 8 gallons per acre of land. But for every 24 gallons of water added to the tank, you add 4 pounds of Devrinol 50 DF. Suppose you add 150 gallons of water to your tank. To figure the acreage of tobacco this will cover:

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

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

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

Or for every 24 gallons of water added to the tank, add 4 pounds of Devrinol 50 DF.

It is easy to see how band applications save money on herbicides. In this example, you can spray 3 acres of tobacco with the band application method for the same cost as spraying 1 acre with a broadcast application.

Other calibration methods are described in the *2009 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.

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

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 2 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 6-1. Expected weed control from herbicides labeled for use in tobacco

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

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.*

Table 6-2. Effect of Spartan rate and application method on stunting, 1998 and 1999

Treatment		*Location* **Duplin 1998**	**Duplin 1999**	**Randolph 1998**	**Randolph 1999**
		Stunting (%)[1]			
Spartan 4F 6 oz/acre	*PPI*[2]	*11 ab*	*5 abc*	*19 bc*	*6 ab*
Spartan 4F[3] *8 oz/acre*	*PPI*	*23 a*	*10 ab*	*11 cde*	*11 a*
Spartan 4F 10 oz/acre	*PPI*	*25 a*	*8 abc*	*31 a*	*3 ab*
Spartan 4F[4] *12 oz/acre*	*PPI*	—	—	*29 ab*	*8 ab*
Spartan 4F 6 oz/acre	*PRE-T*	*0 c*	*3 c*	*0 e*	*8 ab*
Spartan 4F 8 oz/acre	*PRE-T*	*0 c*	*0 c*	*5 de*	*5 ab*
Spartan 4F 10 oz/acre	*PRE-T*	*6 bc*	*4 bc*	*3 e*	*0 b*
Spartan 4F 12 oz/acre	*PRE-T*	—	—	*0 e*	*0 b*

[1] *Treatment averages within a column followed by the same letter are not statistically different and should be considered similar.*

[2] *PPI = Herbicide applied and incorporated into the soil before bedding and transplanting. PRE-T = Herbicide applied preemergence before transplanting. Beds were knocked down to the height of transplanting, then the herbicide was applied to the soil surface before transplanting. Tobacco was transplanted without knocking off additional soil.*

[3] *Labeled rate based on Duplin soil type.*

[4] *Labeled rate based on Randolph soil type.*

Table 6-3. Effect of Spartan rate and application method on redroot pigweed and Palmer amaranth control, 1998 and 1999

Treatment		Location			
		Duplin 1998	**Duplin 1999**	**Randolph 1998**	**Reidsville 1998**
		Palmer Amaranth		**Redroot Pigweed**	
		Control (%)[1]			
Spartan 4F 6 oz/a	PPI[2]	45 bc	86 abc	100 a	100 a
Spartan 4F[3] 8 oz/a	PPI	65 abc	91 a	99 a	100 a
Spartan 4F10 oz/a	PPI	95 a	96 a	99 a	98 a
Spartan 4F[4] 12 oz/a	PPI	—	—	100 a	100 a
Spartan 4F 6 oz/a	PRE-T	99 a	83 abc	100 a	98 a
Spartan 4F 8 oz/a	PRE-T	83 abc	68 bc	100 a	100 a
Spartan 4F 10 oz/a	PRE-T	100 a	66 c	100 a	100 a
Spartan 4F 12 oz/a	PRE-T	—	—	100 a	100 a

[1] Treatment averages within a column followed by the same letter are not statistically different and should be considered similar.
[2] PPI = Herbicide applied and incorporated into the soil before bedding and transplanting. PRE-T = Herbicide applied preemergence before transplanting. Beds were knocked down to the height of transplanting, then the herbicide was applied to the soil surface before transplanting. Tobacco was transplanted without knocking off additional soil.
[3] Labeled rate based on Duplin soil type.
[4] Labeled rate based on Randolph and Reidsville soil types.

Table 6-4. Effect of Spartan rate and application method on yellow nutsedge control, 1998 and 1999

		Location			
		Duplin 1998	**Kinston 1998**	**Reidsville 1998**	**Kinston 1999**
Treatment		——Control (%)[1]——			
Spartan 4F 6 oz/a	*PPI[2]*	*86 a*	*100 a*	*69 a*	*90 a*
Spartan 4F[3] 8 oz/a	*PPI*	*70 a*	*97 a*	*91 a*	*95 a*
Spartan 4F 10 oz/a	*PPI*	*98 a*	*99 a*	*81 a*	*91 a*
Spartan 4F[4] 12 oz/a	*PPI*	—	—	*83 a*	—
Spartan 4F 6 oz/a	*PRE-T*	*98 a*	*99 a*	*74 a*	*49 bc*
Spartan 4F 8 oz/a	*PRE-T*	*98 a*	*100 a*	*71 a*	*71 ab*
Spartan 4F 10 oz/a	*PRE-T*	*86 a*	*93 a*	*69 a*	*49 bc*
Spartan 4F 12 oz/a	*PRE-T*	—	—	*73 a*	—

[1] Treatment averages within a column followed by the same letter are not statistically different and should be considered similar.

[2] PPI = Herbicide applied and incorporated into the soil before bedding and transplanting. PRE-T = Herbicide applied preemergence before transplanting. Beds were knocked down to the height of transplanting, then the herbicide was applied to the soil surface before transplanting. Tobacco was transplanted without knocking off additional soil.

[3] Labeled rate based on Duplin and Kinston soil types.

[4] Labeled rate based on Reidsville soil type.

Table 6-5. Effect of Spartan rate and application method on pitted morning-glory control, 1998 and 1999

Treatment		Location	
		Randolph 1998	**Randolph 1999**
		Control (%)[1]	
Spartan 4F 6 oz/a	*PPI[2]*	*99 a*	*96 ab*
Spartan 4F 8 oz/a	*PPI*	*98 ab*	*98 a*
Spartan 4F 10 oz/a	*PPI*	*99 a*	*99 a*
Spartan 4F[3] 12 oz/a	*PPI*	*100 a*	*99 a*
Spartan 4F 6 oz/a	*PRE-T*	*90 cd*	*59 c*
Spartan 4F 8 oz/a	*PRE-T*	*88 d*	*80 abc*
Spartan 4F 10 oz/a	*PRE-T*	*96 bc*	*66 bc*
Spartan 4F 12 oz/a	*PRE-T*	*92 cd*	*65 c*

[1] Treatment averages within a column followed by the same letter are not statistically different and should be considered similar.
[2]PPI = Herbicide applied and incorporated into the soil before bedding and transplanting. PRE-T = Herbicide applied preemergence before transplanting. Beds were knocked down to the height of transplanting, then the herbicide was applied to the soil surface before transplanting. Tobacco was transplanted without knocking off additional soil.
[3]Labeled rate based on Randolph soil type.

Table 6-6. Effect of application method and incorporation equipment on stunting from Spartan three weeks after transplanting

	Granville	**Harnett**	**Rockingham**	**Robeson**
Application Method or Incorporation Eequipment	———Stunting (%)[1]———			
PRE-T[2]	3 b	3 c	0 b	9 c
No incorporation before bedding	16 a	18 b	1 b	42 a
Two passes with field cultivator before bedding	13 a	24 ab	7 b	38 a
Two passes with finishing disk before bedding	12 a	30 a	21 a	28 b

[1] Treatment averages within a column followed by the same letter are not statistically different and should be considered similar.

[2] Herbicide applied preemergence before transplanting. Beds were knocked down to the height of transplanting, then the herbicide was applied to the soil surface before transplanting. Tobacco was transplanted without knocking off additional soil.

Table 6-7. Large crabgrass control using reduced rates of Command alone or tank-mixed with Spartan in 2004

Treatment		*Location* Moore County	*Location* Randolph County
		——Control (%)[1]——	
Command 3ME 2.0 pt/a	*PPI[2]*	*91 a*	*85 a*
Command 3ME 1.5 pt/a	*PPI*	*76 b*	*76 b*
Command 3ME 1.0 pt/a	*PPI*	*65 c*	*50 d*
Spartan 4F[3] 8 oz/a	*PPI*	*75 b*	*58 c*
Command 3ME 2.0 pt/a & Spartan 4F 8 oz/a	*PPI*	*92 a*	*91 a*
Command 3ME1. 5 pt/a & Spartan 4F 8 oz/a	*PPI*	*94 a*	*87 a*
Command 3ME 1.0 pt/a & Spartan 4F 8 oz/a	*PPI*	*92 a*	*85 a*
Devrinol 50 WDG 2 lb/a	*PPI*	*89 a*	*36 e*
Devrinol 50 WDG 2 lb/a & Spartan 4F 8 oz/a	*PPI*	*89 a*	*64 c*

[1] Treatment averages within a column followed by the same letter are not statistically different and should be considered similar.
[2] PPI = Herbicide applied and incorporated into the soil before bedding and transplanting.
[3] Labeled rate based on soil types at Moore and Randolph County locations

Table 6-8. Chemical weed control in tobacco

Crop	Weed	Herbicide and Formulation	Amount of Formulation Per Acre	Precautions and Remarks
TOBACCO, FLUE-CURED Plant beds	*Annual grass weeds and various broadleaf weeds*	*dazomet (Basamid) 99G*	*7.5 lb/100 yd^2*	*Apply in the fall. Soil temperature should be above 50ºF. Material should be uniformly applied and incorporated. Cover with plastic that is well sealed around edges. Plastic cover must be removed 7 to 10 days before seeding. Refer to label for required germination test. Spectrum of weed control is similar to methyl bromide.*
		metam sodium (Vapam) 3.18 L	*2 gal/100 yd^2*	
		methyl bromide 98%	*9 lb/100 yd^2*	*Thoroughly prepare bed. Apply when moisture level is average and air temperature is above 50ºF. Release gas under plastic cover that is well sealed around edges. Allow cover to remain on bed for 24 hr. Bed can be seeded 24 to 48 hr after removal of cover. Will not control white clover; may not control certain large-seeded broadleaf weeds, such as morningglory and sicklepod.*
	Annual grasses and volunteer wheat	*sethoxydim (Poast) 1.5 EC*	*1 pt/A or 0.33 fl oz/ 100 yd^2*	*Apply to actively growing grass not under drought stress. Apply in 5 to 20 GPA at 40 to 60 psi. Add 2 pt of crop oil concentrate per acre (or 0.67 per 100 yd^2). Use hollow cone or flat fan nozzles. Remove plant bed cover and allow plants to dry before application. Do not replace cover until spray solution has dried on plants. Do not apply more than 1 pt of Poast per acre in the plant bed per season. Do not apply to plants smaller than 1 in. in diameter.*

Table 6-8. *(continued)*

Crop	Weed	Herbicide 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 (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 (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 (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 (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 6-8. *(continued)*

Crop	*Weed*	*Herbicide and Formulation*	*Amount of Formulation Per Acre*	*Precautions and Remarks*
TOBACCO, FLUE-CURED Field, before Transplanting (continued)	*Broadleaf weeds, nutsedges, and some grasses*	*sulfentrazone (Spartan) 4 F*	*8 to 12 oz*	*Excellent control of pigweed, morningglories, and nutsedges. Application rate is based on soil type and organic matter. See Spartan 4 F 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.*
TOBACCO, FLUE-CURED Field, after transplanting	*Most annual grasses and some broadleaf weeds*	*napropamide (Devrinol) 50 WDG*	*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 (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 6-8. *(continued)*

Crop	Weed	Herbicide and Formulation	Amount of Formulation Per Acre	Precautions and Remarks
TOBACCO, FLUE-CURED Field, after transplanting (continued)	*Postemergence control of annual grasses*	*sethoxydim (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.*
TOBACCO, FLUE-CURED Lay-by	*Most annual grasses and some broadleaf weeds*	*napropamide (Devrinol) 50 WDG*	*2 to 4 lb (broadcast, 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 (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.*

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 are in the 2,000- to 2,500-pounds-per-acre range. Higher yields reduce per-pound production costs for acreage-related inputs such as chemicals, fertilizers, 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 to 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.

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, while systemic chemicals retard sucker growth by inhibiting cell division. Maleic hydrazide (MH) is the only true systemic 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 because it must touch the suckers to be effective, although it retards sucker growth by inhibiting cell division.

Proper Strength of Contact Fatty Alcohol Sprays

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 add only enough water to uniformly distribute the chemicals.

The suggested ratio for the first application of C_8-C_{10} contact alcohol products (Off-Shoot T, Fair 85, Kleen-Tac, Sucker Plucker, Royaltac-M, etc.) is 2 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 C_{10} 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 1 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 7-1) 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.

Weak contact solutions, those less than 4 percent for the C_8-C_{10} products or less than 3 percent for the C` products, often control only

Table 7-1. Sucker growth with three different concentrations of C_8-C_{10} contact alcohol sprays

Contact + Water (gallons)	*Percent Contact*	*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.*

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 excess, 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 was 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 at which the upper leaves are large enough to be sprayed with a systemic chemical without causing distortion.

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, and 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 pounds per square inch [psi]). And because it is not absorbed and moved through the plant, it performs better than MH in dry weather. Applying flumetralin by hand (downstalk 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 1 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 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 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.) 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 2 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 5 to 6 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.

Maximizing Sucker Control and Minimizing Residues with MH

MH has saved many hours of labor since its introduction in the early 1950s. It is widely used for sucker control because it usually is effective, relatively inexpensive, and easy to apply. But high residues can reduce demand by domestic as well as export customers. No suitable alternative to MH has been developed, and 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 and therefore the period needed for good sucker control. Unfortunately, longer harvest seasons, coupled with 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 Community, the major importers of United States leaf tobacco, have adopted an 80-parts-per-million (ppm) MH tolerance on 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 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 cigarette 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 that the entire tobacco industry, including producers and farm supply dealers, 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 MHS) will very likely undergo even greater scrutiny and regulation soon. Below are some suggestions to help lower MH residues without reducing sucker control:

1. Use 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 7-2 illustrate the importance of nitrogen rate on sucker control. When the recommended nitrogen rate was exceeded, suckers were more difficult to control. See Chapter 5, "Managing Nutrients," for more information on determining nitrogen rates.

2. Strive 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 trans-

Table 7-2. Sucker control with various rates of nitrogen at Kinston and Reidsville, 1993[a]

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

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

plants. 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.

3. Maximize early sucker control 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 and proper application speed, boom height, nozzle size and arrangement, and pump pressure are all important for good sucker control. (See product labels for instructions.) For alcohol contacts, mixing concentration is particularly important because the spray must be strong enough to burn out the tender primary and secondary suckers but not strong enough to cause leaf burn. For the C_8-C_{10} alcohols, a 4 percent spray (2 gallons of product in 48 gallons of water per acre) will usually be sufficient for the first contact application. Most crops can tolerate a 5 percent spray (2.5 gallons of product in 47.5 gallons water) for the second application, unless the crop is unusually tender. A 3 percent concentration (1.5 gallons of product in 48.5 gallons of water) is suggested for both applications of the C_{10} alcohols. **However, remember that some chemical topping of small plants and slight leaf flecking are good indicators that the contact concentration is strong enough to give good sucker control.**

Timing of chemical application is also important since none of the chemicals, including MH, will adequately control suckers longer than 1 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 90°F. Also, none of the products should be applied to plants wet with heavy dew or to those severely drought-stressed.

4. Apply the labeled rate of MH properly. Unlike fatty alcohol contacts and flumetralin, MH is absorbed by leaves and moved 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 on flue-cured tobacco is 1 quart per 1,000 plants. Most tobacco in North Carolina is planted at approximately 6,000 plants per acre. **The correct rate for 6,000 plants is 1.5 gallons per acre.** (This rate is suitable for most formulations available in North Carolina, which contain 1.5 pounds of active ingredient per gallon of product; some products contain 2.25 pounds of active ingredient per gallon and should be applied at 1 gallon per acre for 6,000 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 4 hours after the first application. Only a half-rate (0.75 gallon of MH per acre) is needed if rain occurs between 4 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. 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 assure MH-free first primings and minimal residues on the second primings.

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. Only 0.05 to 0.1 inch of irrigation significantly reduced MH residues on leaves from both stalk positions.

5. 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 appli-

Table 7-3. MH residues on lower and upper green leaves following various amounts of irrigation, 1992-93

Irrigation Applied (inches)	*MH Residues[a] (ppm)*	
	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/a of MH. MH residues are averages of four experiments.

Table 7-4. Sucker number and weight reductions with sucker control programs including Prime+, 1991-94

Application[a]		Suckers per Acre (Average/25 On-farm Tests)	
3rd	4th	(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% and 5% fatty alcohol contact applications. Rates were 1.5 gal/a for MH and 2 qts/a for Prime+.

cation 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 1 inch in length. Apply the 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.**

Time of MH Application

The systemic suckercide, maleic hydrazide, is the most widely used pesticide on tobacco grown in the United States. More recently, flumetralin, also a systemic suckercide, 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 8 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 8 inches. Growth distortion of upper leaves treated with flumetralin also occurs, but less frequently than that associated with MH. Since upper leaves are usually the most valuable on the plant, researchers at NC State University recently evaluated the effects of these two suckercides used alone or in tank mixes on upper leaf growth, yield, and quality, particularly when applications were early enough to cause upper leaf growth abnormalities.

A field study was conducted in eastern North Carolina from 1999 through 2001 using varieties NC 71 in 1999 and 2000 and K 326 in 2001. Several days following two applications of fatty alcohols, MH or Prime+ was applied alone or as a tank mix when tip leaf lengths averaged 11.5 to 12.5 inches. The same suckercide treatments were applied a week later on different plots when tip leaf lengths averaged 16.5 to 18 inches. Each suckercide was used at labeled rates in 1999 (1.5 gallons of MH and 0.5 gallon of Prime+ per acre), but higher rates of MH were also used in 2000 and 2001. The control treatment each year was four to six fatty alcohol applications plus several hand suckerings as needed. Tip leaf lengths and widths were measured 18 to 24 hours before each systemic suckercide application and at least three more times until final harvest. Yield and quality of cured leaves were determined for the whole plant and also separately for the upper five leaves.

The treatment results and observations were similar each year. But the effects of MH on leaf growth and bronzing were more pronounced in 1999, when soil moisture was better and the plants were more succulent at the time the systemic suckercides were applied. The summary comments below are based on the average results shown in Table 7-5 for labeled rates of MH and/or Prime+ treatments common to each experiment of the study:

- The labeled rate of MH applied on 11.5- to 12.5-inch-long leaves reduced tip leaf growth and caused substantial bronzing of the upper four to five leaves. Both effects became apparent three to four weeks after MH application and, contrary to popular belief, upper leaves injured and bronzed by MH did not recover normal growth as the harvest season progressed. **However, Prime+ application on the shorter leaves did not stunt their growth, and the tank mix of Prime+ with MH was no more detrimental to leaf growth than MH applied alone. The undesirable effects associated with the labeled rate of MH were practically eliminated by delaying application until the following week when tip leaves were 16.5 to 18 inches long.** However, these effects were more pronounced when the MH rate was increased, and the double rate of MH caused some bronzing of upper leaves treated when the tip leaves were 16.5 to 18 inches long. **MH bronzing of the shorter leaves was noticeably and consistently reduced, however, when MH was tank mixed with Prime+.**
- MH residues on and in the upper five cured leaves were measured in two of the three experiments, both of which received substantial rainfall between application time and final harvest. The time of MH application did not substantially

affect MH residues on and in upper leaves, and residue levels were not closely associated with bronzing (i.e., residues were no higher for bronzed leaves treated when 11.5 to 12.5 inches long than for the normal-colored leaves treated a week later). **This implies that MH bronzing, which is traditionally associated primarily with excessive MH application, is also more pronounced when the labeled rate of MH is applied too early.**

- Whole-plant yield and grade index and the grade index of the upper five cured leaves were not consistently affected by when the systemic suckercides were applied. However, cured weights of the upper five leaves treated with Prime+ strongly tended to be higher than for those treated with MH. **In addition, cured weights were 5 to 8 percent higher when MH application was delayed until the tip leaves were 16.5 to 18 inches long.** Surprisingly, the same trend occurred with delayed application of Prime+ even though application of this systemic suckercide

Table 7-5. Leaf area, cured weight, and grade index of upper leaves treated with systemic suckercides on two application dates, 1999-2001 experiments

Tip Leaf Length at Application (in.)	Tip Leaf Area 1-2 Wks before Final Harvest (sq in.)	Leaf Color Index[a]	Upper 5 Leaves	
			Cured Weight (lb/acre)	Grade Index
Contacts Only (Control)				
(4 - 6 Applic.)	133	41	723	58
Prime+ Alone, 0.5 gal/acre				
11.5 - 12.5	136	42	739	61
16.5 - 18	140	42	793	63
MH Alone, 1.5 gal/acre				
11.5 - 12.5	111	37	677	64
16.5 - 18	133	41	714	59
(Prime+ & MH) Tank Mix, 0.5 & 1.5 gal/acre				
11.5 - 12.5	114	34	661	61
16.5 -18	132	39	717	63

[a]*SPAD meter readings taken five to six weeks after the first systemic suckercide applications in 2000 and 2001 experiments only; higher values indicate greener color or less bronzing.*

on the shorter upper leaves did not cause distortion or reduce their growth.

These results indicate that even the labeled rate of MH (1.5 gallons per acre) applied on 11.5- to 12.5-inch-long leaves may discolor and irreversibly stunt their growth, particularly when the upper leaves are tender and succulent at application time. Higher rates of MH further increased leaf stunting and bronzing of similar-sized leaves, but tank mixing the labeled rate of MH with 0.5 gallon per acre of Prime+ was no more detrimental to leaf growth than the labeled rate of MH applied alone. **This study was not designed to identify a specific minimum upper leaf length required for safe MH application. But the results and observations imply that delaying MH application until tip leaves reach 15 to 16 inches long will substantially reduce the risk of upper leaf stunting, discoloration, and the possible weight loss observed in this study when only the labeled MH rate was applied on the shorter leaves.**

Topping and Chemical Sucker Control Programs

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 plus 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 12, "Complying with the Worker Protection Standard"). This information provides specific requirements for personal protective clothing, restricted field reentry intervals, and other restrictions.

Program I (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 fields 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 fields 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 2 quarts of flumetralin per acre at the normal time 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 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 leaves.**

Alternative B. Apply 3 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 C_{10} 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 2 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 C_8-C_{10} 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 1 inch by hand before application.

Alternative B. Apply 2 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 1 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.

Program II (Hand or Dropline Application)

Alternative A. Apply flumetralin using the dropline method with 0.33 to 0.67 fluid ounce of solution per plant without using a contact solution. Prepare the flumetralin solution by mixing no more than 1 gallon of flumetralin in 49 gallons of water (2.5 fluid ounces of flumetralin per gallon of water). Start topping and hand suckering individual plants when approximately 50 percent of the plants are in the elongated-bud-to-early-flower stage. Treat topped plants with flumetralin at or within 24 hours after topping. As the remainder of the plants reach this stage, top them, remove large suckers, and treat the plants. Be careful not to treat previously treated plants or to use more solution than necessary to reach the bottom of the stalk.

Alternative B. Apply a contact solution at the button stage as in step 1 of Program I. When 50 percent of the plants reach the elongated-button-to-early-flower stage, apply flumetralin, preferably with the dropline method as in Alternative A, Program II; or use a power sprayer to apply 2 quarts of flumetralin in 50 gallons of water per acre. The purpose of the initial contact is to allow the smaller plants to become more mature before flumetralin is applied. However, spraying flumetralin may cause distortion of upper leaves less than 10 to 12 inches long. So you must decide whether to spray, use the dropline, or use another alternative in Program I based on the amount of unevenness in your crop.

Do not use surfactants with flumetralin because little, if any, enhanced control is obtained, and many surfactants are phytotoxic to tobacco.

Nozzle Sizes, Arrangements, and Application Speeds

Except for MH applied alone, all currently labeled suckercides 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 suckercide 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 suckercides 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 shown in Table 7-7 (page 88) of *2001 Flue-Cured Tobacco Information*. 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 experiments 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         6
```

The arrangements shown in Table 7-6 provided the best sucker control in these experiments. The differences in sucker number and weight among the three arrangements were not statistically different. 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.

Table 7-6. Sucker numbers and weights per acre in nine experiments for a good sucker control program applied with three nozzle arrangements and/or sizes, 2001-2002

TG Nozzle Sizes (per row)	Gauge Pressure (psi)	Applic. 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.

These results indicate that growers who wish to apply stalk rundown suckercides at faster speeds can do so with confidence if they have uniform row widths, good sprayer equipment, and relatively level land. However, relatively simple three- or four-nozzle-per-row arrangements appear to provide as good or better sucker control than the more elaborate five-nozzle arrangements tested to date.

No matter the 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:

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

Control of Sucker Growth without Using MH or with Reduced Rates of MH

MH Free

MH residues have been a major concern within the tobacco industry for many years (see discussion on page 108 of this chapter). In 2005, a portion of the tobacco produced in North Carolina was grown under an optional contract that did not allow the use of MH. Growers, in return, were paid a premium for delivering tobacco free of MH residues.

Controlling suckers without the use of MH starts with proper use of contact fatty alcohols. Timing of applications and proper concentration of fatty alcohols are crucial to success. Therefore, please see the discussion of proper use of contact fatty alcohols on page 105 of this chapter. Five to seven days after the last fatty alcohol application, flumetralin should be applied. Fatty alcohols have contact activity and flumetralin (Prime+, Flupro, and Drexalin Plus) is a contact local systemic, so both fatty alcohols and flumetralin must contact the sucker to control it. Therefore, using contacts followed by flumetralin alone in some cases has resulted in large suckers late in the season due to missed leaf axils. 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 the leaf axil.

Precision application of contacts and flumetralin is important to reduce the chance of missing the upper leaf axils. Unfortunately that means that straightening leaning plants, reducing application speeds, using a minimum of 50 gpa spray volume, and spraying fewer rows at one time (four rows instead of eight) will be even more important when using contacts and flumetralin alone than when using MH and flumetralin. Growers may be tempted to increase flumetralin rates above the normal 2 quarts per acre when using it alone, but they should be cautioned about potential carryover to other crops (see flumetralin label) when using more than 2 quarts per acre. In addition, using more than 2 quarts per acre of flumetralin does not consistently improve sucker control, primarily because control is so dependant on coverage of all leaf axils, which is not improved by increasing flumetralin rates.

Research was conducted from 2005 to 2007 to evaluate sucker control programs that included only fatty alcohol contacts and flumetralin (Tables 7-7 through 7-9). Results were not consistent across locations. However, it does appear that an additional contact application five to seven days after flumetralin application can improve sucker control. Increasing flumetralin rates from 2 quarts per acre to 3 quarts or 1 gallon (in a single application) did not always improve sucker control. Regardless of treatment, the best overall sucker control was achieved at locations where contact and flumetralin applications were timely and suckers were not allowed to become too large between applications.

In 2006, research evaluated the use of alternative nozzle tips and nozzle arrangements for the application of flumetralin. Three 8006 flat-fan nozzles or four 8004 flat-fan nozzles per row were compared to the current standard TG3-TG5-TG3 arrangement of nozzles. When four 8004 nozzles were used, one 8004 was placed on each end of the standard spray boom and two 8004 nozzles were placed in the center nozzle head. Split applications of flumetralin were also evaluated as a method of improving the efficacy of flumetralin. All flumetralin treatments were preceded by two fatty alcohol applications. Alternative nozzle types and arrangements did not consistently improve sucker control compared to the standard TG3-TG5-TG3 arrangement (Table 7-7b).

Applying 1 quart of flumetralin (Prime +, Flupro, or Drexalin Plus) followed by 1 quart of flumetralin seven days later sometimes improved sucker control compared to 2 quarts applied in a single application, but results were not consistent. Application of 2 quarts of flumetralin followed by 1 quart of flumetralin seven days later consistently provided excellent sucker control at all three locations in 2006 (Table 7-7b) and two of three locations in 2007 (7-7a). However, the level of sucker control achieved with 3 quarts of flumetralin applied in a split application (2 quarts followed by 1 quart seven days later) was greater than has typically been observed in previous studies when 3 quarts of flumetralin were applied in a single application. This would indicate that increasing rates of flumetralin above 2 quarts per acre may only be advantageous if the flumetralin is applied in a split application as discussed above.

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. Growers should be reminded, however, that increasing flumetralin rates increases the risk for flumetralin carryover to sensitive rotational crops.

Reduced Rates of MH

Even if MH use is not completely eliminated, by splitting applications of flumetralin, growers may be able to improve sucker control from flumetralin enough to reduce the need for MH and therefore reduce MH residues. An acceptable level of sucker control was achieved when 1 quart (or 2 quarts) of Flupro was applied as a third application (after two contact applications) and followed by 0.75 or 1 gallon of MH in a tank mixture with 1 quart of Flupro (Table 7-7a). MH residues are reduced in two ways using these treatments. First, and most important, splitting flumetralin applications allows the use of reduced rates of MH without reducing overall sucker control. Second, by using two contact fatty alcohol treatments followed by an application of flumetralin alone, growers are able to harvest the first leaves before MH is applied. Therefore, a portion of the tobacco (the first harvest) is MH free.

Use of Ethephon

Ethephon (Prep, Ethephon 6, Mature XL, 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, as well as 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 1 teaspoon of product in 1 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 or to 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. Each of the four products listed above contains 6 pounds of ethephon per gallon and is labeled to be used at $1^1/_3$ to $2^2/_3$ 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. (See results of curing tests shown on page 93 of *2001 Flue-Cured Tobacco Information*.)

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 7-7a. Control of sucker growth with flumetralin, with and without MH—2007 and 2008

1st & 2nd Application	3rd Application	4th Application	Sucker Weight (lb/acre)	Sucker Count (number/acre)	Percent Control
Central Crops and Oxford Research Stations—2007					
4%/5% Sucker Plucker	MH 1.5 gal & Flupro 2 qt		53	174	99
4%/5% Sucker Plucker	Flupro 2 qt	MH 1.0 gal	231	1,740	98
4%/5% Sucker Plucker	Flupro 1 qt	MH 0.75 gal & Flupro 1qt	317	1,259	97
4%/5% Sucker Plucker	Flupro 2 qt		925	6,480	90
4%/5% Sucker Plucker	Flupro 1 gal		1,169	4,890	89
4%/5% Sucker Plucker	Flupro 1.5 qt	Flupro 1.5 qt	1,096	5,150	89
4%/5% Sucker Plucker	Flupro 1 qt	Flupro 1 qt	1,077	6,180	89
Bertie County—2007					
4%/5% Sucker Plucker	MH 1.5 gal & Flupro 2 qt		225	975	Not calculated for on-farm tests
4%/5% Sucker Plucker	Flupro 2 qt		1,715	3,225	
4%/5% Sucker Plucker	Flupro 2 qt	Flupro 1 qt	525	1,275	
4%/5% Sucker Plucker	MH 1.0 gal & Flupro 2 qt	Flupro 1 qt	160	375	
4%/5% Sucker Plucker	Flupro 2 qts	MH 1.0 gal & Flupro 1 qt	206	600	
Johnston County—2008					
4%/5%/5% Sucker Plucker	MH 1.5 gal & Prime + 2 qt		159	825	Not calculated for on-farm tests
4%/5%/5% Sucker Plucker	Prime + 2 qt	MH 1.5 gal	89	300	
4%/5%/5% Sucker Plucker	Prime + 2 qt	MH 1.0 gal & Prime + 1 qt	220	450	
4%/5%/5% Sucker Plucker	Prime + 3 qt	MH 1.0 gal & Prime + 1 qt	121	300	
4%/5%/5% Sucker Plucker	Prime + 2 qt	MH 0.75 gal & Prime + 1 qt	281	825	
4%/5%/5% Sucker Plucker	Prime + 2 qt	Prime + 1qt	459	975	
4%/5%/5% Sucker Plucker	FST-7 3 gal & Prime + 2 qt		225	750	
4%/5%/5% Sucker Plucker	MH 1.5 gal & Drexalin Plus 2 qt		271	750	

Table 7-7b. Nozzle types and flumetralin applications to control suckers without MH, average of three locations, 2006

Time of Application					*Sucker Weight*	
1st and 2nd Application (3-5 days apart)	***3rd Application (5-7 days later)***	***4th Application (5-7 days later)***	***Nozzle Type***	***Sucker Count (number/acre)***	***(lb/a)***	***(lb/sucker)***
4%/5% Fair 85	*MH 1.5 gal & Prime + 0.5 gal*		*TG3-TG5-TG3*	*1,517*	*534*	*0.35*
4%/5% Fair 85	*Prime+ 0.5 gal*		*TG3-TG5-TG3*	*2,650*	*1,025*	*0.39*
4%/5% Fair 85	*Prime+ 0.25 gal*	*Prime+ 0.25 gal*	*TG3-TG5-TG3*	*2,400*	*1,188*	*0.50*
4%/5% Fair 85	*Prime+ 0.5 gal*	*Prime+ 0.25 gal*	*TG3-TG5-TG3*	*1,650*	*432*	*0.26*
4%/5% Fair 85	*Prime+ 0.5 gal*		*8004-8004-8004 8004*	*3,483*	*866*	*0.25*
4%/5% Fair 85	*Prime + 0.25 ga*	*Prime+ 0.25 gal*	*8004-8004-8004 8004*	*2,333*	*1,314*	*0.56*
4%/5% Fair 85	*Prime+ 0.5 gal*	*Prime+ 0.25 gal*	*8004-8004-8004 8004*	*2,283*	*772*	*0.34*
4%/5% Fair 85	*Prime+ 0.5 gal*		*8006-8006-8006*	*3,716*	*1,248*	*0.34*
4%/5% Fair 85	*Prime+ 0.25 gal*	*Prime+ 0.25 gal*	*8006-8006-8006*	*2,216*	*1,324*	*0.60*
4%/5% Fair 85	*Prime+ 0.5 gal*	*Prime+ 0.25 gal*	*8006-8006-8006*	*1,550*	*519*	*0.33*

All spray applications were applied at 20 psi and 3 mph in 50 gal/acre of total spray volume using a "high-boy" sprayer.
The TG3-TG5-TG3 and 8006-8006-8006 nozzles were spaced approximately 10 inches apart on a single boom designed for one tobacco row.
The 8004 nozzles were used in the same boom design, but two 8004 nozzles were placed in the center nozzle head instead of one.

Table 7-8. Control of sucker growth without MH, Lower Coastal Plain Research Station, 2005

1st/2nd/3rd Application 3-5 days apart	4th Application 5-7 days after last contact	5th Application 5-7 days after P+	Sucker Control (%)	Sucker Weight (lb/a)	Sucker Weight (lb/sucker)	Number of Suckers per Plant	Yield (lb/A)	Quality Index
4%/5%/5% Fair 85	Prime + 0.5 gal (0.25 gal Prime + in each pass, two passes in opposite directions)		72	4,560	0.39	1.90	2,616	85
4%/5%/5% Fair 85	Prime + 0.75 gal (0.38 gal Prime + in each pass, two passes in opposite directions)		83	2,700	0.37	1.15	2,766	85
4%/5%/5% Fair 85	Prime + 0.5 gal		91	1,500	0.31	0.90	2,509	85
4%/5%/5% Fair 85	Prime + 0.75 gal		89	1,560	0.31	0.85	2,569	83
4%/5%/5% Fair 85	Prime + 0.5 gal (tobacco in flower)		84	2,460	0.39	1.00	2,241	85
4%/5%/5% Fair 85	Prime + 0.5 gal	5% Fair 85	94	1,380	0.27	0.90	2,695	83
4%/5%/5% Fair 85	Prime + 0.75 gal	5% Fair 85	90	1,740	0.36	0.90	2,715	85
4%/5%/5% Fair 85	MH 1.5 gal & Prime + 0.5 gal		95	720	0.21	0.70	2,631	85

Table 7-9. Control of sucker growth without MH, Wilson and Wayne counties, 2005

1st/2nd/3rd Application 3-5 days apart	4th Application 5-7 days after last contact	5th Application 5-7 days after P+	Sucker Weight and Number			
			Wilson County		Wayne County	
			(lb/a)	(no/a)	(lb/a)	(no/a)
4%/5%/5% Fair 85	Prime + 0.5 gal (0.25 gal Prime + in each pass, two passes in opposite directions)		201	1,080	1,084	4,002
4%/5%/5% Fair 85	Prime + 0.75 gal (0.38 gal Prime + in each pass, two passes in opposite directions)		233	930	646	2,401
4%/5%/5% Fair 85	Prime + 0.5 gal		529	1,590	1,672	3,335
4%/5%/5% Fair 85	Prime + 0.75 gal		139	540	1,124	3,002
4%/5%/5% Fair 85	Prime + 0.5 gal (tobacco in flower)		411	1,530	1,201	4,936
4%/5%/5% Fair 85	Prime + 0.75 gal (tobacco in flower)		146	780	1,121	4,469
4%/5%/5% Fair 85	Prime + 0.5 gal	5% Fair 85	131	1,080	1,184	2,668
4%/5%/5% Fair 85	Prime + 0.75 gal	5% Fair 85	364	1,590	980	2,201
4%/5%/5% Fair 85	MH 1.5 gal & Prime + 0.5 gal		23	420	283	2,001

Table 7-10. 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)	1.33 to 2.67 pt	1 to 2 lb	Use after second or third priming when remaining leaves are physiologically mature. Determine if field is ready to spray by treating several representative plants at several locations with test kit (or prepare test spray by mixing 1 tsp of product in 1 qt of water). If test leaves begin to yellow in 24 to 72 hr, apply product to field 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 within 24 to 48 hr 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!

Table 7-11. 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 90ºF. 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 control is starting to break down. 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 7-12. *(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.* ***Apply only once per plant per season.*** *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 7-12. *(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 with 20 to 25 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. 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. Agronomic Management Practices Affecting Tobacco Quality

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In 2005, tobacco was produced and marketed without price support for the first time since 1939. Price schedules reflected an emphasis on quality, with deep discounts for unripe and immature grades. In the post-buyout environment, profitability will be directly related to the marketing of quality tobacco produced at the lowest cost.

A number of management practices affect tobacco quality. Some of the most important are as follows:

- Nitrogen rate and time of application
- Topping and sucker control with minimal MH residues
- Harvest rate and ripeness
- Leaf separation by stalk position

Nitrogen Rate and Time of Application

Nitrogen is the most important nutrient affecting tobacco yield and quality. As nitrogen rate increases, the following occur:

- Yield increases to a point then decreases.
- Leaf size increases, but leaf thickness decreases.
- Total alkaloids, including nicotine, increase, and sugars decrease in the cured leaf.
- Maturity and ripening are delayed.
- Cured leaf darkens.
- Sucker growth increases and sucker control decreases.
- Leaf drop and leaf break increase.
- Hornworm and aphid populations increase.
- Blue mold is more severe.

Many growers spend considerable time choosing among sid-edressers such as calcium nitrate, sodium nitrate, 30 percent UAN liquid, and 24S UAN liquid. However, the data indicate that in

the southeastern United States the rate and time of application are more important than the sidedresser. Unless leaching occurs, nitrogen should not be applied after lay-by. Late season application delays ripening and results in variegated unripe grades (Tables 8-1 and 8-2).

Table 8-1. Effect of nitrogen rate on cured leaf color

Nitrogen Rate	Cured Leaf Color: Lemon (L) and Orange (F)	Variegated Ripe (K)	Variegated Unripe (KL, KF, KM, KV)	Nondescript (N)
	Percent of Harvest Leaf			
Low	*76*	*7*	*2*	*5*
Recommended	*53*	*23*	*7*	*16*
Excess	*27*	*26*	*14*	*28*

Table 8-2. Effect of nitrogen rate on the USDA quality factor for cured leaves

Nitrogen Rate	Quality Factor: 3	4	5
	Percent of Harvest Leaf		
Low	*30*	*70*	*0*
Recommended	*25*	*73*	*2*
Excess	*19*	*64*	*17*

Topping and Sucker Control

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 are in the 2,000- to 2,500-pounds-per-acre range. Higher yields reduce per-pound production costs for acreage-related inputs such as chemicals, fertilizers, and some labor expenses. Topping early also improves chemical and physical qualities of the leaf by stimulating root development and alkaloid production and by reducing buildup of insects.

Control of sucker growth is critical to maximizing yield because it allows the plant to concentrate resources on the production of leaves instead of suckers. Suckers can also interfere with mechanical harvesting and become a significant source of foreign matter in cured leaves. The key to successful sucker control is proper timing of suckercide application and use of proper rates of contacts and systemics (see Chapter 7, "Topping, Managing Suckers, and Using Ethephon).

Harvest Rate and Ripeness

When it comes to quality, there is no substitute for harvesting ripe tobacco. The ripening rate is determined by nitrogen uptake, rainfall, temperature, root health, and variety. Thus, ripening is greatly affected by weather conditions and varies considerably from one season to another. The 2002 versus 2003 and 2004 growing seasons were at opposite extremes. The 2002 season was one of the driest seasons on record, with 2003 and 2004 among the wettest. In 2002, tobacco matured quickly in our tests and held for 10 to 20 days before quality declined due to excessive heat. In 2003 and 2004, tobacco ripened slowly, followed by a rapid decline in quality due to excessive rainfall. As a result, there was only a 10-day window to harvest tobacco at the optimum value per acre.

The variety data collected in the holding ability tests are shown in Figures 3-2 through 3-4 in Chapter 3. The study was designed to measure the ripening rate and holding ability by completing the final harvest at various stages of ripeness. The first and second primings were completed at normal times. However, the third (final) priming was made at the following times: treatment 1, 7 days earlier than ideal ripeness; treatment 2, 10 days later than treatment 1 (ripe tobacco); treatment 3, 20 days later than treatment 1; treatment 4, 30 days later than treatment 1; and treatment 5, 40 days later than treatment 1. Thus, tobacco was harvested from slightly unripe (treatment 1) to 30 days past the earliest stage of ripeness (treatment 5).

Treatment 5 is probably unrealistic since there would seldom be a need to delay harvest by 30 days after the tobacco is ripe. But it is a good indicator of how well varieties will hold in the field. **All varieties tested lost yield and value in treatment 5. However, there were significant differences among varieties in the magnitude of the loss.**

From a quality perspective it is important to note that the price per pound almost always increased as harvest was delayed from 7 days early (unripe) to 10 or 20 days later. For the five varieties that were in the 2002 and 2003 tests, the range of increase was from $0.10 to $0.25 per pound in 2002; and from $0.09 to $0.33 in 2003. **Even though weather conditions in 2002 and 2003 were quite different, the trends in quality were the same. Therefore, when it comes to quality, there is no substitute for harvesting ripe tobacco.**

Leaf Separation by Stalk Position

The American blend cigarette is composed of several types of tobacco including flue-cured, burley, and Oriental tobacco. Cigarettes are not only a blend of different types of tobacco, but are also a blend of stalk positions within the different types of tobacco. Each stalk position contributes different characteristics to the cigarette, and proper blending of tobacco types and stalk positions within types is key to producing quality cigarettes and ensuring uniformity of the final product.

Therefore, separation of tobacco into distinct stalk positions during harvest is extremely important to producing a quality, high-demand product regardless of the buying company. (See Figure 1 on the inside back cover.) Cigarette manufacturers and leaf dealers have different preferences for the styles of tobacco they desire to meet customer needs. For example, some cigarette manufacturers would like to see greater production of tip grades for use in blending while others would like to buy less lower-stalk tobacco.

Producing Tip Grades

A tip grade describes certain styles of tobacco from the uppermost stalk positions (see Figure 1 on the inside back cover). Tip grades have specific characteristics that set them apart from the leaf and smoking leaf stalk grades. In recent years, many growers have combined smoking leaf, leaf, and tips into one harvest, which decreases the chance of that tobacco receiving a tip grade and also decreases the blending capabilities of the company. Therefore, the production of tip grades likely begins with better separation of upper-stalk tobacco, i.e., separation of the top four to six leaves into one grade. However, separation of the uppermost leaves during harvest may not be enough to produce cured tobacco with the desired chemical and physical characteristics attributed to a tip grade.

Research was conducted from 2002 through 2004 to evaluate the effects of variety, nitrogen rate, topping height, and separation of the upper-stalk tobacco at harvest on production of tip grades. The study included K 326, NC 71, and Speight 168 varieties and compared recommended nitrogen rates to the recommended rate plus 20 pounds of N and high-topping to normal-topping heights. In addition, the uppermost 10 to 12 leaves were harvested together or divided equally into two harvests. Based on tobacco company evaluations of upper-stalk tobacco from these trials, ripeness and separation of the uppermost leaves had the greatest effect on tip grade production. When the top five to six leaves were kept separate from the rest of the plant and when they were ripe to overripe, they consistently received a tip grade. The nitrogen rate reduced tip grade production only when the high nitrogen rate resulted in greenish or green color grades. Variety had no influence on tip production at any location.

Lower Leaf Removal To Eliminate Lower Stalk Grades

Additional research was conducted to evaluate removing either the bottom four or eight leaves from each plant as a way to reduce production of priming grades (Tables 8-3 and 8-4). Preliminary data from this study indicate that removing the bottom *four* leaves eliminates priming grades and removing the bottom *eight* leaves eliminates priming and lug grades. Removal of four leaves resulted in a 6 percent average reduction in yield and gross value per acre. Removing eight leaves resulted in a 20 to 30 percent average reduction in yield and gross value per acre. Based on the 2005 budget, if eight leaves are removed, the average selling price would need to increase by $0.15 per pound to compensate for the value loss associated with removing eight leaves, even with the savings in curing fuel and harvest and handling labor. If removal of eight leaves eliminates P, X, and C grades, then the average selling price would increase by $0.08 to $0.10 per pound. Consider that increase in average price and the projected increase in fuel costs for 2006, It could result in a similar net profit per acre in 2006 when you compare the net profit of a crop produced with an eight-leaf removal program and the net profit of an entire crop (with no leaves removed).

Table 8-3. Effects of lower leaf removal on yield and value at two locations, 2003 and 2004

Treatment	Yield (lb/a)	Value ($/a)
No leaves removed and 4 harvests	2,805 a	5,060 a
No leaves removed and 3 harvests	2,842 a	5,089 a
Remove 4 leaves and harvest 3 times	2,477 bc	4,453 bc
Remove 4 leaves and harvest 2 times	2,715 ab	4,860 ab
Remove 8 leaves and harvest 3 times	2,237 cd	4,091 d
Remove 8 leaves and harvest 2 times	2,173 d	3,931 d

Treatment averages within a column followed by the same letter are statistically different and should be considered similar.

Table 8-4. Effects of lower leaf removal on yield and value of four selected varieties in Greene County, 2005

Variety	Leaves Removed	Yield (lb/a)	Value ($/a)	Quality Index
Speight 168	None	3,696 a	5,608 a	94 cd
Speight 168	8	2,640 bc	4,191 cd	97 abc
K 346	None	3,393 ab	5,067 abcd	93 d
K 346	8	2,669 bc	4,346 bcd	99 a
K 326	None	3,696 a	5,432 ab	91 d
K 326	8	2,590 c	3,976 d	94 bcd
NC 210	None	3,511 a	5,226 abc	92 d
NC 210	8	2,615 c	4,177 cd	98 ab

Treatment averages within a column followed by the same letter are statistically different and should be considered similar.

9. Managing Diseases

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The Tobacco Disease Situation in 2008

The percent of crop value lost in Table 9-1 is based on reports from 71 percent of the acreage planted with tobacco in 2008. Complete information is available in the *2008 Tobacco Disease Extension Report.*

Black shank caused the highest losses in crop value due to disease in North Carolina during 2008, with losses reported at 4.66 percent. Most of the black shank losses reported were noted in varieties with complete resistance to race 0 of black shank (such as NC 71, NC 297, and NC 72). Populations of the black shank fungus have shifted in several fields from race 0 to race 1 after previous plantings of varieties

Table 9-1. Losses in crop value due to tobacco diseases, 2006-2008. *Percentage of crop value lost is based on reports for 71 percent of the acreage planted with tobacco in 2008.*

	% of Crop Value Lost [a]			% of Total Disease Incidents
Disease	2008	2007	2006	
Black Shank	4.66	3.47	2.12	32.89
Granville Wilt	3.32	1.65	2.17	23.43
Tomato Spotted Wilt	2.87	2.89	3.70	20.25
Mosaic	0.85	0.27	0.18	6.00
Target Spot	0.59	0.77	2.04	4.16
Root-Knot Nematodes	0.53	0.28	0.28	3.74
Pythium Root/Stalk Rot	0.48	0.67	0.54	3.40
Fusarium Wilt	0.27	0.05	0.06	1.87
Barn Rot	0.17	0.16	0.17	1.20
Hollow Stalk (Bacterial Soft Rot)	0.15	0.16	0.14	1.02
Others	0.29	0.23	0.50	2.03
Total	14.17	10.60	11.90	100.00

[a]Dollar losses for the past five years are available in the 2008 Tobacco Disease Extension Report.

with complete resistance to race 0. Those concerned with these population shifts should see the section on black shank in this chapter and Table 9-4B. Black shank occurred in several fields where varieties with complete resistance to race 0 had never been planted or planted only a very few times in the past. In several of these cases, black shank occurrence was due to the prolonged dry conditions and increased stress that the crop was already enduring early in the season.

Tomato spotted wilt incidence was rather low this season. This follows relatively high losses in 2005 (3.9 percent) and 2006 (3.7 percent). The most severe losses were reported in the eastern and southern areas of the state.

Granville wilt incidence was higher than in 2007, when dry conditions kept Granville wilt incidence low. In 2008, Granville wilt incidence was double that of 2007 (3.32 percent). The disease expressed symptoms early to mid-season in several fields where it occurred.

The three diseases mentioned accounted for 10 percent of the crop value lost to disease in 2008 (Table 9-1). In the face of a smaller overall flue-cured crop, these losses represent an enormous reduction in revenues to growers in our state.

Disease Management Practices

An effective disease management program always integrates a combination of tested and approved practices. No one 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 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 9-2).

Table 9-2. 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.*

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 9-3). To be effective, this must be accomplished as soon after harvest as possible. Completing these tasks quickly and thoroughly reduces popu-

Table 9-3. 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 two 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.*

lations of several tobacco diseases, including black shank, Granville wilt, root-knot, mosaic, brown spot, tomato spotted wilt, 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 9-4b 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 9-4b.

Table 9-4a. Resistance ratings of certain varieties to Granville wilt, tobacco mosaic virus, and root knot nematodes. *The **LOWER** the rating for Granville wilt, the **MORE RESISTANT** a variety is.*

Variety	Granville Wilt	TMV	Root Knot	Potential Yield (OVT, 3-year average)
SP 225	3	S[b]	R[a, c]	2,511
NC 810	10	S	R	2,731
SP 227	10	S	R	2,772
K 149	13	S	R	2,781
NC 196	13	S	R	2,944
SP 210	13	S	R	2,488
SP 168	14	S	R	2,782
SP 220	14	S	R	2,715
SP 234	14	S	R	2,666
NC 606	16	S	R	2,774
SP NF3	16	S	R	2,613
CC 27	17	R	R	3,116
GL 939	17	S	R	2,692
SP H20	17	R	R	2,626
K 346	19	S	R	2,667
SP 179	20	S	R	2,670
NC 297	23	R	R	2,909
NC 72	23	S	R	2,902
NC 55	24	S	R	2,886
RG H4	24	R	R	2,769
K 399	26	S	R	2,642
RG 17	28	S	R	2,846
K 326	29	S	R	3,080
NC 71	31	S	R	3,153
NC 291	32	S	R	2,978
RG H51	33	S	R	2,929
K 394	36	S	S	2,877

Table 9-4a. (continued)

Variety	*Granville Wilt*	*TMV*	*Root Knot*	*Potential Yield (OVT, 3-year average)*
Ratings for these varieties may change as more data become available:				
CC 37	*9*	*R*	*R*	*3,111*
PVH 1118	*13*	*S*	*R*	*3,010*
NC 471	*16*	*R*	*R*	*2,693*
CC 13	*17*	*S*	*R*	*2,938*
NC 299	*23*	*S*	*R*	*2,981*
NC 102	*24*	*R*	*R*	*2,744*
CC 700	*19*	*NA* [d]	*NA*	*2,919*
CC 35	*43*	*NA*	*NA*	*NA*
SP 236	*11*	*NA*	*NA*	*2,742*
PVH 2110	*25*	*NA*	*NA*	*NA*

[a]*Resistant*
[b]*Susceptible*
[c]*Varieties resistant to races 1 and 3 of M. incognita*
[d]*No available data.*

Table 9-4b. Resistance ratings of certain varieties to black shank, race 0 and race 1. The LOWER the rating the MORE resistant a variety is.

Variety	Ph gene	Race 0	Race 1	Potential Yield (OVT, 3-yr average)
SP 225	+	7	6	2,511
SP 227	+	4	13	2,772
K 346	-	10	14	2,667
K 399	-	19	16	2,642
SP 220	+	10	16	2,715
SP NF3	-	13	17	2,613
SP 168	+	5	18	2,782
NC 810	+	13	18	2,731
NC 606	-	13	19	2,774
NC 196	+	13	20	2,944
SP 234	+	10	21	2,666
SP H20	+	13	22	2,626
SP 210	-	17	23	2,488
K 394	-	13	24	2,877
K 149	-	19	24	2,781
NC 71	+	10	27	3,153
NC 291	+	12	28	2,978
CC 27	+	13	28	3,116
RG 17	-	36	29	2,846
RG H51	+	14	29	2,929
NC 299	+	12	29	3,010
GL 939	-	24	29	2,692
C 371 G	+	15	30	2,618
NC 72	+	13	31	2,902
RG H4	-	27	31	2,769
GL 973	-	6	32	2,499
SP 179	+	21	32	2,670
NC 297	+	13	32	2,909
CC 37	+	13	34	3,111
K 326	-	29	37	3,080
NC 55	-	30	38	2,886
NC 102	+	13	39	2,744

Table 9-4b. (continued)

Variety	Ph gene	Race 0	Race 1	Potential Yield (OVT, 3-yr average)
K 730	-	36	39	2784
Ratings for these varieties may change as more data become available:				
CC 13	-	35	18	3,116
PVH 1118	+	15	26	2,827
NC 471	+	11	13	2,532
CC 700	NA[b]	13	32	2,919
CC 35	NA	5	6	NA
SP 236	NA	8	12	2,742
PVH 2110	NA	39	18	NA

[a]Adapted by C. Johnson, Virginia Tech
[b]No available data.

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.

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 and wide bed (ridge) 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 further apart in the row. In particular, spacing influences diseases, such as brown spot, target spot, blue mold, and mosaic. 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 9-10).

Diseases in Greenhouses. The most common diseases in greenhouses are caused by rhizoctonia, sclerotinia (collar rot), pythium, and bacterial soft rot (*Erwinia* sp.). 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 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 3 pounds per 1,000 cubic feet. *Do not fumigate inside a greenhouse.* Trays may be stacked, criss-crossed up to 5 feet high, tarped and sealed on concrete or on a tarp, 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. Or use polytubes or other power ventilators that 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 8 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 9-11).

Black Shank. Black shank is caused by a soil-inhabiting fungus (*Phytophthora parasitica* var. *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 9-5).

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 the 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

Table 9-5. Chemical recommendations for fields with recurring economic losses to black shank caused by race 0 of Phytophthora parasitica var. nicotianea

Variety Rating[1]	*Two-Year Rotation*	*One-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 9-4. 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 or use a high rate of a nematicide rated at least Good (See Table 9-6).*

[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.*

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 next 5 to 10 years will probably 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 will 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.

Use of a variety with the ph gene for two or more tobacco crops results in the black shank population changing progressively from race 0 to race 1. When this occurs, the varieties with ph gene will appear to have little resistance and fungicides, such as mefenoxam (Ridomil Gold), will be needed (Table 9-6). 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 7 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 more infected plants that

Table 9-6. Percent of surviving plants and percent of surviving plants required to pay the cost of Ridomil Gold application. *Data are based on 25 on farm tests (1997-2004, NCSU) 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 to 75*	*6*
Preplant + 1st cultivation vs. nothing	*30 to 50*	*4*
Preplant + Layby vs. nothing	*31 to 50*	*4*
1st cultivation vs. nothing	*31 to 50*	*2*
1st cultivation + Layby vs. nothing	*50 to 75*	*4*
Preplant+Layby vs. Layby	*10 to 30*	*2*
Preplant+1st cultivation+Layby vs. Layby	*10 to 30*	*4*
1st cultivation+Layby vs. 1st cultivation	*10 to 30*	*2*

**Percent was calculated under the assumptions that a tobacco plant yields 0.5 pound, 6,000 plants are planted per acre, and average price/pound is $1.65.*

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, number and depth of cultivations may influence the severity of black shank in a field.

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 a 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* spp. 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. *Pythium 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. This increase in pythium may be due to a reduction in competition from the black shank fungus as a result of resistance. High temperatures and soil moisture favor the development of pythium stem rot. Most common tobacco cultivars are susceptible to this disease. Other pythium species, including *Pythium dissotocum* and *P.* Group Hs, have been detected that cause root rot only. 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.

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.

Forecasting blue mold (by C. E. Main). 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* species) 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 issues forecasts 3 times per week, and more often if necessary, from March through August. The forecasts are based upon daily occurrence reports from blue mold cooperators in tobacco-producing states in the United States, Mexico, and Canada. Meteorological surface wind models are 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 7 to 10 days later during the latent period. Blue mold forecast maps of spore trajectories show the source of spores, the pathway the spores will follow in the wind, and the risk of infection, all based upon true forecasts for the next 48 hours. This provides 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, plus additional information on the disease and control recommendations, are available on the Blue Mold Forecast Web page at the following address: http://www.ces.ncsu.edu/depts/pp/bluemold.

Your North American Plant Disease Forecast Center welcomes the participation of all growers, Extension agents, and industry in making this forecast system work. Your suggestions are always welcome. Contact A. L. Mila at almila@ncsu.edu or Z. T. Keever at ztkeever@ncsu.edu.

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 the soil favor Granville wilt bacteria. In fact, wet seasons

Table 9-7. 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/A)***	***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.*

greatly increase infection by these organisms. Infection may not be noticed immediately because wilting symptoms may not appear until plants undergo a moisture stress. Thus, it is not unusual to observe symptoms of Granville wilt several weeks after infection actually occurs.

The Granville wilt bacteria also can infect tomatoes, white potatoes, pepper, eggplant, and peanuts. Ragweed, common to most of North Carolina, can be infected, too, and should be controlled. See Table 9-7 (previous page) 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.

Root-Knot Nematodes (and Other Nematode Problems). Nematodes are microscopic roundworms that live as "obligate parasites," which means that 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, a 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 non-destructive 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

Moderate to high infestations often pose as great or greater a risk than 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 mail them to the Agronomic Division, Nematode Advisory Section, North Carolina Department of Agriculture and Consumer Services, 4300 Reedy Creek Rd., 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 4 acres should be represented by one sample, which should consist of at least 20 cores or subsamples from 6 to 8 inches deep. Samples must not be allowed to dry or heat above 80°F. The results obtained from samples taken in the spring are usually much lower and, therefore, are 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 9-8.

Table 9-8. Nematicides for root-knot control on flue-cured tobacco

Material [a]	*Rate/Acre*	*Method of Application*	*Waiting-Period*	*Control Rating*
Telone C-17(1,3-d+chloropicrin)	*7-10½ gal*	*Fumigant -Row [b]*	*21 days*	*Excellent*
Chloropicrin 100 (chloropicrin)	*3 gal*	*"*	*"*	*Excellent [c]*
Chlor-O-Pic 100 (chloropicrin)	*"*	*"*	*"*	*"*
Pic +(chloropicrin 86%)	*4 gal*	*"*	*"*	*"*
Telone II (l,3-d)	*6 gal*	*"*	*"*	*Excellent*
Temik 15 G (aldicarb)	*20 lb*	*14" Band*	*"*	*Good*
Mocap 6 EC (ethoprop)	*1.33 gal*	*Broadcast*	*14 days [f]*	*Fair*
Furadan 4F (carbofuran)	*1½ gal*	*"*	*"*	*Poor*
Lorsban 4E (chlorpyrifos)	*½ gal*	*Broadcast*	*14 days*	*Good*
Mocap 6EC, (ethoprop)	*⅓ - 1 gal*	*"*	*"*	*"*
Temik 15 G, 17 - 20 lb, 14-inch Band plus Mocap 6EC, 1/3 gal, broadcast				*Good*

[a] Most nematicides can damage plants under certain conditions. Greenhouse-produced plants may be more sensitive to this type of injury.

[b] Apply 6 to 8 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.

[d] Incorporate nonfumigant chemicals immediately to a depth of 4 to 6 inches. A high, wide bed should then be formed immediately. If a product failed to control nematodes in a field when used at these rates, use a different product the next year.

[e] Control varies based on the history of Nemacur use, root-knot species, and other factors.

[f] The 14-day waiting period is for enhanced insect control. Check label for reentry period.

[g] Use at least 1 gallon of Nemacur where nematode populations are high. See Chapter 10, "Managing Insects in a Post-Buyout World," when selecting tank mixes.

Target Spot. Target spot (*Rhizoctonia* sp.) 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. Drop nozzles are highly recommended for Quadris application in the field to assure 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 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 9-4a).

Also, you should rotate fields, clean equipment, and discard seedling trays (if TMV 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. The tomato spotted wilt virus 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 than 400 species of plants, including many native and introduced plants found in North Carolina, it is entrenched in

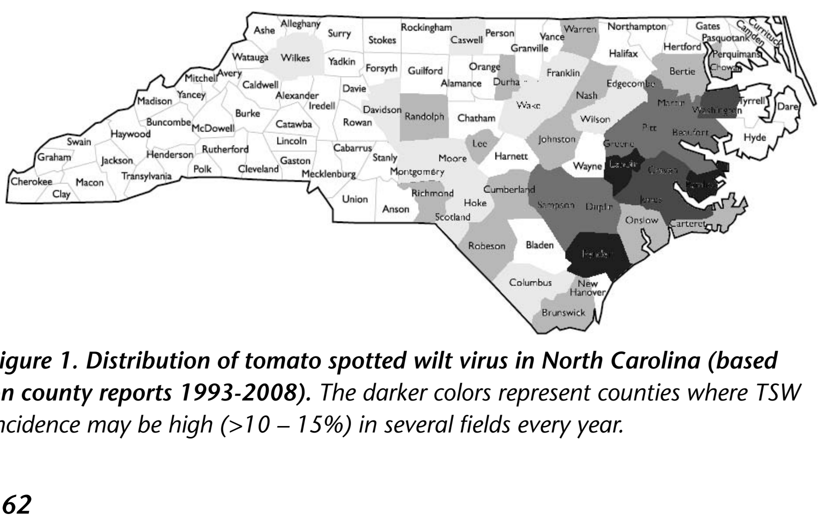

Figure 1. Distribution of tomato spotted wilt virus in North Carolina (based on county reports 1993-2008). *The darker colors represent counties where TSW incidence may be high (>10 – 15%) in several fields every year.*

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 for this disease.

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. Ankle-high and taller plants 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.

The Weed Connection. 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 small-flower 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.

Good Years—Bad Years. 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 did 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.

- Tomato spotted wilt virus 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.

Management. 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.

Cultural Practices. See Chapter 10, "Managing Insects in a Post-Buyout World," for more information.

Weed Management. See Chapter 10 for more information.

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 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 9-9).

The application of Actigard, alone or in combination with Admire or Platinum, as a foliar spray (drench) 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 9-9) averaged about 50 to 70 percent control. This level of control is comparable to the control levels obtained with pesticides for other tobacco diseases.

Table 9-9. Suppression of TSWV with Actigard and Admire Pro, North Carolina

	Percent 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 7 to 14 days before transplanting. Actigard 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 applied in the water bed followed by thorough circulation of the water in the bed to insure uniform distribution of the material.

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 1,000 plants (Admire 2F at 1.8 oz/1,000 plants) in the greenhouse. Lower rates of Admire are adequate if only insect control is needed. 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.** In our tests, Platinum used alone in the greenhouse at 1.3 ounces per 1,000 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 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 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 one 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: *Control of Tobacco Mosaic Virus on Flue-Cured Tobacco*; *Granville Wilt; Brown Spot; Black Shank*; and *Tobacco Disease Management in Greenhouses* are available from your county Cooperative Extension Center.

Compendium of Tobacco Diseases, 68 pp., is available from the American Phytopathological Society. Call 1-800-328-7560 to order.

North American Plant Disease Forecast Center:
http://www.ces.ncsu.edu/depts/pp/bluemold

Plant Pathology Tobacco Disease Information Notes:
http://www.ces.ncsu.edu/depts/pp/notes/Tobacco/tobacco_contents.html

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.

Acknowledgements

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Table. 9-10. 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.*	*Carbamate (ferbam) 76WP 4 lb/100 gal water* *Dithane Rainshield (mancozeb)* ***Plant bed*** *1 lb/100 gal* ***Greenhouse*** *0.5 lb/100 gal (sprayed)* *DO NOT USE FERBAM IN GREENHOUSES.*	*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*	

Table. 9-10. (continued)

Disease	*Cultural Management*	*Chemicals (Read and Follow the Label)*	*Comments*
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 two to three weeks after seeding.*
Soilborne Diseases *(Root-knot, Granville wilt, black shank, some damping-off)*	*Plant bed: Select warm, well-drained site.*	*Methyl bromide 98% 9 lb/100 sq yd*	*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.*
	Greenhouse trays: Wash trays. Steam at 160 - 175° F for 30 min.	*Methyl bromide 98% 3 lb/1,000 cu ft*	*Stack trays criss-cross up to 5 ft. Tarp and seal over air-tight surface. Fumigate for 24 hours. Aerate for 48 hours.*
Target Spot *(Rhizoctonia* sp.*)*	*Clip plants frequently to allow foliage to dry.*		*See Blue Mold.*
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. 9-11. 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 9-2). Maintain soil pH near 6.0.*	*Chloropicrin at 3 gal/a* *Pic + at 4 gal/a* *Telone C-17 at 10.5 gal/a*	*Observe 21-day waiting period between application and transplanting.*
Black Shank (*Phytophthora parasitica* var. *nicotianae*)	*Rotate (Table 9-2).* *Use resistant varieties (Table 9-4). Destroy stalks and roots (Table 9-3). Plant on high, wide bed. Cultivate infested fields last. Manage nematodes.*	*Ridomil Gold EC , LS (WSP) at* *1+.5 pt (lb)/a* *1+1 pt (lb)/a* *1+1+1 pt (lb)/a* *Ultra Flourish (2x Ridomil Gold rates)* *Ridomil Gold, 1 pt (lb)/a + Telone C-17 at 7 gal/a* *Ridomil Gold, 1 pt (lb)/a + Chloropicrin at 3 gal/a* *Ridomil Gold, 1 pt (lb)/a + Pic + at 4 gal/a*	*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 9-5.*

Table 9-11. *(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..*
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.*

Table 9-11. *(continued)*

Disease	*Cultural Management*	*Chemicals (Read and Follow the Label)*	*Comments*
Fusarium Wilt (*Fusarium oxysporum f. sp. nicotianae*)	*Rotate. Destroy stalks and roots (Table 9-3). Avoid root wounding. Use resistant varieties. Manage nematodes.*	*None*	*Significant problem only when root-knot or root injury is present.*
Granville Wilt *(Ralstonia solanacearum)*	*Rotate (Table 9-2). Destroy stalks and roots (Table 9-3). Use resistant varieties (Table 9-4). (All varieties may be severely damaged.) Avoid root wounding. Plant on high, wide bed. Manage nematodes.*	*Chloropicrin at 3 gal/a* *Pic + at 4 gal/a* *Telone C-17 at 10.5 gal/a* *See Table 9-6.*	*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 9-3). Rotate with fescue.*	*None usually required. See Table 9-6.*	*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.*

Table 9-11. *(continued)*

Disease	*Cultural Management*	*Chemicals (Read and Follow the Label)*	*Comments*
Root-knot *(Meloidogyne incognita)* *(M. arenaria)* *(M. javanica)* *(M. hapla)*	*Destroy stalks and roots (Table 9-3). Rotate (Table 9-2). Use resistant varieties (Table 9-4). Take and submit fall nematode samples.*	*For nematicides see Table 9-7.*	*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*	
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*	*Easily confused with brown spot.*
Tobacco Cyst *(Osborne's cyst)* *(Globodera tabacum)*	*Rotate (avoid tomato and pepper). Destroy stalks and roots (Table 9-3).*	*Temik at 20 lb/a* *Telone C-17 at 10.5 gal/a*	

Table 9-11. *(continued)*

Disease	*Cultural Management*	*Chemicals (Read and Follow the Label)*	*Comments*
Tobacco Mosaic Virus *(Field)*	*Do not plant infected seedlings. Rotate (Table 9-2). Destroy stalks and roots (Table 9-3). Use resistant varieties (Table 9-4). 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.*		
Weather Fleck *(Ozone air pollution)*	*None*	*None*	*No practical control.*

10. Managing Insects in a Post-Buyout World

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Insect pressure in 2008 was moderate for most pests. The most notable feature of the 2008 growing season was its length. Tobacco was in the field longer than typical for several reasons. Late rain delayed plant adsorption of nitrogen, keeping plants green in the field into September. Increasing tobacco production scale, with fewer growers and larger farms particularly in eastern North Carolina, likely put a premium on barn space, leaving plants to hold in the field until space for curing was available. What this meant from an insect standpoint was that plants were open to damage for a much longer time. Growers likely applied more hornworm treatments because of this; and in many locations, we saw breakdowns of a systemic insecticide for protection against flea beetles and aphids late in the season. With farm size likely to continue its increase, this situation will become more common in the future.

We do not have a good understanding of the timing of Admire breakdown at the end of the season, nor do we have reliable treament thresholds for aphids and flea beetles under these conditions. Because late-season aphids feed primarily on secondary sucker grower, their management is of less concern. But flea beetle feeding has the potential to significantly damage tip leaves waiting for harvest. In 2009, we will begin to investigate strategies for flea beetle management in late-season tobacco because of these observations.

The long, hot summer also aggravated tobacco budworm numbers. Growers throughout the state were concerned about difficult-to-control budworms, and in many cases, treated for these insects several times. Because insecticide treatments were appearing to be less effective than desired, tobacco budworm populations from fields with high pest pressure were assayed for resistance to spinosad, the active ingredient in Tracer. No resistance was observed. Cases of poor control are likely due to high pressure and hot weather, which may have resulted in more tightly closed buds and larval stem tunneling, and possibly an additional budworm generation.

Tomato spotted wilt virus (TSWV) remains a fact of life for N.C. tobacco growers. For the 2009 edition of the *Flue Cured Tobacco Guide*, we have placed TSWV management information in Chapters 9 and 10 on disease and insect management. The TSWV management recommendations presented in this chapter are primarily directed at the thrips vector

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 expensive to control. The most common problems have been with crickets, vegetable weevils, and aphids, but ants, slugs, and other pests can cause problems 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. Always 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 that can move to the 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 pests may be uncommon tobacco pests, for which no labeled pesticides are available or which 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 with insulation from the cold.

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 protects the 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 can be used to check for unevenness in your spray pattern. A metaldehyde bait (Deadline Bullets) is labeled for control of slugs in tobacco greenhouses. To avoid plant injury, don't 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 such as Affirm, Amdro, diazinon, fipronil, or Orthene. Some of these materials are slow acting, so start early.

Control 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). They damage tobacco by tunneling into the stalk below the soil surface. This may kill or stunt plants and possibly open even resistant varieties to soil-borne diseases. Stunting and the need to reset plants can result in an uneven, costly, and difficult-to-manage crop. 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 with post-transplanting rescue treatments; you must decide in advance whether you need to use soil-applied insecticides (Table 10-1). If there is a history of wireworms, if the field was weedy, or if the field is heavily infested with soil-borne diseases such as black shank and Granville wilt, a preventive treatment is probably justified. In other cases, the decision is less

Table 10-1. Soil-applied insecticides for wireworm control

Insecticide and Formulation	***Amount/Acre***	***Remarks***
Furadan 4F	*1-1½ gal*	*Apply broadcast to soil surface. Disc in within 30 minutes. Lorsban also provides some cutworm control. Some of these materials are highly toxic. Liquid formulations are generally more hazardous.*
Lorsban 15G	*13½-20 lb*	
Lorsban 4E	*2-3 qt*	
Lorsban 75WG	*2.67 lb*	
Mocap 15G	*13 lb*	
Mocap 6EC	*⅓ gal*	
Capture LRF [a]	*3.4 - 6.8 fl oz*	*Apply at transplant in transplant water or incorporate pretransplant into the top 4 in. of soil.*
Brigadier [ab]	*3.8 - 6.8 fl oz.*	*Apply in transplant water.*
Admire Pro	*0.6 - 0.8 fl oz per 1,000 plants*	*Apply to plants in greenhouse followed by immediate wash-off, OR apply in transplant water.*
Platinum 2SC	*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.*

obvious. Insurance treatments for wireworms add to the costs of production and add pesticides to the environment.

Either contact insecticides (Furadan, Lorsban, Mocap, Capture) or systemic insecticides (Admire, Platinum) can be used for wireworm control. Both types have provided good control in tests, but the systemics also provide control of aphids and flea beetles. Whether you choose a contact or a systemic, good application techniques are important. (1) Broadcast materials should be thoroughly incorporated in the top 6 inches of 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. (2) For systemics applied in the greenhouse, apply materials evenly and wash them off thoroughly to move the insecticide to the potting soil. (3) For transplant water treatments, carefully check the calibration of setters and be careful not to let concentrations (rates) build up when refilling partially empty water tanks. This is particularly important with more concentrated formulations of insecticides.

Using both a contact and a systemic insecticide for wireworm control is seldom, if ever, necessary. When selecting soil-applied insecticides, always consider the possible effect on groundwater and surface water. See Chapter 13, "Protecting People and the Environment When Choosing and Using Pesticides," for information on leaching and runoff potentials.

Cutworms. Cutworms are occasionally a problem in scattered fields, but most fields do not require treatment. Because of this fact and since a rescue treatment is available, spending extra money on 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 often 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 an over-the-top spray (Table 10-6) 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 they are low-lying with heavier soils. Because most cutworm species are active only at night, treatments are most effective if made late in the day.

Other pests. Occasionally growers may encounter 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. Another uncommon (fortunately) soil pest is the white-fringed beetle. This introduced pest is a beetle grub, white or cream colored and a bit *C* shaped. The grub has no legs, but does have a distinct head capsule. Damage is similar to that of wireworms, but much more extensive and intense. Neither of these pests can be controlled after transplanting, but you may want to talk to your local agent about management options for future years.

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 possible. The decision to use pesticides and selection of the appropriate pesticide should also include considerations of environmental impacts, 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, (3) preventive chemical treatments applied to the soil, and (4) insecticides applied after a problem develops (remedial treatment). Natural mortality is also important and should be allowed to control pests whenever possible. Calendar-based, over-the-top spray schedules add costs and often lead to more problems than they control. They should be avoided.

Cultural control practices. 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. Also, most add little or nothing to the cost of production.

1. Destroy overwintering sites and hosts of aphids and flea beetles near greenhouses or plant beds (garden greens, wild mustard, dock).

2. Destroy unused plants as soon as transplanting is complete. Undestroyed plants may become breeding sites for several insect pests and sources for diseases like blue mold.
3. Practicing weed control minimizes sources of tobacco thrips, the main vector of TSWV. 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 also minimizes thrips habitat. Grasses are poor hosts for TSWV and do not support vector species of thrips.
4. Prepare fields as early as practical if cutworms are a regular pest.
5. 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. (But remember that late-planted tobacco usually yields less.)
6. To reduce the attractiveness of the crop to budworms and hornworms, use no more than recommended rates of nitrogen. This also makes the crop a less suitable host for aphids and allows it to be harvested sooner.
7. Practice early topping and good sucker control to reduce the attractiveness of the crop and to deny a source of food to pests such as budworms, hornworms, and aphids.
8. To reduce grasshopper invasion, keep borders clean and avoid haying grasshopper-infested meadow strips near tobacco.
9. Destroy stalks and roots immediately after harvest to deny food and overwintering sites to pests. This is important in management of budworms, hornworms, and flea beetles. It is also very important in control of diseases. To be most effective, all farmers in an area should carry out this practice.
10. Use good production practices to give the crop a good start, keep it healthy, and quickly get it out of the field (where it is exposed to pests).

Conservation of beneficial insects. There are many species of parasite and predator insects that occur naturally and kill insect pests in tobacco. The importance of these beneficials 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 three steps.

1. Minimize or avoid using systemic insecticides that may reduce the populations of beneficial as well as pest insects. Stilt bugs (which feed on budworm and hornworm eggs) are especially sensitive to some systemic insecticides.
2. Do not use insecticides after transplanting unless it is absolutely necessary. Many insecticides reduce the number of predators and parasites in a field. This can result in more pests later on. Even a few fields left untreated can provide a refuge for beneficial insects. From these fields, beneficials can re-invade treated fields once the pesticide is no longer active.
3. If an insecticide is necessary, consider the effect on beneficial insects in making your choice. (See page 181.)

Use of soil-applied systemic insecticides for preventive control. Sys-temic 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 (Tables 10-2 and 10-3).

There are several reasons you might choose to use one of these materials:

Table 10-2. Effectiveness of soil-incorporated insecticides

Material	*Wireworm*	*Aphid*	*Flea Beetle* [a]	*TSWV Suppression* [c]
Admire and generic imidacloprids	*Intermediate*	*Best*	*Best*	*Best*
Di-Syston	*No*	*No*	*Intermediate*	*No*
Furadan	*Intermediate*	*No*	*Best*	*No*
Lorsban	*Intermediate*	*No*	*No*	*No*
Mocap	*Intermediate*	*No*	*No*	*No*
Orthene (TPW)	*No*	*Fair or inconsistent*	*Best*	*No*
Platinum, T-MOXX	*Intermediate*	*Best*	*Best*	*Low*
Temik	*No*	*Best*	*Intermediate* [b]	*No*

Note: No = Not recommended.

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

[b] *Broad band or broadcast treatment only; less effective if placed outside initial root zone.*

[c] *Imidacloprid suppresses TSWV by altering thrips feeding behavior. Platinum (thia-methoxam) does not appear to provide the same benefit, but, when combined with Actigard, may result in suppression.*

1. They offer some insurance against loss to insect pests and against the need to apply rescue treatments. This can be important to farmers with many scattered fields or limited labor and equipment or to those who have difficulty controlling insects for any other reason.
2. They may slow the development of aphid populations and provide more time to detect and react to this pest.
3. They may do other things besides control leaf-feeding insects (they may control nematodes or wireworms or reduce tomato spotted wilt infection, for example), and this may increase yield or quality even when leaf-feeding insects are absent.

Table 10-3. Preplant systemic insecticides for insect control in the field

Insects	***Insecticides & Formulations***	***Amount per Acre***	***Remarks***
Flea beetles	*acephate* *(Acephate 75E)* *(Acephate 97UP)*	 *1 lb* *¾ lb*	*Transplant water treatment. Higher rates than shown may injure plants. Use 100+ gal water/a.*
	carbofuran *(Furadan 4F)*	*1-1½ gal*	*Broadcast in 15-40 gal spray. Under certain weather conditions, flecking or premature flowering may occur.*
Aphids and flea beetles	*aldicarb* *(Temik 15G)*	*10-14 lb band* *20 lb broadcast*	*See state label for rates and application. Flea beetle control is reduced when granules are placed away from plants (shank application).*
	imidacloprid *(Admire Pro)*	*0.4-0.6 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 defoamers or use in combination with other pesticides.*
	thiamethoxam *(Platinum 2SC)* *(T-MOXX)*	*0.5 - 1.3 fluid oz per 1,000 plants*	
Aphids (suppression only)	*acephate* *(Acephate 75E)* *(Acephate 97UP)*	 *1 lb* *¾ lb*	*Transplant water treatment. Higher rates than shown may injure plants. Use 100+ gal water/a.*

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

1. Most offer protection against only one or two pests (usually aphids and early-season flea beetles); budworm and hornworm numbers are seldom reduced by use of a systemic and sometimes are actually increased.
2. Protection is not always season-long, and it may not be adequate to keep pests from reaching damaging levels.
3. Systemics may reduce the numbers of beneficial insects, such as stilt bugs, in the field, and this may actually increase pest pressures.
4. Each year many untreated fields never reach threshold for the pests controlled by a systemic; in those cases, treatment would have been an unneeded expense.
5. Most pesticides pose at least some risk to humans and the environment (groundwater, for example).
6. The public is concerned about pesticide use in their communities and on the commodities they buy.
7. There is always a risk that a systemic will injure tobacco and reduce yield or quality. **Remember, in numerous on-farm tests, leaf-feeding insects have been economically and effectively managed without systemics.**

Be cautious about combining systemics. There is no advantage in using two chemicals that do similar jobs and seldom any advantage in using two or more systemics. You will get little or no additional control for your extra expense, and the likelihood of crop damage is increased. There are also specific label restrictions limiting the use of foliar applications of neonicotinoid insecticides following a long-acting soil application of the same or another neonicotinoid (IRAC group 4A) insecticide. See Chapter 13 for an explanation of IRAC codes and resistance management suggestions.

Determining the need for remedial control (rescue treatments)—treatment thresholds for insects. It is clear that an insect like the hornworm can cost you part, if not all, of your profit. It is also possible, though, to reduce profits by applying insecticides that are not needed. The point at which it pays to treat is called a threshold. Thresholds have been proven in many tests and used successfully by N.C. farmers for many years.

Tobacco budworms: Before the crop flowers, treat when 10 percent or more of plants checked are infested with budworms. Do not count plants that have damage but no live worms. Budworms will not usually cause significant loss after buttoning and are not counted after that time. This threshold is extremely conservative; based on much recent research, tobacco budworms must generally reach much higher populations to cause economic loss under the growing conditions found in most of North Carolina.

Tobacco hornworms: Treatment is justified when one or more hornworms larger than 1 inch and without parasite cocoons (*Cotesia*) are found per 10 plants checked. Since worms with parasite cocoons eat much less, they should be counted as 1/5 of a worm (that is, five worms with cocoons equal one healthy worm).

Flea beetles: Treat when small plants average four or more beetles per plant. Treat large plants when there are 60 or more beetles per plant or when the lower leaves begin to look ragged or lacy at the base (near the stalk).

Aphids (plant lice): Treat when 10 percent or more of plants have as many as 50 aphids on any upper leaf before topping. Do not wait until hundreds of aphids are present to count a plant infested. This threshold should be used carefully. Before topping, populations can increase rapidly beyond 10 percent infestation. Do not delay initiating treatment.

Japanese beetles, loopers, and grasshoppers: No exact thresholds have been established, but as a rule, treat when anticipated damage is equal to or greater than that caused by a 10 percent budworm infestation.

Cutworms, vegetable weevils, mole crickets, and slugs: Treat when 5 percent or more of small plants (within three weeks of transplanting) are killed or injured.

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.

Determining the need for remedial control—scouting for insects. To use thresholds, you must know the pest level in each field. To get this information, check, or 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 (1 to 3 acres) and 10 in an average-size field (4 to 8 acres). In larger fields, add two stops for each additional 4 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 take samples near field borders (within 30 feet) since pests are often much more numerous there. (It is a good idea to look along borders, however. 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. For example, say to yourself, "I'll stop 10 plants up this row." At each stop, check five plants in a row for insects. Count the number of hornworms and budworms and aphid-infested plants and estimate the number of flea beetles per plant. Also note any other insects or damage. When you leave the field, compare your results with the treatment thresholds.

Don't make decisions on all of your fields based on information from only one or two. Insect levels may vary greatly, even among similar fields. If you cannot check all your fields regularly, assign or hire someone to do it for you. Even if you can regularly scout, it may be a better use of your time to have this job done for you. Scouting is your insurance against pest damage; it must be done on a regular basis.

Choosing a remedial insecticide. No one insecticide is best for all pests or even for a single pest under all conditions. 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 control, you must know with which pests you are dealing.

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 these insects. (This does not mean you should always look for broad-spectrum insecticides. Often, narrowly targeted materials, which are usually less detrimental to beneficials and the environment are the best choice.) Table 10-4 shows the effectiveness of insecticide sprays

Table 10-4. Effectiveness of foliar insecticides against insect pests

Insecticide	*Insect Pest Control Level*			
	Aphid [a]	***Budworm***	***Flea Beetle***	***Hornworm***
Actara	*Excellent*	*No*	*Excellent*	*No*
Assail [b]	*Excellent*	*No*	*No*	*NR*
B. thuringiensis spray [c]	*No*	*Moderate* [cd]	*No*	*Excellent*
Denim	*No*	*Good*	*No*	*Excellent*
Fulfill	*Good*	*No*	*No*	*No*
Lannate	*Fair*	*Moderate* [e]	*Good*	*Excellent*
Orthene	*Excellent*	*Moderate* [e]	*Excellent*	*Excellent*
Provado	*Excellent*	*No*	*Excellent*	*No*
Sevin	*No*	*No*	*Good*	*Excellent*
Tracer	*No*	*Good*	*No*	*Excellent*
Warrior	*No*	*Moderate* [e]	*No*	*Excellent*

Note. Moderate also means the insecticide may be less consistent.
No = Not recommended.
[a] *Aphid control ratings are based on maximum labeled rates.*
[b] *Aphid rating for Assail is based on limited data.*
[c] *B.t. is sold under a variety of trade names.*
[d] *B.t. products seem to be more effective against budworms as the season progresses.*
[e] *In some tests, Orthene, Lannate, and Warrior have performed at a good level against budworms.*

Table 10-5. Remedial treatments for insect control in the field

Insect	Insecticides & Formulations	Amount per Acre	Reentry Time [a]	Remarks
Aphids	acephate (Acephate 75E) (Acephate 97UP)	 1 lb ¾ lb	 24 24	Good coverage is essential with any product.
	imidacloprid (Provado 1.6F) (Nuprid 1.6F) (Nuprid 2F)	3-4 oz	12	
	thiamethoxam (Actara 25WDG)	2-3 oz	12	
	pymetrozine (Fulfill 50WG)	2¾ oz	12	
	acetamiprid (Assail 70 WP)	1.1-1.7 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 (Tracer)	1.4-2 oz	4	Use one or three solid cone nozzles no more than 12 inches above the bud. Apply 25-50 gal water/a with at least 40-60 lb pressure. Do not use Warrior within 40 days of harvest.
	emamectin benzoate (Denim 0.16EC)	 8 oz	 48	
	methomyl (Lannate 90SP) (Lannate 2.4 LV)	 ½ lb 1½ pt	 48 48	
	lambda-cyhalothrin (Warrior 1CS)	 2.5-3.0 oz	 24	
	acephate (Acephate 75E) (Acephate 97UP)	 1 lb ¾ lb	 24 24	
	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	
	flubendiamide (Belt SC)	2-3 fl oz	12	14-day preharvest interval

[a] Minimum interval (hours) between application and worker reentry into field. Restricted entry intervals may change in the future; follow the label.

Table 10-5 *(continued)*

Insect	***Insecticides & Formulations***	***Amount per Acre***	***Reentry Time*** [a]	***Remarks***
Cutworms	*acephate*			*In late afternoon, apply in 25-50 gal water.*
	(Orthene 75SP)	*1 lb*	*24*	
	(Orthene 97PE)	*¾ lb*	*24*	
Flea beetles	*acephate*			*For best control with any product, spray entire plant.*
	(Acephate 75E)	*⅔ lb*	*24*	
	(Acephate 97UP)	*½ lb*	*24*	
	imidacloprid			
	(Provado 1.6F)	*3-4 oz*	*12*	
	(Nuprid 1.6F)			
	thiamethoxam			
	(Actara 25WDG)	*2-3 oz*	*12*	
	methomyl			
	(Lannate 90SP)	*¼-½ lb*	*48*	
	(Lannate 2.4LV)	*1½ pt*	*48*	
	carbaryl			
	(Sevin 80S)	*1¼-2½ lb*	*12*	*Do not use carbaryl on small plants.*
	(Sevin XLR Plus)	*1-2 qt*	*12*	
	(Sevin 4F)	*1-2 qt*	*12*	
Grasshoppers	*acephate*			*If possible, also treat a few yards beyond the field border.*
	(Acephate 75E)	*⅔ lb*	*24*	
	(Acephate 97UP)	*½ lb*	*24*	
Hornworms	*acephate*			*If applications are necessary during harvest, make them immediately after rather than before priming.*
	(Acephate 75E)	*⅔ lb*	*24*	
	(Acephate 97UP)	*½ lb*	*24*	
	spinosad	*1-1½ oz*	*4*	
	(Tracer)			
	carbaryl			
	(Sevin 80S)	*1¼-2½ lb*	*12*	*Do not use carbaryl on small plants.*
	(Sevin XLR Plus)	*1 qt*	*12*	
	(Sevin 4F)	*1-2 qt*	*12*	
	methomyl			
	(Lannate 90SP)	*¼-½ lb*	*48*	
	(Lannate 2.4LV)	*¾-1½ pt*	*48*	
	Bacillus thuringiensis			
	(Agree)	*1-2 lb*	*4*	
	(Biobit HP)	*¼-½ lb*	*4*	
	(Crymax)	*½-1 lb*	*4*	
	(Deliver)	*½-1 lb*	*4*	
	(DiPel DF)	*¼-½ lb*	*4*	
	(DiPel ES)	*½-1 pt*	*4*	
	(Javelin WG)	*⅛ -¼ lb*	*4*	
	(Lepinox WDG)	*1 lb*	*12*	

[a] *Minimum interval (hours) between application and worker reentry into field. Restricted entry intervals may change in the future; follow the label.*

Table 10-5 *(continued)*

Insect	Insecticides & Formulations	Amount per Acre	Reentry Time [a]	Remarks
Hornworms *(continued)*	*emamectin benzoate (Denim 0.16EC)*	*8 oz*	*48*	*Denim has a 14-day pre-harvest interval*
	flubendiamide (Belt SC)	*2-3 fl oz*	*12*	*14-day preharvest interval*
Japanese beetles	*carbaryl*			
	(Sevin XLR Plus)	*1-2 qt*	*12*	*Do not use carbaryl on small plants.*
	(Sevin 80S)	*1¼-2½ lb*	*12*	
	(Sevin 4F)	*1-2 qt*	*12*	
	imidacloprid (Provado 1.6F) (Nuprid 1.6F)	*4 oz*	*12*	
	thiamethoxam (Actara 25WDG)	*2-3 oz*	*12*	
	acephate			
	(Orthene 75SP)	*1 lb*	*24*	
	(Orthene 97PE)	*¾ lb*	*24*	
Loopers	*Bacillus thuringiensis*			*Good coverage, especially of lower leaves, is essential.*
	(Agree)	*2 lb*	*4*	
	(Biobit HP)	*1 lb*	*4*	
	(Condor OF)	*1⅔ qt*	*4*	
	(Crymax)	*1-1½ lb*	*4*	
	(Deliver)	*1-1½ lb*	*4*	
	(Dipel DF)	*½-1 lb*	*4*	
	(Dipel ES)	*1-2 pt*	*4*	
	(Javelin WG)	*1 lb*	*4*	
	(Lepinox WDG)	*2 lb*	*12*	
	spinosad (Tracer)	*2-2.9 oz*	*4*	
	methomyl			
	(Lannate 90SP)	*½ lb*	*48*	
	(Lannate 2.4LV)	*1½ pt*	*48*	
	acephate			
	(Orthene 75SP)	*1 lb*	*24*	
	(Orthene 97PE)	*¾ lb*	*24*	
Slugs	*metaldehyde (Deadline Bullets)*	*12-40 lb*	*12*	*Apply at dusk. Do not put bait on plants.*
Stink Bugs	*acephate*			
	(Acephate 75E)	*1 lb*	*24*	
	(Acephate 97UP)	*¾ lb*	*24*	

[a] Minimum interval (hours) between application and worker reentry into field. Restricted entry intervals may change in the future; follow the label.

against major leaf-feeding insects, and Table 10-5 shows general recommendations.

Which insecticides offer the longest-lasting control? If pest pressures are expected to continue over several days, a longer-lasting pesticide is a good choice. On the other hand, these materials may be more detrimental to beneficial insects and the environment and may not be needed if the pest pressure will be brief. In on-farm tests, Orthene, Tracer, and Sevin provided the longest-lasting control of hornworms. DiPel and Lannate provided control for a shorter period. Against aphids, Orthene and Provado normally hold populations in check for at least two weeks. In the last few years, control with pymetrozine (Fulfill) has been somewhat inconsistent, with shorter residual control in some but not all tests. Aphids may rebound after treatment with Lannate within a few days.

What are the hazards to the applicator and other workers? When choosing pesticides, consider the hazard presented by each and the ability 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* are slightly hazardous to relatively hazardless. You also need to consider the protective equipment requirements of the worker protection standards (see Chapter 12, "Complying with the Worker Protection Standard").

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 runoff potentials, you should choose remedial (and soil-applied) chemicals carefully (see Chapter 13, "Protecting People and the Environment When Choosing and 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 4 to 48 hours.

Do tobacco buyers have concerns about insecticide residues? Most farmers are aware of the concern many buyers have about maleic hydrazide (MH) residues. Because of concern about residues of endosulfan (Golden Leaf Tobacco Spray, Phaser, Thiodan), we no longer recommend its use in tobacco. If your buyers are concerned about residues, choose another insecticide or restrict the use of problem insecticides to the early season—several weeks before harvest begins. Take care to prevent drift of any unregistered pesticides onto tobacco when they are being applied to another 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 insecticide and is given on the label. For example, the pyrethriod lamda-cyhalothrin (Warrior) has a 40-day preharvest interval (PHI) restriction.

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. Lannate, which has a short residual in the field, is only somewhat detrimental. Tests in cotton indicate that Tracer also is only somewhat detrimental, but data are not available in tobacco. Orthene and Sevin are moderately detrimental.

Is rotation of 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. When appropriate, alternate newer insecticides with different modes of action like Fulfill, Provado, Actara, and Tracer with the *Bacillus thuringiensis* products and with older insecticides.

How much does the material cost? Cost is always a consideration. Remember, though, 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.

Steps in Managing Aphids

Aphid populations can build up very rapidly. An actively growing population can double in size in only 2.2 days. Because of this trait, aphids require very close attention and a carefully planned management program. The following steps should be combined in a total management program.

1. Control aphids in the greenhouse or plant bed. Begin by destroying any winter host plants (such as garden greens

and wild mustard) near beds or greenhouses. If needed, use remedial insecticides. Such control may help reduce the spread or transport of aphids into the field. Once transplanting is complete, destroy beds and remove plants from greenhouses.

2. Consider planting early. Evidence from Virginia and North Carolina indicates that early-planted tobacco may escape some aphid pressure. (Tobacco planted very late may also escape some damage but typically yields less for other reasons.) If you plant over a lengthy period, expect fields planted near the normal time for your area to need the most attention and protection from aphids.
3. Do not exceed recommended nitrogen rates. Overfertilization encourages aphid buildup. This also encourages sucker growth, and suckers help support aphids in the second half of the season.
4. Consider using a soil-applied systemic insecticide for preventive control. The best of these materials usually eliminate aphids as a management concern during the growing season. Remember, however, that systemics add to the cost of production and may have other disadvantages. Aphids can be managed quite well without their use.
5. Don't wait too long to begin rescue treatments. Watch tobacco closely. Do not wait until aphids reach high numbers or sooty mold and damage are evident before beginning treatment. By this time, much damage will have been done, and the aphids will be difficult to bring below damaging levels. Treat as soon as the threshold is reached (10 percent of plants lightly infested).
6. Choose effective insecticides. (See Tables 10-4 and 10-5.)
7. Use maximum labeled rates for moderate to heavy infestations.
8. Apply insecticides carefully. Good coverage of the underside of leaves is necessary. Use nozzles that produce a fine spray (hollow cone or small solid cone), at least 60 PSI, and adequate water (at least 25 gallons per acre). It may be best to avoid spraying on very hot afternoons.
9. Wait at least three days after treatment before determining whether control has been adequate.
10. If control is poor, switch to another recommended insecticide before treating again. If treatment is begun when aphid numbers are low and the application is made carefully, poor control could indicate the buildup of resistance. Switching insecticides could reduce the chance of further buildup and ensure adequate control. Newer pesticide labels now list the

Insecticide Resistance Action Committee (IRAC) code for each insecticide. These codes are explained and presented in Chapter 13. When selecting insecticides to treat the same insect more than once, select materials with different modes of action, represented by different IRAC codes. Fulfill (IRAC 9B), Acephate (1A), and Provado (4A) each have different modes of action.

11. Continue to watch the field carefully. Aphids may build up to the threshold level again (especially if control is marginal).
12. Top and begin sucker control at the 50 percent button stage. Topping and sucker control speed the decline of aphids and may be important in controlling a difficult population or preventing a low population from reaching damaging levels.
13. When treating for other pests, consider using insecticides that are not the most effective against aphids. This may help avoid the development of resistance in aphids.

On-farm tests have shown that combining cultural and other practices is effective in reducing aphid problems. These tests compared less careful production practices to a combination of early planting (two weeks before average for the area), the use of minimum recommended amounts of nitrogen, topping at 50 percent early button, and good sucker control. In most locations, this combination reduced aphid numbers and in some cases eliminated the need to spray. Such reductions may not always be adequate to prevent the need for rescue treatments, but they are important in a total management program.

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 people realize. 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, utilizing cultural practices (choosing a resistant variety, avoiding excessive nitrogen, topping early, 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.

If you do decide to use an insecticide, refer to Tables 10-4, 10-5, and 10-6 in making your decision. Some older pesticides have been less effective in recent years. Don't simply rely on decisions you may have made years ago.

Apply insecticides carefully. Budworms are often hidden in the bud, and, 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 practi-

Table 10-6. Reductions in budworm damage in N.C. tests, 1998-2008

Insecticide [a]	*Percent Reduction in Leaf Loss* [b]	*Number of Trials* [c]
Belt SC, 3-4 fl oz	*79*	*3*
Coragent, 3-7 fl oz [d]	*71*	
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 [e]	*73*	*7*

[a] *Rates are in units of formulated product per acre, all treatments over-the-top sprays except 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] *Coragen is not currently registered in tobacco, but registration is anticipated in 2009.*

[e] *Lambda-cyhalothrin, tested as Warrior 1CS in five tests, as Karate Z in two others.*

cal, no more than 12 inches above the bud (or about 6 inches above the uppermost leaf tips). Do not treat after topping, except in very unusual cases. Budworms don't cause significant damage to maturing tobacco unless there are at least several on each plant.

Thrips and Tomato Spotted Wilt Virus

The tomato spotted wilt virus is moved from plant to plant by tiny insects called *thrips*. Thrips 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, even so, not more than 1/8-inch long. Young thrips are smaller, wingless, and usually yellow. Obviously, these small insects are easily overlooked. 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 it's warm, and there may be several generations during the growing season.

Not every thrips you see on your tobacco is spreading tomato spotted wilt. (Yes, the word thrips is both singular and plural.) Although there are many species of thrips, most of them either cannot carry tobacco spotted wilt virus 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.

Tomato spotted wilt virus is carried from plant to plant inside the insect vector and not just on the outside of the insect's mouthparts. This means 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 hatching from an egg. The same thrips cannot move the disease to another plant until it (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 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 10-7).

The application of Actigard, alone or in combination with Admire or Platinum, as a foliar spray (drench) 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

Table 10-7. Suppression of TSWV with Actigard and Admire Pro, North Carolina

	Percent of Plants Infected by Tomato Spotted Wilt Virus				
County, Year	***Untreated Control***	***Admire Pro 0.8 oz/ 1,000 Plants***	***Actigard 1 oz/ 50,000 Plants***	***Admire Pro 0.8 oz/1,000 Plants + Actigard 1 oz/50,000 Plants***	***Admire Pro 0.8 oz/1,000 Plants + Actigard 0.5 oz/per acre***
Duplin, 2006[a]	*44*	*41*	*38*	*26*	
Sampson, 2006[a]	*10*	*9*	*9*	*7*	
Onslow, 2006[a]	*26*	*15*	*20*	*10*	
Jones, 2007[a]	*32.4*	*17.7*	*19.1*	*15.3*	
Sampson, 2007[a]	*14.7*	*11.3*	*6.0*	*4.5*	
Craven 2007[b]	*NA*	*13.8*	*NA*		*4.3-8.9*
Duplin 2007[a]	*7*	*2.83*	*2.13*	*1.08*	
Jones 2008[b]	*30*	*11.8*	*NA*		*5.5-6.8*
Average	*23*	*15*	*16*	*10.6*	*4.9-7.8*

[a] Data are from K. Cherry's thesis research, Department of Plant Pathology, NCSU.

[b] In the Craven 2007 trial and the Jones 2008 trial, foliar treatments of Actigard were applied in the field at different times. Actigard treatment timings coordinated with the peak thrips flight post-transplant resulted in the greatest reduction of TSWV incidence. These data are from research in NCSU's Department of Entomology.

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 (Table 10-7) averaged about 51 percent control. This level of control is comparable to the control levels obtained with pesticides for other tobacco diseases.

Tests in 2007 and 2008 using the Morsello-Kennedy thrips flight models to time foliar Actigard applications in the field was extremely promising; properly timed applications dramatically reduced incidence in these trials.

Use of pesticides of any type usually comes at a price. Our tests have shown that foliar 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 5 to 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 1,000 plants (Admire 2F at 1.8 oz/1,000 plants) in the greenhouse. Lower rates of Admire are adequate if only insect control is needed. 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.

In our tests, Platinum used alone in the greenhouse at 1.3 ounces per 1,000 plants has not reduced TSWV significantly. However, the combination of Platinum and Actigard has been as effective as the combination of Admire and Actigard. Research was conducted in 2005 and 2006 to evaluate the use of Actigard in float water instead of a drench application. Although this application method further reduced TSWV infection, phytotoxicity may be even more pronounced.

Cultural Practices. Field selection and the transplanting date do impact disease, but the effect of the transplanting date is not consistent enough from year to year to include in a management plan. TSW 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. Research is still under way to determine how we might use weed management to manage TSWV. It is not clear whether vigorous early-spring weed control immediately around fields can be cost-effective in reducing the disease in tobacco. However, a few management tools appear promising.

1. Weedy small grain fields and fallow fields destined for no-till soybeans or cotton are potentially 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 at the time you are transplanting 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.
2. 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 and 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.
3. 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.

Tobacco Splitworm: An Emerging Pest?

The tobacco splitworm, more accurately known as the potato tuberworm, has been a minor pest of tobacco for many years. In most years, only a few fields (if any) in the state suffered significant damage by splitworms, and this was generally in the first half of the season. The situation was much different in 2002. Numerous fields in the coastal plain and northern piedmont were heavily infested, and this infestation occurred in the second half of the season. From 2003 through 2006, the occurrence of splitworms was again closer to the long-term average. But in 2007, populations were the highest we have ever observed. The dry hot weather may have contributed to these record numbers, particularly considering that the last year with comparable damage, 2002, was also dry. 2008 splitworm populations were generally low, although monitoring traps captured moths and feeding damage was observed.

Splitworm moths are small (wingspan is about ½-inch), grayish brown, and have the back edge of the wings 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. This leaves a thin, irregular window in the leaf, and of course destroys 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. In some cases, the larvae also tunnel into the stem or into the bud area. The latter can cause distorted leaves and, sometimes, topping of the plant. When infestations begin early in the growing season (which was the usual case prior to 2002), splitworms may affect all leaves of the plants nearly at once. If the infestation begins later, as it has since 2002, it more typically starts on the lower leaves and moves up the stalk.

No threshold for this pest has been established, but if 10 percent or more of plants are significantly infested (10 or more mines), control is probably justified because populations of this insect can increase very rapidly. There are few good options for control. Limited testing with Warrior has shown good control in North Carolina and Virginia, but its very long pre-harvest restriction (40 days) that makes it almost impossible to use except in the first few weeks of the season. Denim is also somewhat effective, but it too has a long pre-harvest restriction (14 days). Coragen and Belt, the newly registered caterpillar insecticides, have shown some promise against these insects in greenhouses and limited field studies. If an infestation occurs during the harvest period, you may be able to eliminate some of the problem by harvesting leaves with mines and following with insecticide sprays (this is not a recommendation to harvest unripe tobacco).

Organic Insect Management

There is increasing grower and industry interest in organic and PRC tobacco production. Fortunately, we have 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, and this work will begin in 2009.

Pesticide Issues

The number of generic imidacloprid (Admire) products available on the market continues to increase. Our limited experience in 2007 and 2008 with some of these materials suggests that, in general, they have efficacy comparable to Admire and pose no greater or lesser risk for plant injury; but we have not been able to assess all of these materials under a variety of growing conditions. Formulations vary among these generic materials and may differ in their effects on tobacco plants under varying growing conditions. Growers should try any new material on a limited acreage to assess how it will behave in their system prior to committing to large-scale use of the insecticide.

One new insecticide is available for use in tobacco, starting in 2008. Belt SC (Bayer Crop Sciences) has activity against caterpillars (tobacco budworms and hornworms). Another new lepidopteran material will likely be registered in 2009. Coragen (DuPont) has the same mode of action as Belt (IRAC Group 28), and has performed similarly in tests. Information on the efficacy of both these materials for budworms is included in Table 10-6. These two products are also listed in Table 10-5.

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 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 100 pounds of tobacco.
- Storage area: 6 teaspoons DiPel DF or Biobit HP per 2½ gallons of water. Use ½ gallon per 1,000 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. Re-infestation 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.

11. Curing and Mechanization

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From the early development of bulk curing, a few guidelines have always been 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. Maintain proper control of the curing conditions.
4. Make sure that your equipment and barn are energy efficient and well maintained.

With the ever-increasing fuel costs and reduced cured leaf prices, it is critical that growers apply these recommended guidelines to increase their curing efficiency. In addition, the heat exchanger retrofit systems require annual adjustments and inspections that are different than those needed by the direct-fired curing systems used in the past. The information provided in this chapter can help you to 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. Uniform loading is essential in both rack and box barns. A barn full of racks or boxes that are not uniformly loaded is almost sure to cure improperly and waste fuel and electricity. Although many rack barns are still in use, they typically have been replaced with box barns. This is mainly due to the box barn's increased capacity and ease of integration into completely mechanized leaf handling systems. Although most curing containers can be effectively loaded by hand, many types of mechanical loading systems have become available. Green leaf box loading systems have become more common as growers have become more dependent on mechanization.

Mechanical loading systems load the boxes with thin uniform layers of leaf and incorporate a system to weigh the quantity of green leaf in each box. Overloaded boxes can result in scalded tobacco, particularly on lower-stalk tobacco. More often, however, scalded or improperly cured tobacco results from uneven loading that allows air to pass through less densely loaded areas while bypassing more densely loaded areas. Typically the middles of the boxes are loaded more densely than the sides, especially when hand loaded. Weighing the boxes allows the grower to load each with exactly the same amount of green tobacco and minimize the density variations. The box bulk density—the pounds of green leaf per unit of box volume—significantly affects the airflow through the packed bed of tobacco. As the amount of green leaf per box (bulk density) increases, the resistance to the flow of air also increases. The fan must overcome this resistance to produce a desired airflow. Thus, an accurate green weight measurement will assist with determining the optimum loading rates for your particular barn-retrofit combination.

Many growers comment that weighing the green leaf per box has eliminated or minimized the curing problems associated with lower-stalk tobacco. Boxes that are not uniformly loaded may result in drying at different rates due to the variations in bulk density. 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 consumption per cure. Although the electricity component of the energy required for curing is approximately 10 to 15 percent of the total, the electricity cost is approximately 20 to 25 percent of the total curing cost.

Furthermore, proper placement of racks or boxes is a must for adequate airflow. It has been estimated that a ½-inch crack between adjacent boxes may allow as much as 50 percent of the air to “short-circuit” past the tobacco. Good box-to-barn and box-to-box sealing should be obtained for maximum leaf ventilation and top-quality cures. The same holds true for racks. Although good cures can be obtained with slight air leakage between containers that are provided adequate airflow, poor cures are likely when low airflow occurs with leakage, nonuniform loading, or both.

Maintain Proper Control of the Curing Conditions

Proper control of the temperature and relative humidity are essential for efficient tobacco curing. Because very few relative humidity sensors can function accurately in the harsh curing environment, relative humidity is not measured directly. The relative humidity is indirectly monitored by measuring both the dry- and wet-bulb temperatures.

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 input 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. Provided there is sufficient air movement around the wetted wick for evaporation to occur, the wet-bulb thermometer indicates the wet-bulb temperature.

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 to the maximum weight of water vapor the air can hold for a given dry-bulb temperature. The higher the relative humidity is, the slower the evaporation rate and vice versa. The difference between the dry-bulb and wet-bulb temperature determines the relative humidity of the air. Thus, the difference between the two temperatures indicates the amount of moisture in the air and is often referred to as the *drying potential* or *wet-bulb depression*.

As the temperature difference between the dry-bulb and wet-bulb increases, the relative humidity of the air decreases, resulting in an increase in the drying potential. A smaller difference in temperature indicates an increase in the relative humidity and a decrease in the drying potential. If the air were completely saturated, which means the relative humidity would be 100 percent, the dry-bulb and wet-bulb temperatures would be the same. The tobacco-drying rate depends on the dry-bulb temperature, wet-bulb temperature, and airflow rate.

Curing Phases

Figure 12-1 illustrates the dry-bulb and wet-bulb curing schedule used for normal ripe tobacco. Also shown is the relative humidity associated with the given dry- and wet-bulb temperatures. Typically the curing schedule is divided into three phases defined as *yellowing*, *leaf drying*, and *stem drying*. Although each phase in the figure is divided into 48-hour intervals, the actual time required may vary. The curing schedule is a general guide, and the actual schedule followed may deviate due to factors such as the tobacco ripeness and maturity, weather, airflow, and other influences. The maximum relative humidity occurs during the yellowing phase of the curing schedule, and the minimum occurs during stem drying.

Yellowing involves a delicate balance between maintaining a high relative humidity, but 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 over-drying. Removal of as much water as possible during yellowing while maintaining the proper humidity can reduce fuel consumption, thus improving energy efficiency. Likewise, as sufficient moisture is removed during yellowing, the drying action will help to improve airflow through the containers. The resistance to airflow will decrease as the tobacco dries and shrinks, thus improving air passages around the leaves.

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 and increasing the air's drying potential. 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,

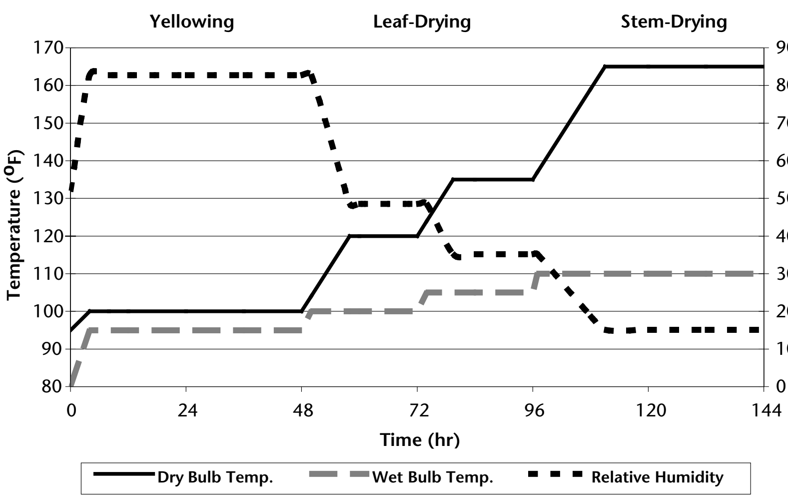

Figure 12-1. Typical curing schedule for normal ripe tobacco

therefore minimizing the possibility of leaf scalding. By the end of the leaf-drying phase, the tobacco's moisture content has significantly decreased.

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 control the humidity, but accurate and optimum control of the curing environment and fuel consumption require the use of a wet-bulb thermometer. 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, but also one of the least used, is the proper use of a wet-bulb thermometer. Measuring the wet-bulb temperature also allows the grower to control and monitor the actual leaf temperature as long as the leaf contains sufficient moisture. Monitoring the leaf temperature will help to avoid the curing problems mentioned previously in this chapter. To control the wet-bulb temperature, and therefore 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 over-ventilate to avoid browning or scalding the tobacco. It only requires a few degrees difference in the wet-bulb temperature to significantly increase or decrease the drying potential of the air, especially during the early stages of the curing schedule when the dry-bulb temperature is only a few degrees higher than the wet-bulb temperature. As the damper opening is increased, the ventilation rate and fuel consumption increase. Fuel consumption increases because heat energy is required to raise the dry-bulb temperature of the volume of ambient air coming into the barn. The amount of energy wasted increases as the dry-bulb temperature increases, which is highest during the stem-drying phase.

As the damper opening increases, 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. Curing with a lower than recommended wet-bulb temperature 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.

A barn with excessive air leaks may make it difficult to maintain the desired wet-bulb temperature and, therefore, 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. Although most dampers are adjusted manually, they can be adjusted automatically. Automatic ventilation systems use the wet-bulb temperature measurement as an input signal to a fractional horsepower motor that is connected to the damper. The motor adjusts the damper opening in small increments to maintain the desired wet-bulb temperature.

Automatic damper control provides continuous monitoring of the wet-bulb temperature, resulting in more accurate ventilation control, which can decrease fuel consumption during curing. The amount of fuel savings associated with any automatic damper control will depend on how well a grower is currently managing the ventilation process. Automatic control systems can also monitor the dry-bulb and wet-bulb temperatures and transmit this information to a central location, such as an office or home. This allows the grower to observe the real-time curing conditions of each barn connected to the system. As growers continue to consolidate most of their barns, the remote monitoring capability has a significant time management benefit. Less time is spent opening and closing barn doors and making damper adjustments multiple times daily. Additionally, alarm conditions can be established that will notify the grower if problems occur during curing. Although automatic curing control systems can help to improve curing management, the desired curing conditions are inputs based on year of experience curing tobacco.

Regardless of whether damper control is manual or automatic, if the wick on the wet-bulb dries out, the measured temperature is higher than the actual wet-bulb temperature. As a result, the damper is opened in an attempt to lower the wet-bulb temperature, which leads to over-ventilation. Therefore, keeping the wet-bulb wick from becoming too dry during curing is critical to proper ventilation control. Automatic ventilation systems will not function properly if this occurs. Growers may have noticed that curing with heat exchangers has resulted in less ventilation (a narrowing of the damper opening) than direct-fired curing for a desired wet-bulb temperature. The indirect-fired heating system externally vents all of the water vapor produced during the combustion process, resulting in a drier heat. Although good cures can result from guessing the wet-bulb temperature, over-ventilation and increased fuel consumption are almost guaranteed.

A wet-bulb thermometer or hygrometer can be purchased from your fuel dealer or an agriculture supply merchant. An inexpensive homemade wet-bulb thermometer also can be constructed from 1-inch PVC components. The homemade wet-bulb has a larger water reservoir to minimize replenishing during curing as compared to the hygrometer. Contact your local cooperative Extension agent to obtain additional information about constructing a homemade wet-bulb thermometer.

Wet-Bulb Thermometer Location

The drying process occurs at a constant wet-bulb temperature. Therefore, the wet-bulb temperature should be the same below and above the tobacco. However, the dry-bulb temperature below the tobacco will be greater than above. As the air passes through the mass of tobacco, the moisture content increases and the temperature decreases due to the evaporative cooling. 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 for evaporation. Typically, the wet-bulb 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 decrease in moisture

absorption. Remember, if the wick becomes dry, the wet-bulb thermometer will indicate an incorrect wet-bulb temperature, which will result in over-ventilation and increased fuel consumption. This also applies to the automatic ventilation systems that use a wet-bulb thermometer.

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 if the equipment, barn, or both are poorly maintained.

It is important to follow any annual maintenance requirements recommended by both the heat exchanger and burner manufacturers to ensure 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 should be inspected to ensure proper operation. The heating systems are not unlike other mechanical systems that require annual inspection and service to maintain a high level of performance and prolonged life.

Burner Efficiency

Combustion is a chemical process. A burner facilitates the conversion of the chemical energy contained in the fuel to heat. All fuels contain a certain and fixed heat content per unit measure. For example, if a liquefied petroleum (LP) gas burner were 100 percent efficient, it would produce approximately 90,500 British thermal units (Btu) for each gallon of LP gas burned. In practice, some of the fuel passes through the burner unburned and is, therefore, wasted. A well-designed and -maintained burner limits this waste to no more than 1 or 2 percent.

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. Even a thin coating of soot can reduce the heat exchanger efficiency considerably. It has been estimated that a 1/8-inch layer of soot accumulation on the heat exchanger surfaces can increase fuel consumption by approximately 8 percent.

When too much air is present, the excess air cools the combustion gases and carries heat out before it can be captured by the heat exchanger. Adjusting the correct air-fuel ratio on a burner is essentially the same as adjusting the air-fuel ratio on an engine carburetor. Although an approximately correct burner air-fuel ratio may be set by eye (a blue instead of orange flame), the proper air-fuel ratio can best be achieved with a combustion analyzer.

Most fuel dealers have some type of combustion analyzer and the experience to assist with adjusting the heat exchanger burner. The combustion analyzer probe is inserted into a small hole drilled in the heat exchanger exhaust stack. The most accurate location in the stack to perform this test is where the pipe first exits the barn. At this location, any additional heat in the pipe is not transferred to the curing air inside the barn. Combustion analyzers are quick and easy to use, and they can assist with significantly reducing fuel costs each year. In addition, your local cooperative Extension agent can assist with questions about this procedure.

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. As the excess air is increased, the percentage of CO_2 decreases and the percentage of O_2 increases, which results in wasted fuel and cooler flame temperatures. The excess air acts as a heat sink and absorbs significant amounts of the heat energy released during the combustion process, which significantly decreases the flame temperature.

The general practice is to supply 5 to 50 percent excess air depending on the fuel type, combustion equipment, and other factors. Since LP gas and natural gas are already in a vapor form when mixed with air, they typically require less excess air than fuel oil. Also refer to the burner manual for any additional information or recommended excess air values. The manual may list the fan shutter setting for a given burner firing rate (Btu/hr), but a combustion test should always be performed to verify the excess air percentage. The goal is to minimize the excess air quantity, but provide enough to ensure complete combustion. The correct quantity of excess air will result in higher flame temperatures, increase contact time between the hot combustion gases and heat exchanger surfaces, and minimize soot accumulation. As a result, a properly tuned burner will increase heat transfer.

Some combustion analyzers calculate and display the excess air percentage based on the CO_2 and O_2 measurements. Additionally, the exhaust gas temperature, combined with the excess air parameters, can be used to calculate and display the thermal efficiency, expressed as a percentage. 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 equal to and exceeding 80 percent should be targeted. An ideal stack temperature is in the range of 350 to 450°F. The heat exchanger and burner work together. Consequently, a properly tuned burner can assist with significantly improving the heat exchanger performance.

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 (Btu/hr) greatly influences the efficiency of a particular heat exchanger.

Check the correct burner-firing rate . Typically the burner-firing rate is 325,000 to 450,000 Btu/hr, which depends on the amount of green tobacco loaded, fan output, and other factors. A burner operating at a high capacity can easily overwhelm a modest heat exchanger designed for a smaller burner. Most modern fuel oil and LP gas burners are adjustable in capacity (Btu/hr) over a considerable range. For the most efficient operation, balance the burner and heat exchanger. 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 the early part of leaf drying when the barn temperature should be between 125°F and 135°F. Adjust the heat output of the burner so that the burner is operating nearly continually during this time. For example, a burner that is on for a minute and off for several is probably operating at too great an output and inefficiently overwhelming the heat exchanger. Further, in the short time the burner is operating, the heat exchanger may be getting red hot, inducing severe thermal stresses in the metal and ultimately shortening its life.

An Energy Efficient Barn

A statewide bulk barn energy audit program 20 years ago demonstrated conclusively that the quality of cured tobacco as well as the cost of curing depended heavily on the barn's condition. Fuel savings as high as 50 percent were documented when poorly maintained barns were thoroughly reconditioned. A bulk curing barn is not so much a structure as a piece of equipment. And 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.

Curing fuel is a significant cost of tobacco production. Even a brand new, well-insulated bulk barn uses only about 60 percent the heat value of the fuel to cure the tobacco. The remaining 40 percent of the heat is lost through the walls of the barn by conduction and radiation, out the exhaust stack, or through air leaks. Leaky and poorly maintained barns without insulation, on the other hand, may waste as much as 60 percent of the fuel. Many growers don't realize how much fuel their older barns are wasting until they put a new barn down beside their old ones. The difference in fuel use sometimes can be startling.

Most bulk barns are situated on a 4-inch-thick pad of concrete. Some are insulated, but most are not. This is unfortunate. Test after test has shown that even a small amount of insulation will reduce the amount of fuel used and pay for itself several times over during the life of the barn. 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.

All of the bulk barns made today have insulated walls and ceilings. Some of the older ones do not. Nothing can reduce the cost of curing like properly installed insulation. There are several ways to insulate a bulk barn. Growers have used fiberglass batts and foam board with some success. However, experience has shown that the best all-around insulation for a bulk curing barn is sprayed-on polyurethane. In addition to its excellent insulation properties, sprayed-on polyurethane will seal cracks and openings. One-half to ¾-inch of sprayed-on polyurethane insulation is usually sufficient. Doubling the thickness of insulation will not double the saving. Be careful to keep the insulation off the rails of rack-type barns and other places where it may be rubbed off and mixed with the tobacco. Pieces of polyurethane insulation are very difficult to remove from cured tobacco and will result in very serious contamination issues. All barns now must completely cover the insulation with sheet metal to prevent contamination.

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. A few minutes spent with a screwdriver and hammer will be time well spent. Doors are particularly noticeable sources of maintenance problems. Hinges work loose, and gaskets get hard and torn and need periodic replacement. It is also a good idea to reseal the foundation joint with a good grade of butyl caulking compound. A 15-foot-long, ¼-inch gap between the foundation channel and the pad can increase curing costs by 10 percent.

Curing Efficiency

While the thermal efficiency is the combined efficiency of the combustion process and heat transfer (burner and heat exchanger), we must consider the entire process of tobacco curing to understand efficiency. In essence, curing efficiency is the system efficiency (barn plus burner and heat exchanger) and bottom line that can be quantified in pounds of cured leaf per gallon of fuel consumed. For example, what if you are taking out 3,000 pounds of cured leaf per barn and the fuel consumption is 300 gallons of LP gas? That would indicate a curing efficiency of 10 pounds 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. Because some of the heat is lost up the stack with a heat exchanger, a burner/heat exchanger delivering the same amount of heat (in terms of Btu/hr) to the curing barn as that delivered by a direct-fired system will necessarily require more fuel. Surprisingly, however, some growers reported no increase in fuel use or even that their retrofitted barns use less fuel. There are several possible explanations, with the most likely being that many of the direct-fired burners needed maintenance and adjustments.

Data have been collected over the last two seasons from multiple locations to determine the curing efficiency. Gas meters were installed on curing barns at each location to measure the fuel consumption, in cubic feet of LP gas, for each cure. Most of the barns were insulated and all-metal construction, but the heat exchanger manufacturer, burner firing rates, and curing management varied, which can have a significant effect on the curing efficiency. The cured leaf weight and, if possible, the tobacco green weight were recorded also. The average curing efficiency ranged from approximately 7.34 to 13.98 pounds cured leaf per gallon of LP gas. These are significant differences in curing efficiency, and consequently the cost per pound of cured leaf. Table 11.1 shows the estimated cost per pound cured for varying curing efficiencies and fuel cost. 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 efficiency, the lower the curing cost. As an example, if two growers were paying $2.00 per gallon for LP gas, but their curing efficiencies averaged over the season were 9 lb/gal and 11 lb/gal respectively, the difference is approximately $0.04 (0.222 minus 0.182) per pound cured. Multiplying this difference by the total pounds cured can run into thousands of dollars over a season. This costs does not account for the fan electricity use, which will vary with fan motor horsepower and the cure length. Growers should target an average curing efficiency of at least 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 increase with middle- and upper-stalk leaf. To obtain the targeted efficiency and significantly reduce curing cost, all the energy-saving strategies recommended for bulk curing should be applied. Not being able to obtain the targeted curing efficiency indicates that some aspect of the system, barn and heat exchanger, or curing management is not operating efficiently. More than one aspect of the system or its management may be involved.

Although most growers can estimate their fuel consumption and curing efficiency over the entire season, installing a gas meter on a single barn can provide accurate fuel consumption information to assist with evaluating your system performance and curing management. Contact your local fuel supplier or barn service technician for more information on installing a gas meter.

Table 11-1. Estimated curing cost for varying curing efficiencies and fuel cost

	Fuel Cost ($/unit)												
	1.50	**1.60**	**1.70**	**1.80**	**1.90**	**2.00**	**2.10**	**2.20**	**2.30**	**2.40**	**2.50**	**2.60**	**2.70**
lb/gal	$/lb Cured												
7	0.214	0.229	0.243	0.257	0.271	0.286	0.300	0.314	0.329	0.343	0.357	0.371	0.386
8	0.188	0.200	0.213	0.225	0.238	0.250	0.263	0.275	0.288	0.300	0.313	0.325	0.338
9	0.167	0.178	0.189	0.200	0.211	0.222	0.233	0.244	0.256	0.267	0.278	0.289	0.300
10	0.150	0.160	0.170	0.180	0.190	0.200	0.210	0.220	0.230	0.240	0.250	0.260	0.270
11	0.136	0.145	0.155	0.164	0.173	0.182	0.191	0.200	0.209	0.218	0.227	0.236	0.245
12	0.125	0.133	0.142	0.150	0.158	0.167	0.175	0.183	0.192	0.200	0.208	0.217	0.225
13	0.115	0.123	0.131	0.138	0.146	0.154	0.162	0.169	0.177	0.185	0.192	0.200	0.208

12. Complying with the Worker Protection Standard

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The U.S. Environmental Protection Agency Worker Protection Standard is a regulation that requires actions by employers to protect agricultural workers from the risk of pesticide-related illness or injury. To protect your workers, you must be aware of the Worker Protection Standard and comply with its requirements. To plan effectively, you must also understand how compliance might affect your operation.

To fulfill the requirements imposed by the Standard, you must protect workers and pesticide applicators in three ways:

1. ***Provide training on pesticide safety and information about the specific pesticides used on the farm.*** Much of this information must be posted in a central location, including specifics on recent pesticide applications (location of application, name of the pesticide, EPA registration number, active ingredient, time and date of application, restricted-entry interval, and the time when workers may reenter the field).
2. ***Ensure protection against exposure.*** 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 fields, or both) and make sure that workers do not enter treated fields during restricted-entry intervals (with some very specific exceptions). This may require careful scheduling of pesticide application and field work so that they do not conflict. Personal protective equipment requirements vary from pesticide to pesticide and may be different for applicator/handlers and mixer/loaders. Protective equipment also is required for entry into fields during the restricted-entry interval. Restricted-entry intervals also vary by pesticide and are given on labels (generally 4, 12, 24, or 48 hours). Protective equipment requirements for fumigant labels are expected to change in 2009; 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 mitigate or minimize the impacts of pesticide exposure.*** This includes making available decontamination sites and emergency assistance in case of exposure. For full information on the Worker Protection Standard, consult your local Cooperative Extension agent.

The following table 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. Remember, however, that the information in this table is presented in good faith as a reference. 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.

Table 12-1. Worker Protection Standard information

Note: Changes to labels can occur at any time; this information **does not** *take the place of the product label.* ***Always read and follow label directions.***

Product Trade Name (common name) EPA Reg. No. Company Name	***Signal Word***	***Restricted-Entry Interval (REI)*** [1]	***Worker Notification*** [2]	
Acephate 75 SP AG *(acephate)* *EPA Reg. No. 51036-236* *Micro Flo*	*Caution*	*24 hrs.*	*either*	*either*
Acrobat MZ *(dimethomorph & mancozeb)* *EPA Reg. No. 241-383* *BASF Corp.*	*Caution*	*24 hrs.*	*either*	*either*
Actara 25 WDG *(thiamethoxam)* *EPA Reg. No. 100-938* *Syngenta Crop Protection*	*Caution*	*12 hrs.*	*either*	*either*
Actigard 50 WG *(acibenzolar-S-methyl)* *EPA Reg. No. 100-922* *Syngenta Crop Protection*	*Caution*	*12 hrs.*	*either*	*either*
Admire Pro *(imidacloprid)* *EPA Reg. No. 264-827* *Bayer CropScience*	*Caution*	*12 hrs.*	*either*	*either*
Agree WG *(Bacillus thuringiensis* subsp. *aizawai)* *EPA Reg. No. 70051-47* *Certis USA LLC*	*Caution*	*4 hrs.*	*either*	*either*

[1] 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.

[2] 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 (both columns in the table with "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 ("YES" in both columns of table), 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.

Table 12-1. *(continued)*

Product Trade Name ***(common name)*** ***EPA Reg. No.*** ***Company Name***	***Signal Word***	***Restricted-Entry Interval (REI)*** [1]	***Worker Notification*** [2]	
Antak *(C10 fatty alcohol)* *EPA Reg. No. 19713-18* *Drexel Chemical Co.*	*Caution*	*24 hrs.*	*either*	*either*
Alias 2F *(imidacloprid)* *EPA Reg. No. 264-758-66222* *Makhteshim-Agan of N.A.*	*Cauation*	*12 hrs*	*either*	*either*
Assail 70WP *(acetamiprid)* *EPA Reg. No. 8033-23-4581* *Cerexagri*	*Caution*	*12 hrs.*	*either*	*either*
Belay 16WSG *(clothianidin)* *EPA Reg. No. 66330-52* *Arysta LifeScience*	*Caution*	*12 hrs.*	*either*	*either*
Belt *(flubendiamide)* *EPA Reg No. 264-1025* *Bayer CropScience*	*Caution*	*12 hrs.*	*either*	*either*
Biobit HP *(Bacillus thuringiensis* subsp. *kurstaki)* *EPA Reg. No. 73049-54* *Valent BioSciences Corp.*	*Caution*	*4 hrs.*	*either*	*either*
Brom-O-Gas *(95% methyl bromide)* *EPA Reg. No. 5785-4, -42* *Great Lakes Chemical Corp.*	*Danger*	*48 hrs.*	*yes*	*yes*
Butralin FC *(butralin)* *EPA Reg. No. 33688-4-400* *Chemtura*	*Danger*	*12 hrs.*	*either*	*either*
Capture LFR *(bifenthrin)* *EPA Reg. No. 279-3302* *FMC Corporation*	*Warning*	*12 hrs.*	*either*	*either*
Check MH 15 *(maleic hydrazide)* *EPA Reg. No. 19713-20-5549* *Coastal AgroBusiness*	*Caution*	*12 hrs.*	*either*	*either*

Table 12-1. (continued)

Product Trade Name ***(common name)*** ***EPA Reg. No.*** ***Company Name***	***Signal Word***	***Restricted-Entry Interval (REI)*** [1]	***Worker Notification*** [2]	
Chlor-O-Pic *(99% chloropicrin)* *EPA Reg. No. 5785-17* *Great Lakes Chemical Corp.*	*Danger Poison*	*48 hrs.*	*yes*	*yes*
Chlorpyrifos 4 E AG *(chlorpyrifos)* *EPA Reg. No. 19713-520* *Drexel* *EPA Reg. No. 66222-19* *Makhteshim Agan of N.A.* *EPA Reg. No. 51036-291* *Micro Flo*	*Warning*	*24 hrs.*	*either*	*either*
Chlorpyrifos 15 G *(chlorpyrifos)* *EPA Reg. No. 19713-505* *Drexel Chemical Co.* *EPA Reg. No. 51036-300* *Micro Flo*	*Caution*	*24 hrs.*	*either*	*either*
Command 3 ME *(clomazone)* *EPA Reg. No. 279-3158* *FMC Corp.*	*Caution*	*12 hrs.*	*either*	*either*
Crymax *(Bacillus thuringiensis* subsp. *kurstaki)* *EPA Reg. No. 70051-86* *Certis USA, LLC*	*Caution*	*4 hrs.*	*either*	*either*
Deliver *(Bacillus thuringiensis* subsp. *kurstaki)* *EPA Reg. No. 70051-69* *Certis USA, LLC*	*Caution*	*4 hrs.*	*either*	*either*
Denim 0.16 EC *(emamectin benzoate)* *EPA Reg. No. 100-903* *Syngenta Crop Protection*	*Danger*	*48 hrs.*	*either*	*either*
Devrinol 2-EC *(napropamide)* *EPA Reg. No.70506-64* *United Phosphorus Inc.*	*Danger*	*12 hrs.*	*either*	*either*
Devrinol 50-DF *(napropamide)* *EPA Reg. No. 70506-36* *United Phosphorus Inc.*	*Caution*	*12 hrs.*	*either*	*either*

Table 12-1. *(continued)*

Product Trade Name ***(common name)*** ***EPA Reg. No.*** ***Company Name***	***Signal Word***	***Restricted-Entry Interval (REI)*** [1]	***Worker Notification*** [2]	
DiPel DF *(Bacillus thuringiensis* subsp. *kurstaki)* *EPA Reg. No. 73049-39* *Valent Agricultural Products*	*Caution*	*4 hrs.*	*either*	*either*
DiPel ES *(Bacillus thuringiensis* subsp. *kurstaki,* strain ATBS351*)* *EPA Reg. No. 73049-17* *Valent Agricultural Products*	*Caution*	*4 hrs.*	*either*	*either*
Di-Syston 8 *(disulfoton)* *EPA Reg. No. 264-734* *Bayer CropScience*	*Danger Poison*	*48 hrs.*	*yes*	*yes*
Dithane DF Rainshield *(mancozeb)* *EPA Reg. No. 62719-402* *Dow AgroScience*	*Caution*	*24 hrs.*	*either*	*either*
Fair Plus *(maleic hydrazide)* *EPA Reg. No. 51873-2* *Fair Products, Inc.*	*Caution*	*12 hrs.*	*either*	*either*
Fair 30 *(maleic hydrazide)* *EPA Reg. No. 51873-9* *Fair Products, Inc.*	*Caution*	*12 hrs.*	*either*	*either*
Fair 80 SP *(maleic hydrazide)* *EPA Reg. No. 51873-17* *Fair Products, Inc.*	*Caution*	*12 hrs.*	*either*	*either*
Fair 85 *(C6, C8, C10, C12 fatty alcohols)* *EPA Reg. No. 51873-7* *Fair Products, Inc.*	*Warning*	*24 hrs.*	*either*	*either*
Flupro *(flumetralin)* *EPA Reg. No. 73631-2-400* *Chemtura*	*Warning*	*24 hrs.*	*either*	*either*

Table 12-1. *(continued)*

Product Trade Name ***(common name)*** ***EPA Reg. No.*** ***Company Name***	***Signal Word***	***Restricted-Entry Interval (REI)*** [1]	***Worker Notification*** [2]	
FST-7 *(C10 fatty alcohol and maleic hydrazide)* *EPA Reg. No. 51873-6* *Fair Products, Inc.*	*Danger*	*24 hrs.*	*either*	*either*
Fulfill *(pymetrozine)* *EPA Reg. No. 100-912* *Syngenta Crop Protection*	*Caution*	*12 hrs.*	*either*	*either*
Furadan 4 F *(carbofuran)* *EPA Reg. No. 279-2876* *FMC Corp.*	*Danger Poison*	*48 hrs.*	*yes*	*yes*
Golden Leaf Tobacco Spray *(endosulfan)* *EPA Reg. No. 66222-63* *Makhteshim-Agan of N. A.*	*Danger Poison*	*24 hrs.*	*either*	*either*
Javelin WG *(Bacillus thuringiensis* subsp. *kurstaki)* *EPA Reg. No.70051-66* *Certis USA, LLC*	*Caution*	*4 hrs.*	*either*	*either*
Kleen-Tac 85 *(C8 & C10 fatty alcohols)* *EPA Reg. No.5549-74* *Coastal AgroBusiness*	*Warning*	*24 hrs.*	*either*	*either*
Lannate LV *(methomyl)* *EPA Reg. No. 352-384* *DuPont*	*Danger Poison*	*48 hrs.*	*either*	*either*
Lannate SP *(methomyl)* *EPA Reg. No. 352-342* *DuPont*	*Danger Poison*	*48 hrs.*	*either*	*either*
Lepinox WDG *(Bacillus thuringiensis* subsp. *kurstaki,* strain EG7826 solids*)* *EPA Reg. No. 70051-89* *Certis USA LLC*	*Warning*	*12 hrs.*	*either*	*either*

Table 12-1. (continued)

Product Trade Name ***(common name)*** ***EPA Reg. No.*** ***Company Name***	***Signal Word***	***Restricted-Entry Interval (REI)*** [1]	***Worker Notification*** [2]	
Leven-38 *(C10 fatty alcohol and maleic hydrazide)* *EPA Reg. No. 19713-105* *Drexel Chemical Co.*	*Warning*	*24 hrs.*	*either*	*either*
Lorsban 4 E *(chlorpyrifos)* *EPA Reg. No. 62719-220* *Dow AgroSciences*	*Warning*	*24 hrs.*	*either*	*either*
Lorsban 15 G *(chlorpyrifos)* *EPA Reg. No. 62719-34* *Dow AgroSciences*	*Caution*	*24 hrs.*	*either*	*either*
Lorsban 75 WG *(chlorpyrifos)* *EPA Reg. No. 62719-301* *Dow AgroSciences*	*Warning*	*24 hrs.*	*yes*	*yes*
Mature XL *(ethephon)* *EPA Reg. No. 1812-361-51873* *Fair Products, Inc.*	*Danger*	*48 hrs.*	*yes*	*yes*
Mocap 15 G *(ethoprop)* *EPA Reg. No. 264-457* *Bayer CropScience*	*Danger Poison*	*48 hrs.*	*yes*	*yes*
Mocap EC *(ethoprop)* *EPA Reg. No. 264-458* *Bayer CropScience*	*Danger Poison*	*48 hrs.*	*yes*	*yes*
M-Pede *(potassium salts of fatty acids)* *EPA Reg. No. 53219-6* *Dow AgroSciences*	*Warning*	*12 hrs.*	*either*	*either*
Nemacur 3 *(fenamiphos)* *EPA Reg. No. 264-731* *Bayer CropScience*	*Danger Poison*	*48 hrs.*	*yes*	*yes*

Table 12-1. *(continued)*

Product Trade Name ***(common name)*** ***EPA Reg. No.*** ***Company Name***	***Signal Word***	***Restricted-Entry Interval (REI)*** [1]	***Worker Notification*** [2]	
Nuprid 1.6F *(imidacloprid)* *EPA Reg. No. 228-484* *NuFarm Americas Inc.*	*Caution*	*12 hrs.*	*either*	*either*
Nuprid 2F *(imidacloprid)* *EPA Reg. No. 228-484* *NuFarm Americas Inc.*	*Caution*	*12 hrs.*	*either*	*either*
Off-Shoot T *(C6, C8, C10, C12 fatty alcohols)* *EPA Reg. No. 57582-3* *Cochran Corp.*	*Warning*	*24 hrs.*	*either*	*either*
Orthene 75 S *(acephate)* *EPA Reg. No. 59639-26* *Valent Agricultural Products*	*Caution*	*24 hrs.*	*either*	*either*
Orthene 97 *(acephate)* *EPA Reg. No. 59639-91* *Valent Agricultural Products*	*Caution*	*24 hrs.*	*either*	*either*
Pendimax 3.3 *(pendimethalin)* *EPA Reg. No. 68156-6-62719* *Dow AgroSciences*	*Caution*	*24 hrs.*	*either*	*either*
Phaser 3 EC *(endosulfan)* *EPA Reg. No. 264-638* *Bayer CropScience*	*Danger Poison*	*24 hrs.*	*either*	*either*
Pic Plus Fumigant *(chloropicrin)* *EPA Reg. No. 8853-6* *Hendrix and Dail, Inc.*	*Danger Poison*	*48 hrs.*	*yes*	*yes*
Platinum *(thiamethoxam)* *EPA Reg. No. 100-939* *Syngenta Crop Protection*	*Caution*	*12 hrs.*	*either*	*either*

Table 12-1. *(continued)*

Product Trade Name** **(common name)** **EPA Reg. No.** **Company Name	***Signal Word***	***Restricted-Entry Interval (REI)*** [1]	***Worker Notification*** [2]	
Poast *(sethoxydim)* *EPA Reg. No. 7969-58-51036* *Micro Flo*	*Warning*	*12 hrs.*	*either*	*either*
Prep *(ethephon)* *EPA Reg. No. 264-418* *Bayer CropScience*	*Danger*	*48 hrs.*	*yes*	*yes*
Prime + EC *(flumetralin)* *EPA Reg. No. 100-640* *Syngenta Crop Protection*	*Danger*	*24 hrs.*	*either*	*either*
Provado 1.6 F *(imidacloprid)* *EPA Reg. No. 264-763* *Bayer CropScience*	*Caution*	*12 hrs.*	*either*	*either*
Prowl 3.3 *(pendimethalin)* *EPA Reg. No. 241-337* *BASF Ag Products*	*Caution*	*24 hrs.*	*either*	*either*
Prowl H_2O *(pendimethalin)* *EPA Reg. No. 241-418* *BASF Ag Products*	*Caution*	*24 hrs.*	*either*	*either*
Ridomil Gold EC *(mefenoxam)* *EPA Reg. No. 100-801* *Syngenta Crop Protection*	*Caution*	*48 hrs.*	*either*	*either*
Royal MH-30 *(maleic hydrazide)* *EPA Reg. No. 400-84* *Chemtura*	*Caution*	*12 hrs.*	*either*	*either*
Royal MH-30 SG *(maleic hydrazide)* *EPA Reg. No. 400-165* *Chemtura*	*Caution*	*12 hrs.*	*either*	*either*

Table 12-1. (continued)

Product Trade Name (common name) EPA Reg. No. Company Name	*Signal Word*	*Restricted-Entry Interval (REI)* [1]	*Worker Notification* [2]	
Royal MH-30 XTRA *(maleic hydrazide) EPA Reg. No. 400-452 Chemtura*	*Caution*	*12 hrs.*	*either*	*either*
Royaltac-M *(C6, C8, C10, C12 fatty alcohols) EPA Reg. No. 400-451 Chemtura*	*Danger*	*24 hrs.*	*either*	*either*
Sevin 4 F *(carbaryl) EPA Reg. No. 264-349 Bayer CropScience*	*Caution*	*12 hrs.*	*either*	*either*
Sevin 80 S *(carbaryl) EPA Reg. No. 264-316 Bayer CropScience*	*Warning*	*12 hrs.*	*either*	*either*
Sevin XLR Plus *(carbaryl) EPA Reg. No. 264-333 Bayer CropScience*	*Caution*	*12 hrs.*	*either*	*either*
Spartan 4 F *(sulfentrazone) EPA Reg. No. 279-3220 FMC Corp.*	*Caution*	*12 hrs.*	*either*	*either*
Sucker-Plucker *(C6, C8, C10, C12 fatty alcohols) EPA Reg. No. 19713-35 Drexel Chemical Co.*	*Warning*	*24 hrs.*	*either*	*either*
Sucker-Stuff *(maleic hydrazide) EPA Reg. No. 19713-1 Drexel Chemical Co.*	*Caution*	*12 hrs.*	*either*	*either*
Super Boll *(ethephon) EPA Reg. No. 1812-361 Griffin LLC*	*Danger*	*48 hrs.*	*yes*	*yes*

Table 12-1. (continued)

Product Trade Name (common name) EPA Reg. No. Company Name	***Signal Word***	***Restricted-Entry Interval (REI)*** [1]	***Worker Notification*** [2]	
Super Sucker-Stuff *(maleic hydrazide) EPA Reg. No. 19713-20 Drexel Chemical Co.*	*Caution*	*12 hrs.*	*either*	*either*
Telone C-17 *(1,3-dichloropropene + chloropicrin) EPA Reg.No. 62719-12 Dow AgroSciences*	*Danger*	*5 days*	*yes*	*yes*
Telone II *(1,3-dichloropropene) EPA Reg. No. 62719-32 Dow AgroSciences*	*Warning*	*5 days*	*yes*	*yes*
Temik 15 G *(aldicarb) EPA Reg. No. 264-330 Bayer CropScience*	*Danger Poison*	*48 hrs.*	*yes*	*yes*
Ten-Tac *(C-10 fatty alcohol) EPA Reg. No. 5549-79 Coastal AgroBusiness*	*Caution*	*24 hrs.*	*either*	*either*
Terramaster 4 EC *(etridiazole) EPA Reg. No. 400-422 Chemtura*	*Danger*	*12 hrs.*	*either*	*either*
Terramaster 35 WP *(etridiazole) EPA Reg. No. 400-416 Chemtura*	*Warning*	*12 hrs.*	*either*	*either*
Terr-O-Gas *(67% methyl bromide + chloropicrin) EPA Reg. No. 5785-24 Great Lakes Chemical Corp.*	*Danger Poison*	*48 hrs.*	*yes*	*yes*
Thiodan 3 EC *(endosulfan) EPA Reg. No. 1386-338-72693 Universal Crop Protection Alliance LLC*	*Warning*	*48 hrs.*	*either*	*either*

Table 12-1. *(continued)*

Product Trade Name (common name) EPA Reg. No. Company Name	***Signal Word***	***Restricted-Entry Interval (REI)*** [1]	***Worker Notification*** [2]	
T-MOXX *(thiamethoxam)* *EPA Reg. No. 100-939-5187* *Fair Products*	*Caution*	*12 hrs*	*either*	*either*
Tracer *(spinosad)* *EPA Reg. No. 62719-267* *Dow AgroSciences*	*Caution*	*4 hrs.*	*either*	*either*
Ultra Flourish *(mefenoxam)* *EPA Reg. No. 55146-73* *Nufarm Americas Inc.*	*Warning*	*48 hrs.*	*either*	*either*
Vapam HL *(metam sodium)* *EPA Reg. No. 5481-468* *Amvac Chemical Corp.*	*Danger*	*48 hrs.*	*yes*	*yes*
Vydate L *(oxamyl)* *EPA Reg. No. 352-372* *DuPont*	*Danger Poison*	*48 hrs.*	*either*	*either*
Warrior 1CS *(lambda-cyhalothrin)* *EPA Reg. No. 100-1112* *Syngenta Crop Protection*	*Warning*	*24 hrs.*	*either*	*either*
XenTari *(Bacillus thuringiensis* subsp. *aizawai)* *EPA Reg. No. 73049-40* *Valent BioSciences Corp.*	*Caution*	*4 hrs.*	*either*	*either*

13. Protecting People and the Environment when Choosing and Using Pesticides

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Despite their usefulness, pesticides pose varying degrees of risk to people and the environment. We all need to make choices that minimize these risks. Of particular concern are keeping nutrients and pesticides out of both 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 water quality and to reduce pesticide exposure to humans and wildlife.

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. This protects the environment and also saves money by reducing pesticide and fertilizer use. Refer to the sections on insect, disease, and weed management, and on sucker control for proper management of these pests.

Fertilizer use also affects both pest problems and water quality. Be sure to have your soil tested field by field and to apply only those nutrients recommended. Refer to Chapter 5, "Managing Nutrients," for guidelines.

When selecting a pesticide, also consider resistance and how to minimize it. Three organizations have developed categories for pesticides with the same *mode of action* (MOA). These codes are listed on all new 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 rotation between MOAs that would minimize resistance. To assist in chemical selection, FRAC, IRAC, and HRAC codes are listed in Table 13-1.

Select Pesticides Carefully

While cultural practices are important parts of a sound pest management program, pesticides often must still be used. When this is the case, take care to match the pesticide with the pest. First, identify the pest, then select an effective pesticide, rate, and application method. Remember to consider potential effects on water and safety to humans and wildlife when choosing a pesticide.

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). The lower the number, the more toxic the substance is. An LD_{50} can be used only to measure acute (short-term) toxicity and is not a measure of chronic (long-term) toxicity, such as the ability to cause diseases like cancer.

Information on acute toxicity can be found in Table 13-1 below. Information on chronic toxicity can be found on Material Safety Data Sheets (MSDS) that your pesticide dealer can provide. In general, it is best to choose the least toxic pesticide (to humans) that will do the job. Use extreme caution with pesticides that have low LD_{50}s, such as Temik, Mocap, Nemacur, and Furadan.

Apply Pesticides Carefully

Care must be taken to make sure pesticides are applied only to the tobacco crop. This is especially important with aerial application. 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.

Most human exposure to pesticides occurs in one of three ways: (1) exposure to skin (dermal), (2) ingestion (oral), or (3) inhalation (breathing vapors). The use of protective clothing by handlers and applicators is the best defense against pesticide exposure and is specified on each pesticide label. These requirements should be followed carefully. The potential for harmful pesticide exposure is greater when handling concentrated pesticides (not mixed with water) than with using a diluted solution (mixed with water in a sprayer). Thus, be especially careful in the mixing/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 1-800-848-6946. The center provides 24-hour consultant service for diagnosing and treating human illness resulting from toxic substances.

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 disking and 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. These guidelines are based on knowledge of the chemical characteristics of different pesticides and are summarized in Table 13-1. This list includes most of the commonly used tobacco pesticides.

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. 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 as 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 100 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 13-1. Water contamination potential and mammalian toxicity of commonly used tobacco pesticides

The footnoted items in Table 14-1 should be interpreted as follows:

[a] *Most common trade names; others may be in use as well.*

[b] *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.*

[c] *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.*

[d] *Leaching occurs when pesticides are moved downward in solution. Potentials by Natural Resources Conservation Service, 2004. NA = not available.*

[e] *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 the* Crop Protection Handbook 2003 *or material safety data sheets.*

** = Technical material. Technical material (pure active ingredient) may be more or less toxic than the formulated material. NA = not available.*

[f] *Telone C-17 also contains chloropicrin.*

Common Name	Trade Name(s) [a]	Surface Loss Potential (Solution) [b]	Surface Loss Potential (Adsorbed) [c]	Leaching Potential [d]	FRAC, IRAC, or HRAC MOA Grouping	Mammalian LD_{50} [e]	
						Oral	Dermal
acephate	Orthene	Intermediate	Low	Low	1A	1,030*	10,250*
acetamiprid	Assail	Intermediate	Low	Intermediate	4A	1,064	>2,000
acibenzolar-S-methyl	Actigard	Intermediate	Low	Intermediate	P	> 5,000	> 2,000
aldicarb	Temik	Intermediate	Low	High	1A	1.0*	> 2,000
bifenthrin	Capture LFR	Low	Low	Low	3A	54.5	2,000
butralin	Butralin	High	High	Low	K1	891	> 2,000
carbaryl	Sevin XLR Plus	Intermediate	Low	Low	1A	500	> 2,000
carbofuran	Furadan	High	Intermediate	High	1A	8.0	> 3,000

Table 13-1. (continued)

Common Name	Trade Name(s) [a]	Surface Loss Potential (Solution) [b]	Surface Loss Potential (Adsorbed) [c]	Leaching Potential [d]	FRAC, IRAC, or HRAC MOA Grouping	Mammalian LD_{50} [e]	
						Oral	Dermal
chloropicrin	Chlor-O-Pic 100	Intermediate	Low	Low	8B	NA Inhalation danger	NA
chlorpyrifos	Lorsban	Low	Intermediate	Low	1B	96	2,000
clomazone	Command	Intermediate	Low	Intermediate	F3	1,369*	> 2,000*
clothianidin	Belay	NA	NA	NA	4A	3,900	>5,000
dichloropropene	Telone IITelone C-17 [f]	Intermediate	Low	High	8B	224 Inhalation danger	333
dimethomorph	Acrobat	High	Intermediate	Intermediate	40	3,900*	> 2,000*
disulfoton	Di-Syston	High	Low	Intermediate	1B	3.3	9.2
emamectin benzo-ate	Denim	NA	NA	NA	6	1,516	> 2,000
endosulfan	Thiodan, Phaser	Intermediate	High	Very Low	2A	23*	359*
ethephon	Prep, Super Boll, Mature XL	Low	Intermediate	Low		3,030	1,560
ethoprop	Mocap	Intermediate	Low	High	1B	16	2.4
etridiazole	Terramaster	Intermediate	Intermediate	Low	14	1,077	> 5,000
fenamiphos	Nemacur	High	Intermediate	High	1B	10.6	71.5
flubendiamide	Belt	Low	Low	Low	28	2,000	2,000
flumetralin	Prime+	Low	Intermediate	Low		3,100	NA

Table 13-1. (continued)

Common Name	Trade Name(s) [a]	Surface Loss Potential (Solution) [b]	Surface Loss Potential (Adsorbed) [c]	Leaching Potential [d]	FRAC, IRAC, or HRAC MOA Grouping	Mammalian LD_{50} [e] Oral	Mammalian LD_{50} [e] Dermal
imidacloprid	*Admire, Provado, Nuprid, many others*	*High*	*Intermediate*	*High*	*4A*	*4,143*	*> 2,000*
lambda-cyhalothrin	*Warrior*	*Low*	*Intermediate*	*Very Low*	*3A*	*351*	*>2,000*
maleic hydrazide	*Several*	*Intermediate*	*Low*	*Low*		*> 5,000*	*> 5,000*
mancozeb	*Dithane*	*High*	*High*	*Low*	*M3*	*> 5,000*	*> 5,000*
mefenoxam	*Ridomil Gold*	*High*	*Intermediate*	*High*	*4*	*1,172*	*> 2,020*
metaldehyde	*Metaldehyde*	*Intermediate*	*Low*	*Low*		*283*	*NA*
metam sodium	*Vapam*	*Intermediate*	*Low*	*Intermediate*	*Z*	*1,891* Inhalation danger	*> 3,074*
methomyl	*Lannate*	*Intermediate*	*Low*	*High*	*1A*	*17*	*5,880*
napropamide	*Devrinol*	*High*	*Intermediate*	*Intermediate*	*K3*	*4,640*	*NA*
oxamyl	*Vydate*	*Intermediate*	*Low*	*Low*	*1A*	*5.4**	*2,960**
pebulate	*Tillam*	*Intermediate*	*Low*	*Low*	*N*	*1,675**	*> 2,000**
pendimethalin	*Prowl*	*Intermediate*	*High*	*Low*	*K1*	*3,956*	*2,200*
pymetrozine	*Fulfill*	*NA*	*NA*	*NA*	*9B*	*> 5,000*	*> 5,000*
sethoxydim	*Poast*	*Intermediate*	*Low*	*Low*	*A*	*3,200*	*> 5,000*
spinosad	*Tracer*	*Low*	*Intermediate*	*Low*	*5*	*> 5,000*	*NA*
sulfentrazone	*Spartan*	*High*	*Intermediate*	*High*	*E*	*2,855**	*> 2,000**
thiamethoxam	*T-MOXX, Platinum, 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.

The Tobacco Plant

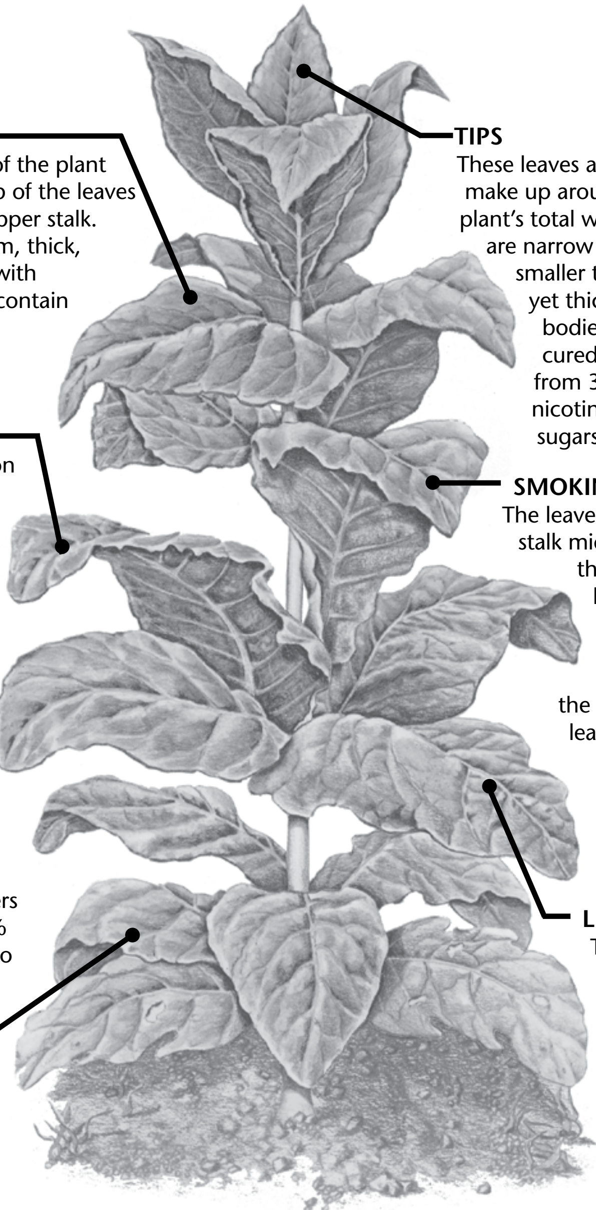

Figure 1. Characteristics of tobacco leaves based on stalk position

More than 2,500 different chemical compounds have been identified in the leaves of commercially grown tobacco. The most important of these is nicotine, of course. But the various sugar levels found in the plant also play a vital role when different tobaccos are blended. The nicotine and sugars in the leaves will vary according to soil, light conditions, moisture, and temperature, as well as stalk position.