CONTENTS

Authors

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Extension Personnel Working with Burley Tobacco

The following are the county Cooperative Extension Service personnel with burley tobacco responsibility as of January 4, 2010.

County	*Name*	*Telephone*
Alamance	Roger Cobb	336-570-6740
Alexander	Allison Brown	828-632-4451
Alleghany	David Isner	336-372-5597
Ashe	Della Deal	336-219-2650
Avery	Adam Keener	828-733-8270
Buncombe	Jeff Bradley	828-255-5522
Caswell	Joey Knight	336-694-4158
Cherokee	Doug Clement	828-837-2210
Cherokee Reservation	Sarah McClellan-Welch	828-497-3521
Clay	Silas Brown	828-389-6305
Davidson	Troy Coggins	336-242-2083
Davie	Greg Hoover	336-751-6297
Edgecombe	Art Bradley	252-641-7815
Forsyth	Tim Hambrick	336-767-8213
Franklin	Wil Strader	919-496-3344
Graham	Randy Collins	828-479-7979
Granville	Paul Westfall	919-603-1350
Guilford	Wick Wickliffe	336-375-5876
Haywood	Tony McGaha	828-456-3575
Henderson	Jeff Bradley	828-697-4891
Iredell	Mike Miller	704-878-3153
Jackson	Christy Breedenkamp	828-586-4009
Johnston	Bryant Spivey	919-989-5380
Lee	Susan Condlin	919-775-5624

County	*Name*	*Telephone*
Macon	Alan Durden	828-349-2046
Madison	Elizabeth Ayers	828-649-2411
McDowell	Dan Smith	828-652-7121
Mitchell	Jeremy DeLisle	828-688-4811
Montgomery	Roger Galloway	910-576-6011
Moore	Taylor Williams	910-947-3188
Nash	Charlie Tyson	252-459-9810
Person	Derek Day	336-599-1195
Polk	Kendra Bissette	828-894-8218
Pitt	Mitch Smith	252-902-1702
Randolph	Troy Coggins	336-318-6002
Rockingham	Brenda Sutton	336-342-8230
Rutherford	Jan McGuinn	828-287-6015
Stokes	Tim Hambrick	336-593-8179
Surry	JoAnna Radford	336-401-8025
Swain	Christy Breedenkamp	828-488-3848
Transylvania	Jeff Bradley	828-884-3109
Vance	Paul McKenzie	252-438-8188
Warren	Paul McKenzie	252-257-3640
Watauga	Eddy Labus	828-264-3061
Wilkes	Matt Miller	336-651-7331
Wilson	Norman Harrell	252-237-0111
Yadkin	Nancy Keith	336-679-2061
Yancey	Stanley Holloway	828-682-6187

1. U.S. Tobacco Situation and Outlook

A. Blake Brown
Extension Economist—North Carolina State University
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U.S. Tobacco Production Summary

Tobacco remains an important source of farm income in the United States. North Carolina, which produces the most tobacco of any state in both acres and pounds, had cash receipts from tobacco of $687 million in 2008. Kentucky, the second greatest producer, had cash receipts of $383 million. At least 11 states produce tobacco, with a total value of production for the U.S. of $1.48 billion in 2008. Total U.S. production of all classes of tobacco is estimated at 805 million pounds from 347,000 acres in 2009.

FDA Regulation of Tobacco Products: Impact at the Farm Level

In June 2009, the President signed into law the Family Smoking Prevention and Tobacco Control Act authorizing the Food and Drug Administration (FDA) to regulate tobacco products—such as cigarettes, cigars, and smokeless tobacco. This legislation sets forth guidelines for regulating tobacco products in many areas of production and sales, including advertising, retail sales, ingredients, introduction of new tobacco products, and reporting. Rule making and implementation will occur over a period of years. The regulations are at the tobacco manufacturer and sales levels. FDA is prohibited from regulation directly on the farm, but the regulation of tobacco products will have significant impacts on the farm sector.

Demand for tobacco from farms likely will decline due to several factors resulting from FDA regulation of tobacco products:

- Increased regulation of tobacco products, including more stringent controls on advertising, should cause cigarette consumption to decline more rapidly, leading to a decline in tobacco used in cigarettes.

- Increased manufacturer costs associated with regulation likely will be passed to consumers in the form of higher cigarette prices, further reducing demand for cigarettes and tobacco.
- Regulation, such as adoption of additional tobacco product standards, could lead to changes in cigarette composition. These changes may result in less leaf tobacco being used per cigarette, further reducing total demand for leaf tobacco. Development of modified-risk tobacco products would have a similar effect.
- If regulation results in shifts in tobacco use from cigarettes to smokeless products, then demand for cigarette-type tobaccos (flue-cured and burley) would be reduced. (Flue-cured is the predominate tobacco type grown in North Carolina, South Carolina, Virginia, Florida, and Georgia.) Demand could increase for the dark tobaccos that are used in smokeless products and grown predominately in Tennessee and Kentucky.

Although FDA regulation will almost certainly contribute to further declines in overall demand for tobacco by U.S. manufacturers, regulations may result in some farmers having a comparative advantage over others in supplying manufacturers with tobacco that helps tobacco products comply with regulations. If tobacco product standards cause manufacturers to require specialized production of tobacco or require more stringent control and monitoring of pesticide use in tobacco, then some producers may gain a comparative advantage over others in producing this tobacco. This factor would lead to further restructuring of the farm sector, probably in the form of additional consolidation and specialization.

U.S. producers might have some comparative advantage over some foreign producers in meeting specialized requirements of manufacturers because of advanced technologies and integrated pest management programs already in place. This comparative advantage could partially offset negative impacts on demand for U.S. tobacco as U.S. manufacturers substitute domestic tobacco for imported tobacco. Consequently, U.S. imports of tobacco may decline. A U.S. comparative advantage is not certain over all foreign tobacco producers. Tobacco production is vertically integrated and closely controlled by leaf processors and manufacturers in some countries, such as Brazil. Brazil tobacco is the chief competitor of U.S flue-cured tobacco. Tobacco imports may also decline as some small manufacturers using high proportions of imported tobacco exit the industry if they cannot profitably meet FDA standards.

Exports of unmanufactured tobacco are very important economically to U.S. tobacco farmers, comprising about 50 percent of U.S. flue-cured tobacco disappearance and over 80 percent of U.S. burley tobacco disappearance. How FDA regulation will affect tobacco exports is difficult to project. One possible scenario is that a separate production scheme and market for exportable leaf tobacco will emerge to meet the potentially different requirements of foreign buyers. A second possible scenario is that the foreign purchasers of U.S. tobacco will request tobacco that meets the same standards as tobacco produced for the FDA-regulated domestic market. Some combination of both scenarios is also possible. If the second scenario is dominant or if regulations were imposed on tobacco for export, U.S. exports likely would decline because buyers who do not desire tobacco produced to these standards (or who are unwilling to pay the potentially higher price) may shift their purchases to foreign tobacco producers. It is highly unlikely that either scenario would significantly affect tobacco consumption outside the U.S., except in a case where many other countries adopted the same requirements.

In summary, the net impact on U.S. farms of FDA regulation of tobacco products likely will be further reduction in demand for unmanufactured leaf tobacco. Regulation of tobacco products will also impact farm structure with reduction in farm numbers and specialization of remaining farms.

Flue-cured Tobacco Situation and Outlook

According to the USDA's crop report, U.S. flue-cured tobacco acreage was estimated at 223,500 in 2009, up 500 acres from 2008. Estimated average yield per acre was 2,307 pounds, up 3 percent from 2008. The 2009 flue-cured crop production estimate was 515.5 million pounds, up 3.3 percent from 499.2 million pounds in 2008.

In North Carolina, the state that produces the most tobacco, flue-cured tobacco acreage was 174,000 acres, up 3,000 acres from 2008. Production in North Carolina was estimated at 417.4 million pounds, up 8 percent from 2008. Unlike other traditional tobacco-producing states, North Carolina has increased production since the tobacco buyout. Since 2004, production of flue-cured tobacco has increased 21 percent from 344 million pounds in 2004 to 408 million pounds in 2009. North Carolina now produces 80 percent of U.S. flue-cured tobacco and about 50 percent of total U.S. tobacco production. Tobacco farms in North Carolina have consolidated into larger units with production concentrated along Interstate 95, reaching from the Clinton area in the south to the Nashville area in the north. Farmers continue to exit tobacco production outside this area.

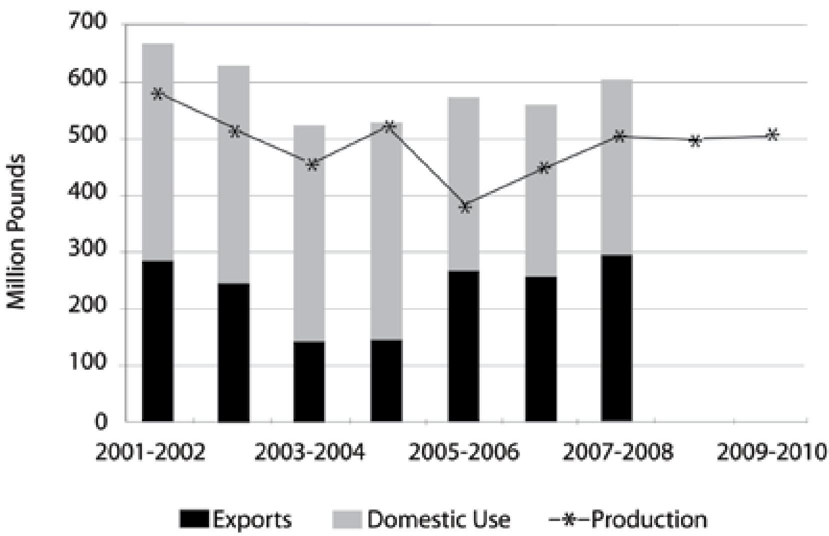
Although flue-cured tobacco market prices are difficult to estimate because all flue-cured tobacco is grown on contract, the USDA–NASS still reports prices. USDA–NASS reported an average price per pound of $1.757 for the 2008 crop. Farmers and Extension agents reported prices averaging from $1.75 to $1.85 per pound across all stalk positions for the 2008 crop, up $.25 to $.30 from 2007. The increase in prices from 2007 to 2008 reflected increases in fuel and fertilizer costs. Increased production costs in recent years have dampened anticipated increases in production, despite higher prices. Prices in 2009 seem to be at similar levels to 2008, with the exception of one tobacco manufacturer. Farmers have reported that prices from one major manufacturer have averaged substantially less than in 2008.

A factor having a major impact on the continuation of tobacco farms is the replacement of curing barns. Ten years have passed since barns were retrofitted to reduce nitrosamines, and few new barns have been added since. Most big box barns were added during the early and mid-1990s. Shrinking production since the late 1990s has allowed farmers to cull barns. As some farmers exited, barns have been culled or moved to areas of expanding production. However, this aging curing infrastructure must be replaced in the near future. As has been the case for several years, the deciding factor for many farmers of whether to continue tobacco production will be the ability to cover replacement costs of curing barns. Recent inquiries place the cost of a new 10-box curing barn at around $35,000, installed. Farmers must have adequate returns to justify this investment and must feel secure about the future of their contracts for a period sufficient to pay for the barn.

Global flue-cured tobacco production is expected to be 9.46 billion pounds in 2009, up about 3 percent from 2008, according to Universal Tobacco Company's August 2009 issue of *World Leaf Production*. Production was up in China and estimated to be about 5.18 billion pounds. Brazilian flue-cured production (the chief competition to U.S. flue-cured) declined from 1.340 billion pounds in 2008 to 1.316 billion pounds in 2009.

Total use of U.S. flue-cured tobacco has increased since the end of the tobacco program because increases in exports have outweighed continued declines in use by domestic manufacturers. In the 2008 marketing year, exports of flue-cured tobacco were 284 million pounds. Domestic use, while below 2004 levels, increased slightly from the previous year to 316 million pounds. Consequently, exports made up 47 percent of total use.

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*	*344.0*	*63.4*	*57.6*	*521.5*
2005	*5.5*	*27.8*	*273.9*	*39.9*	*33.7*	*380.8*
2006	*2.9*	*30.1*	*324.0*	*48.3*	*42.0*	*447.2*
2007	*n/a*	*39.8*	*376.8*	*46.1*	*41.0*	*503.8*
2008	*n/a*	*33.6*	*384.7*	*39.9*	*41.0*	*499.2*
2009	*n/a*	*21.0*	*417.6*	*37.0*	*39.9*	*515.5*



Source: USDA–NASS, USDA–AMS

Figure 1-1. U.S. Flue-Cured Disappearance vs. Production (Source: USDA–NASS, USDA–AMS)

Burley Situation and Market Outlook

Despite some adverse demand conditions, U.S. burley acreage is forecast to be slightly higher in 2009 compared to 2008, with most of the increase attributable to the 5,000 additional acres planted in Kentucky. This higher acreage level occurred despite a reduction in contract volume by most U.S. purchasers. Higher acreage, combined with better anticipated yields, is resulting in a U.S. burley crop expected to total 214.9 million pounds according to the USDA crop report — 6 percent higher than the 2008 burley crop. Accounting for some states not included in USDA estimates, the 2009 burley crop could exceed 220 million pounds. The early crop is reportedly curing well; however, unfavorable weather conditions in September have put in question both the quantity and quality of the late crop.

The USDA no longer tracks world tobacco production. Relying on the August 2009 Universal Leaf Tobacco Company *Production Report*, world burley production is estimated to be 15 percent higher in 2009, following a 19 percent increase in 2008. According to the report, burley production in North and South America markets has been relatively flat in recent years, with burley production in Africa more than doubling since 2007. Although the lower quality African styles of "filler" leaf do not directly compete with the higher quality "flavored" burley produced in the U.S., Brazil, and Argentina, the African leaf nevertheless enters the supply chain and is most likely partially substituting for U.S. burley in blends worldwide.

Table 1-2. U.S. burley tobacco production, 2004 to 2009, in millions of pounds

Year	*Kentucky*	*Tennessee*	*Pennsylvania*	*North Carolina*	*Others*	*U.S. Total*
2004	*206.7*	*46.1*	*n/a*	*6.6*	*32.8*	*292.2*
2005	*143.5*	*34.0*	*4.8*	*5.0*	*16.1*	*203.4*
2006	*153.3*	*30.8*	*11.6*	*6.6*	*15.0*	*217.3*
2007	*154.0*	*20.8*	*10.8*	*6.6*	*15.2*	*207.4*
2008	*147.0*	*24.7*	*9.9*	*5.6*	*14.3*	*201.5*
2009	*161.2*	*27.3*	*9.8*	*5.9*	*10.7*	*214.9*

Note: Totals exclude Indiana (and some other minor states since 2004) and Missouri in 2009. Source: USDA, NASS, Crop Production Report, November 2009.

On the demand side, domestic use of U.S. burley is declining in the midst of higher taxes, smoking restrictions, shifting of U.S. cigarette production overseas, and technological changes in cigarette manufacturing. Domestic use may be down to approximately 50 million pounds, compared to averaging nearly 400 million pounds during the decade of the 90s. And after three straight years of export growth to record high levels (exceeding 250 million pounds in 2007), U.S. burley exports fell by more than 40 percent last year and are down 12 percent during the first 7 months of 2009. Thus, after several years in the early post-buyout era when total U.S. burley disappearance was in the range of 250 to 300-plus million pounds, it will likely decline below 200 million pounds for the 2009–2010 marketing year. However, favorable exchange rates between the U.S. and Brazil are narrowing the price difference between U.S. and Brazilian burley. Along with a rebounding world economy and emerging markets, this narrowing price difference could entice cigarette manufacturers seeking flavor burley to reevaluate U.S. burley in their purchasing and blending decisions.

With higher 2009 U.S. and world supplies, reportedly excessive inventories of lower quality U.S. tobacco held by manufacturers from

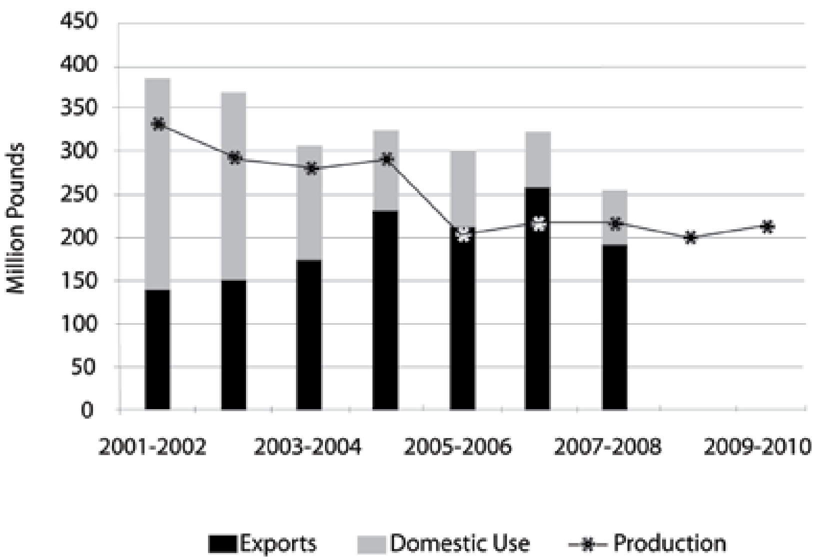


Figure 1-2. U.S. Burley Disappearance vs. Production
(Source: USDA–NASS/ERS; 2006-2008 disappearance estimates by UK.)

previous crops, and declining demand, quality will be an even greater factor in determining the success of the 2009 U.S. burley market. Excellent quality burley, based on contract prices and incentives, should continue to gross a per-pound price in the $1.70 and $1.80 ranges. However, lower quality tobacco within contracts will likely receive noticeable price discounts, while lower quality tobacco outside of contracts could yield very disappointing offers. Auction warehouse operators and co-op officials have been assessing various marketing alternatives for the anticipated excessive burley that does not receive an acceptable price.

The outlook for 2010 hinges critically on opportunities in the export market as domestic consumption is likely to continue to decline amidst declining U.S. cigarette production and consumption. World burley supplies are likely to outstrip demand in 2010. But if the 2009 U.S. burley crop generates a decent supply of quality leaf, U.S. burley exports may rebound modestly from recent declines in response to favorable exchange rates, emerging markets for American-blended cigarettes, and a slowly improving world economy. Even with this potential opportunity, it is difficult to anticipate a situation where cigarette manufacturers and dealers will ask U.S. growers to plant additional acreage in 2010. In addition to a reduction in acreage, the U.S. burley industry will likely see additional consolidation in the coming years as low-quality and low-yielding producers who are not able to secure contracts will likely exit the industry – especially in the era of heightened regulation of the U.S. tobacco industry, which will likely increase record-keeping, costs of production, and production management changes for tobacco producers.

Dark Tobacco Production and Outlook

Dark tobacco acreage and production is down considerably in 2009, following an excessive build-up last year. According to the USDA's September crop report, dark fire-cured acres fell 11 percent, while dark air-cured acreage was off 28 percent as buyers pulled back considerably from the big boost in contract volume in 2008. Total U.S. dark fired production is pegged by the USDA (September 2009 crop report) at 54.5 million pounds, compared to 62.2 million pounds in 2007 and crops generally around 40 to 50 million pounds in previous years. For dark air-cured, the USDA is projecting a 2009 crop of 18.7 million pounds versus a massive 25.3 million-pound crop last year and more typical crops of 10 to 15 million pounds during the early years of the post-buyout era.

(It should be noted that some industry officials believe the USDA is too optimistic in its 2009 dark estimates.) The dramatic drop-off in dark tobacco production is totally supply driven, not demand driven. Snuff consumption, the primary use of dark tobaccos, has been increasing steadily over the past two decades in response to successful product promotion, emerging smoking restrictions, and reduced health risk claims. However, snuff consumption and production

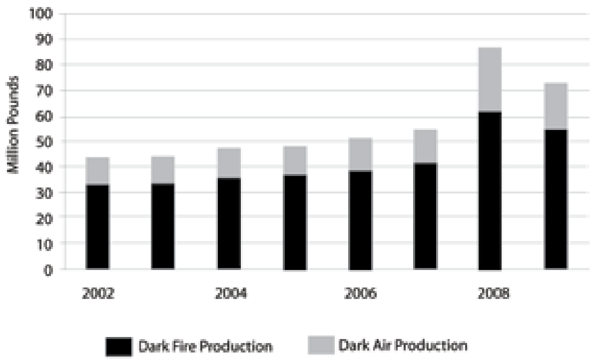


Figure 1-3. U.S. Dark Tobacco Production (Source: USDA–NASS/ERS)

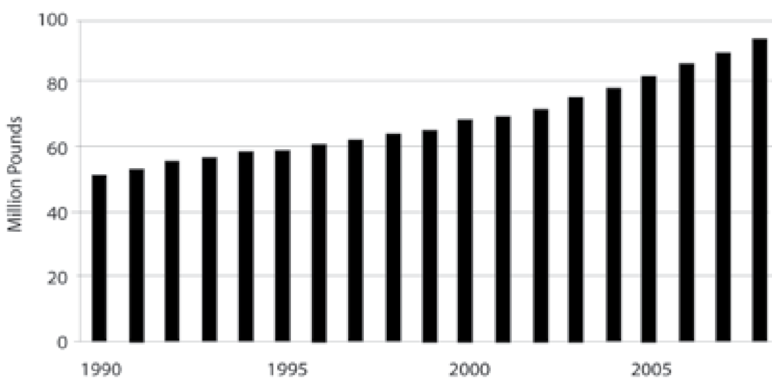


Figure 1-4. U.S. Snuff Tobacco Consumption (Source: USDA–ERS and TMA)

has been somewhat stagnant during the first half of 2009. Dark air-cured prices are expected to average around $2.25 per pound for 2009 and $2.55 per pound for dark fire-cured—slightly above last year's and pre-buyout prices.

While dark tobacco growers experienced a dramatic decline in contract pounds for 2009, the longer-term outlook for dark tobacco remains a lot more favorable compared to the outlook for burley. If current USDA production estimates for 2009 materialize, the industry may still need some downward adjustment in acreage in the coming year to balance supply and demand. An improving U.S. economy, additional smoking restrictions, and the perception of lower health risks associated with smokeless tobacco consumption relative to cigarettes should enable snuff consumption to revert back to its growth pattern (or at least stay relatively stable), which should allow dark tobacco acreage to remain above pre-buyout levels.

U.S. Cigarette Industry

U.S. cigarette production has declined over 40 percent in the last decade. This decline is in part due to continued declines in U.S. cigarette consumption. U.S. cigarette consumption declined from 430 billion cigarettes at the beginning of this decade to a projected 327

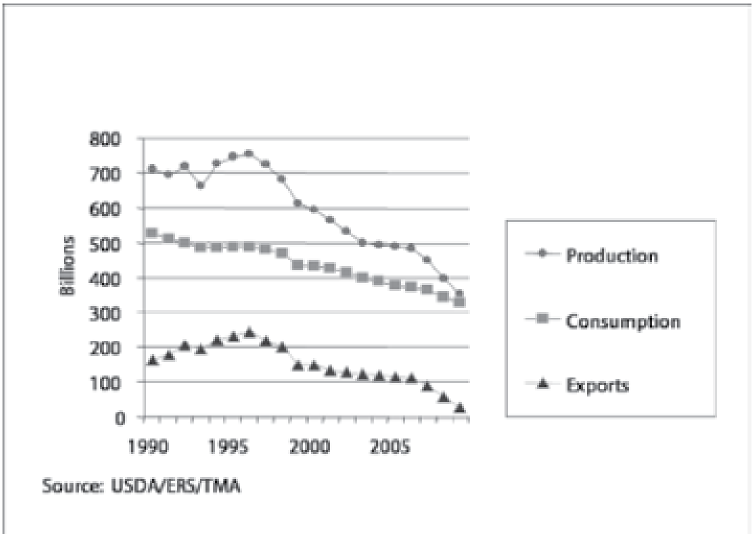


Figure 1-5. U.S. Cigarette Production, Consumption, and Exports (Source: USDA–ERS and TMA)

billion cigarettes for 2009. 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 a projected 27 billion cigarettes for 2009.

Implementation of the FDA regulation of tobacco products will have major impacts on the U.S. cigarette industry. Small manufacturers may find compliance challenging. Major manufacturers will likely place more emphasis on harm reduction technologies. In recent years, major manufacturers have also invested in companies producing smokeless products.

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USDA—Agricultural Marketing Service. 2009, Sept. Tobacco Stocks as of July 1, 2009. Publication No. TOB-202. Washington, D.C.: Agricultural Marketing Service.

USDA—National Agricultural Statistics Service. 2009, Nov. 1. Crop Production Report. Ithaca, N.Y.: USDA Economics, Statistics and Market Information System. Online: http://usda.mannlib.cornell.edu/MannUsda/viewDocumentInfo.do?documentID=1046.

Universal Leaf Tobacco Company. 2009, Aug 21. World Leaf Production. Richmond, Va.: Universal Corporation. Online: http://www.universalcorp.com/Reports/SelectReport.asp?ID=725&Menu=Tob

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

NEW!! Beginning April 3, 2009, all employers must use the revised I-9 form available online. The new form has (Rev. 02/02/09) or a later date printed on the bottom right corner.

New!! E-Verify is a voluntary, free, Internet-based system for matching an employee's Social Security number with other I-9 information. For most cases, employers receive one of three feedbacks in 3-5 seconds: the information is verified, system needs a day or two to look into it, or there is a problem. The E-Verify is NOT a replacement for the I-9 form and should not be used until after an employee has completed the I-9 form. E-Verify can be used only for new hires. Although it is voluntary, if E-Verify is used for one new hire, then employers must continue to use it for all new hires. Many other rules, regulations, and requirements must be followed. Go to: http://www.uscis.gov/portal/site/uscis/ and select "E-Verify" in the right column. Be sure to read all information, particularly the Quick Reference Guide and manual under "Getting Started" and employees' rights under "For employees."

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 than 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 $106,800 for 2009 and again in 2010. 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 $19,700 of each employee's wages in 2010. 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 or 1-800-688-8349. http://www.ic.nc.gov/.

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 any time 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**.

3. Variety Information

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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 Tes*t.

The purpose of the Regional Minimum Standards Program is to ensure that varieties planted by growers are acceptable to the tobacco industry. Once a breeding line is genetically stable, it can be entered into the Regional Preliminary Test (RPT) conducted cooperatively by university personnel in Kentucky, Tennessee, Virginia, and North Carolina. Breeding lines that pass the minimum standards for chemical quality in the RPT are eligible for entry into the Regional Quality Test (RQT). If a breeding line passes the RQT, 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. For many years, the OVT has been conducted at the Mountain Research Station at Waynesville, N.C., and at the Upper Mountain Research Station near Laurel Springs, N.C. From 2005 through 2008, tests were also conducted at the Upper Piedmont (Reidsville) and Border Belt (Whiteville) Research Stations. In 2009, burley OVT trials were conducted at the Upper Mountain Research Station (Laurel Springs), the Upper Piedmont Research Station (Reidsville), and the Upper Coastal Plain Research Station (Rocky Mount). These replicated tests include popular commercial varieties and hybrids and advanced breeding lines from North Carolina State University and other public and private breeding programs within the burley belt.

Variety Selection

To select the best variety for your fields, consider disease resistance first (Table 9-1). The level of resistance needed for soilborne diseases varies depending on field history, length of rotation, and crops grown in rotation with tobacco (see Chapter 9, "Disease Management," and Chapter 10, "Disease Management in the Piedmont and Coastal Plain"). Blue mold resistance is important in western North Carolina, and two varieties, NC 2000 and NC 2002, are moderately resistant to this disease.

Once you determine the necessary level of disease resistance, consider agronomic characteristics such as yield, quality, and time of maturity. Time of flowering is an indication of maturity and is an important consideration in choosing varieties suitable for the short growing season in western North Carolina.

Table 3-1 displays the yield and grade index data from the 2005 and 2006 tests at Whiteville, the 2006 - 2009 tests at Reidsville, and the 2008 tests at Rocky Mount and Kinston. Table 3-2 displays the yield and grade index data from the 2005 – 2008 tests at Waynesville and Laurel Springs. (The 2009 yield and grade index data for the Upper Mountain Research Station are not yet available.) Table 3-3 shows the flowering data for 2008 and 2009 at the locations where tests occurred.

Table 3-1a. Performance of commercial varieties in the North Carolina Official Variety Tests at the Border Belt and Upper Piedmont Research Stations, 2005 – 2009

	Border Belt Whiteville				Upper Piedmont Reidsville							
	2005		2006		2006		2007		2008		2009	
Variety	Yield (lb/a)	Grade Index	Yield (lb/a)	Grade Index	Yield (lb/a)	Grade Index	Yield (lb/a)	Grade Index	Yield (lb/a)	Grade Index	Yield (lb/a)	Grade Index
NC 3 LC									1,821	80	2,055	83
NC 4 LC							2,666	80	1,726	68	2,091	81
NC 5 LC	2,763	72	2,560	71	1,928	76	2,379	78	1,724	78	1.994	79
NC 6 LC	2,959	68	2,206	66	1,839	73	2,940	83	1,605	73	2,178	79
NC 7 LC	3,028	69	2,249	65	2,106	71	2,727	83	1,756	74	2,058	78
NC 2000 LC	2,553	65	1,927	65	1,710	70	2,460	77	1,574	74	2,051	76
NC 2002 LC	2,571	74	2,240	68	1,924	73	2,265	80	1,549	75	1,849	81
NC BH 129 LC	2,551	73	2,157	65	2,081	75			1,641	74	2,159	83
TN 86 LC									1,796	75	1,748	78
TN 90 LC	2,363	70	1,880	69	1,968	71	2,262	77	1,672	76	1,907	82
TN 97 LC									1,579	72	2,033	78
KY 907 LC									1,712	76	2,321	79
KT 200 LC	2,772	72	2,209	69	1,759	73	2,344	80	1,706	77	1,774	77
KT 204 LC	2,443	67	2,293	66	1,802	67	2,466	79	1,791	73	2,299	78
KT 206 LC									1,561	74	2,121	76
R 610 LC	2,432	74	2,271	70	1,767	73	2,249	79	1,803	75	2,222	83

Table 3-1a continued

Variety	Border Belt Whiteville				Upper Piedmont Reidsville							
	2005		2006		2006		2007		2008		2009	
	Yield (lb/a)	Grade Index	Yield (lb/a)	Grade Index	Yield (lb/a)	Grade Index	Yield (lb/a)	Grade Index	Yield (lb/a)	Grade Index	Yield (lb/a)	Grade Index
R 630 LC	2,535	70	2,011	70	1,848	73	2,304	80	1,756	76	2,170	82
R 712 LC	2,480	73	2,446	67	2,033	78	2,601	82	2,003	78	2,374	79
HB 04P LC	2,350	75	2,216	65	1,900	68	2,483	81	1,894	80	2,500	82
HB 3307 LC											2,218	77
KY 14 x L8 LC	2,284	75	2,212	73	1,678	72			1,930	79		
N 126 LC									1,948	78	2,430	82
N 777 LC									1,748	78	2,400	84
N 7371 LC											2,497	81
CLAY'S 403 LC											2,223	83
CLAY'S 404 LC											2,345	85

A blank table cell indicates that no data are available for a variety in a year and location.

Table 3-1b. Performance of commercial varieties in the North Carolina Official Variety Tests at the Upper and Lower Coastal Plain Research Stations, 2007-2008

	Upper Coastal Plain Rocky Mount				Lower Coastal Plain Kinston	
	2007		2008		2008	
Variety	Yield (lb/a)	Grade Index	Yield (lb/a)	Grade Index	Yield (lb/a)	Grade Index
NC 3 LC			1,940	77	3,310	78
NC 4 LC	2,233	77	2,285	76	2,653	74
NC 5 LC	2,458	76	2,157	71	3,254	76
NC 6 LC	2,353	80	2,483	78	3,300	77
NC 7 LC	2,326	80	2,002	77	2,729	78
NC 2000 LC	2,232	76	2,273	77	2,994	71
NC 2002 LC	2,130	78	2,041	76	3,249	78
NC BH 129 LC			2,279	72	3,553	79
TN 86 LC			2,190	75	2,679	75
TN 90 LC	2,007	78	1,746	67	3,622	79
TN 97 LC			2,223	75	3,074	76
KY 907 LC			2,411	70	3,644	76
KT 200 LC	2,239	77	2,115	71	3,381	76
KT 204 LC	2,260	79	2,032	76	2,764	77
KT 206 LC			2,192	71	3,315	78
R 610 LC	2,452	78	1,996	74	3,229	78
R 630 LC	2,262	79	2,242	73	3,104	78
R 712 LC	2,298	78	1,976	68	2,884	77
HB 04P LC	2,304	79	2,258	73	3,383	79
KY 14 x L8 LC			2,344	78	3,297	78
N 126			2,165	71	3,669	78
N 777 LC			2,603	72	3,056	76

A blank cell indicates that no data are available for the variety in a year and location.

Table 3-2a. Performance of commercial varieties in the North Carolina Official Variety Test at the Mountain Research Station, 2005-2008

	Mountain, Waynesville							
	2005		2006		2007		2008	
Variety	Yield (lb/a)	Grade Index	Yield (lb/a)	Grade Index	Yield (lb/a)	Grade Index	Yield (lb/a)	Grade Index
NCBH 129 LC	2,348	39	3,410	80			3,656	51
NCS 3 LC							3,138	50
NC 4 LC					3,614	78	3,026	53
NC 5 LC	2,648	56	3,682	77	3,467	80	3,762	48
NC 6 LC	2,493	51	3,214	80	3,599	84	3,598	41
NC 7 LC	2,877	66	3,315	80	3,591	86	3,507	72
NC 2000 LC	2,653	55	2,726	78	3,485	86	2,914	59
NC 2002 LC	2,625	39	2,882	80	3,518	85	3,063	43
KT 200 LC	2,760	56	3,226	75	3,504	86	3,110	58
KT 204 LC	2,808	41	3,400	76	3,768	84	3,711	50
KT 206 LC							3,782	62
TN 90 LC	2,703	54	2,965	77	3,572	80	3,374	61
TN 86 LC							3,391	37
TN 97 LC							3,252	40

Table 3-2a continued

	Mountain, Waynesville							
	2005		**2006**		**2007**		**2008**	
Variety	**Yield (lb/a)**	**Grade Index**	**Yield (lb/a)**	**Grade Index**	**Yield (lb/a)**	**Grade Index**	**Yield (lb/a)**	**Grade Index**
KY 907 LC							3,582	52
KY 14 x L8 LC	2,390	57	3,056	77			3,411	62
R 610 LC	2,321	51	2,990	78	3,478	87	3,431	73
R 630 LC	2,387	45	2,655	78	3,413	79	3,172	70
R 712 LC	2,759	54	3,036	79	3,632	83	3,743	53
HB 04P LC	2,612	57	3,347	77	3,399	79	3,825	51
N 126 LC							3,910	62
N 777 LC							3,439	60

A blank table cell indicates that no data are available for a variety in a year and location.

Table 3-2b. Performance of commercial varieties in the North Carolina Official Variety Test at the Upper Mountain Research Station, 2005-2008

	Upper Mountain, Laurel Springs							
	2005		2006		2007		2008	
Variety	Yield (lb/a)	Grade Index	Yield (lb/a)	Grade Index	Yield (lb/a)	Grade Index	Yield (lb/a)	Grade Index
NCBH 129 LC	2,689	67	2,839	42			4,073	81
NC 3 LC							3,564	72
NC 4 LC					2,560	80	3,515	62
NC 5 LC	2,057	56	2,665	34	3,038	78	3,865	58
NC 6 LC	2,196	58	3,124	38	2,736	82	3,785	74
NC 7 LC	1,688	42	2,754	39	2,639	84	3,582	73
NC 2000 LC	2,746	68	2,706	42	2,233	86	3,732	80
NC 2002 LC	2,336	69	2,502	42	3,084	86	3,582	76
KT 200 LC	1,857	44	2,638	34	2,435	84	3,922	65
KT 204 LC	2,660	65	2,510	30	2,767	83	3,935	77
KT 206 LC							4,156	79
TN 86 LC							3,638	71
TN 90 LC	1,918	42	2,277	33	2,491	82	3,574	74
TN 97 LC							3,853	73

Table 3-2b continued

Variety	Upper Mountain, Laurel Springs							
	2005		2006		2007		2008	
	Yield (lb/a)	Grade Index	Yield (lb/a)	Grade Index	Yield (lb/a)	Grade Index	Yield (lb/a)	Grade Index
KY 907 LC							3,546	73
KY 14 x L8 LC	2,397	70	2,246	46			3,596	73
R 610 LC	2,304	58	2,210	36	2,785	83	3,494	79
R 630 LC	2,032	42	1,842	31	2,638	83	3,220	78
R 712 LC	2,873	67	2,558	33	3,253	81	3,827	77
HB 04P LC	2,458	54	2,459	40	3,387	86	3,250	68
N 126 LC							4,012	77
N 777 LC							3,795	77

A blank table cell indicates that no data are available for a variety in a year and location.

Table 3-3a. Flowering times for commercial varieties in the North Carolina Official Variety Test at five locations in 2008

	2008 (% Flowering on Designated Date)				
Variety	***Kinston June 30***	***Reidsville July 28***	***Waynesville Aug. 12***	***Laurel Springs Aug. 4***	***Rocky Mount July 14***
NC 3 LC	*70*	*50*	*45*	*55*	*70*
NC 4 LC	*55*	*50*	*30*	*25*	*85*
NC 5 LC	*70*	*40*	*40*	*25*	*65*
NC 6 LC	*60*	*15*	*35*	*20*	*60*
NC 7 LC	*30*	*20*	*10*	*0*	*75*
NC 2000 LC	*45*	*10*	*0*	*5*	*55*
NC 2002 LC	*70*	*50*	*40*	*55*	*65*
NC BH 129 LC	*60*	*90*	*55*	*70*	*50*
TN 86 LC	*70*	*35*	*25*	*25*	*50*
TN 90 LC	*70*	*70*	*85*	*40*	*60*
TN 97 LC	*55*	*35*	*30*	*30*	*60*
KY 907 LC	*65*	*55*	*20*	*40*	*60*
KT 200 LC	*55*	*30*	*5*	*5*	*70*
KT 204 LC	*65*	*40*	*80*	*10*	*50*
KT 206 LC	*45*	*25*	*35*	*25*	*55*
R 610 LC	*70*	*70*	*60*	*65*	*55*
R 630 LC	*70*	*95*	*95*	*70*	*80*
R 712 LC	*75*	*90*	*70*	*60*	*60*
HB 04P LC	*75*	*95*	*85*	*85*	*70*
KY 14 x L8 LC	*80*	*95*	*95*	*100*	*85*
N 126	*65*	*80*	*50*	*70*	*60*
N 777 LC	*55*	*40*	*0*	*5*	*55*

Table 3-3b. Flowering times for commercial varieties in the North Carolina Official Variety Test at two locations in 2009

	2009 (% Flowering on Designated Date)	
Variety	***Reidsville July 10***	***Laurel Springs Aug. 10***
NC 3 LC	*60*	*70*
NC 4 LC	*45*	*30*
NC 5 LC	*60*	*20*
NC 6 LC	*45*	*15*
NC 7 LC	*25*	*0*
NC 2000 LC	*0*	*0*
NC 2002 LC	*65*	*75*
NC BH 129 LC	*70*	*65*
TN 86 LC	*25*	*40*
TN 90 LC	*80*	*90*
TN 97 LC	*55*	*40*
TN 907 LC	*75*	*30*
KT 200 LC	*5*	*15*
KT 204 LC	*65*	*35*
KT 206 LC	*45*	*30*
R 610 LC	*100*	*75*
R 630 LC	*100*	*70*
R 712 LC	*90*	*50*
HB 04P LC	*100*	*80*
HB 3307 LC	*55*	*50*
N 126 LC	*100*	*55*
N 777 LC	*100*	*0*
N 7371 LC	*100*	*0*
CLAY'S 403 LC	*100*	*55*
CLAY'S 404 LC	*100*	*90*

4. Producing Healthy Transplants in a Float System

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To produce high-quality tobacco, growers must begin with healthy transplants. An ideal transplant is disease free, hardy enough to survive transplanting shock, and available for transplanting on time. In general, early transplanted tobacco yields more than late-transplanted tobacco. The historical last-frost date for a region is a good guideline for selecting a date for setting out transplants, but the five-day weather forecast is better. In general, tobacco that has been transplanted for several days can tolerate frost better than recently transplanted tobacco.

The greenhouse float-system method produces excellent quality transplants with uniform stem lengths in a very predictable time period. However, the weather does affect production in the greenhouse. For example, cool, cloudy conditions can delay germination. Unseasonably warm temperatures in February and March can increase the rate of plant growth, causing problems with stem and root diseases, particularly if the seeds are planted in the greenhouse too early. Successful transplant production in a greenhouse requires intensive management with great attention to details. Little problems can become big problems very quickly.

Transplant production costs per acre increase when the percentage of usable transplants decreases. 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).
- Reduce spiral rooting.
- 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 cost of $5 per sample. Growers receive a detailed report about the nutritional suitability of each water sample for transplant production.

Collect a 16-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

Researchers continue to investigate tray design in relationship to production costs and disease management. 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 tradtional-depth trays.

Recently 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 fhe 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.

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

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.

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 coumn 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.

Manage Spiral Rooting

Spiral roots (aerial roots) can cause significant stand losses. In general, the reduction in the number of usable transplants is about one-half of the percentage of spiral rooting. For example, if 10 percent of the cells in a tray contain spiral roots, a grower can expect the number of usable transplants to be be reduced by 5 percent. Some of the conditions that may induce spiral rooting can occur when seeds are sown.

Causes of spiral rooting. Researchers have found that spiral rooting results from complex interactions among the variety sown, pelleting material, growing medium, and environment. For example, differences in spiral rooting among varieties are common. We do not know if these differences are genetic, a coincidence involving the time of germination and an environment favorable for spiral root development, the seed pelleting material, or some combination of these factors. Tests have shown differences in spiral rooting when different companies coated the same seed lot of one variety. Differences in spiral rooting have also been observed when the same company coated seeds of the same variety. The greenhouse environment is also a factor. We commonly see differences in spiral rooting levels when tests with the same seed and growing medium are conducted by specialists in Virginia, North Carolina, and South Carolina.

Differences in spiral root incidence have also been observed between brands of growing medium. However, a brand of growing medium may cause more spiral roots than others one year, but not the next.

Recent observations suggest that pellets harden after repeated cycles of drying and rewetting, similar to the conditions that occur when temperature and humidity in the greenhouse change from day to night. The hard pellet then becomes a barrier between an emerging root and the growing medium, preventing normal root penetration. Research in North Carolina that has found increased spiral rooting under hot and sunny conditions supports these observations. Thus, spiral roots may occur when the greenhouse environment contributes to the growing medium being too wet, as well as when the surface of the medium is too dry. Therefore, seeding date will not consistently reduce spiral rooting because the set of known "good" environmental conditions is too narrow.

Primed seeds. Priming is a seed treatment that begins the germination process in a seed company's laboratory. After the early stages of germination occur from exposure to warm temperature, darkness, water, and then light, the seeds are dried. This treatment produces seeds that are at the same stage of germination when purchased by the grower, and seedlings emerge quickly and uniformly. However, research has shown that priming sometimes improves the rate of seedling emergence (by one to two days) but seldom improves the uniformity of emergence. There is also considerable variation in priming response among varieties tested and among seed lots within a variety. Therefore, the decision to prime seeds should be made by the seed company, based on pretesting of individual seed lots, rather than by the grower (unless the grower intends to cover seeds with growing medium to prevent spiral rooting).

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.

Promote Uniform Growth

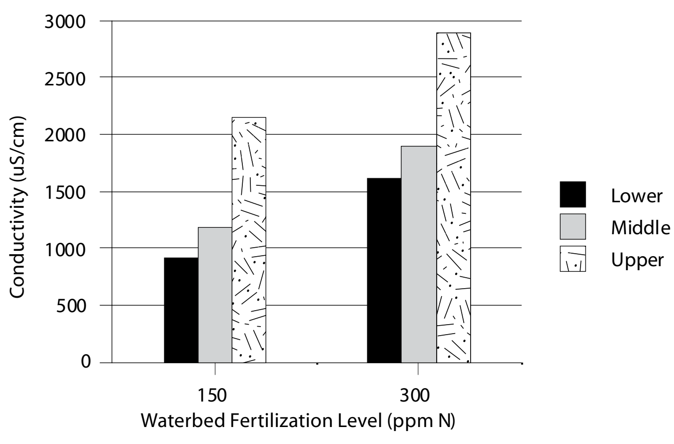
Monitor and Manage Fertilizer Salts in the Growing Medium

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 4-1). 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.

Figure 4-1. Conductivity of a soilless medium at two fertilization levels and at three depths in the cell.



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 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

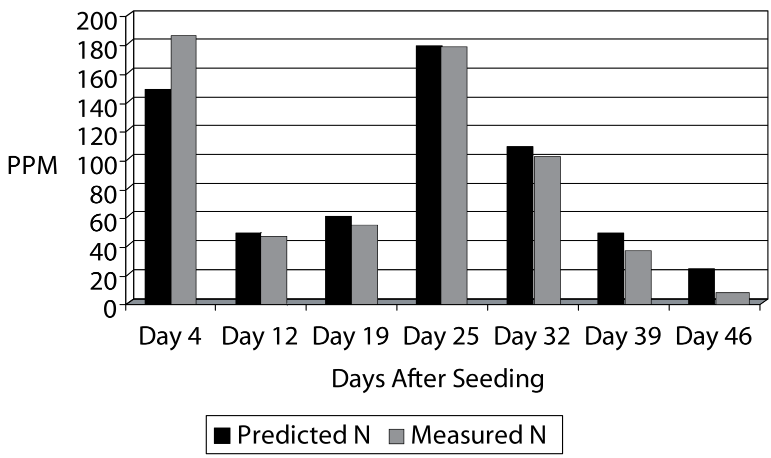
Growers with fertilizer injection systems have been successful in using a constant application rate of 100 parts per million (ppm) nitrogen from 20-10-20, 16-4-16, 16-5-16, 15-5-15, or similar ratio fertilizers. For noninjected systems, fertilizer can be added to the water in two steps. Research has shown that excellent transplants can be obtained from an initial application of fertilizer to supply 75 to 100 ppm nitrogen within seven days after seeding plus a second application to supply 75 to 100 ppm nitrogen four weeks later. Use a complete fertilizer (with 2-1-2, 3-1-3, or 4-1-4 ratios) 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 4-2). 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.

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.

Figure 4-2. A comparison of predicted (based on conductivity) and measured nitrogen concentrations in a float bed, 2002.



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 15-5-15, and 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. However, over-application of acidic fertilizers in low-alkalinity water can reduce the solution pH to less than 4.0, which damages roots (if plant roots grow into the waterbed).

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 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:*

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

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

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 collectg 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. Fertilization

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While fertilizer recommendations have been developed on an economic basis—which includes maximum yield, fertilizer cost, labor for application, and anticipated return—concerns for the environment also must be considered. This makes fertilizer use efficiency important. Based upon current fertilizer prices and tobacco yields, you can save 10 to 12 cents per pound of cured leaf through efficient fertilizer use. You can do this only through the use of soil tests to determine the available supply of nutrients in the soil.

Importance of Soil Testing

In the fall of 2004, many tobacco fields were flooded during tropical storms Frances and Ivan. Soil testing is very important following flooding or heavy duration rainfalls. Floodwaters leach nutrients such as nitrogen, sulfur, boron, magnesium, and potassium from the soil below the root zone. In addition, floodwaters may deposit sediment from upstream or may cause severe erosion. In either of these situations, soil pH and nutrient levels may be very different than in previous years. The only way to know for sure is to soil-test as soon as possible.

Soil testing also allows you to manage soil pH to ensure maximum yields and to minimize the possibility of manganese toxicity. Over time, soil pH declines in our soils in western North Carolina. Soil pH values as low as 4.0 have been identified in fields showing symptoms of manganese toxicity. Regular soil testing and following lime application recommendations will prevent this decline. Soil pH should be maintained in the range of 5.5 to 5.8 to maximize growth and minimize manganese toxicity. Proper liming may also aid in managing black shank disease.

For maximum economic returns, apply only the recommended rates of nutrients. Most burley tobacco producers have used complete fertilizers, such as 5-10-15, for many years and have built fertility levels in the soil. Soil test summaries over the past few years show that

70 to 80 percent of soils analyzed for burley tobacco contain high levels of phosphorus and potassium and require little or no addition of these nutrients for maximum yields. Soil testing will correctly identify the nutrients needed.

Seedling Boron Fertility

Boron deficiency may be a problem for both greenhouse and bed-grown transplants. In the case of float solutions, many growers have used soluble fertilizers containing 0.0068 percent boron, which may result in boron deficiency. The soluble tobacco-grade fertilizers contain 0.01 to 0.02 percent boron. When non-tobacco-grade fertilizers are used at the manufacturer's suggested rates, the boron concentration would be only 0.068 part per million (ppm) in the float water versus 0.360 to 0.720 ppm boron from tobacco grades. It is important to use the tobacco-grade fertilizers. Additional application of boron to the float water or routine foliar application should not be needed. In the case of ***confirmed*** boron deficiency, you may make foliar applications of 0.1 pound boron (0.5 pound Solubor) per 100 gallons to either greenhouse or seedbed plants. This treatment may be repeated in 10 days if needed. Be sure that any sprayer used has been thoroughly rinsed to prevent seedling damage due to herbicide or growth regulator residue. ***Caution:*** Remember that tobacco plants are very susceptible to boron toxicity. Do not assume that if a little is good, more is better. Severe plant damage can occur from over-application of boron.

Effect of Cold Temperatures on Seedling Boron Uptake

Boron deficiency symptoms are similar to those of cold injury. Boron deficiency is unlikely if you use a fertilizer with the proper boron content, make foliar applications, or both. If in doubt, have boron deficiency confirmed with tissue analysis.

Past research has determined that cool temperatures may temporarily delay uptake of boron, even if there is sufficient boron in the float solution. The temperature conditions that inhibit boron uptake are similar to those that cause cold injury. Most likely, the two conditions are not related except that the same weather conditions may cause both. Cold injury symptoms should disappear on their own as soon as the temperature increases. Boron uptake also should improve when temperatures increase. If you use a boron spray, it would be a good idea to leave a few trays untreated to see if indeed the spray was really needed. More information and photographs of cold injury, boron deficiency, and boron toxicity, are available in the on-line publication *Cold Injury and Boron Deficiency in Tobacco Seedlings* (AGW-439-54), which is available on the Internet at **www.soil.ncsu.edu**.

A complete discussion of other aspects of seedling fertility and production can be found in Chapter 4, "Transplant Production in the Float System." More information can be found in the publication *Tobacco Seedling Nutrition in the Greenhouse Float System* (AGW-439-48), which is also available on the Internet at **www.soil.ncsu.edu**.

Field Fertility

A well-planned fertilization program depends on the use of soil analysis and its proper interpretation. The following is a guideline for obtaining a representative soil sample and interpreting the results to develop a fertilizer program.

Soil Sampling Procedure

Because of soil variability, it is important to take samples from several locations in each field. Samples may be taken with a soil core sampler, shovel, or hand trowel and should be taken to a depth of at least 6 inches. Thoroughly mix the samples in a plastic bucket (never use a galvanized bucket because zinc contamination could occur). Fill each soil box, obtained from your county Cooperative Extension center, to the indicated level. Label the boxes carefully so that you will know which field the sample represents when the results are returned. Fill out the soil sample information sheet and submit the samples to the address shown on the box. If samples are to be sent to Raleigh by U.S. mail, write "Soil Sample" on the outside of the container in which they are shipped because there is a special postal rate for shipping soil samples. Be aware that late fall through early spring are extremely busy periods for the soil analysis laboratory, so you may find significant delays in getting results back from samples submitted then.

Interpreting the Soil Test Report

Note: The following information on soil analysis interpretation is based on the N.C. Department of Agriculture and Consumer Services publication *Crop Fertilization Based on North Carolina Soil Tests*. Soil testing is a service of the Agronomic Division of NCDA&CS. The top line of each soil test report, which is shaded green and labeled "Test Results," gives the results of analyses performed on your soil. These results are given in the following order and interpretation:

Soil Class. Soils are grouped into three classes in North Carolina: mineral (MIN), mineral-organic (MO), and organic (ORG). Classification is determined from soil analyses of the sample and its geographic location. Soils on which burley tobacco is grown are all classified as mineral and designated MIN.

HM%. Percent humic matter is a measure of the soluble organic constituents of the soil. The absolute value is not critical but, in general, the higher the value, the better. It generally runs 3 percent or lower and cannot be used as a guide for herbicide application based upon organic matter.

W/V. Weight/volume refers to the weight per unit volume of the soil and varies with the soil texture and organic matter content. A clay loam will have a value of approximately 1.0, whereas the value for a sandy loam may be 1.15 or higher. Also, as the organic matter content increases, the W/V declines.

CEC. This stands for *cation exchange capacity*. It is a measure of the soil's capacity to hold cations such as calcium, magnesium, potassium, hydrogen, aluminum, iron, manganese, zinc, and copper. A high CEC is desirable because leaching of fertilizer nutrients is less likely, and higher reserves can be maintained, thus assuring an adequate supply throughout the growing season. Tobacco soils generally have a CEC between 3.5 and 15.0. You can raise this value through practices that increase the soil's organic matter, such as by planting cover crops, applying manure, and using conservation tillage systems.

BS%. The base saturation percent indicates the portion of the CEC that is occupied by nutrient cations, principally calcium, magnesium, and potassium. Generally, the higher the base saturation, the higher the plant nutrient supply and the less acidity present to interfere with plant growth. A well-limed and fertilized soil will have a BS% of 80 or higher.

Ac. Extractable acidity is the portion of the CEC occupied by the acidic cations aluminum and hydrogen. This is one of the values used to calculate the lime requirement of the soil. It will be relatively low when the soil is properly limed for tobacco production.

pH. This logarithmic expression represents the concentration of hydrogen ions in soil solutions. A pH of 7.0 is neutral, and at pH 6.0, the concentration of hydrogen is 10 times higher than at pH 7.0. This measurement is important because the availability of several plant nutrients is related to the soil pH. For burley tobacco, the value should be 6.0 or slightly higher.

P-I and K-I. These index values represent the plant nutrient availability of phosphorus and potassium. They are interpreted as low if the index is below 25, medium if it is 26 to 50, high if it is 51 to 100, and very high if it is above 100. For burley tobacco, these index values should be at least 100.

Ca% and Mg%. These values refer to the percentage of CEC occupied by calcium and magnesium. On a well-limed tobacco soil, Ca% should be 60 or higher and Mg% should be between 10 and 20.

Mn-I, Zn-I, Cu-I, and S-I. Manganese, zinc, copper, and sulfur are the remaining four elements that are routinely measured in soil samples. Manganese (Mn), zinc (Zn), and copper (Cu) are micronutrients, and sulfur is a secondary nutrient. All four are expressed as index values with 25 and above being adequate for normal plant growth. On many tobacco soils, the Mn-I may be over 100, a level that frequently results in manganese toxicity symptoms, especially if the pH is below 6.0.

Suggested Lime and Fertilizer Treatments

The second line of the soil test report for each sample lists the suggested lime and fertilizer treatments. These suggested treatments are based upon test results and were determined through many years of research and experience to result in maximum yield and quality. Under the suggested treatment, the following will appear:

Lime. Any lime application suggested on your report is designed to raise and maintain the soil pH between 5.8 and 6.2. In addition to supplying the essential calcium and magnesium, lime neutralizes aluminum, which becomes toxic to plant roots when the soil pH is too low. Increasing the soil pH also reduces the availability of manganese contained in most burley tobacco soils. The plants also take up and use phosphorus more efficiently when soils are properly limed.

There are two basic types of agricultural limestone applied to soil in North Carolina—dolomitic and calcitic. *Dolomitic limestone* is a mixture of calcium and magnesium carbonates containing at least 120 pounds Mg per ton. It is the preferred source if a $ appears in the Mg block of your report for suggested treatment. *Calcitic limestone*, which is calcium carbonate, does not contain magnesium, so it may be used for all applications where supplemental magnesium is not required.

Lime applications are most effective in the fall. However, finely ground limestone, as required by North Carolina law to be sold as agricultural limestone, may be broadcast and disked in just before transplanting.

Fertilizers. Burley tobacco producers have generally used a 5-10-15 fertilizer that has built high levels of soil phosphate and potash. Frequently, only a nitrogen application is necessary.

N rate. The column marked N (nitrogen) will have a rate of 160 to 200 pounds N per acre. Research results (Table 5-1) have shown no benefit from N application rates above 160 to 175 pounds per acre on fields producing yields less than 2,500 pounds per acre, whereas 200 pounds of nitrogen per acre are required in fields producing more than 2,500 pounds per acre. Nitrogen may come from any source shown in Table 5-2. On many soils, the recommended nitrogen may be broadcast and disked in before setting. However, on sandy textured, well-drained soils, you can achieve greater fertilizer efficiency by applying no more than 100 pounds of nitrogen per acre preplant and by topdressing the remainder 30 days after setting. Applying more than the recommended rates of nitrogen reduces use efficiency and increases the risk of groundwater contamination.

Table 5-1. Effect of nitrogen rate on the percentage of maximum yield (two yield levels)

N rate (lb/a)	Yield Levels	
	Less than 2,500 lb/a	Greater than 2,500 lb/a
	Percentage of Maximum Yield	
150	91	75
175	99	84
200	100	94
225	99	97
250	98	100

P_2O_5. This column indicates the suggested rate of phosphorus (P_2O_5) to be applied per acre. This rate is based upon the level present in the soil and reflects the amount required to raise the soil test P-I to approximately 100, which should give maximum yields. Although low levels of phosphorus may severely stunt tobacco growth, there is no advantage in exceeding the recommended rates. Any phosphorus source may be used and should be thoroughly incorporated. This is especially important if the soil test level is low.

K_2O. This column indicates the suggested rate of potash (K_2O) to be applied per acre. Potassium sulfate (0-0-50) or potassium nitrate (13-0-44) should be used. ***Do not*** *use muriate of potash (0-0-60)* as a potassium source because it contains chlorine, which causes poor curing and interferes with burning of the tobacco product. Many non-tobacco-grade complete fertilizers, such as 5-10-10 or 19-19-19, are blended with the chlorine-containing 0-0-60. For this reason, do not substitute a complete fertilizer for a tobacco-grade fertilizer.

Mg. An A, O, or $ will appear in this column depending upon the need for magnesium (Mg). An A, O, or a blank indicates no special need for Mg, and any lime source may be used. If a $ appears, any lime applied should be of the dolomitic type.

Cu, Zn, and Mn. These columns are normally blank because they represent micronutrients, and no general deficiencies of this type have been identified in burley tobacco grown in western North Carolina.

B. Boron is a highly soluble and leachable nutrient; field deficiencies have been experienced when wet winters are followed by heavy, late winter snowfall or heavy rains. Extremely low boron in tobacco tissue results in bud dieback and leaf distortion. In some cases where boron was below 10 ppm in tissue, the leaf midribs and stem have developed corky tissue. Foliar spray applications of 0.1 pound boron per 100 gallons may be used. ***Caution: Remember that tobacco plants are very susceptible to boron toxicity. Do not assume that if a little is good, more is better.***

Once N, P_2O5, and K_2O requirements have been established, consider how to supply these required nutrients at the most economical prices. Table 5-2 lists some of the recommended fertilizers for tobacco. Assuming that the soil test results were medium (P-I=50, K-I=50), the recommendation would be to add 160 to 200 pounds N, 90 pounds

P_2O_5, and 150 pounds K_2O per acre. Using Table 5-2, you could select 1,000 pounds of 5-10-15, which would supply the P_2O_5, K_2O, and 50 pounds of N. If your yield level is normally less than 2,500 pounds per acre, refer to Table 5-1 and select an N rate of 150 to 175 pounds. Since 5-10-15 supplied 50 pounds of N, you would need to add another 100 to 125 pounds of N, which could be supplied by 400 pounds of ammonium nitrate (33-0-0). Custom-blended fertilizer materials are available in most areas and can be used to meet fertility needs more effectively. By inquiring about the local price of these materials, you can also select a less costly fertilizer program.

Table 5-2. Fertilizer materials and amounts to supply N, P_2O_5 and K_2O rates suggested on the soil test report

Material	*Amount (lbs/a)*	*lbs/a*		
		N	*P_2O_5*	*K_2O*
5-10-15	1,000	50	100	150
18-46-0	100	18	46	0
0-46-0	100	0	46	0
0-0-50	100	0	0	50
13-0-44	100	13	0	44
33-0-0	100	33	0	0
16-0-0	500	80	0	0
46-0-0	100	46	0	0

Special Thanks

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6. Cover Crops For Burley Tobacco

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Cover crops are an essential component of burley tobacco production. Planting a winter cover crop is necessary for minimizing soil erosion and for maintaining organic matter in the soil. Many, if not all, farm plans developed by the U.S. Department of Agriculture Natural Resources Conservation Service have a cover crop component. In addition to providing ground cover during the winter, cover crops also provide either "green manure" for plowdown, mulch for no-till, forage for livestock, or grain and straw if allowed to mature. Below is a brief description of common cover crops.

Rye

Burley tobacco growers use rye as a winter cover probably more than any other small grain. Most ryes grow well in the fall (even late fall) and are the first cover crops to continue growing in late winter or early spring. This makes rye a top choice for tobacco growers who have little time in the fall to sow a cover before winter. Rye provides the most biomass to turn under in early spring. It also provides forage for grazing animals and straw if harvested before mature seeds are formed or after rye seed harvest.

Triticale

Triticale is now available to burley tobacco growers as an alternative small grain for winter cover cropping. Triticale was developed by combining rye and wheat genetics. This small grain has good winter hardiness and excellent biomass in early spring (similar to rye), but is shorter in height than rye (more like wheat). Triticale seed may be hard to find some years, and its price may be higher than prices for other small grains. Triticale, however, can provide superior biomass to plow under for the following summer crop.

Barley

Barley provides a sufficient source of biomass to be managed in the spring. It does not grow as tall as rye, but will tiller and may produce as much straw, forage, or plowdown as rye. Even though barley eventually produces the equivalent biomass of rye, it does so later in the spring. Also, the possibility of winterkill is greater with barley. Plan to plant in late September or early October for greatest survival.

Wheat

Using wheat as a cover crop works well and provides an additional option of grain harvest. Wheat also should be planted in September or October and produces biomass similar to that of barley. It, too, can be grazed before turning under. You can also harvest it for grain and remove the straw.

Oats

Oats can be managed to provide many options for the grower. Planting fall oats in September or October in most of North Carolina will provide a cover crop and good late-spring biomass. It can be grazed, or you can make it into hay or harvest the grain and straw. Planting spring oats in August can provide a good winter-killed mulch. Spring oats, however, have survived some of our milder winters. Thus, you may need to kill spring oats with herbicides in some years if you do not plow them under.

Ryegrass

This grass has great potential use as a green manure and as a forage or hay material, but grower beware! It has the potential to become a difficult pest on some farms. Ryegrass tends to grow rather slowly in the fall; therefore, it provides only moderate winter erosion protection if planted in late fall. Ryegrass will produce an abundant supply of biomass by late spring. Grazing and spring hay from ryegrass can be excellent, and its fine, extensive root system makes it a great source for plowdown. Because of the resiliency of ryegrass, you should avoid using it in sites where a garden or tobacco plant beds are to be established. This source of cover does not provide much biomass if plowed early in the spring.

Legumes

Three legumes are available for winter cover cropping. Hairy vetch has a viney growth habit and a high nitrogen content, and it grows slow during the winter. The Austrian winter pea also has a viney growth habit and a high nitrogen content, and it grows slow during the winter, but it can frost-heave. Crimson clover has an upright growing habit and grows slow during winter, and it has a moderate nitrogen content. All these legume winter cover crops need to be planted by late September or early October. Frost heaving can cause the seedlings to dry out during the winter; plants are susceptible to heaving when they are very small and their roots are not established. All legume seed costs will be double or triple what the cost per acre would be for small grains, but legumes will supply nitrogen in greater quantity to the soil than small grain if left until late April or early May before plowdown.

Mixing Grass and Legumes

Combining grass and legumes may prove better than planting either alone. Grasses protect soil during the winter and also produce great forage or plowdown organic matter. Legumes do not grow well during the winter, but they grow abundantly in late spring and produce high protein forage and lots of nitrogen as plowdown for the following crop. Crimson clover is the best legume to grow with a grass. Crimson's height matches well with barley, wheat, and oats, but it may be shaded by rye, resulting in less growth than desired. Hairy vetch has been sown with grass cover crops for many years, with the grass and vetch combination being used as a hay or plowdown.

Plowdown

Many growers plow down winter cover crops in late winter or very early spring. Try to resist this temptation until cover crops have gained sufficient biomass. Plowing early defeats the main purpose of growing cover crops—to supply organic matter—and does not allow legume cover crops to develop at all. If you need to plow early, use a grass cover crop (rye) that produces good fall growth and provides maximum biomass for incorporation.

Seeding Rate

Seeding rates are 1 to 1½ bushels per acre for rye, triticale, barley, and wheat and 2 bushels per acre for oats. Crimson clover should be planted (broadcast) at 20 to 25 pounds per acre, hairy vetch at 20 to 30 pounds per acre, and Austrian winter peas at 25 to 35 pounds per acre. Drilling legumes can reduce rates by 5 pounds per acre. If you plant in late fall, use the higher rates for good seed establishment and soil protection.

7. Weed Management in Conventional and No-till Burley Tobacco

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An environmentally sound weed management program is a critical part of profitable tobacco production. Although several chemical weed control programs are available for burley tobacco, not all weeds can be handled chemically. Therefore, attention also must be given to other weed management systems, such as crop rotation, early root destruction, cultivation, and growing a healthy crop to better compete with weeds.

Problems That Weeds Cause in Tobacco

In Plant Beds

- Severe competition sometimes leading to stand loss.
- Interference with pulling plants.
- Lower-quality plants.

In the Field

- Lower yield and quality.
- Increased production costs.
- Interference with harvesting.
- Chemical imbalances in cured leaf that reduce smoke flavor.
- Increase in the spread of tobacco mosaic virus (TMV) in susceptible varieties, as well as an increase in the spread of black shank through root injury during cultivation. TMV can also be spread mechanically by the tool bars or undersides of tractors when they contact taller plants.
- Increase in the spread of other diseases. Horsenettle and ground cherry increase TMV, etch virus, and vein mottling virus. You should eliminate horsenettle and ground cherry in and around burley fields.

- Loss of quality. If tobacco is cut and laid on the ground where weeds are present, it can rot and lose quality because of increased moisture associated with the weeds.

Some weeds, such as nutsedge, ragweed, fall panicum, and hairy galinsoga, differ in susceptibility to herbicides (Table 7-1). Therefore, you must correctly identify weeds to properly select a herbicide.

Herbicides labeled for tobacco control weeds by restricting growth during seed germination. They do not affect weed seeds that do not germinate (dormant seeds) or weeds that have emerged from the soil. Exceptions are Spartan, which gives good control of nutsedge 8 to 10 inches tall, and Poast, which gives excellent control of emerged grasses. To select the herbicide and rate, you must keep accurate field records that give the type and number of weeds expected.

Weed Control in Conventionally Planted Burley Tobacco

Crop Rotation

Crop rotation is important in handling weed problems in tobacco, as well as in disease and nematode management. Large-seeded broadleaf weeds, including cocklebur, morningglory, jimsonweed, and sicklepod, and small-seeded broadleaf weeds, such as ragweed and hairy galinsoga, are not controlled by most tobacco herbicides. They can be controlled more easily in corn. Most perennials are difficult to control in tobacco. Annual grass populations have generally decreased over the years in tobacco fields, whereas ragweed, hairy galinsoga, horsenettle, and nutsedge have increased. It may not be as easy to use rotation as a weed control tool in burley because of the limited availability of land and of other crops to grow in the rotation.

Crop Competition

Crop competition can be an effective tool in weed management. Tobacco grows rapidly, and the large leaves shade weeds. For example, studies at N.C. State University have shown that if ragweed is controlled for as long as two weeks after transplanting flue-cured tobacco, the ragweed will not reduce yields. Weeds coming in later could still interfere with harvest, however, and increase Granville wilt in flue-cured tobacco.

Table 7-1. 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 signalgrass	*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*
Apple of Peru	*G*	*P*	*N*	*P*	*E*	*P*
Cocklebur	*F*	*P*	*N*	*P*	*FG*	*P*
Common purslane	*FG*	*E*	*N*	*E*	*GE*	*G*
Hairy galinsoga	*G*	*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 upon average to good soil and weather conditions for herbicide performance and upon proper application rate, technique, and timing.
E = excellent control, 90% or better *G = good control, 80-89%*
F = fair control, 60-79% *P = poor control, 1-59%*
N = No control *— = has not been tested*

In burley, crop competition is somewhat limited as a weed control tool because burley is planted later in the season, the rows are wider, and weeds grow fast in western North Carolina. Use good cultural practices to promote rapid tobacco growth, and use as narrow rows as recommended to help shade weeds. With current recommendations for wider rows to leave more space between plants and drive rows to aid in blue mold control, greater pressure will be placed on the weed control program.

Cultivation

Mechanical cultivation is still needed in burley tobacco because herbicides cannot completely control all weeds. However, no more than two cultivations are necessary. Excessive and late cultivations can spread TMV and other viruses and injure root systems. Root injury can increase problems with Granville wilt, black shank, and nutrient uptake.

There is probably less need for cultivation in burley tobacco than in flue-cured tobacco because burley usually does not need to be on a row ridge. Also, many burley growers have full-time jobs elsewhere and do not have time to cultivate. When you cultivate, keep it shallow so tobacco roots will not be pruned. In some cases, breaking the soil crust to allow better soil aeration could benefit burley tobacco. But cultivation in burley tobacco increases soil erosion, and most burley is grown on erodible slopes. (See section on "Producing No-Till Burley Tobacco" in this chapter.) The Water Quality Division of the N.C. Department of Environment and Natural Resources has shown that sediment is the greatest cause by far of degraded surface-water quality.

Herbicides

In most agronomic row crops, North Carolina growers have rapidly turned to herbicides for weed control with much less cultivation and no hand hoeing. Herbicides are used on about 85 percent of the burley acreage in North Carolina. Adding herbicides to weed control programs in tobacco provides some advantages:

- Increases efficiency as farms get larger and transplanting is extended over a longer period. With herbicide use, growers do not have to stop transplanting to cultivate the tobacco transplanted first.

- Eliminates the need for hoeing.
- Provides good insurance against wet weather and cultivation problems, especially in clay soils. Most burley soils are very sticky when wet.
- Increases rotation opportunities. With good control of nutsedge now possible, producers may be able to bring more land into a proper rotation.
- Reduces the number of cultivations needed, which saves money and reduces soil erosion.
- Reduces the spread of diseases, especially TMV and other viruses and black shank, as well as reduces nematode populations.
- Increases yields— generally by 150 to 450 pounds per acre.
- Simplifies harvest. Fields are cleaner of weeds for burley harvest.

Selecting and Applying Herbicides for Conventional Burley Tobacco

In Plant Beds

Fumigate with methyl bromide in the fall or use dazomet (Basamid). The only herbicide now available for use after sowing beds is sethoxydim (Poast), which controls young grass weeds.

In Fields

Certain herbicides may be applied before transplanting or within seven days after transplanting (Table 7-2). For example, Poast can be applied up to 42 days before harvest. There are advantages and disadvantages to each time of application, but each is suitable for a given weed population and grower's situation. Growers are reminded that it is essential to correctly identify the weed to properly select a herbicide (Table 7-1) and that county Extension agents can help identify weeds. Also, growers should read the label before purchasing a herbicide to see whether the product controls the weed and to determine the proper rate.

Pretransplant Soil-Incorporated Herbicides (PPI)

Pretransplant-incorporated herbicides offer several advantages. Growers can tank mix them with other chemicals to save one or more

Table 7-2. Herbicide application methods

Herbicide	Soil Incorp. before Trans-planting	Surface Applied before Trans-planting	Applied Overtop within 7 Days after Trans-planting	Applied Overtop up to 42 Days before Harvest
Command 3ME		x	x	
Devrinol 50DF			x	
Devrinol 2E	x			
Poast				x
Prowl 3.3EC	x			
Spartan 4F	x	x		
Tillam 6E	x			

trips across the field, and they can gain more consistent weed control than with overtop applications because there is less dependence on rainfall for activation. In addition, when poor field conditions delay transplanting, a pretransplant-incorporated herbicide will help prevent weed growth that may start in freshly prepared soil.

The most serious disadvantage of using these herbicides is crop injury. Prowl, Tillam, and Devrinol have the potential to limit root growth and cause slow early-season growth (stunting). Spartan does not affect root growth directly; however, foliar symptoms and stunting have been observed. Stunting is most likely during cool, wet springs. Poor incorporation, applying high rates, and tank mixing two or more herbicides increase the chance for injury. Research and observations suggest the possibility of additional root injury and stunting when the full rate of flumetralin was used for sucker control the previous year. Proper crop rotation will prevent this problem. If crop rotation is not possible, you should use the 2-quart-per-acre rate of flumetralin in a recommended sucker control program. (See Chapter 11, "Topping and Sucker Management," for recommended programs.)

If root injury does occur, it is important to remember that slow plant growth is due to a poor root system rather than a lack of nutrients. Adding more nitrogen will not increase the growth rate but will contribute to rank growth, slow ripening, more unripe grades, and lower warehouse prices.

Poor incorporation is a leading cause of root injury. Uneven incorporation leads to areas of concentrated herbicide in the soil. When tobacco is transplanted into these areas, root growth is restricted, resulting in root-bare areas often found on shanks of stunted plants. Tractor speed, disk shape, and disk size are all important for uniform incorporation of the chemical. Finishing or smoothing harrows with small, spherical-shaped disks incorporate chemicals more uniformly than larger cutting harrows with cone-shaped disks. Also, finishing harrows incorporate the chemical one-half as deep as the disks run, whereas larger 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 a 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.

You can reduce root injury 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. Stunting of the crop from improper soil incorporation is most likely to occur with Tillam 6E and Devrinol tank mixed, then Tillam 6E or Prowl, and is least likely with Command.

Command gives excellent control of many grasses and offers control of many broadleaf weeds found in North Carolina burley tobacco fields, such as common ragweed, jimsonweed, common lambquarters, prickly sida, Pennsylvania smartweed, and hairy galinsoga, as well as partial control of common cocklebur. Refer to Table 7-1 for a more complete list of weeds controlled by Command and other herbicides. Also, see the Command 3ME label for incorporation and setback restrictions. One weakness of Command is that it offers very poor control of redroot pigweed.

Research with Command has shown that tobacco is sufficiently tolerant of this herbicide. Little or no stunting has been observed; an occasional white leaf or plant has been noted, but plants recover with no adverse effects on yield or quality.

Devrinol 2E gives long-lasting control. It provides some suppression of ragweed and hairy galinsoga if good rainfall comes soon after application. The label has rotation restrictions because of possible soil carryover. Devrinol may leave residues that stunt small grain growth, especially when it is soil incorporated. If the small grain crop is used only as a cover crop, this stunting is not considered a problem. The potential for carryover can be reduced by making band applications to the soil surface rather than by incorporating it in the soil or applying it broadcast on the soil surface. Check the label for restrictions on rotational crops and the use of cover crops. If Devrinol is incorporated, using the lower labeled rate, fall tillage, and destroying stalks and roots early will reduce the chance of carryover to small grains.

Prowl 3.3EC gives long-lasting grass control. Does not control ragweed or hairy galinsoga.

Spartan 4F may be soil incorporated before transplanting, and weed control from PPI applications of Spartan is more consistent when soil moisture is limited. However, research has shown that stunting is more likely and usually more severe when Spartan is soil incorporated than when it is applied to the soil surface (see discussion of Spartan 4F in the "Pretransplant Soil Surface-Applied Herbicides (PRE-T)" section below).

Tillam 6E should be incorporated immediately after application. It gives short-term nutsedge suppression. Apply as close to transplanting as possible because Tillam 6E does not last long in soil. It does not control ragweed or hairy galinsoga.

Pretransplant Soil Surface-Applied Herbicides (PRE-T)

Spartan 4F provides excellent control of nutsedge, morningglories, and redroot pigweed. It gives fair to good control of hairy galinsoga and poor control of ragweed (Table 7-3). Burley growers who might bed their rows must knock row ridges down to the height of the transplanting before Spartan application. Some stunting of tobacco usually occurs with Spartan, but normal growth resumes and yields are not reduced. Still, there is not a wide margin of safety with Spartan and tobacco.

Spartan is very sensitive to soil organic matter content and soil type. You must follow the label carefully to obtain expected weed control without stunting the crop. Growers who plan to use Spartan should have a commercial lab test their soil and determine the percentage of organic matter and soil classification.

Although several growers did not get control with Spartan in fields with heavy hairy galinsoga infestations in 1997, growers have achieved good control in more recent years when they followed label rate recommendations more closely. Spartan has given excellent control of hairy galinsoga in research tests. For fields with heavy infestations of hairy galinsoga or the presence of ragweed, Command should be used in conjunction with Spartan. Better control has been obtained if Command is applied immediately after transplanting.

See the Spartan label for rotational crop guidelines because of possible soil carryover. This will not generally be a problem in the burley area. For example, soybeans can be planted anytime after application; wheat, barley, rye, and oats can be planted after 4 months; corn and sorghum after 10 months; and sweet corn after 18 months.

The Spartan label also indicates that the product can be used as a pre-transplant soil-incorporated (PPI) application. However, the possibility of injury to the tobacco is greatly increased and weed control is only slightly better when Spartan is applied PPI rather than PRE-T. Few burley growers have implements that will uniformly incorporate Spartan 2 to 2½ inches deep.

In on-farm tests (Tables 7-3 and 7-4), weed control from Spartan and Command applied PPI was as good as PRE-T applications. The PRE-T applications received adequate rain early on to activate all herbicides applied. Therefore, there was no advantage to incorporating herbicides. Treatments which included Devrinol did not control certain weeds as well as treatments which included Command and Spartan.

Herbicide Application at or Following Transplanting

Devrinol 50DF or Command 3ME may be applied at or immediately after transplanting. Application at transplanting is encouraged because it is more likely to control early-germinating weed seeds, and the moisture in freshly tilled soil helps move the herbicide into contact with weed seed. Also, application at transplanting saves a trip over the field and provides insurance against early season rains, which can prevent reentry into the field. Either herbicide can be used after a pretransplant application of Spartan to improve annual grass, hairy galinsoga, and ragweed control. Command is preferred for the latter two weeds.

Herbicides applied to the soil surface depend on water to move the chemicals into the soil where weed seeds germinate. Therefore, they fit well in irrigated situations. If rainfall does not occur within three to five days, a light cultivation may help activate the herbicide. Lack of rainfall early in the season can result in reduced weed control when herbicides are applied to the soil surface. Some growers have experienced reduced control due to low soil moisture in recent years.

Herbicide Application Overtop up to 42 Days Before Harvest

Poast gives good control of most annual and perennial grasses when sprayed overtop tobacco and the grass weeds. Poast gives fair to good control of barnyardgrass and excellent control of giant, green, and yellow foxtail; fall and Texas panicum; and broadleaf signalgrass up to 8 inches tall. It also controls large and smooth crabgrass and crowfoot grass up to 6 inches tall. It is effective on volunteer rye and wheat up to 4 inches tall. Poast also controls bermudagrass up to 6 inches tall and rhizome johnsongrass up to 25 inches tall.

Use 1.5 pints of Poast per acre with 2 pints per acre of a non-phytotoxic oil concentrate. If a second application is needed for johnsongrass, use 1 pint per acre with the oil concentrate when the johnsongrass is 12 inches tall. Do not apply more than 4 pints of Poast per acre per season to tobacco including the amount applied in seedbeds. Do not apply to grasses under stress or if rainfall is expected within one hour following application because grass control will be unsatisfactory. Do not apply Poast with other pesticides.

In larger tobacco, you can improve results by using a semi-directed spray to cover grasses that might be under tobacco leaves. Tobacco is very tolerant of Poast. In flue-cured tobacco, however, some slight leaf margin burn has been noted when Poast was applied under high temperatures and humidity. This is less likely in the burley area, but if such conditions do occur at application, reduce the rate of oil concentrate by one-half.

Poast can be very helpful in no-till burley tobacco since grass weeds are not controlled well in some situations. See the label for further details on the use of Poast in tobacco. Do not apply within 42 days of harvest.

Weed Management in No-Till Burley Tobacco

Researchers have concentrated on the evaluation of new herbicides, especially for better control of broadleaf weeds, and on developing techniques to grow no-till tobacco. Several herbicides have given good control of annual and perennial grasses when sprayed overtop tobacco. These are known as *postemergence grass herbicides*. Poast is now

Table 7-3. Average results of on-farm herbicide tests in Buncombe and Yancey counties in 2004

Treatment	Rate lb a.i./a	Method of Application	Yellow Nutsedge [a]	Carpet-weed [b]	Goose-grass [a]	Johnson-grass [b]	Redroot Pigweed [a]	Venice-mallow [a]	Black Nightshade [a]	Hairy Galinsoga [b]
			% of Weeds Controlled							
Spartan	0.313	PPI	100	94	96	96	99	89	100	81
Spartan + Command	0.313 + 0.75	PPI	99	99	97	98	99	92	100	92
Spartan + Command	0.313 + 0.50	PPI	96	97	86	92	98	81	100	90
Spartan + Devrinol	0.313 + 1.00	PPI	100	100	93	95	100	73	99	90
Command + Devrinol	0.75 + 1.00	PPI	35	76	95	95	83	90	67	88
Spartan + Command	0.313 + 0.50	PRE-T	99	99	100	96	99	97	100	94
Spartan + Command	0.313 0.50	PRE-T	100	99	99	98	100	94	100	95
Spartan + Devrinol	0.313 + 1.00	PRE-T	100	99	93	93	100	93	97	81
Command + Devrinol	0.75 + 1.00	PRE-T	37	72	93	95	89	92	76	82

[a] Data from one location.
[b] Data from two locations.

Table 7-4. On-farm herbicide evaluation test, Mitchell County, 2005

Treatment	Rate lb a.i./a	Control of Hairy Galinsoga		Crop Stunting	
		21 DAT[b]	42 DAT	21 DAT	42 DAT
		%			
Spartan[a]	0.31	91	79	9	10
Command[a]	0.75	86	82	0	0
Devrinol[a]	2.0	69	64	3	3
Spartan +Command	0.31 0.75	93	90	6	6
Spartan +Command	0.31 0.50	89	85	7	6
Spartan +Devrinol	0.38 1.0	90	75	9	12
Spartan +Devrinol	0.25 0.75	86	76	7	6
Command +Devrinol	0.75 1.0	88	86	6	9
Command +Devrinol	0.75 0.75	79	87	2	2

[a] All treatments applied preplant incorporated (PPI)
[b] DAT = Days after treatment.

available for postemergence grass control and is a big help in no-till tobacco.

Also, there will be fewer new herbicides for tobacco. Tobacco is a relatively small acreage crop, and it is not profitable for chemical companies to develop herbicides for tobacco. Enide and Paarlan were lost because of the high cost of re-registering.

Spartan is a big help for weed control in no-till tobacco. (See section on "Selecting and Applying Herbicides for Conventional Burley Tobacco" in this chapter.) Since 1997, Spartan has been evaluated not only in experiment station tests in no-till burley, but also in on-farm tests. Table 7-5 gives the results of tests conducted at the Upper Mountain and Mountain Research Stations in 1999 comparing the effectiveness of Spartan, Command, and Devrinol in no-till versus conventional-till tobacco.

In this experiment, no-till tobacco was compared to conventional-till to determine what effect not tilling before planting and a good rye mulch has on the performance of several herbicides. In most instances, Spartan, Command, and Devrinol gave better weed control in no-till plots than in conventional-till plots. The weaker a herbicide is on a weed species, the more no-till improved the results. There was less improvement in favor of no-till if the herbicide gave excellent control of a particular weed.

Tables 7-6 and 7-7 show the results from on-farm tests in no-till tobacco in Alleghany and Haywood counties. Spartan rates are based on soil texture and the percentage of organic matter, and many soils where burley tobacco is produced in North Carolina require the highest labeled rate for control of targeted weeds. Applying Spartan before planting and Command after planting was as effective as tankmixing of Spartan and Command before planting.

Producing No-Till Burley Tobacco

There appears to be much interest in no-till burley tobacco in North Carolina and other burley-producing states. Many growers see it as the only way to comply with soil conservation requirements. Others see it as a better way to farm, saving topsoil and making agriculture more sustainable. In research tests over 13 years, yields were about the same when tobacco was transplanted into a killed rye cover crop or sod, as compared to conventionally tilled and transplanted tobacco (Table 7-8). Growers are now interested in no-till burley because it is easier to meet conservation requirements where land for rotation is limited. Some growers had to switch to this production practice in 1994.

Table 7-5. Effect of no-till in rye mulch vs. conventional tillage on weed control, 1999

	Upper Mtn. Research Station[a]								Mtn. Research Station[b]			
	Hairy Galinsoga		Yellow Nutsedge		Redroot Pigweed		Common Purslane		Yellow Nutsedge		Pennsylvania Smartweed	
	NT	T	NT	T	NT	T	NT	T	NT	T	NT	T
Herbicide	% of Weeds Controlled											
Spartan [c]	89	68	94	82	100	100	98	91	100	99	100	100
Command [c]	86	61	66	44	79	61	95	90	60	60	94	100
Devrinol [c]	80	63	69	44	86	76	89	66	78	44	77	89
Spartan [c] + *Command* [d]	97	78	95	85	99	99	99	97	99	100	100	100

[a] Control ratings are an average of data taken at 30, 51, and 113 days after planting except for hairy galinsoga, which was at 113 days only. NT = no-till; T = conventional tillage.

[b] Control ratings are an average of data taken at 21 and 44 days after planting.

[c] Applied pre-planting to mulch or soil surface.

[d] Applied immediately after transplanting.

Table 7-6. On-farm no-till herbicide evaluation test, Alleghany County, 1999

Treatment	Rate lb a.i./a	Control of Hairy Galinsoga		Crop Stunting	
		27 DAT [c]	48 DAT	27 DAT	48 DAT
		%			
Spartan [a]	0.25	85	74	0.0	0.7
Spartan [a]	0.31	89	76	1.0	1.3
Spartan [a]	0.38	99	93	0.3	1.3
Spartan [a] +Command [a]	0.25 0.75	99	95	1.3	0.7
Spartan [a] +Command [a]	0.31 0.75	97	95	1.3	0.3
Spartan [a] +Command [a]	0.38 0.75	100	99	1.3	1.0
Spartan [a] +Command [b]	0.25 0.75	98	94	1.0	1.0
Spartan [a] +Command [b]	0.31 0.75	99	96	1.3	1.0
Spartan [a] +Command [b]	0.38 0.75	100	99	1.3	2.0

[a] Applied before transplanting.
[b] Applied immediately after transplanting.
[c] DAT = Days after treatment.

Table 7-7. On-farm no-till herbicide evaluation test, Haywood County, 1999

Treatment	***Rate lb a.i./a***	***Control of Redroot Pigweed***		***Control of Yellow Nutsedge***	***Stunting of Tobacco Plants***	
		24 DAT [c]	***46 DAT [c]***	***46 DAT [c]***	***24 DAT [c]***	***46 DAT [c]***
		——— % ———				
Spartan [a]	*0.25*	*100*	*95*	*96*	*0.3*	*0.3*
Spartan [a]	*0.31*	*100*	*97*	*100*	*0.7*	*0.7*
Spartan [a]	*0.38*	*100*	*99*	*100*	*1.7*	*0.7*
Spartan [a] +Command [a]	*0.25 0.75*	*100*	*99*	*97*	*0.7*	*0.3*
Spartan [a] +Command [a]	*0.31 0.75*	*100*	*100*	*95*	*0.3*	*1.0*
Spartan [a] +Command [a]	*0.38 0.75*	*100*	*95*	*100*	*1.3*	*1.0*
Spartan [a] +Command [b]	*0.25 0.75*	*100*	*99*	*100*	*1.0*	*1.0*
Spartan [a] +Command [b]	*0.31 0.75*	*100*	*96*	*97*	*1.0*	*1.3*
Spartan [a] +Command [b]	*0.38 0.75*	*97*	*100*	*100*	*1.0*	*1.3*

[a] Applied before transplanting.
[b] Applied immediately after transplanting.
[c] DAT = Days after treatment.

Here are some experiences and current recommendations on no-till burley:

1. Transplant properly. Two systems of mulch or cover may be used: a killed rye cover crop or a killed sod. Three types of transplanting may be used: planting directly into the mulch with a transplanter with a coulter and double disc row opener, transplanting into a narrow tilled strip after using a Ro-Till or similar tillage implement, or transplanting with a sub-surface tillage transplanter (described in item 9 below). With any no-till transplanter, cut press wheels to a 2-inch width and reinforce the rim. The narrow wheel packs soil around plants better.

2. Select a field with low weed pressure if possible. Do not try no-till production in fields with bermudagrass or heavy infestations of perennial broadleaf weeds such as horsenettle and trumpet creeper. Control perennial weeds the year before, especially in sod situations. You can, however, grow no-till in fields with nutsedge by using Spartan and in fields with johnsongrass by using Poast. If you do not use established sod as the mulch, till land in the fall and seed an Abruzzi rye cover crop.

3. Incorporate lime and phosphorus in the fall if suggested by soil tests. Apply soil pesticides for insect and disease control according to label directions based on knowledge of past insect and disease problems and based on nematode assays. Do not apply Ridomil in the fall. Low-lying fields may be bedded before planting the cover crop. Do not leave beds in a peak, however, because planting will be more difficult the next spring.

4. Sow a small-grain cover crop because a good cover is essential for successful no-till tobacco. Abruzzi rye is the best cover because it produces

Table 7-8. Tobacco yield under conventional and no-till systems at the Mountain and Upper Mountain Research Stations, 1989-94

Year	*Conventional Tillage*	*No-Till*
	———lb/a———	
1989	*2,943*	*3,268*
1990	*2,925*	*3,019*
1991	*2,393*	*2,752*
1992	*2,095*	*2,413*
1993	*2,369*	*2,649*
1994	*2,095*	*1,576*

a lot of biomass and chemically suppresses weeds. *Sow at a rate of 3 bushels per acre.* Apply fertilizer as for a small grain crop to get good cover-crop growth. The heavier the mulch, the fewer the weeds.

5. Kill the cover crop. Spray with Gramoxone Extra plus surfactant about two weeks before planting to kill the cover crop. If Roundup is used, apply it four weeks before transplanting. If Gramoxone Extra is used early, a second application may be needed before transplanting to kill rye regrowth or emerged weeds.

6. Take weed control action as needed. If planting into sod, perennial weeds are more likely. Spray with Roundup four weeks before transplanting. Spray again with Gramoxone Extra if needed just before transplanting because annual weeds may emerge through the killed sod before transplanting.

7. Broadcast phosphorus and potash before transplanting. Apply nitrogen as a band placement at planting.

8. Irrigate before transplanting if soil is dry and hard and irrigation is available. The cover crop will have depleted the soil moisture, and tobacco will grow poorly if it is not irrigated. Apply Ridomil according to the label before transplanting. Rainfall or irrigation will be needed before or after transplanting to move Ridomil into the soil.

9. Consider using a transplanter. A commercially available transplanter with a double-disc row opener with a coulter added in front has done a good job of planting into a variety of mulches. An alternative is a coulter followed by a straight shank running 6 to 8 inches deep or a Ro-Till tillage implement to loosen a furrow followed by a conventional transplanter with a sword opener. The sub-surface tillage transplanter, however, has given us the best stands yet. Developed by Virginia Tech and a no-till cabbage grower, it was used to make successful no-till plantings of tobacco in North Carolina from 1993 through 2000. This planter uses a large, straight coulter followed by a winged knife to loosen a narrow furrow. A conventional transplanter is attached to the row-opener frame. Press wheels need to be narrowed to achieve better packing of soil around transplants.

10. Transplant as usual. Field-grown and greenhouse plants have worked equally well. Normally, no-till tobacco grows more slowly than tobacco planted conventionally in early season. Therefore, no-till tobacco should be planted first. If the soil is too dry or too moist, the planter slit may not close tightly in the non-strip-tillage method of planting. Use extra weight on planter press wheels and cut off part of the press wheels' edges to make them narrower. This puts more pressure on the sides of the slit.

11. Fertilize properly. If broadcast fertilization was not used, apply the recommended amount of fertilizer in one or two bands 4 to 5 inches deep with a disc opener that will cut through the mulch. Disturb as little soil as possible. Do this at transplanting or immediately after. The second-choice method would be to band the fertilizer on the soil surface and irrigate. Broadcasting phosphorus and potash and side-banding nitrogen works best in no-till.

12. Control weeds. Apply Spartan on the mulch and soil surface before transplanting, or apply Devrinol or Command after planting. If it does not rain within five days, irrigate to wet the soil 2 to 4 inches. Irrigation or rainfall is necessary to wash the herbicide off the mulch and into the soil. A tank mix of Command and Devrinol gives good results. Spartan is the best herbicide to use for no-till tobacco. Apply it to the soil surface before transplanting. Do not apply overtop tobacco. For improved control of annual grass, hairy galinsoga, and ragweed, use Command after transplanting. Over several years, we have found that using Spartan before transplanting plus Command or Devrinol after transplanting gives better weed control than a tank mix applied before transplanting. The over-top treatment apparently controls weed emergence caused by the soil disturbance of the transplanter. Observations of Spartan over several years in no-till and conventional-till burley tobacco indicate that better control is obtained in no-till with borderline tolerant weeds such as hairy galinsoga, ragweed, and annual grasses. The mulch aids in weed suppression (Table 7-5). Stunting of tobacco from Spartan is less likely in no-till than in conventional-till.

13. Carry out subsequent weeding, if needed, by pulling up scattered weeds by hand or by by using a lawn mower, string trimmer, or a narrow sickle-bar mower between the rows. Growers have found these methods easier than hand hoeing conventional-till tobacco. You can mount lawn mowers to the cultivator frames on a tractor to make mowing between rows easier. You also can use Poast overtop for postemergence grass control, although Poast will not control broadleaf weeds.

14. Apply sidedress nitrogen to the surface beside the plants, or 3 to 4 inches deep with a disc-opener applicator. Increase the total nitrogen rate by one-fourth over what is normally recommended for conventional-till tobacco to make up for the nitrogen the mulch ties up.

15. Handle insect, disease, and sucker control as you would for a conventional crop. Viral diseases and black shank have been less of a problem in no-till tobacco. Slugs have been a problem most years in burley. Watch closely for slugs and apply bait at the first sign. Reapply as needed.

16. Learn proper management skills. Since no-till crop production requires greater managerial ability, growers trying no-till tobacco must commit to carrying out the necessary practices for success. Those trying it for the first time should do so on a small part of their crop until they learn proper management skills.

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.

8. Insect Management in a Changing Burley World

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The previous two growing seasons were remarkably dry, but the 2009 growing season brought a return to more normal precipitation. Although the greater precipitation was welcome as an alternative to the drought of the past two years, the timing of the rain provided its own unique challenges. Rain pushed transplant back for many, particularly in western North Carolina, resulting in a longer field season.

More tobacco fields than normal experienced cutworm injury in 2009. This increase in cutworm damage may also be related to weather patterns. Cooler, wetter weather likely limited cutworm movement before transplant and resulted in greater oviposition in recently planted tobacco fields. In some areas of the Midwest, 2009 black cutworm flights (*Agrotis ipsilon*) flights were about one week later than in the previous three years. Our recommendation remains that growers do not invest in expensive, preventative cutworm treatments, especially as a reaction to damage observed in 2009. In a year like 2009, where cutworm damage often appeared to be the result of moth oviposition in and near tobacco fields following transplant, preventative treatments may not provide acceptable control. There are several good options for remedial cutworm control, which are described in this chapter. The cutworm damage in 2009 reminded us, however, that fields need to be scouted following transplant to detect this damage before it becomes widespread. Tobacco fields should be scouted for cutworm damage beginning at the edges at least once a week in the 4 weeks following transplant.

In response to the significant shift in burley tobacco production from western mountains to eastern, nontraditional areas in recent years, a two-year project was conducted to determine if insect pressures differ between these production regions. This project was completed in 2009, and key findings are shared in this chapter.

Protecting Seedlings

Virtually all tobacco seedlings are now produced in greenhouses, and plant bed seedling production has been eliminated. For any remaining growers producing seedlings in plant beds, regular scouting (at least once per week) is essential to detect damage early. Growing seedlings in a greenhouse or float bed does not protect them from insect damage. In fact, some insect problems may be greater in greenhouses than in conventional beds. Many of the same pests can impact seedlings regardless of where they are grown. These potential pests include cutworms, slugs, grasshoppers, crickets, and aphids. Where they occur, red imported fire ants can also become greenhouse pests, and rodents can also occasionally damage seedlings. A relatively small area damaged in the greenhouse can translate to large plant losses, and therefore, plants should be scouted regularly. Managing pests in greenhouses requires careful planning, close observation, and a systematic approach.

Sanitation

Sanitation in and around greenhouses and float beds is essential. Keep houses free of trash, supplies, equipment, or other items that are not necessary. Insects (and other pests) can be supported or protected by materials left in the greenhouse. Keep the area surrounding the greenhouse clean. A strip of bare soil, sand, or gravel around the house may reduce entry of insect pests.

Cold

Keeping empty greenhouses or covered float beds open during cold periods may help reduce insects wintering inside. Do not leave any materials (trays or pots) in the house to provide pests with insulation from the cold.

Solarization

Closing the greenhouse or covered float bed during the summer and bringing the temperature up to 140°F (but not higher) for several days may help reduce insect numbers. Again, you should remove any insulating material that protects the insects. Also, remove any materials that can be damaged by high heat.

Fallow Periods

Growing other plants, such as ornamentals or vegetable seedlings, in greenhouses may be an attractive way to help recover the cost of the house. Remember, however, that these plants can introduce or sustain insect pests that may be new to you and very difficult to control. If possible, use greenhouses only for tobacco production. Otherwise, keep them empty as much as possible, especially just before beginning tobacco production. Growing other plants from seed is preferable to bringing in seedlings from another location.

Insecticides

Watch plants carefully and treat with an insecticide if insects threaten an adequate supply of healthy plants. Orthene 97 PE may be used at ¾ tablespoon per 3 gallons of water for each 1,000 square feet of bed. (Orthene 75 SP can be used at 1 tablespoon per 3 gallons of water.) Uniform and thorough coverage is important. Metaldehyde bait (Deadline Bullets) is labeled for control of slugs in tobacco greenhouses. Metaldehyde, however, is most effective when slugs do not have access to water. Thus, metaldehyde may lose some effectiveness when used around float beds. If plants are being produced organically, Sluggo (iron phosophate) baits are organically acceptable (OMRI listed). Other insecticides are labeled for use around the outside of the greenhouse or outdoor float bed or within a greenhouse if other crops (but not tobacco) are present. Check with your county Extension agent or the *North Carolina Agricultural Chemicals Manual* for further information on available materials. 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, Extinguish, fipronil, or Orthene. Some of these materials are slow acting, so start early. Extinguish is a fire ant bait that is also labeled for use on crop land. Bait treatments typically provide longer acting control than mound drenches, but baits must be applied when ants are actively foraging.

Managing Soil Insects in the Field

Soil Insects

Wireworms. Wireworms, the most important of the soil-inhabiting insects that attack tobacco, are present in the soil when tobacco is transplanted. They may stunt or kill young plants and can open up even resistant varieties to soilborne diseases. Tobacco often recovers from wireworm damage with no yield loss. If conditions are not favorable, however, yield loss may occur. In any case, stunting and resetting result in an uneven, more difficult-to-manage crop. If young plants are stunted or dying, check for wireworms. Dig up several plants, and check the underground stem for feeding scars and tunnels.

Cutworms. Cutworms are fairly common in North Carolina, particularly during wet springs. 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. Feeding at night, these pests cut off small plants near the ground or, occasionally, cut off individual leaves. During the day, they hide beneath the soil surface. If you find cut plants, dig around the base of several injured plants to be sure cutworms are present. Scouting and pesticide applications, if necessary, should be conducted at dusk for best results.

Controlling Soil Insects

Step 1. Prepare fields as far in advance of transplanting as practical to reduce the chance of problems with cutworms. Also keep fields and field borders as free of weeds as possible to reduce cutworm and slug problems.

Step 2. Because there are no rescue treatments for wireworms, you must decide in advance whether to use a soil-applied insecticide.

Wireworm populations are typically highest in fields most recently planted in corn or in sod. If wireworms have been problematic in the past at a location and the previous crop was conducive to high wireworm populations, treatment is likely justified. If there is a history of significant wireworm damage in the field, preventive treatment may be justified.

If you decide that chemical control of wireworms is justified, you have two choices (Table 8-1). You can use a contact material (Capture LFR, Lorsban, or Mocap) that only controls soil insects, or you can use a systemic insecticide that will also control aphids and flea beetles (imidacloprid (Admire and others) or thiamethoxam (Platinum). Both contact and systemic insecticides can provide good control of wireworms, and there is seldom, if ever, a need to use both. Keep in mind that some of these materials are very toxic and all label safety specifications should be followed (see Chapter 14: Protecting People and the Environment when Choosing and Using Pesticides for toxicity information on tobacco insecticides). Whether you choose a contact or a systemic, 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 unless the label recommends 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.

Step 3. Cutworms occur in scattered locations, are rarely damaging enough to cause measurable yield loss, and should be controlled with remedial (rescue) treatments (Table 8-9). Preventive control is not generally recommended. However, in rare cases, preventive treatment is an option for fields that consistently have cutworm problems (usually low-lying fields with heavy soils or high weed populations). In fields with a history of cutworm damage, adult flight traps can be used to determine when eggs are being laid and, therefore, if and when to scout for larvae.

Managing Leaf-Feeding Insects

Major Pests

Flea Beetles. Flea beetles spend the winter in litter and plant trash around or in tobacco fields. In the spring, they move into plant beds or the fields. Most farmers know the shot-hole appearance of leaves chewed by adult beetles, but the tiny, white larvae also feed on tobacco roots. If heavy, this feeding can stunt plant development. Three or four generations are produced each year. Adult beetles cause the most significant damage just after transplanting and and may also occur after topping and before harvest. The late-season beetles are often overlooked, but their impact on yield and quality is being assessed.

Budworms. Budworms occasionally tunnel in the stalk or leaf midribs, and they sometimes top plants. The most common damage, however, is from feeding on small bud leaves before the plant has flowered. Tobacco plants can compensate for leaf feeding, and this type of damage typically does not result in yield loss. Budworm pupae spend the winter in the soil. In May and June, moths emerge from the soil and begin to lay eggs on tobacco and other hosts. There are three or four generations each year, but only the first two cause significant damage. Later generations feed on mature tobacco, suckers, and regrowth or on other crop plants and weeds. It is these budworms that overwinter and start the cycle again the following year.

Table 8-1. Soil-applied insecticides for wireworm control

Insecticide and Formulation	*Rate/Acre*	*Remarks*
Capture LFR	*3.4 - 8.5 fl oz*	*Incorporate pretransplant or apply in transplant water.*
Lorsban 15G	*13.5-20 lb*	*Apply to soil surface. Disk in within 30 minutes. Some of these materials are highly toxic. Use with care. Lorsban may also provide some cutworm control.*
Lorsban Advanced	*2 pt*	
Mocap 10G	*20 lb*	
Mocap 6EC	*1/3 gal*	
Admire Pro	*0.6 -1.2 oz per 1,000 plants*	*Apply to tobacco in greenhouses or float beds 1-3 days before transplanting and wash off leaves immediately, OR apply in transplant water.*
T-MOXX, Platinum 2SC	*0.27 - 0.43 oz per 1,000 plants*	

Aphids. Aphids (sometimes called plant lice) draw plant juices from the leaves with their sucking mouthparts. This can distort leaves and reduce leaf body. Aphids also produce a waste product called honeydew, which collects on leaves. This material encourages the growth of sooty mold, which darkens the leaf before and after curing. As a result of these effects, aphids affect quality as well as yield. During the fall, winter, and spring, aphids are found on wild hosts such as mustard and dock and on garden greens. In the spring, winged forms fly to tobacco, where they give birth to wingless forms. These quickly produce young of their own, and large colonies of aphids can build up rapidly.

Several species of aphids, including the tobacco aphid, transmit viral tobacco diseases such as etch, potato virus Y (PVY), and vein banding. It takes only a few seconds for a winged aphid to transmit the disease after landing on a plant. No insecticide acts quickly enough to prevent transmission.

Hornworms. Hornworms overwinter in the soil as pupae. When adult moths emerge, they fly to tobacco or related plants to lay eggs. Hornworms can be a problem throughout the season and can feed on hanging tobacco in the barn. Late in the season, most hornworms feed on suckers and plant regrowth. These worms make up most of the overwintering population.

Steps in Managing Insects

The goal of insect management is not to kill insects but to keep net profits high. Thus, it is not only necessary to protect the crop from significant loss but also to keep the costs of protection as low as possible. Growers stand the best chance of doing this, especially over several years, if they combine a variety of insect control tools into an efficient system. There are four basic types of insect control: (1) cultural control, (2) biological control, (3) preventive chemical treatments applied to the soil, and (4) insecticides applied after a problem develops (remedial treatment).

Cultural Control Practices. Several production practices reduce the chance 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 important in good crop management as well. Also, most add little or nothing to the cost of production; some may actually reduce costs.

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

2. Control pests such as aphids and flea beetles in the greenhouse to avoid taking them to the field with the transplants. Destroy unused plants in greenhouses as soon as transplanting is complete. Undestroyed plants may become a breeding site for insects and diseases.

3. Consider planting as early as practical. Early planting reduces the chance of hornworm and aphid problems. (Late planting may reduce budworm numbers, but late-planted tobacco usually yields less and may be damaged by frost.)

4. Keep fields and field borders free of weeds and trash.

5. Practice early topping and good sucker control to make the crop less attractive to budworms and hornworms. Moths of these pests are strongly attracted to flowers to lay their eggs. Topping and sucker control also often speed the decline of aphids, especially under hot, dry conditions. Early topping is important in controlling a difficult population of aphids or in preventing a low population from reaching damaging levels.

6. To reduce the chance of grasshopper invasion, avoid haying grasshopper-infested meadow strips near tobacco.

7. To prevent regrowth, destroy roots immediately after harvest, denying food and shelter to pests like flea beetles, budworms, and hornworms. Disking and plowing may also kill overwintering budworms and hornworms in the soil. Root destruction is most effective when practiced by everyone.

8. Give the crop a good start, keep it healthy, and get it out of the field (where it is exposed to pests) within a reasonable time.

9. Fertilize only to the recommended N levels. Excessively fertilized plants are particularly attractive to aphids.

10. In areas where tomato spotted wilt virus (TSWV) is problematic, do not burn down or mow weeds or winter cover crops in drainage ditches, hedgerows, or adjacent fields two weeks before or after transplant. Doing so can cause thrips movement into tobacco and result in great virus transmission. Destroy weeds or cover in adjacent areas four weeks or more before transplant.

Conservation of Beneficial Insects. The importance of beneficial insects for controlling insect pests is great. For example, stilt bugs (thin brown or gray bugs with long, thin legs and antennae) are common in tobacco. Each may eat up to 80 budworm eggs in its lifetime. These are eggs that never hatch to damage your crop. Hornworms are attacked by a series of predators (including the stilt bug and paper wasps) and parasites (like *Cotesia congregata*, the wasp that forms white cocoons on the backs of the hornworm) that often kill over 90 percent of the worms. To make the most of these free, natural controls, follow these steps.

1. Minimize or avoid using systemic insecticides that may reduce the populations of beneficial, as well as pest, insects. Systemics are insecticides that are taken up by the plant and later kill insects feeding on the leaves of stems. Stilt bugs are especially sensitive to systemic insecticides.

2. Avoid unnecessary insecticide sprays after transplanting. Make treatment decisions on a field-by-field basis. Some fields may not need treatment, and these can serve as a refuge for beneficials.

3. If an insecticide is necessary, consider the effect on beneficials in choosing materials.

Soil-Applied Systemic Insecticides for Preventive Control. Several soil-applied systemic insecticides are available. There are several reasons these materials might be used: (1) They offer some insurance against loss to undetected or uncontrolled insects. (2) They offer some protection against the need to apply rescue treatments later in the season when you might be busy with other things. (3) They may slow the buildup of pests like aphids and give you more time to detect and react to the pest. (4) They may do things besides control leaf-feeding insects (control wireworms or suppress tomato spotted wilt infection, for example).

On the other hand, there are disadvantages to using a systemic insecticide: (1) Most offer protection against only one or two pests. For even those insects controlled, protection is seldom season-long, and pests may reach damaging levels and require over-the-top sprays for control. (2) Systemics may reduce the numbers of beneficial insects, increasing pest pressures. (3) If the pest does not occur, the treatment may have been an unneeded expense. (4) Most pesticides pose some risk to the environment. (5) Under certain conditions, systemics can reduce yield or quality. (6) Most insects can be controlled with over-the-top sprays once it is certain they will be a problem. In low pest years, this will probably be cheaper.

Soil-applied systemic insecticides are not generally recommended unless the risk of insect attack is high and there is reason to think remedial treatments will not be possible or effective. Because of resistance management restrictions, systemics may also limit the materials that can be applied as rescue treatments should they become necessary.

Imidacloprid (Admire and others) or thiamethoxam (Platinum) can be used as a transplant water treatment like some other insecticides, but they may also be applied as a spray to greenhouse or float-bed plants one to three days before transplanting and then washed off the leaves onto the potting soil. These insecticides are then moved into the field in the plant and potting soil and help protect plants from aphids, early-season flea beetles, and wireworms.

If you use a systemic insecticide, first decide which insects most need control. (It is best to concentrate on the most important pest in the field.) Tables 8-2 and 8-3 show the average results from four tests of common systemics, and Table 8-4 rates these insecticides and lists the pests for which they are recommended. Recommendations, including rates and application methods are shown in Table 8-5.

Do not combine systemics targeted at the same insect pests. There is no advantage in using two chemicals that do similar jobs, and doing this increases costs and the likelihood of crop damage.

Remember, systemics are not a guarantee against pests; you should still check fields at least weekly.

Determining the Need for Remedial Control (Rescue Treatments)

Treatment Thresholds. You can reduce your profit by applying insecticides when they are not needed. Tobacco can compensate for some damage, so a relatively small number of pests in a field may not affect yield or quality at all. The point at which the cost of insect damage outweighs the cost of treatment is called a *threshold*. Thresholds have been used successfully by North Carolina farmers for many years.

When the value of tobacco per pound goes down, the economic threshold goes up. However, the changes in value we expect will not change thresholds by more than a few percentage points. Thus, we will continue to recommend the same thresholds as in the past. Be aware, nonetheless, that these thresholds are even more conservative for lower value tobacco. Cheaper tobacco deserves less protection, not more.

Tobacco budworms. Before flowering, treat when 10 percent or more of the plants checked are infested with live budworms of any size. Do not count plants that have damage but no live worms. Budworms will not usually cause significant loss after buttoning and, therefore, are not counted after this point. This threshold is very conservative. In most recent tests on flue-cured tobacco, up to 100 percent infestation has not significantly lowered yields.

Table 8-2. Test of systemic insecticides for aphid control in flue-cured tobacco, average of four tests, 2000-2003

Treatment [a]	***Application*** [b]	***% Plants Aphid Infested at Peak Infestation***
Untreated control		*34.1*
Orthene 97 PE, 0.77 lb/a	*TPW*	*21.3*
Admire 2F, 1.4 oz/1,000 plants	*TRAY*	*0.3* [c]
Platinum 2SC, 1.3 oz/1,000 plants	*TRAY*	*0.3* [c]

[a] *Treatment rates are shown in units of formulation.*

[b] *TPW = transplant water treatment. TRAY = applied as spray to transplants in greenhouse trays, washed off immediately.*

[c] *Results with transplant applications were similar to results with greenhouse application in tests where both were applied.*

Table 8-3. Flea beetle damage in plots treated with systemic neonicotinoid insecticides, 2009.

Trade Name (Active Ingredient)	***Rate Per Acre*** [a]	***Flea Beetle Feeding Holes per plot*** [b]
Untreated control	*N/A*	*1012*
Platinum (thiamethoxam)	*0.8 fl oz*	*7.25*
Admire Pro (imidacloprid)	*1.2 fl oz*	*5.75*
Admire Pro (imidacloprid)	*0.6 fl oz*	*18.5*
Advise 2F (imidacloprid)	*1.0 fl oz*	*11.75*
Couraze 2F (imidacloprid)	*1.0 fl oz*	*2.75*
Macho 2F (imidacloprid)	*1.0 fl oz*	*15.75*
Torrent 2F (imidacloprid)	*1.0 fl oz*	*8.50*
Widow (imidacloprid)	*1.0 fl oz*	*12.25*

[a] Treatment rates are shown in units of formulated product.
[b] All treatments are significantly different from the untreated control, but NOT significantly different from each other.

Table 8-4. Efficacy ratings for soil-incorporated insecticides

Insecticide	***Wireworm***	***Aphid***	***Flea Beetle*** [a]
Admire	**	***	***
Capture	**	*NR*	*NR*
Furadan	*NR*	*NR*	**
Lorsban	**	*NR*	*NR*
Mocap	**	*NR*	*NR*
Orthene (transplant water)	*NR*	*	**
Platinum	**	***	***

**** = best control; ** = intermediate control; * = fair or inconsistent control; NR = not recommended or not registered.*
[a] Ratings for flea beetle control are for early season.

Table 8-5. Preplant systemic insecticides for insect control in the field

Insects	***Insecticides and Formulations***	***Amount/ Acre***	***Remarks***
Flea beetles	*acephate* *(Orthene 75 SP)* *(Orthene 97 PE)*	 *1 lb* *¾ lb*	 *Transplant water treatment. Higher rates may injure plants. Use 100+ gallons water per acre. Provides 3 to 4 weeks of control.*
Aphids and flea beetles	*imidacloprid* *(Admire Pro)* *thiamethoxam* *(Platinum 75 SG)*	 *0.6 - 0.8 fluid oz per 1,000 plants* *0.17 - 0.43 fluid oz per 1,000 plants*	 *Apply in transplant water, OR apply as a spray over top of greenhouse plants in trays and wash off immediately. Transplant within three days.*
Aphids (suppression only)	*acephate* *(Orthene 75 SP)* *(Orthene 97 PE)*	 *1 lb* *¾ lb*	 *Transplant water treatment. Higher rates may injure plants. Use 100+ gallons water per acre. Rarely adequate for season-long control*

Note: Most soil-applied insecticides can injure plants under some conditions. Greenhouse and float-bed plants may be more sensitive to this type of injury.

Tobacco hornworms. Treatment is justified when the equivalent of at least one worm larger than 1 inch without parasite cocoons is found per 10 plants checked. Because worms with cocoons feed less, they should be counted as one-fifth of a worm (in other words, five worms with cocoons = one healthy worm).

Flea beetles. Treat when small plants average four or more beetles per plant. Treat large plants when you estimate 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. Treat when 10 percent or more of plants have 50 or more aphids on any upper leaf before topping. Do not wait until there are hundreds of aphids to count a plant as infested. Treatment at 10 percent is effective and will prevent losses. However, populations can increase rapidly beyond this point. If a field is approaching threshold, scout more frequently than weekly to allow for timely treatment. Do not delay treatment. At or after topping, treat when 20 percent or more of plants are infested.

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

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

Tobacco splitworm: The tobacco splitworm has been a minor pest of tobacco for many years. Splitworm moths are small (wingspan is about ½-inch), grayish brown, with 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 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) limits its use to the first few weeks of the season. Denim is also somewhat effective but also has a long pre-harvest restriction (14 days). Belt is registered for tobacco splitworm, but efficacy data is limited. If a splitworm infestation occurs during the harvest period, growers may be able reduce populations by harvesting leaves with mines and following with insecticide sprays (this is not a recommendation to harvest unripe tobacco).

If you suspect a field may soon reach threshold for a pest (for example, if you find many hornworms less than 1 inch long or many plants with small aphid colonies), check the field again in two to three days. It is better to check again than to treat below the threshold because beneficial insects, weather, or other factors may keep the pest from reaching threshold. Also keep in mind that these thresholds were developed as guidelines for average conditions. In unusual situations, use your judgment in applying thresholds.

Scouting. To use thresholds, you need to know the pest level in each field. Thus, you must check or scout fields regularly, ideally once a week. To scout a field, walk through it (being sure to cover all areas). Stop at several representative locations to check plants for insects. Make eight stops in a field of 3 acres or less and 10 in fields of 4 to 8 acres. The pattern of stops is not critical, but stop once or more in

Table 8-6. Effectiveness of foliar insecticides against insect pests

	Insect Pest			
Insecticide	***Aphid*** [a]	***Budworm***	***Flea Beetle***	***Hornworm***
Actara	****	*NR*	****	*NR*
Assail	****	*NR*	*NR*	*NR*
B. thuringiensis spray [b]	*NR*	** [c]	*NR*	****
Belt	*NR*	***	*NR*	****
bifenthrin[d] *(Capture 2EC, Capture LFR, and others)*	*NR*	***	*NR*	***
Denim	*NR*	***	*NR*	****
Fulfill	***	*NR*	*NR*	*NR*
Lannate	*NR*	** [e]	***	****
Orthene	***	**	***	****
Provado	****	*NR*	****	*NR*
Sevin	*NR*	*NR*	***	***
Tracer	*NR*	***	*NR*	****
Warrior[d]	*NR*	** [e]	*NR*	****

*Note. **** = excellent control, *** = good control, ** = moderate control, * = fair control, NR = not recommended.*

[a] *Aphid control ratings are based on maximum labeled rates.*

[b] B.t. *is sold under a variety of trade names.*

[c] B.t. *products seem to be more effective against budworms as the season progresses.*

[d] *Bifenthrin and Warrior have long preharvest interfals and should only be used on early season hornworm populations.*

[e] *In some tests, Lannate, and Warrior have performed at a *** level against budworms*

each area of the field. Check, but do not concentrate on, the field borders. Do not bias your sample by stopping to count when you see damage. 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 plants that have budworm larvae present and the number that have 50 or more aphids on any leaf. Count hornworms and estimate the number of flea beetles per plant. Also note other insects or damage. Then compare your results with the thresholds. Avoid the temptation to make decisions on several fields based only on information from one or two. Insect levels may vary greatly even among similar fields.

Choosing a Remedial Insecticide

Table 8-7. Effect of insecticides on budworms in five field trials

	Percent Reduction in Budworm Damage [b]				
Treatment [a]	***Burley 1999***	***Burley 2008***	***Flue 2004***	***Flue 2008***	***Flue 2009***
Belt SC 4 fl oz/acre (2008) 3 fl oz/acre (2009)	—	*77.8*	—	*84.3*	*75.0*
DiPel ES 1-2 pt/acre	*66.8*	—	*59.0*	—	—
Capture LFR 3.4 fl oz/acre	—	—	—	—	*82.3*
Denim 0.16EC 8 oz/acre	—	—	*87.6*	—	—
Lannate 2.4LV 1.5 pt/acre	*72.8*	—	—	—	—
Orthene 97PE 0.77 lb/acre	*64.1*	—	*52.9*	—	—
Tracer 4SC 1.5 oz/acre	*75.0*	*50.8*	*90.6*	*76.5*	*80.0*
Warrior 1CS 2.5 oz/acre	—	—	*87.3*	—	—

[a] *Rates in units of formulated product. All treatments applied as directed spray into the bud.*
[b] *Compared to untreated check, higher number indicates less damage.*

Table 8-8. Effect of foliar insecticides on aphids in five field trials

	Aphid Infestation Rating 1 - 2 Weeks after Treatment [a]	
Treatment, Rate/Acre	Burley 2001	Flue-Cured Avg. of Four Trials 2001-2005 [a]
Untreated	2.28	2.65
Actara 2.0 oz	1.01	0.39
Fulfill, 2.75 oz	—	0.73
Lannate 2.4LV, 1.5 pt	—	2.11 [b]
Orthene 97, 0.77 lbs	0.91	0.42
Provado, 3 oz	—	0.45
Assail	—	0.29 [b]

[a] Individual plants rated 0-5 based on the number of aphids on most infested leaf, averaged over plot.

[b] Lannate was included in only two tests; the untreated check in those tests averaged 3.61. Assail was included in only one test; the untreated check in that test was 1.75.

No one insecticide is best for all pests or even for a single pest under all conditions. If you need to use an insecticide, choose one that fits the conditions and your needs when the pest problem occurs. To make this choice, ask yourself:

1. *What insect pest or pests need to be controlled?* To do a good job of control, you must know which pests you are dealing with.

2. *Which insecticides are the most effective against the pest or pests?* If two or more insects are damaging a field, the best choice would be an insecticide providing good control of them all. Table 8-6 shows the effectiveness ratings for insecticide sprays against major leaf-feeding insects. Table 8-7 shows the results of four tests against budworms, and Table 8-8 shows results against aphids.

3. *Which insecticides offer the longest-lasting control?* If pest pressures are expected to continue over a long period, choose a pesticide with a long-lasting effect. On the other hand, these materials may be more harmful to beneficials and may not be needed if the pest pressure will be brief. Longevity trials of new pesticides are being conducted, but of the standard insecticides, Tracer has demonstrated the longest suppression of hornworms in on farm tests.

4. What are the hazards to the applicator and other workers? Do not take lightly the hazards of using pesticides both to mixers and applicators. When choosing pesticides, consider the hazard potential and the ability of the person doing the application. Pesticides bear signal words to indicate hazards of use. Products bearing the words *Danger-Poison* are highly hazardous; those marked *Warning* are moderately hazardous; and those marked *Caution* are slightly hazardous. Carefully read the label of any pesticide and follow all personal protective equipment (PPE) regulations.

5. What are the hazards to groundwater and surface water? Pesticides differ in their potential for leaching into groundwater or running off into surface water. You should consider these risks when choosing remedial and soil-applied insecticides (see Chapter 14, "Protecting People and the Environment when Choosing and Using Pesticides").

6. Will the insecticide restrict field work? Worker Protection Standards prohibit hired workers from entering treated areas to do routine field work for a period after treatment. The length of this period depends on the chemical and is given on the label. Restricted entry periods usually range from 4 to 48 hours (see Chapter 14.

7. Will the insecticide restrict time of harvest? All of the commonly used insecticides in conventionally grown tobacco require a set interval of time between application of insecticides and harvest. Sometimes this interval can be quite long and render the use of an insecticide impossible. Check the label and choose a material that fits your harvest needs..

8. What effect will various insecticides have on beneficial insects? Some insecticides are more detrimental to beneficial insects than others. The *Bacillus thuringiensis* products, such as DiPel, have minimal effect on beneficials. Orthene, Lannate, pyrtheriods (IRAC Group 3), and Sevin are relatively harmful to beneficials.

9. Do tobacco buyers have concerns about insecticide residues? Most farmers are aware of the concern many buyers have about maleic hydrazide (MH) residues. There is also concern about residues of endosulfan (Golden Leaf Tobacco Spray, Phaser, Thiodan), acephate (Orthene), and pyrethroids. Because of residue concerns and the fact that effective alternatives exist, we no longer recommend the use of endosulfan in burley tobacco. If growers chose to use pyrethroids (Capture 2EC, Capture LFR, Brigadier, Karate, Warrior, and others) for insect management, they must pay careful attention to the preharvest interval (PHI) for these materials. Most of these are PHIs preclude applications after layby.

10. How much does the material cost? Remember that a poorly chosen insecticide can actually increase your pest problems. The real costs of such a choice could be much more than just the cost of the material.

11. Is this the first time treating for this pest? If previous insecticide applications have been made to control the same insect pest during the season, as is often the case for hornworm and budworms, select a material with a different MOA than that which was previously used. (see Chapter 14 for information on IRAC codes and how to use them).

Spray Adjuvants. Adjuvants are materials you add to pesticide sprays to improve performance, reduce drift, improve coverage, or reduce pesticide breakdown. Some insecticide labels suggest an adjuvant be used for best results; most do not. If the label does not suggest using an adjuvant, it is safest not to use one. There have been instances in recent years of growers damaging tobacco with adjuvants, and on-farm tests have shown little if any improvement in control with them. Therefore, we do no recommend adjuvants for use with the insecticides currently used in tobacco. If an insecticide label does suggest using an adjuvant, you should investigate any adjuvant carefully before using it. Be sure the material has been tested or has a history of use specifically in tobacco. Adjuvants that work well in other crops may damage tobacco. Follow insecticide and adjuvant labels carefully.

Burley Grown in Nontraditional Areas

The movement of burley tobacco production east has exposed plants to different, and often, more intense insect pressure. Research conducted on burley grown in the piedmont and coastal plain of North Carolina have demonstrated that incidence of systemic tomato spotted wilt virus (TSWV) under a variety of field conditions is higher in burley than in comparable flue cured tobacco. Greenhouse assays comparing burley varieties (NC 7 and TN 90) to non burley varieties confirmed that commonly grown burley varieties may be more susceptible to TSWV than flue cured varieties.

When grown in the adjacent plots to flue cured varieties, burley tobacco plants appeared no more or less susceptible to the major leaf feeding insects (budworms, flea beetles, and hornworms).

Pesticide Issues

One new insecticide with activity against Lepidopteran pests (budworms and hornworms) was available in 2009. Belt (flubendiamide), produced by Bayer CropSciences, was widely used, primarily due to early season shortages of Tracer. Belt is at least as effective as Tracer against budworms and hornworms.

Precautionary Statement on Pesticides

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

Acknowledgments

Research on insect pressure in nontraditional areas was conducted by Mariah J. Bock in partial fulfillment of an M.S, degree in entomology at NC State University under the supervision of C.E. Sorenson.

Table 8-9. Remedial treatments for insect control in the field

Insect	*Insecticides and Formulations*	*Amount/ Acre*	*Remarks*
Aphids	*acephate (Orthene 75 SP) (Orthene 97 PE)*	*1 lb ¾ lb*	*Good coverage is essential with any material.*
	imidacloprid (Provado 1.6 F and others)	*2-4 oz*	
	thiamethoxam (Actara 25WDG)	*2-3 oz*	
	acetamiprid (Assail 30SG)	*1.5 - 4 oz*	
	pymetrozine (Fulfill 50 WG)	*2.75 oz*	
	lambda-cyhalothrin, MOA 3A (Warrior) (Karate Xeon)	*2.5-3.0 oz 0.96-1.92 fl oz*	*Note: Long Preharvest Interval*
	methomyl (Lannate 90 SP) (Lannate 2.4 LV)	*½ lb 1½ pt*	*Initial control is fair to good, but aphids rebound quickly*
Budworms	*acetamiprid, (Assail) 30 SG*	*1.5-2.5 oz*	*Assail has ovicidal activity only.*
	spinosad (Tracer)	*1.4-2 oz*	*Use one or three solid cone nozzles 12 inches over-top of row. Apply 25 to 50 gallons of water per acre with 40 to 60 lb pressure*
	emamectin benzoate (Denim 0.16EC)	*8 oz*	
	methomyl (Lannate 90 SP) (Lannate 2.4 LV)	*½ lb 1½ pt*	
	flubendiamide (Belt)	*2-3 fl oz*	*Do not apply more than 3 ft oz/ acre every 5 days oro 12 ft oz/ acre per season.*
	acephate (Orthene 75 SP) (Orthene 97 PE)	*1 lb ¾ lb*	
	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*	
	lambda-cyhalothrin (Warrior 1CS) (Karate Xeon)	*2.5-3.0 oz 0.96-1.92 fl oz*	*Use lambda-cyhalothrin only in first 6 weeks (40-day preharvest interval)*

Table 8-9 (continued)

Insect	Insecticides and Formulations	Amount/ Acre	Remarks
Cutworms	*acephate* *(Orthene 75 SP)* *(Orthene 97 PE)*	 *1 lb* *¾ lb*	 *In late afternoon, apply in 25 to 50 gallons water.*
	flubendiamide (Belt)	*2-3 fl oz*	*Do not apply more than 3 ft oz/ acre every 5 days or 12 ft oz/acre per season.*
	lambda-cyhalothrin, (Warrior) 1CS *(Karate Xeon)*	 *2.5-3.0 oz* *0.96-1.92 fl oz*	*Use lambda-cyhalothrin, only in first 6 weeks (40-day preharvest interval)*
Flea beetles	*acephate* *(Orthene 75 SP)* *(Orthene 97 PE)*	 *2/3 lb* *½ lb*	 *Spray entire plant.*
	imidacloprid *(Provado 1.6 F and others)*	 *2-4 oz*	
	thiamethoxam *(Actara 25WDG)*	 *2-3 oz*	
Flea beetles (continued)	*methomyl* *(Lannate 90 SP)* *(Lannate 2.4 LV)*	 *¼-½ lb* *1½ pt*	
	carbaryl *(Sevin 80 S)* *(Sevin XLR Plus)* *(Sevin 4F)*	 *1¼-2½ lb* *1-2 qt* *1-2 qt*	 *To avoid plant injury, do not use carbaryl on small plants.*
Grass-hoppers	*acephate* *(Orthene 75 SP)* *(Orthene 97 PE)*	 *1/3 - 2/3 lb* *½ lb*	 *If possible, also treat a few yards outside field.*
Hornworms	*acephate* *(Orthene 75 SP)* *(Orthene 97 PE)*	 *2/3 lb* *½ lb*	
	Bacillus thuringiensis *(Agree)* *(Biobit HP)* *(Crymax)* *(Deliver)* *(Dipel DF)* *(Dipel ES)* *(Javelin WG)* *(Lepinox WDG)*	 *1-2 lb* *¼-½ lb* *½-1 lb* *½-1 lb* *¼-½ lb* *½-1 pt* *1/8 -¼ lb* *1 lb*	
	carbaryl *(Sevin 80 S)* *(Sevin XLR Plus)* *(Sevin 4 F)*	 *1¼-2½ lb* *1 qt* *1-2 qt*	
	flubendianide (Belt)	*2-3 fl oz*	*Do not apply more than 3 ft oz/ acre every 5 days or 12 ft oz/acre per season*

Insect	*Insecticides and Formulations*	*Amount/ Acre*	*Remarks*
	methomyl *(Lannate 90 SP)* *(Lannate 2.4 LV)*	 *¼-½ lb* *¾-1½ pt*	
	spinosad *(Tracer)*	 *1-2 oz*	
	emamectin benzoate *(Denim 0.16EC)*	 *8 oz*	*Denim may not be used within 14 days of harvest.*
Japanese beetles	*carbaryl* *(Sevin XLR Plus)* *(Sevin 80 S)* *(Sevin 4 F)*	 *1-2 qt* *1¼-2½ lb* *1-2 qt*	*Do not use carbaryl on small plants.*
	imidacloprid *(Provado 1.6 F and others)*	*4 oz*	
	thiamethoxam *(Actara 25WDG)*	 *2-3 oz*	
Slugs	*metaldehyde* *(Deadline Bullets)*	 *12-40 lb*	*Treat at dusk. Do not put on plants.*
Suckfly	*carbaryl,* *(Sevin) 80 S* *(Sevin) 4 F*	 *1.25-2.5 lb* *1-2 q*	*Sometimes needed on late planted tobacco or in northern areas. Apply thoroughly to all parts of plant. Repeat if necessary. Carbaryl is the only material labeled for suckfly in tobacco.*

[a] *Minimum interval (hours) between application and worker reentry into field. Reentry times may change; follow directions on the product label.*

9. Disease Management

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Diseases can be very destructive in burley tobacco fields. Blue mold and black shank are two such diseases in North Carolina. Blue mold is a disease that is introduced each year from outside the region because the pathogen does not typically overwinter in this state. On the other hand, the organisms that incite black shank, brown spot, black root rot, Granville wilt, and viral infections are persistent and can overwinter in our burley region, thus requiring different management strategies. This chapter describes the most prevalent burley tobacco diseases in North Carolina and outlines control recommendations. Growers whose crops are affected should accurately identify the disease and take the necessary precautions to reduce or eliminate epidemics. Disease control practices can be divided into three basic approaches: crop rotation, use of resistant varieties, and chemical control.

Crop Rotation

All burley growers should consider rotating crops regularly. Crop rotation is a very practical and inexpensive means of controlling soilborne diseases, and it can help reduce the incidence of brown spot and some viral diseases. Crop rotation requires that tobacco not be planted in the same field for successive years. If possible, use at least a three-year rotation. The longer the rotation, the more successful the outcome will be. Without tobacco or other susceptible host plants, population levels of many pathogens will be reduced. Crop rotation is especially effective in reducing black root rot, which is common in burley growing regions.

Resistant Varieties

Using resistant varieties (Table 9-1) can be an effective and inexpensive method of disease control. Unfortunately, no single variety possesses resistance to all diseases. If resistant varieties are available, their use is essential when pathogens have been previously identified in the field. For example, if a disease such as black shank is present on your

Table 9-1. Burley varieties and relative levels of disease resistance

Variety	Black Root Rot	Mosaic	Fusarium Wilt	Wildfire	Black Shank	Brown Spot	Vein Mottling	Etch	Blue Mold
Clay 403	Susc	—	—	—	Susc	—	—	—	V Susc
Clay 501	Mod	High	Mod-High	Mod-High	Mod [e]	Susc	Susc	Susc	Susc
Clay Hybrid 402	High	High	Mod	High	Susc	—	Susc	Susc	Susc
KT 204 LC	High	High	Susc	High	High [e]	—	High	Mod	Susc
KY 14	Mod [a]	High	High	High	Susc	Tol	Tol	Tol	V Susc
KY 14 x L8	Mod	High	Mod	High	High [b]	Tol	Susc	Susc	Susc
KY 907	High	High	Mod	High	Low	—	High	Mod-High	Susc
KY 910	High	High	—	High	Mod-High	—	High	Mod	Susc
N 88	Low	—	—	—	Low	—	—	—	Susc
NC 2000	Low	High	V Susc	High	Susc	Susc	Susc	Susc	Mod
NC 2002	Low	High	V Susc	High	Susc	Susc	Susc	Susc	Mod
NC 3 [c]	High	High	V Susc	High	Low	—	High	High	Susc
NC 5 [c]	High	High	V Susc	High	High [d]	—	High	High	Susc
NC 6 [c]	High	High	V Susc	High	High [d]	—	High	High	Susc
NC 7 [c]	High	High	—	—	High	High			
NCBH 129	High	High	V Susc	High	Susc	Susc	Susc	Susc	Susc
PF-561	High	High	High	—	Mod	—	—	—	Tol
Rickard 6-10	Mod	High	—	—	Mod	—	Susc	Susc	Tol
Rickard 7-11	Mod	High	—	High	Susc	—	Susc	Susc	Susc
TN 86	High	Susc	V Susc	High	Mod	—	High	Mod-High	Susc
TN 90	High	High	V Susc	High	Mod	—	High	Mod-High	Tol
TN 97	High	High	Susc	High	Mod	—	High	Mod	Susc
VA 509	Low	Susc	Low	High	Mod	V Susc	Susc	Susc	Susc

[a] Abbreviations used: Mod = Moderate; Tol = Tolerant; Susc = Susceptible; V Susc = Very Susceptible; — = Not Tested.
[b] High resistance to Race 0 only, highly susceptible to Race 1. *[c] Has high resistance to root-knot nematode.*
[d] High resistance to Race 0 and low resistance to Race 1. *[e] High resistance to both Race 0 and Race 1.*

farm, choose one of the varieties from Table 9-1 that have moderate to high resistance to black shank. However, even resistant varieties can be damaged by disease when pathogen levels are high or when other management tools are not used. The use of resistant varieties is only one part of an effective disease management program.

Chemical Control

Chemical control is used to manage diseases when crop rotation is ineffective or resistance is not available. For example, crop rotation has no effect on the occurrence of blue mold, and only a few blue mold resistant varieties are available. Hence chemical control is an important step in preventing blue mold. In other cases, chemicals are used in combination with crop rotation and resistance to improve the level of disease control. For example, black shank is managed best by combining the use of resistant varieties with chemical treatment of the soil.

Disease Management During Transplant Production

The availability of disease-free transplants is essential to producing a successful burley crop. A grower's first question should be, "Where will I get transplants for my next crop?" And the answer should be, "I'll grow my own and do the best job I can to produce healthy plants."

Some past blue mold epidemics were the direct result of importing transplants infected with blue mold into our burley area from either out of state or from outside the region. Other diseases, such as black shank and target spot, have also been introduced on transplants produced out of state. Growing your own transplants is your best assurance that you do not bring someone else's disease problem to your farm. The following section describes seedling diseases that have given growers problems in the past and offers control recommendations.

Seedling Diseases

Salt injury. This problem results when high concentrations of soluble salts are found near the soil surface. Symptoms are most pronounced in dry weather. Plants affected by high soluble salts become dehydrated, wilt, and may turn yellow with browning or burning along leaf margins. In extreme cases, plants die. A white coating on the soil surface indicates that high salt levels are present. Frequent shallow waterings enhance the problem, whereas thorough drenching of the beds for two or three consecutive days will correct the condition.

Angular leaf spot. Angular leaf spot (ALS) or blackfire is caused by a bacterium that is closely related to the wildfire bacterium. ALS lacks the yellow halo observed with wildfire. Also, varieties resistant to wildfire are not necessarily resistant to ALS. Spots are initially water-soaked and circular to slightly angular. As time progresses, the spots turn tan, brown, or black and angular. Some plant beds have been seriously affected by ALS in the past, especially during wet conditions. The angular leaf spot bacterium can overwinter on old tobacco debris, and there is evidence it may be seedborne. Sprays with streptomycin have been effective in controlling this disease if applied when first observed. Since the disease is favored by moisture, irrigate beds only when leaves can dry before nightfall. Avoid late-evening irrigations.

Anthracnose. This fungal disease has not been prevalent in the recent past. However, it remains a potential problem. The disease causes spots that are initially small, water-soaked, and depressed. The spots enlarge to 3 millimeters ($^1/_{10}$-inch) in diameter and turn gray-white with a brownish border. Small plants can be stunted or killed. If diseased plants are transplanted to the field, the disease can continue to develop, causing leaf spots, petiole and stem cankers, distortion, and dwarfed plants. The fungus causing anthracnose overwinters on a number of host plants as well as on old tobacco trash. Take precautions to prevent surface drainage water from washing into the plant bed since it can carry the anthracnose fungus. Protectant fungicides aid in controlling this disease.

Boron deficiency. Boron deficiency can be mistaken for cold injury, with the exception that it develops during favorable weather for plant growth. The bud stops growing, and the leaves adjacent to the bud become yellow or whitish and are fluted and constricted where the leaves attach to the main stem. Soils and water supplies in the North Carolina burley area are generally low or deficient in boron. Refer to the fertilization sections (Chapters 4 and 5) for guidelines on the proper application of boron to prevent and correct this problem.

Blue mold. Blue mold is a serious threat to tobacco plants in float or plant beds and greenhouses. Humid, rainy weather during transplant production is very favorable for blue mold development. Young plants become systemically infected and die. Transplants infected with blue mold either remain stunted after transplanting or die. Spread of the pathogen will have already occurred by the time the disease is noticed. Infected transplants also act as an inoculum source, possibly infecting an entire crop. If blue mold shows up in the beds or greenhouse, it is advisable to destroy the transplants rather than plant them. Prevent blue mold by properly using protectant-type fungicides as outlined below.

Damping-off. Damping-off is a catchall term to describe a disease that kills young seedlings. The disease initially appears as random areas of wilted, yellow, stunted, or dead plants and can be caused by at least two different organisms, pythium and rhizoctonia. This disease is more prevalent in float systems than ground beds. Gassing beds with methyl bromide destroys these fungi in the soil, but they can easily be reintroduced after seeding. Thus, take care to prevent contaminated soil from being introduced into beds or float systems, and spray with protectant-type fungicides. ***Note:*** Nitrogen rates above 150 ppm promote rapid seedling growth, which results in succulent seedlings that are more susceptible to this disease.

Target spot. Target spot is a fungal disease caused by races of *Rhizoctonia solani* that are different from those causing damping-off in plant beds and greenhouses. Symptoms begin as small, circular water-soaked spots with a ring-like appearance when leaves are held up to a light source. The primary source of inoculum of this pathogen among seedlings is infested trays, therefore the best control method is sanitation of trays.

Recommendations for Outdoor Plant Beds

Drainage. The bed site should have good drainage within and around beds. Plant beds that have poor internal drainage favor development of damping-off, and beds where surface drainage is not diverted allow the introduction of diseases, including anthracnose, angular leaf spot, and black shank.

Fumigation. Fumigate beds at a rate of 1 to 2 pounds of methyl bromide per 100 square feet of bed. This treatment destroys weed seeds, pathogens, and insects in the soil.

Protectant fungicides. Spray plant beds weekly with a protectant fungicide to control damping-off, anthracnose, and blue mold. Start when plants have reached the size of a dime. Use either Dithane DF Rainshield at 1 tablespoon or Ferbam Granuflo (ferbam 76 percent) at 2 tablespoons per gallon of spray. Spray weekly, starting with 3 gallons at the first application and ending with 5 gallons per 100-square-yard bed at the last application before transplanting. ***Note:*** The federal labels for Forum, Acrobat 50WP, Acrobat MZ, and Actigard 50WG are **for field use** only and do not include plant bed use. Use of Actigard 50WG on burley seedlings may cause severe stunting, yellowing, death, or all of these.

Streptomycin. Should angular leaf spot appear, begin weekly applications of streptomycin (sulfate or nitrate). Mix 2 teaspoons of either the 17 or 21 percent formulation per gallon of water, and apply 3 to 5 gallons per 100 square yards. Repeat weekly until the disease stops, or up to five applications. Do not exceed the recommended rate since plant injury can occur.

Destroy plant beds. Destroy beds as soon as transplanting is completed. This is very important to prevent buildup or carry-over of diseases in the plant bed, especially blue mold, which could become a source for field infection.

Recommendations for Greenhouse and Float-Bed Transplant Production

It is important to prevent introduction of pathogens into the greenhouse. Thoroughly wash transplant trays and dip them in a 10 percent chlorine bleach solution before reusing. Rinse trays and allow them to air dry, then gas with methyl bromide. Stack trays cross-wise, cover with plastic to seal, and release from the top of the stack 3 pounds methyl bromide per 1,000 cubic feet of treated space. ***Warning:*** The methyl bromide treatment should be carried out only outdoors and not in a contained space such as a greenhouse. Use every precaution as instructed on the methyl bromide label.

Dithane DF Rainshield has a 24(c) registration in North Carolina for use during tobacco transplant production for blue mold control in greenhouse and float-bed systems. The rate for Dithane DF Rainshield is less in greenhouse and float-bed systems because of possible injury of more tender plants produced in these systems. ***Important:*** Mix only 1 level teaspoon of Dithane DF Rainshield per gallon of spray, and apply every five to seven days. Apply 3 gallons of spray per 1,000 square feet on small (dime-size) plants, and increase to 6 to 12 gallons per 1,000 square feet as plants grow. ***Note:*** Forum, a new BASF product, has replaced Acrobat MZ and Acrobat 50WP. Forum, Acrobat 50WP, Acrobat MZ, and Actigard 50WG are strictly prohibited in all transplant systems (greenhouse and float-bed).

Although Terramaster 35WP is no longer manufactured, Terramaster 4EC has a federal label for the control of pythium damping-off in tobacco float beds. Where pythium has been identified, apply Terramaster 4EC at 1.4 fluid ounces per 100 gallons of float water three weeks after seeding, or later, as a curative treatment. Mix thoroughly in the float water, and ***do not*** exceed the 1.4-ounces-per-100-gallon rate as severe stunting may result. ***Do not*** make applications later than 8 weeks after seeding.

In addition, avoid wetting foliage or allowing high humidity in the greenhouse. Make sure the greenhouse has a proper ventilation system that keeps leaves as dry as possible. A horizontal airflow system does this best. Add heat at night to reduce humidity in the greenhouse. Avoid overhead irrigation and fertilizer to keep leaves dry and reduce disease pressure. In addition, never dispose of used media or plants within 100 yards of the greenhouse.

Soilborne Diseases and Their Management

Black root rot, black shank, and root-knot are soilborne diseases present to varying degrees on farms in the burley production areas. These diseases interfere with water movement and nutrient uptake by plant roots. If you have been growing tobacco on the same land continuously for several years and yields have been declining, these diseases have probably been increasing. Determine whether pathogens are present and make plans to manage them.

Black Root Rot

Black root rot is a common soilborne disease in the burley area. Fields that have been in tobacco several years and show stunted and uneven growth in the first six weeks after transplanting are likely infested with the black root rot fungus, *Thielaviopsis basicola*. Black root rot can be distinguished from other soil problems by pulling up and examining plant roots. Affected roots have blackened root tips, and larger roots develop brown or black lesions. Black root rot can be controlled by using one or more of the measures described below.

Crop rotation. Rotating tobacco with nonleguminous crops such as corn or grass is an effective method of keeping the black root rot organism at low levels. However, in the mountain burley area, crop rotation is not always a viable alternative because of limited sites that are suitable for burley production. In this situation, one of the measures below may be necessary.

Resistant varieties. In fields where black root rot is known to be present, use resistant varieties. Highly resistant varieties, such as TN 86, TN 90, and NCBH 129, among others, do very well in fields infested with black root rot without crop rotation or soil fumigation. However, some growers prefer other varieties, such as Clay 403, NC 2000, and NC 2002, which are susceptible to the disease. In this case, crop rotation or use of a multipurpose fumigant would be beneficial.

Soil fumigation. A multipurpose fumigant may be beneficial where tobacco is grown continuously. Fumigants effective against black root rot include Telone C-17, Terr-O-Gas 67, and Chlor-O-Pic (see Table 9-4). Apply these materials in the row in high, wide beds at least three weeks before setting.

Black Shank

Black shank is a devastating disease of tobacco that has been increasing in North Carolina's burley area over the past several years. The disease is caused by the fungus-like organism *Phytophthora nicotianae*, which attacks the roots, stems, and lower leaves of tobacco plants. In North Carolina, fields infested with black shank usually contain races 0 and 1. However, since the deployment of the *Php* gene in resistant varieties (which provides complete resistance to race 0), incidence of race 1 has increased dramatically. Race 1 is now the dominant race in North Carolina. The sudden appearance of yellowed and wilted plants about six to eight weeks following transplanting is very striking. High soil moisture also enhances this disease. In many cases, black shank has been brought to the farm in contaminated soil on equipment or on transplants produced elsewhere. Or it has been introduced by irrigation or floodwaters downstream from a field infested with black shank. If black shank is present on your farm or if your field has been flooded from weather events, plan to reduce or prevent losses by using a combination of the management practices described below.

Crop rotation. Rotating tobacco is an effective way to reduce populations of the black shank pathogen because tobacco is the only reported host for this organism. Because the pathogen is persistent, rotation will not eliminate the organism entirely, even after long rotations, so plan to use other control measures outlined below.

Resistant varieties. Do not plant highly susceptible cultivars such as KY 14, Clay 403, NC 2000, or NC 2002 in fields where black shank has been identified. Instead, consider cultivars with moderate resistance to both Race 0 and Race 1 (for example, VA 509, TN 86, or the newer variety, KT 204 LC). KY 14 × L8 is highly resistant to Race 0, but very susceptible to Race 1 of black shank. If black shank was evident on this variety in the past, use a variety with moderate resistance to all races of the pathogen (Table 9-1). Some newer varieties (for example, KY 910) are highly resistant to Race 0, but have low to moderate resistance to Race 1 (Tables 9-2 and 9-3). However, it is ***not*** advisable to continue planting the same variety year after year in the same black-shank-infested field as the black-shank pathogen can overcome plant resistance in time. Never plant the same variety more than two years in a row in an infested field.

Chemical control. If rotation is impractical, satisfactory control can usually be achieved by planting a resistant variety as well as applying the higher labeled rate of Ridomil Gold EC (2 to 3 pints per acre) or Ultra Flourish (2 to 3 quarts per acre). ***Note:*** Ridomil Gold SL is a new formulation replacing Ridomil Gold EC. A split application of Ridomil Gold SL (or Ultra Flourish), for example, 1 pint (1 quart) preplant, 1 pint (1 quart) at first cultivation, and 1 pint (1 quart) at lay-by, will provide better black shank control than if the chemical is applied all at once. Using Ridomil alone with a susceptible variety will not normally provide sufficient control. Failure to control nematodes in fields treated with these chemicals may result in poor control of black shank. Soil fumigants are moderately effective in reducing losses to black shank but may not eliminate the pathogen, therefore they also should be used only with resistant varieties (see Tables 9-2 and 9-3).

Fusarium Wilt

Fusarium wilt causes yellowed and wilted leaves usually on one side of the plant. Plants may look like they are infected with black shank,

Table 9-2. Variety and Ridomil effects on black shank (Race 0)

			Percentage of Plants with Black Shank					
	Resistance		Effect of Variety (No Ridomil)			Treated with Ridomil Gold		
Variety	Race 0	Race 1	7/1	7/30	8/26	7/1	7/30	8/26
Clay 403	susc	susc	16	93	100	0	46	95
TN 90	mod	mod	0	8	22	0	1	6
TN 97	mod+	mod+	0	6	10	0	0	2
KY 14 × L8	high	susc	0	10	18	0	0	0
KY 910	high	mod -	0	1	2	0	0	0
NC 9805	high	mod -	0	0	0	0	0	0

Note: Results of an on-farm test at the Joe Ramsey farm, Buncombe County, in 1999. Race 0 was the predominant black shank strain present. Ridomil Gold 4EC treatments were applied three times: 1 pt/a at transplanting, first cultivation, and lay-by.

Table 9-3. Variety and Ridomil effects on black shank (Race 1)

Variety	*Resistance*		*Percentage of Plants with Black Shank*					
			Effect of Variety (No Ridomil)			*Treated with Ridomil Gold*		
	Race 0	*Race 1*	*7/2*	*7/30*	*8/26*	*7/2*	*7/30*	*8/26*
Clay 403	*susc*	*susc*	*51*	*90*	*98*	*0*	*29*	*66*
TN 90	*mod*	*mod*	*0*	*8*	*33*	*0*	*0*	*4*
TN 97	*mod+*	*mod+*	*0*	*3*	*26*	*0*	*0*	*0*
KY 14 × L8	*high*	*susc*	*4*	*23*	*49*	*0*	*0*	*8*
KY 910	*high*	*mod -*	*0*	*17*	*44*	*0*	*1*	*6*
NC 9805	*high*	*mod -*	*1*	*12*	*47*	*0*	*0*	*1*

Note: Results of an on-farm test at the Jerry Garland farm, Yancey County, in 1999. Race 1 was the predominant black shank strain present. Ridomil Gold 4EC treatments were applied three times: 1 pt/a at transplanting, first cultivation, and lay-by.

except the base of the stalk will not be black. This disease was virtually eliminated many years ago by the development of resistant varieties, but it has recently reappeared. Burley varieties, such as KT 204 LC, TN 86, TN 90, NCBH 129, NC 2000, and NC 2002, are very susceptible to fusarium wilt. Thus, planting these varieties may eventually cause buildup and appearance of this disease. Returning to varieties with resistance to fusarium wilt is the best control strategy.

Granville Wilt

Granville wilt, also known as bacterial wilt, was first identified in Granville County, North Carolina, in the 1880s. The disease occurs in warm-temperate zones around the world, and is particularly serious in Asia, and North, South, and Central America. In the U.S., Granville wilt is only a problem in the traditional flue-cured areas of North and South Carolina. However, growers are now more concerned about this disease due to the expansion of burley production into the piedmont and coastal plain of North Carolina. This disease causes wilting, stunting, and yellowing of foliage; symptoms can show up during any stage of plant growth. On young plants, wilting of one or more leaves will occur during the hottest part of the day, followed by recovery in the evening. Often, leaves will wilt only on one side of the plant. Plants with Granville wilt have dark brown to black streaks within the internal stalk tissue just beneath the outer bark, instead of a uniform, medium brown discoloration as seen in plants infected with fusarium.

Granville wilt is caused by the persistent soil bacterium *Ralstonia solanacearum*, which also infects tomato, potato, pepper, eggplant, and peanuts. Currently, there are no burley varieties with resistance to Granville wilt. An integrated approach should be taken to manage this disease, including crop rotation, nematode management, soil fumigation, and stalk-and-root destruction at the end of harvest.

Root-knot

Root-knot is generally not a problem on burley tobacco in western North Carolina. However, root-knot nematodes (*Meloidogyne* species) may become damaging during hot and dry seasons. Affected crops are stunted; have yellow, thin leaves; and produce low yields. The presence of galls and irregular enlargements on the roots are indications that root-knot nematodes are present. Soil samples may be sent to the Nematode Advisory Service of the North Carolina Department of Agriculture and Consumer Services Soil Testing Laboratory for assay. Root-knot nematodes may be managed by a three-year crop rotation with corn or other grain, or by use of any of the fumigant or nonfumigant nematicides (see Table 9-4). Clay Hybrid 402, NC 2, NC 3, NC 5, and NC 6 have very high resistance to root-knot nematodes.

Soil Fumigation Considerations

Some burley farmers may choose to use fumigation, based on definite need and expected benefit. Generally, fields in continuous tobacco production with declining yields will probably benefit from fumigation (see Table 9-4). Multipurpose fumigants (Telone C-17, Terr-O-Gas 67, and Chlor-O-Pic 100) should be used for the fungal diseases black root rot, black shank, fusarium wilt, and Granville wilt. Root-knot nematodes can be controlled with both fumigant (Telone II) and nonfumigant (for example, Nemacur 3 and Mocap) nematicides, as well as with multipurpose fumigants. When using these materials, follow all directions and precautions carefully. Refer to Table 9-4 for information on fumigants.

Foliar Diseases

Blue Mold

Blue mold disease is caused by *Peronospora tabacina*, a fungus-like organism that is not known to overwinter in tobacco-producing areas in the U.S. Likely sources of yearly blue mold epidemics are windblown spores from tobacco crops in Mexico and the Caribbean, or from wild tobacco in the southwestern United States. Blue mold is introduced into North Carolina every year by windblown spores from infected tobacco in other states or from the importation of infected transplants. Once blue mold is present, its development depends on weather conditions. Spores require wet leaves for germination and infection. Cloudy weather increases susceptibility; sunlight is fatal to spores and stops the production of new spores. Therefore, blue mold is most severe during periods of cloudy, wet weather and stops developing during sunny, dry weather.

Blue mold occurrence has been variable in North Carolina's burley crop since 1995. In 2008, the blue mold epidemic was the lightest on record. Only 11 counties in the U.S. and southern Canada had reported infections. Only one report of blue mold came from the mountains of western N.C., in Haywood County, on September 5. In 2003 through 2006, weather conditions were very favorable for the disease; however, resistant varieties and other control methods prevented rapid spreading and kept disease severity low in the burley region of North Carolina. All isolates of the blue mold pathogen collected in recent years tested in Kentucky and North Carolina have been resistant to Ridomil. With the development of Ridomil-resistant strains of the pathogen, the disease has become more difficult to control. Growers can do several things, however, to reduce the risk from this very important disease.

Burley transplants. You should produce your own transplants or ob-

Table 9-4. Fumigants for soilborne disease control

Disease	*Material*	*Amount per acre*	*Waiting period before planting*	*Precautions*
Root-knot [a]	*Fumigant dichloropropene (Telone II)*	*6 gal*	*21 days*	*Rates are for in-row injection. Apply 6 to 8 inches deep and form a high, wide bed. Apply when the soil is above 55°F and moist, but not wet. If soil is wet following application, you may need to wait longer than three weeks before transplanting to avoid injury. Follow all instructions on manufacturer's label.*
Black root rot *Black shank* *Root-knot* *Fusarium wilt* *Granville wilt*	*Multipurpose fumigants* *dichloropropene + chloropicrin (Telone C-17)* *chloropicrin (Chlor-O-Pic 100) (Chloropicrin 100) (PicPlus)*	*10.8 gal* *3 gal*	*21 days* *21 days*	

[a] *Non-fumigants such as ethoprop (Mocap 10G/15G/EC), and carbofuran (Furadan 4F) also are labeled for root-knot nematode. See the* 2009 North Carolina Agricultural Chemicals Manual.

tain them locally to avoid bringing in blue mold on infected transplants from out of state. Spray seedlings every five to seven days with a protectant fungicide. In outdoor beds, spray weekly with either Dithane DF Rainshield at 1 tablespoon or Ferbam Granuflo (ferbam 76 percent) at 2 tablespoons per gallon of spray, starting when plants are the size of a dime. Apply 3 to 5 gallons of spray per 100 square yards of bed. In greenhouse and float-bed systems, use a lower rate of Dithane DF Rainshield (1 teaspoon per gallon), starting at 3 gallons per 1,000 square feet when plants are small and increasing to 6 to 12 gallons per 1,000 square feet just before transplanting.

Field. Regional growers have relied on Acrobat MZ (a prepackaged mixture of dimethomorph and mancozeb) for blue mold control for several years. However ***Acrobat MZ is no longer manufactured and has been replaced with Acrobat 50WP*** (dimethomorph only). To make this even more confusing, Acrobat 50WP has also been replaced with a liquid formulation of dimethomorph with the trade name of *Forum*. Because dimethomorph has been reported to select for resistance in other pathogens when not used with a protectant fungicide, the label requires application of Forum only in tank mixtures. The current recommendation for tank mixing is Dithane DF Rainshield (mancozeb), which has a 24(c) registration in the state of North Carolina. Actigard 50WP, metalaxyl, and mefenoxam are not suitable mixing partners with Forum due to different methods of application and label restrictions. When blue mold threatens, tank mixes of Forum and Dithane DF Rainshield should be applied weekly anytime between transplanting and topping. No phytotoxic (damaging) effects have been observed with this combination. Actigard 50WG also is effective against blue mold and should be used preventively, but it may be applied with a low-pressure sprayer directed over top of the row; complete coverage is not necessary. It has a narrow window of use, starting when tobacco is 18 inches high or approximately five weeks after transplanting and up to topping. Actigard 50WG may be phytotoxic on burley tobacco, causing yellowing, stunting, and yield loss if applied during the first four weeks after transplanting. Actigard 50WG is a systemic product that induces the plant to resist blue mold ***beginning four to five days following application***. The induced resistance will persist for approximately 10 days, and Actigard 50WG must then be reapplied to continue protection. Due to this four- to five-day delay in plant response to Actigard 50WG, this chemical is not recommended as the first chemical application when blue mold is forecasted immediately in your area. Use the following guidelines for applying

Acrobat 50WP and Actigard 50WG.

When blue mold warnings are issued for your area, begin weekly sprays with tank mixes of Forum and Dithane DF Rainshield using the rates listed in Table 9-5. Apply 20 gallons of spray solution per acre within three weeks of transplanting, increasing the number of gallons per acre as plants grow, up to a maximum of 100 gallons of spray solution per acre. Do not exceed 32 ounces per acre total for the season. Spray to obtain complete coverage, and before blue mold shows up in the field. Because thorough coverage is critical for control, application of Forum tank mixes is allowed only with tractor-driven air-blast equipment, mist blowers, and some aerial equipment. See Figure 9-1 for a suggestion of when to use tank mixes of Forum or Actigard 50WG according to the labels. Other products are labeled for blue mold control, but some are phytotoxic to burley and some are not as effective as Forum or Actigard (see Table 9-6). ***Note:*** Use only properly registered products. Always follow label instructions carefully to avoid possible damage.

Field fungicide application. For tank mixes of Forum to effectively control blue mold, you must start spraying early, spray at least weekly, and cover the entire plant. Start sprays when blue mold warnings are issued; do not wait until there is widespread disease in the field. Repeated applications are necessary to protect new growth. Leaf area can more than double in a week, so 50 percent or more of the leaf

Table 9-5. Tank mix rates for Acrobat 50WP or Forum + Dithane DF Rainshield

Weeks of Growth after Transplant	Tank Mix Rate		Spray Volume for Tractor-driven Sprayer (gallons/acre)	Spray Volume for Backpack Mist Blowers (gallons/acre)
	Acrobat 50 WP (oz) or Forum (fl oz)	Dithane DF Rainshield (oz)		
Recently transplanted to 3 weeks after transplanting	2	6	20	10
3-4 weeks (knee high)	3	12	40	20
4-5 weeks (waist high)	4	18	60	30
6-7 weeks (chest high)	6	24	80	40
7 weeks after transplanting & beyond (shoulder high) [a]	7	30	100	50

[a] shoulder height until topping

can be unprotected following an earlier fungicide application. With tank mixes of Forum, spray for maximum coverage by using a high-pressure sprayer, with sprayer drops between rows, and hollow-cone nozzles (see Figure 9-2). For small plantings of up to 1 acre, a backpack mist blower can be used effectively, provided care is taken to cover all plant surfaces with the spray. As an alternative to Forum, Actigard 50WG may be used once tobacco reaches 18 inches (approximately five weeks after transplanting). Make two over-the-row applications, 10 days apart, at 0.5 ounce of product per 20 gallons per acre. If blue mold threatens before plants reach 18 inches tall and 10 days after the second Actigard application, protect plants with tank mixes of Forum. A video, "Blue Mold: Controlling a Devastating Disease," is available from Communication Services in the College of Agriculture and Life Sciences at N.C. State University. Contact your county Extension center for more information.

Table 9-6. Blue mold fungicide test results, Mountain Research Station, Waynesville, N.C., 2006

Material and Amount	*Application Timing*	*Phytotoxicity Rating (0-5)* [a]	*Blue Mold % LAD* [b] *Aug 28*
Nontreated control	—	*0.4*	*38.9*
Acrobat 50WP tank-mixed with Dithane DF [c]	*preventive (7 appl)*	*0.0*	*1.2*
Forum tank-mixed with Dithane DF [c]	*preventive (7 appl)*	*0.0*	*0.7*
Quadris 8.0 fl oz	*preventive (1 appl at lay-by)*	*1.2*	*32.8*
Quadris 16.0 fl oz	*preventive (1 appl at lay-by)*	*1.3*	*23.3*
Quadris 32.0 fl oz	*preventive (1 appl at lay-by)*	*1.2*	*19.3*
Reason 500 SC 5.5 fl oz [d]	*preventive (7 appl)*	*0.0*	*1.0*
Reason 500 SC 8.2 fl oz [d]	*preventive (7 appl)*	*0.0*	*0.8*
Aliette 80 WP 3.0 lb	*preventive (7 appl)*	*1.0*	*2.7*
Quadris 16 fl oz ***and*** *Acrobat 50WP tank-mixed with Dithane DF* [c]	*preventive (1 appl at lay-by) preventive (7 appl)*	*0.5*	*0.5*

[a] Phytotoxicity ratings were based on 0-5 scale where: 0 = none, 1 = trace, 2 = light, 3 = moderate, 4 = heavy, 5 = severe weather fleck.

[b] % LAD is an estimate of the percentage of leaf area damaged by blue mold.

[c] Depending on plant size: Acrobat 50 WP rates ranged from 4.0 to 7.0 oz; Dithane DF rates ranged from 18.0 to 30.0 oz; and Forum rates ranged from 4.0 to 7.0 fl oz (see Table 9-6).

[d] Reason is a product from Bayer CropScience that is ***not*** *yet labeled for tobacco.*

Variety resistance. North Carolina State University plant breeders have been selecting and breeding for resistance to blue mold for several years and have released NC 2000 and NC 2002. Both varieties have shown good resistance to blue mold in fungicide trials at Waynesville and Laurel Springs (Table 9-7). However, these varieties are not resistant to black shank. Growers not equipped to spray with fungicides might consider growing these varieties, provided black shank is not present. All other commercial varieties are susceptible to blue mold, but some appear more tolerant than others (see Table 9-8). As indicated by Table 9-8, spraying with dimethomorph (along with mixing partner Dithane DF Rainshield) will maximize a variety's yield potential.

Other precautions. Cultural and sanitation practices can prevent the establishment of blue mold or slow its spread.

- Destroy plant beds as soon after transplanting as possible. Conditions in an old plant bed are usually ideal for establishing

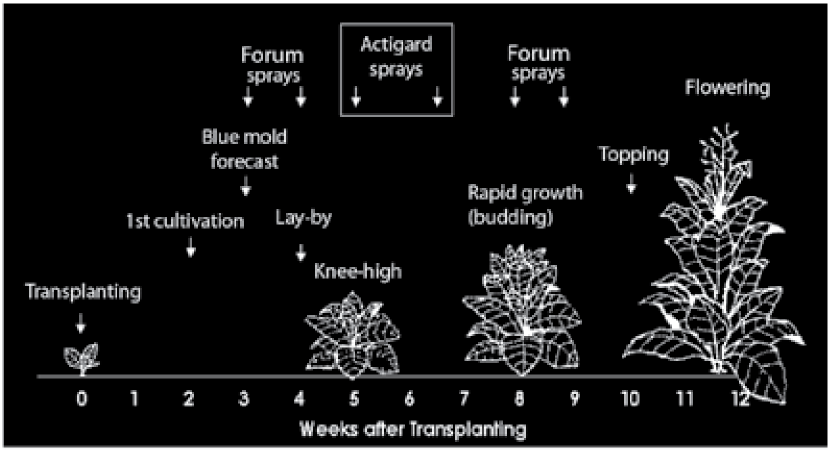

Figure 9-1. Burley growth and fungicide applications for blue mold. *This figure shows one possible strategy for using Forum and Actigard 50WG to manage blue mold. If blue mold is forecast the third week after transplanting, begin weekly sprays of Forum tank mixes. At week five (18-inch tobacco), make the first of two applications of Actigard 50WG.Apply the second 10 days later. If blue mold-favorable weather persists, continue with Forum tank mixes until topping.*

the disease and for spreading spores to the crop in the field.

- Avoid planting areas in the field that receive early morning or late afternoon shade. Blue mold will become established in shaded areas first, even during relatively unfavorable conditions. Once established in the shade, it will move into the rest of the field when weather conditions become more favorable.
- Avoid close plant spacing, both in the row and between rows. Close plant spacing contributes to shading, reduces air movement, and prolongs wetting of foliage, factors that favor disease development. Plants should be at least 18 inches apart in rows 4 feet apart. Spacing this wide or wider will help slow disease spread.
- Do not harvest early if blue mold begins to develop late in the season. Top plants at the button stage and allow leaves to mature and gain weight normally. Topping slows development and further spread of the blue mold organism.

Blue mold forecasts. The North American Plant Disease Forecast Center, located at N.C. State University, issues blue mold forecasts each Monday, Wednesday, and Friday, 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

Table 9-7. Blue mold variety test results, 1999, 2000, and 2001 [a]

	1999		2000		2001	
Variety and Treatment	% LAD [b] Aug 10	Yield lb/a	% LAD July 26	Yield lb/a	% LAD July 31	Yield lb/a
Clay 403, nontreated	41.8	3,523	48.3	2,772	35.4	2,596
TN 90, nontreated	10.7	3,592	26.3	2,676	9.6	2,549
NC 2000, nontreated	2.8	3,503	1.4	2,965	1.4	2,702
NC 2002, nontreated	1.9	3,889	6.4	2,801	3.9	2,839
Clay 403, Acrobat MZ	3.3	4,182	2.8	3,191	1.8	3,340

[a] 1999 and 2000 results are from Mountain Research Station, Waynesville, N.C., and 2001 results are from Upper Mountain Research Station, Laurel Springs, N.C.
[b] % LAD is an estimate of the percentage of leaf area damaged by blue mold.

wind models are used to generate maps of spore movement, reports of favorable weather conditions and of regional weather, and the ***outlook*** for new outbreaks (high, medium, or low risk). The forecasts, plus additional information, are available on the World Wide Web at **http://www.ces.ncsu.edu/depts/pp/bluemold/** and by calling toll-free at 1-800-662-7301 (press 2 for burley).

Every county Cooperative Extension center is linked to the forecast system, and agents can provide growers with timely information on blue mold. An example of a blue mold forecast for eastern Tennessee and western North Carolina burley is shown in Figures 9-3 and 9-4. The disease was forecast to move from southeastern Georgia toward the burley region on May 15, 2002 (Figure 9-3). Blue mold was reported near Jonesborough, Tennessee, on June 6. Later, the disease was forecast to move from the Jonesborough area to northwestern North Carolina and was discovered in Avery and Watauga counties on July 10. Map trajectories show the source of spores, the pathway the spores will follow in the wind, and the risk of infection, all based upon forecasts for the next 48 hours. These forecasts can provide growers with two days' warning should they decide to apply protectant fungicides.

If blue mold appears on your farm this season, contact your county Extension agent so he or she can inspect your crop to confirm the

Figure 9-2. Spraying fungicides in burley tobacco with a high-pressure hydraulic boom sprayer with drop nozzles between rows. *The proper sprayer provides maximum spray coverage, which is necessary to control blue mold with foliar-applied fungicides.*

Table 9-8. Blue mold damage rankings for different burley varieties and yields from nonsprayed and Acrobat MZ-sprayed research plots at Laurel Springs, N.C., 1996 and 1997

	Percentage of Blue Mold Damage in Nonsprayed Tobacco				Yields (lb/a)								Gain from Spraying
					Nonsprayed				Acrobat MZ-sprayed				
Variety	1996	1997	Avg	Rank*	1996	1997	Avg	Rank	1996	1997	Avg	Rank	lb/a
PF 561	17.3	10.7	14.0	1	2,158	2,608	2,383	1	2,409	2,634	2,522	10	139
TN 90	15.1	15.1	15.1	2	2,179	2,039	2,109	8	2,481	2,767	2,624	4	515
R 6-10	17.3	15.1	16.2	3	2,041	2,291	2,166	6	2,365	2,728	2,546	8	380
KY 14 × L8	19.6	15.1	17.4	4	2,260	2,490	2,375	2	2,521	2,715	2,618	5	243
TN 86	26.3	14.1	20.2	5	1,784	2,179	1,982	11	2,361	2,797	2,579	6	597
NCBH 129	32.8	21.8	27.3	6	1,881	2,082	1,981	12	2,278	2,737	2,507	11	526
VA 509	35.4	19.6	27.5	7	2,155	2,189	2,172	5	2,125	2,741	2,433	13	261
KY 907	35.4	21.8	28.6	8	1,845	2,247	2,046	10	2,409	2,655	2,532	9	486
NC 3	35.4	30.8	33.1	9	1,965	2,239	2,102	9	2,393	2,718	2,556	7	454
NC 2	41.8	30.8	36.3	10	1,715	2,036	1,876	13	2,239	2,285	2,262	14	386
R 7-11	30.8	43.8	37.3	11	2,084	2,350	2,217	3	2,679	3,138	2,909	2	691
KY 14	50.3	30.8	40.6	12	1,825	2,505	2,165	7	2,635	2,909	2,772	3	607
Clay 403	48.3	37.3	42.8	13	1,993	2,360	2,176	4	2,877	3,153	3,015	1	839
KY 8959	54.8	37.3	46.0	14	1,672	1,852	1,762	14	2,311	2,581	2,446	12	684

Variety rankings from 1-14 are from least to most susceptible to damage from blue mold and from highest to lowest in yield for nonsprayed and Acrobat MZ-sprayed tobacco based on two-year averages.

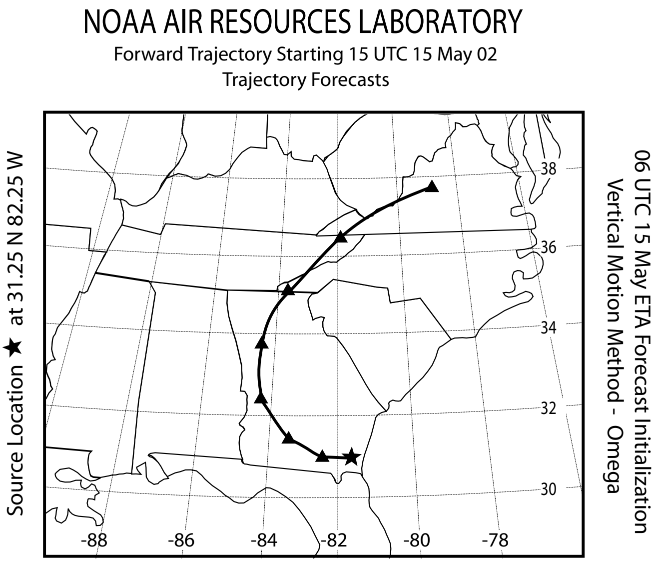

Figure 9-3. Blue mold trajectory from southeastern Georgia over Jonesborough, Tennessee, on May 15, 2002

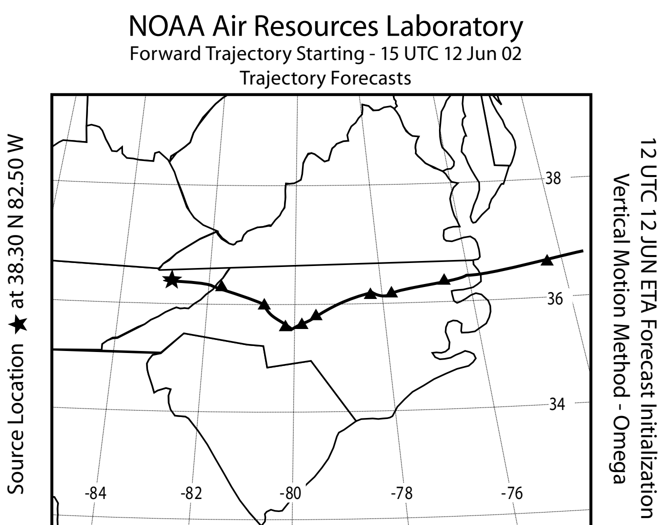

Figure 9-4. Blue mold trajectory from Jonesborough, Tennessee, area over northwestern North Carolina on June 12, 2002

disease. This way, other farmers can be alerted to its presence and will have time to take the necessary preventive measures against the disease.

Brown Spot

Brown spot is a fungal disease caused by *Alternaria alternata*, which is carried over from crop to crop on leaf and stalk debris left in the field at the end of the season. Usually, brown spot causes only minor damage. However, some fields have had heavy losses. Besides the characteristic brown leaf spots, the fungus also can induce formation of leaf abscission layers, which cause premature leaf drop. Various factors, including variety, excess nitrogen, and nematodes, may enhance the development of brown spot. No fungicides are registered for control of brown spot; however, treatments for blue mold control will also reduce brown spot.

Target Spot

Target spot is a fungal disease caused by races of *Rhizoctonia solani* that are different from those causing soreshin. Due to weather conditions during the growing season in 2005, target spot was a serious problem in North Carolina, as saturated soils and leaf moisture favored spore formation and germination of this fungus.

Target spot is difficult to distinguish from brown spot; both diseases are favored by frequent rainfall and high humidity. With target spot, as the lesions enlarge, they become somewhat circular, light colored, and papery thin with a target-like pattern of concentric rings. Because the lesions are fragile, these areas usually drop out from the leaf, leaving a shot-hole appearance. The severity of this disease depends on weather conditions, as the pathogen is always present in our soils.

Quadris flowable fungicide received a label in 2006 to help control this disease on flue-cured and burley tobacco as this product provides superior control of target spot when applied once at lay-by (16 to 32 fl oz). In previous trials conducted by N.C. State University, the application of Quadris caused a phytotoxic reaction on burley tobacco by increasing weather flecking (see Table 9-6). However, this level of spotting should not typically affect yield or leaf quality. Removing the lower leaves and ensuring adequate nitrogen are the only alternative management tactic currently available for target spot on burley tobacco.

Viral Diseases

Viral diseases can cause significant losses to burley crops in North Carolina. Virus incidence varies from year to year, and during the past 25 years it has ranged from a high of 60 percent in 1979 to a low of 5 percent in 1982. Several viruses occur in the crop, and their incidence may vary from region to region.

Tobacco vein mottling virus and tobacco etch virus are the two most important found in burley tobacco in North Carolina. Other viruses, such as alfalfa mosaic virus (AMV), tobacco streak virus, tobacco ringspot virus, and potato virus Y (PVY), are generally of low incidence but occasionally cause significant losses in individual fields. PVY is of concern because its incidence has been increasing recently, and some strains of the virus can cause severe losses in burley tobacco. In fact, a damaging necrotic strain of PVY was found for the first time on burley tobacco in North Carolina in 1988. Another virus causing severe damage that appears to be increasing in North Carolina, especially in flue-cured tobacco, is tomato spotted wilt virus (TSWV). Incidence of TSWV this past growing season in 2007 was rather high due to dry weather conditions favoring thrips populations.

Tobacco vein mottling virus and tobacco etch virus are transmitted by aphids and overwinter in several species of weeds. Controlling aphids with insecticides in individual North Carolina tobacco fields has proven ineffective in reducing virus incidence. Eliminating inoculum sources, primarily weeds, is not practical under the cultural conditions where burley tobacco is produced. The most effective control for tobacco vein mottling virus and tobacco etch virus is the use of tolerant and resistant varieties. KY 14, once widely planted, has moderate tolerance to these viruses. Newer varieties such as TN 86, TN 90, NC 2, NC 3, NC 7, and KY 907, have moderate to high resistance to tobacco vein mottling virus and tobacco etch virus. However, some of these varieties are susceptible to tobacco mosaic virus (TMV), AMV, and the necrotic strain of PVY.

For more information on these viruses and their epidemiology, see *Plant Pathology Information Notes* 194, 197, 203, and 246, available at your county Cooperative Extension center.

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.

10. Disease Management in the Piedmont and Coastal Plain

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In the past few years, more than half of North Carolina's burley crop has been produced outside the mountains—the traditional burley-growing region. Now burley is being grown in both the piedmont and coastal plain by growers who traditionally have grown flue-cured tobacco. This situation created the need for investigating some of the most important diseases of tobacco, black shank and Granville wilt, under conditions prevailing in the nontraditional burley areas of North Carolina. The current chapter is a brief summary of our investigations since 2006.

The Tobacco Disease Situation

Black shank caused the highest losses in burley crop value due to disease in North Carolina during 2009. Most of the black shank losses reported were noted in fields where varieties with complete resistance to race 0 of black shank have been extensively used. Timely application of mefenoxam assisted several growers in avoiding high losses from black shank this year. In 2009, there was a light epidemic of blue mold. Blue mold reported in five counties in North Carolina. All cases but one were burley tobacco.

Field Diseases

It is not advisable to plant burley tobacco in fields that were previously planted in flue cured tobacco for several years, even if diseases were not observed in the flue cured crop previously.

Black Shank. Rotation, varietal resistance, and chemicals are usually integrated into a management program for black shank. Resistant varieties are an important tool for managing black shank. In 2006 – 2008, on-farm variety tests were conducted in fields where race 1 was the predominant strain. Most burley varieties did not have high levels of resistance to black shank (Table 10-1). When compared to flue-cured tobacco, burley starts showing black shank symptoms earlier, and final mortality is higher than in flue-cured varieties. In 2009, on farm trials were conducted with burley commercial cultivars and experimental lines. Some of the experimental lines demonstrated high levels of resistance equivalent to resistance incorporated in flue cured tobacco. This effort will continue in the next few years. When chemical control is used in a timely manner, the final percentage of dead plants can be as low as in flue-cured varieties (Table 10-2).

Table 10-1. Resistance ratings of certain varieties to black shank, race 1, and Granville wilt

Variety	*Black Shank Rating*[a]	*Granville Wilt Rating*[a]	*Average Rating*
BURLEY			
KT 200	*7*	*31*	*19*
KT 204	*11*	*27*	*20*
NC5	*16*	*31*	*24*
KTH 2406	*2*	—[b]	—
NC 7	*23*	*34*	*28*
L 8	*45*	—[b]	—
NC 6	*31*	*27*	*29*
KT 206	*7*	—	—
NC 2002	*58*	*50*	*54*
Ky 14 × L8	*52*	—	—
NC 2000	*70*	*53*	*61*
FLUE-CURED			
K 346	*14*	*19*	*17*
NC 71	*27*	*31*	*29*
NC 72	*32*	*23*	*27*
CC 27	*30*	*17*	*23*
K 326	*34*	*29*	*33*

[a]*Disease index was calculated as for the flue-cured varieties. Thus, disease indices for flue-cured and burley cultivars are directly comparative. The disease index was calculated from all disease incidence evaluations, and earlier evaluations were more heavily weighted. Thus, the disease index reflects both disease incidence (percentage) as well as the time of the season that the disease appeared. Higher indices reflect more disease.*

[b]*No ratings available.*

Table 10-2. Ridomil Gold SL effect on black shank, race 1, by variety

		% of Plants with Black Shank			
Rate	Timing	K 326	NC 71	NC 7	KY 204
Untreated		79	63	68	28
1 pt/acre	Layby	59	41	41	10
1 pt/acre	1st cultivation, layby	3	2	3	0
1 pt/acre	Layby, 3 weeks after layby	60	57	29	16
1 pt/acre	Pretransplant, 1st cultivation, Layby	7	2	3	2

Results from an on-farm test at the Badgett Farm in Surry County in 2007. Similar results were obtained from a second on-farm test at Weavil Farm in Forsyth County in 2007.

Granville Wilt. The recommended ways to manage Granville wilt include these strategies:

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.

Several burley varieties are not resistant to Granville wilt (Table 10-3). However, when a fumigant is applied, burley mortality is reduced significantly (Table 10-3). Fumigant and variety effect varies and depends significantly on the Granville wilt severity in each field.

Pesticides should be used only when cultural practices alone cannot manage the disease satisfactorily. Pesticide environmental impact must be carefully considered. For optimum benefit, it is essential to know the disease and its severity. Also, 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 that is most effective on a different problem. Chemicals aid in disease control only if used properly. For soil application, the soil must be in good tilth—not too dry or too wet. Chemical effectiveness is usually directly related to a material's ability to move freely in the soil. Thus, 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.

Table 10-3. Fumigant effect on Granville wilt by variety

Variety	Granville Wilt Rating[a]			
	Edgecombe County, 2006		Franklin County, 2006	
	No Fumigation	Chloropicrin 3 gal/acre, row	No Fumigation	Chloropicrin 3 gal/acre, row
KT 204	55	10	4	5
NC 2000	64	20	57	37
NC 2002	65	32	48	25
NC 3	66	22	27	12
NC 6	45	26	12	10
NC 7	61	48	13	6
TN 90	71	23	1	2

[a]*The lower the rating, the more resistant the variety.*

Other Resources

Tobacco Disease Information Notes. Plant Pathology Extension, NC State University. Available from your county Cooperative Extension center and online:
Granville Wilt (TDIN-002). www.ces.ncsu.edu/depts/pp/notes/Tobacco/tdin002/tdin002.htm
Black Shank (TDIN-004). www.ces.ncsu.edu/depts/pp/notes/Tobacco/tdin004/tdin004.htm

Shew, H. D. 1991. *Compendium of Tobacco Diseases*. St. Paul, Minn.: American Phytopathological Society.

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

A Precautionary Statement on Pesticides

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11. Topping And Sucker Management

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Topping

Topping in the button stage gives tobacco the desired chemical and physical characteristics that lead to high yields of high-quality leaf. Delayed topping beyond the button- to first-flower stages can reduce yields (Table 11-1). Topping stimulates root growth, the source of nicotine, which also improves drought tolerance and nutrient absorption. Early topping also makes the plants less "top-heavy," which, along with better root growth, helps prevent plants from blowing over. Early topping increases yield (if suckers are controlled) by increasing growth of upper leaves. It also stimulates production of secondary plant products that accumulate in the leaves and improves their quality and smoking characteristics. In addition, early topping lowers the population of several insects that are attracted by the flowers. However, early topping does stimulate sucker growth, so a good sucker control program is necessary to ensure high yields of acceptable quality. Suckers longer than 1 inch should be removed at topping before sucker control chemicals are applied.

Topping height should be at a leaf number that will satisfy buyer preferences. Upper leaves are usually smaller at harvest time when plants are topped relatively high, late, or both. At least one contract buyer has expressed a need for more ripe, mature tip grade (T) tobacco

Table 11-1. Effect of topping time on yield of burley tobacco in North Carolina, 1974 and 1975*

Topping Stage	*Yield (lb/a)*
Early Button	*2,820*
Late Button	*2,776*
Early Flower	*2,676*
Late Flower	*2,645*

**Average of 13 experiments conducted by Bob Davis and Gerald Peedin (Crop Science Extension Specialist Emeritus).*

and may request its growers to top higher than traditionally recommended.

Sucker Control

Four types of chemicals are available for sucker control:

- Contacts (fatty alcohols), which kill small suckers by touching and burning them.
- Contact-local systemics (Prime+, Flupro or Butralin), which must touch the suckers to be effective, although they also retard sucker growth by inhibiting cell division.
- A systemic (maleic hydrazide [MH]), which moves from sprayed leaves to small sucker buds and retards their growth by inhibiting cell division.
- Mixtures of two of these chemical types.

You can make these mixtures on the farm or buy some of them as prepackaged products. Except for MH applied alone, all of these chemical types or their tank mixes must run down the stalks and touch the sucker buds to be most effective. Consequently, the stalk must stand straight so the solution will flow down all sides of the stalk. The applicator can direct the solution down the stalk in a plant-to-plant (by-hand) operation. This technique requires more labor than an overall spray application, but more plants can be treated with the same spray volume. When you use MH in tank mixes with the other chemicals, you must wet the leaves on the upper third of the plant as well as direct just enough solution down the stalk to reach the soil. Proper use and application methods for all types of sucker control products and their tank mixes, when appropriate, are discussed below.

Contacts or Fatty Alcohols

The fatty alcohols, when mixed with water to the proper dilution, form a milky-white emulsion. Avoid using cold water because the product may not totally disperse. Within a few hours after application, the sucker buds turn brown and gradually dry up. The proportion of fatty alcohol to water is critical. If the concentration is too weak, sucker control will be poor; if it is too strong, the leaves as well as the suckers will be "burned." If the burning is too great in leaf axils, leaf drop may also occur. Bacterial soft rot is usually associated with leaf drop. Frequent rain and humid conditions, along with excess nitrogen, aggravate the situation.

A 3 to 4 percent solution is suggested on the contact label. To prepare a large amount of spray solution, mix 1.5 to 2 gallons of the product with 48 gallons of water. This will treat 7,500 to 8,000 plants per acre. To prepare a smaller amount, use 1 pint of the product and 3 gallons of water. This will treat 470 to 490 plants. Mix thoroughly! Occasional agitation is suggested because the fatty alcohols, which are lighter than water, tend to float on the water. Therefore, you should pour fatty alcohols into the spray tank while adding water. This will provide some agitation. If the fatty alcohols are added after the tank is full of water, proper mixing is more difficult. Also, if the water is too cold, the mixture may have small curds and look like sour milk. Thorough mixing and some warming are necessary before application.

Contact-Local Systemics

Flumetralin (Prime+ and Flupro). When properly diluted in water, flumetralin makes a yellow emulsion. It controls sucker growth by stopping cell division in sucker buds that are touched or wetted. Consequently, the suckers do not grow, but remain present as living, greenish-yellow tissue for several weeks after application. One application at topping will give good sucker control until harvest unless rain occurs within two hours after application. If you make a plant-to-plant, down-stalk application, mix 1 gallon of flumetralin in 49 gallons of water; this will treat 7,500 to 8,000 plants per acre. For a smaller amount, use 0.5 pint of the product in 3 gallons of water; this will treat 460 to 480 plants. Use only enough solution per plant to wet the stalk and suckers without any excess accumulation on the soil at the base of the plant. With careful application, you should be able to treat about twice as many plants with the down-stalk method as you would with the over-top, overall spray method.

Flumetralin may be tank mixed with products containing MH. Mix 2 quarts of flumetralin with ½ to the full rate of MH. The ¾ rate of MH (1.5 gallons per acre for most MH products containing 1.5 pounds active ingredient per gallon) tank mixed with flumetralin has given satisfactory sucker control on vigorous crops and on crops harvested more than three weeks after application.

Butralin. Butralin is a dinitroaniline and chemically similar to flumetralin. Generally, all of the suggestions and precautions regarding application procedure, activity, and the like for Butralin are the same as those for flumetralin. However, application rates may differ. Like flumetralin, Butralin may be used alone or mixed with products containing MH. However, mixing Butralin with less than 1.5 to 2 gallons per acre of MH is not currently labeled. Check the label for proper application and mixing of this product. Contact your county Extension agent about the availability of Butralin for the 2008 season.

Maleic Hydrazide (MH)

MH is a true systemic; that is, when sprayed on the leaves, it is absorbed and moved to growing sucker buds. It stops cells from dividing in these buds. Therefore, MH does not have to wet the suckers to be effective, but does require good soil moisture for adequate absorption by leaves. Most MH-containing products make a light, straw-colored solution. If the MH-containing product also contains fatty alcohol (FST-7 or Leven-38), the spray mixture is milky-white. Such a product will have the characteristics of both the fatty alcohols and the MH-containing products. MH will not control large suckers, so you should remove them at application.

The suggested rate of MH is no more than 2 gallons of product in 48 gallons of water per acre. For a smaller amount, use 1 pint of product in 3 gallons of water. The former should treat approximately 7,500 to 8,000 plants per acre, and the latter about 460 to 480 plants. MH should be applied as an overall spray, wetting the upper leaf surfaces on the upper third of the plants. Applying MH to lower leaves will not improve sucker control but may increase MH residues. When MH is applied alone, use a nozzle tip and pressure that give a fine spray. When MH is tank mixed with products requiring stalk rundown, use a larger nozzle tip and lower pressure that give a coarse spray to improve stalk rundown. Applying MH alone down-stalk will not provide adequate sucker control.

Mixtures of Two Chemical Types

MH plus Fatty Alcohol (FST-7 or Leven-38). The suggested concentration of an MH product that also contains a C10 fatty alcohol is no more than 3 gallons of the product in 47 gallons of water.

For a smaller amount, use 1.5 pints of the product in 3 gallons of water. The former should treat approximately 7,500 to 8,000 plants per acre, and the latter about 480 to 500 plants. Use a coarse nozzle tip that promotes stalk run-down but also wets the upper leaves. The fatty alcohols in these products are more active than those in most other contact products, and excessive rates may cause substantial leaf burn, leaf drop, or both.

MH and Flumetralin (Prime+ or Flupro) Tank Mix. The suggested concentration of flumetralin in a tank mix with MH is 2 quarts per acre of flumetralin with ½ to the full rate of MH. After removing suckers larger than 1 inch, apply the tank mix as a coarse spray in 50 gallons per acre of total spray mixture at 20 to 25 pounds per square inch at the recommended time for MH application. For a smaller amount, mix 0.25 pint of flumetralin and 1 pint of MH in 3 gallons of water. Use a coarse spray that promotes stalk run-down but also wets the upper leaves. A fine spray such as used for MH alone may reduce stalk run-down and therefore reduce sucker control by flumetralin.

MH and Butralin Tank Mix. Generally, all of the suggestions regarding tank mixing MH and flumetralin, such as application procedure, timing, and the like, are the same as for tank mixing MH and Butralin. You should treat immediately after topping, at least 30 days before anticipated harvest. The tank mix should contain 1.5 to 2 gallons of MH plus 2 quarts of Butralin mixed in 50 gallons of water per acre. For a smaller amount, mix 0.25 pint of Butralin and 0.75 pint of MH in 3 gallons of water. Use a coarse spray that promotes stalk run-down but also wets the upper leaves.

Spray Equipment

Keep equipment clean, free of other pesticides, and in good working condition. When you plan to spray over-top, always calibrate the sprayer first. If using a hand sprayer, 1 gallon of spray solution should cover approximately 150 plants (0.75 ounce per plant). This amount approximates 50 gallons per acre using high-clearance equipment. Apply fatty alcohols and tank mixes of MH with flumetralin or Butralin with relatively low pressure (20 pounds per square inch), keeping the nozzle tips away from the leaves. Low pressure forms larger droplets and promotes stalk run-down. Some leaf injury occasionally occurs with contacts if the spray solution puddles or hangs on the leaf edges. When applying flumetralin or Butralin alone or in tank mixes with MH, adjust spray volume so that the solution does not accumulate on the soil at the base of the plants. This will reduce the chance of soil residue carryover and possible stunting of following crops.

MH used alone should be applied as a fine spray. Cover the leaves well for maximum absorption. However, FST-7 or Leven-38 should be applied like tank mixes of MH with flumetralin or Butralin.

Suggested Practices

These practices are based on registered instructions given on product labels, research, experience from on-farm tests, and practical information from growers. Always follow instructions provided on the product label.

Option I

Apply fatty alcohols down-stalk or over-top at the button stage, then top the plants 24 hours later. See Chapter 15, "Worker Protection Standards," for restricted field entry intervals for other tobacco pesticides. Approximately one week later, apply MH, Stifle, Prime+, Flupro, Butralin, or a tank mix of MH with Prime+, Flupro or Butralin. Using a 3 percent contact before applying systemic products substantially reduced sucker number and weight per acre in most previous tests, including the 2006 on-farm tests (Table 11-2).

Option II

Wait until all plants are in the elongated-button to early-flower stage, and apply MH, Stifle, FST-7 or Leven-38, Prime+, Flupro, Butralin, or a tank mix of MH with Prime+, Flupro or Butralin. Top and remove all suckers longer than 1 inch before spraying. Top down to a 10- to 12-inch leaf because all of the products have systemic activity and may stunt or distort shorter leaves, or both, particularly when they are very tender and succulent at application time.

Option III (for uneven crops)

Top as individual plants reach the elongated-button to early-flower stage, and apply Prime+, Flupro, or Butralin down-stalk to the topped plants. Repeat the procedure as later plants reach this flower stage, being careful not to re-treat previously treated plants.

General Comments

Sucker-controlling agents work best when applied under good soil moisture conditions. Do not apply them on wilted plants. For best results, make applications on dry plants in the morning. Try to choose a day when the possibility of afternoon rainfall is small. The fatty alcohols, flumetralin, and Butralin will be effective if no rain falls for two hours after application. However, reapplication of these products generally is not suggested; reapplication of fatty alcohol may contribute to leaf drop, and reapplication of flumetralin or Butralin on light soils may cause stunting of the next crop, particularly if a dinitroaniline product was also used for weed control. MH products are most effective if no rain occurs for 10 to 12 hours after application. If rain should fall three to six hours after MH application, reapply one-half the labeled rate of MH the following day to maintain control. If the first application was a tank mix of MH with flumetralin or Butralin, reapply only the ½ rate of MH; reapplication of flumetralin or Butralin may increase the chance of stunting following crops.

2008 On-farm Test Results

Table 11-2 shows the results averaged over two sucker control tests conducted at the Upper Piedmont and Mountain Research Stations in 2008. Suckers 1 inch or longer were removed before the first treatment, with no other hand suckering until sucker number and weights were recorded just before harvesting four weeks later. All treatments were applied as a coarse spray in 50 gallons of spray volume per acre (gpa). Percent sucker control was calculated based on topped, but not suckered, treatment.

Two gallons or 1.5 gallons of Royal MH alone provided excellent sucker control. The tank mixtures of 1.5 gallons of Royal MH and 0.5 gallons of Flupro or 1.0 gallon Royal MH and 0.5 gallons of Butralin also provided excellent sucker control. Off Shoot-T at 3 percent followed by a tank mixture of Off Shoot-T at 3 percent and Butralin at 0.75 or 0.5 gallons or Butralin alone did not consistently provide acceptable sucker control. Reduced rates of MH can be used when contacts or one of the dinitroanalines (Butralin, Prime+, or Flupro), or a combination of these, are used.

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 11-2. Burley tobacco sucker control test, average of the Upper Piedmont and Mountain Research Stations—2008

		Sucker		
Treatment	*Rate per Acre*	*Weight/ Acre (lb)*	*Number/Acre*	*Control (%)*
Royal MH-30	*2.0 gal*	*0*	*0*	*100*
Royal MH-30	*1.5 gal*	*0.89*	*65*	*99.9*
Royal MH-30 & Flupro	*1.5 gal & 0.5 gal*	*0*	*0*	*100*
Off Shoot-T/ Off Shoot-T & Butralin	*3% / 3% & 0.5 gal*	*105*	*324*	*89*
Butralin	*1.0 gal*	*130*	*612*	*86*
Off Shoot-T/ Off Shoot-T & Butralin	*3% / 3% & 0.75 gal*	*68*	*288*	*93*
Royal MH-30 & Butralin	*1.0 gal & 0.5 gal*	*0*	*0*	*100*

Off Shoot-T, when not used in a tank mixture, was applied in the early-button stage. All other treatments were applied five to seven days later, immediately after topping when 50 to 60 percent of the plants were in the early flower stage.

Table 11-3. A summary of the most current sucker control recommendations for burley tobacco

Chemicals and Formulations	***Amount of Formulation Per Acre***	***Precautions and Remarks***
CONTACT TYPE *C8 - C10 fatty alcohol* *6.01 lb/gal*	*1.5 to 2 gal** *(3 to 4%)*	*Apply in button-to-early-flower stage as coarse, low-pressure (20-25 psi) spray directed downward on plant tops. Leaf burn may occur with high application rates and pressure, especially on tender or wilted plants when the temperature exceeds 90oF. Application before dew dries may reduce effectiveness.*
SYSTEMIC TYPE *maleic hydrazide (MH)* *Liquids, various brands* *1.5 lb/gal* *2.25 lb/gal*	 *1.5 to 2 gal* *1 to 1.33 gal*	*For all systemic products, apply to upper $^1/_3$ of plant in 20-50 gal water per acre after topping to 10- to 12-inch leaf. Effectiveness is reduced when the product is applied to drought-stressed or wilted plants or before dew has dried. Apply a single repeat application only if wash-off occurs within 6 hours. For water-soluble products, see rate information below and read labels carefully for mixing instructions.*
60% water-soluble products *Fair 80 SP or Sucker Stuff 80 (WS)*	 *3.75 lb*	*Rate for 6,000 plants per acre. Adjust rate accordingly for other plant populations.*
Royal MH-30 SG	*4 to 5 lb*	
CONTACT + SYSTEMIC MIXTURE *C10 fatty alcohol +* *maleic hydrazide (MH)* *(FST-7 or Leven-38)*	 *9 qt**	*Apply downward on plant tops as coarse, low-pressure (20-25 psi) spray after topping down to 10- to 12-inch leaf. Follow precautions given above and label restrictions for both contact and systemic-type chemicals. Applying high rates or reapplying after wash-off may contribute to leaf drop.*

Table 11-3. (continued)

Chemicals and Formulations	Amount of Formulation Per Acre	Precautions and Remarks
CONTACT, LOCAL-SYSTEMIC TYPE		Apply downward on plant tops as coarse, low-pressure (20-25 psi) spray after topping down to 8- to 10-inch leaf. Remove suckers longer than 1 inch immediately before application and missed suckers when seen. Apply only once per plant per season. Excessive volume that causes downstalk runoff on soil increases the chance of soil residue carryover that may harm the growth of small grains and corn or cause early-season stunting of the next tobacco crop when a dinitroanaline herbicide is also used. Rainfall within two hours may reduce effectiveness.
flumetralin (Prime+or Flupro)	1 gal*	
butralin (Butralin)	3 to 4 qt*	
SYSTEMIC + CONTACT, LOCAL SYSTEMIC		Apply as tank mix downward on topped plants as coarse, low-pressure (20-25 psi) spray at time recommended for MH application. Follow precautions given above and label restrictions for both systemic and contact, local-systemic chemicals. The ¾ rate of MH (1.5 gal/a for most products) tank-mixed with Prime+, Flupro or Butralin has given satisfactory sucker control on vigorous crops and on those harvested more than three weeks after application.
maleic hydrazide (MH) + flumetralin (Prime + or Flupro)	½ to full rate MH + 2 qt Prime+ or Flupro*	
maleic hydrazide (MH) + Butralin	Full rate MH + 2 qt Butralin*	
SYSTEMIC + CONTACT, LOCAL SYSTEMIC		Apply downward on topped plants as coarse, low-pressure (20-25 psi) spray at time recommended for MH application. Use higher rate on heavy suckering varieties or when sucker pressure is heavier. Follow precautions given above and label restrictions for both systemic and contact, local-systemic type chemicals.
(Stifle)	1.5 to 2 gal*	

* Mix in sufficient water to total 50 gallons of spray per acre.

12. Chemical-free Burley Tobacco

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Producers are now growing chemical-free tobacco in both the burley and flue-cured regions of North Carolina. Production methods have to be altered to take into account the lack of some pesticides and fertilizer materials allowable in traditional tobacco production. The following production guidelines should be useful for the production of chemical-free tobacco. Tobacco company requirements may differ depending on the type of tobacco requested for their use.

Variety Selection

Only varieties that have disease resistance should be used (see Chapters 9 and 10 on disease management). Burley varieties NC 2000 and NC 2002 have moderate blue mold resistance and have worked well in past chemical-free burley research experiments.

Transplant Production

This phase of production may be the most difficult. Fertilizer materials and pesticides commonly used in the transplant float system are restricted, and alternative materials that may work in the field (decomposing manures and organic fertilizer sources) are not necessarily suitable for the float system. Cool weather also limits nutrient availability in outside plant beds because cool soils will slow decomposition of these fertilizer materials. Outbreaks of insects and diseases will be difficult to control in greenhouse float beds and outside plant beds. For more information on this subject, see Chapter 4, "Producing Healthy Transplants in a Float System."

Field Preparation

Two important considerations for tobacco production will be the use of a legume or grass cover crop planted the winter before tobacco production and, if available, the use of manure and compost.

Cover Crops

Cover crops will improve soil quality and provide plant nutrients when the cover decomposes. Plowing small grain cover crops in late March or early April will allow the vegetation to decompose midway through the burley growing season and provide around 40 pounds nitrogen (N) and potassium (K) per acre and 5 pounds phosphorous (P) per acre. Late spring plowing will provide more uptake of small grain plant nutrients; however, decomposition will be more difficult due to the inability of microbes to quickly decompose this mature vegetation.

Legumes will have little growth early in the spring, so plowing for this winter cover material should be delayed for maximum nutrient accruement. Legumes can fix nitrogen by removing N_2 from the air, transforming it to ammonia in the plant, and by eventually converting it to plant protein. Once plowed under, legumes should immediately begin decomposing and provide plant-available nitrogen, phosphorus, and potassium (75, 15, and 80 pounds per acre, respectively, for late spring plowing). For more discussion on cover crops, see Chapter 6, "Cover Crops for Burley Tobacco."

Manures

Manures, too, should be considered as replacements for synthetic chemical fertilizers. Both spring and fall manure application will benefit tobacco and can replace some or most of the fertilizer requirements. Applying animal manure in the fall rather than in the spring will allow more plant nutrients to be available during the tobacco growing season. Having a chemical analysis performed on the manure will provide information on the amount of available and total nutrients in the manure and tell how much additional manure to apply. Additional information can be found on the Web at these addresses: **http://www.ncagr.com/agronomi/sfn12.htm** and **http://www.soil.ncsu.edu/publications/Soilfacts/AG-439-18/**

Fertilizer Application

Burley tobacco requires 180 to 200 pounds N per acre for a crop of 2,500 pounds per acre. Most synthetic fertilizer materials contain plant nutrients that are available when applied to the soil. This makes for easy application of fertilizer, and growers can time application with plant uptake, especially at sidedress. Two chemical-free fertilizer materials that may be allowable include bulldog soda (16-0-0) and potassium magnesium sulfate (0-0-22). Using fertilizer materials that are organically based (that is, the materials need to decompose for plant nutrients to become available) requires some decomposition by microbial activity. Although some plant nutrients may be immediately available, most nutrients must undergo a process called mineralization to become soluble in the soil and eventually available for plant uptake. Mineralization by microbial activity requires oxygen and water to proceed. Although most soils contain sufficient water for microbial activity, having irrigation available (either overhead or trickle) will optimize organic material decomposition by soil microbes.

Past experiments at the Upper Mountain Research Station using various sources of organic fertilizer materials showed first that it was very important in a dry summer to have irrigation for chemical-free tobacco. The location of our experiment was an upland site, and with 28 days of no rain late in the growing season, tobacco was considerably taller and produced higher yields in the irrigated treatment compared to the nonirrigated treatment. The following year at the Mountain Research Station we had continuous rain during the summer, and no irrigation was necessary.

Organic Sources of Available Fertilizer

Organic sources of available fertilizer include soybean meal, cottonseed meal, composted chicken litter, composted chicken processing waste (meat/bone meal at 9-3.5-1), and other bagged materials sold at local farm suppliers. Bagged materials will have the amount of available nutrients confirmed by laboratory analysis. Soybean and cottonseed meal analyses give measurements close to 7 percent N, 1.2 percent P_2O_5, 1.5 percent K_2O for soybean meal; and 6 percent N, 3 percent P_2O_5, 1.5 percent K_2O for cottonseed meal. Composted chicken litter and processing waste have value due to the nitrogen, phosphorus, and potassium in these materials. Always consider having a chemical analysis performed on the material being used as fertilizer.

Our experiments on-station have given us important information on potential tobacco yield response from these materials. Composted chicken manure gave us less tobacco yield than the other organic fertilizer materials. This was due to the large amount of bedding (a carbon source) that was mixed with the manure. This carbon addition reduced the amount of available nitrogen in the soil due to immobilization (microbial activity that uses nitrogen when decomposing carbon material). All the other materials produced similar good tobacco yields. Organic materials do decompose slowly, providing more plant nutrients late in the season when tobacco is growing rapidly. Consider three factors when choosing a fertilizer source. (1) Any materials used must be allowed by the company buying your leaf, (2) the availability of the materials selected, and (3) the cost of the materials.

Weed Control

Mechanical cultivation will be required between tobacco rows, and hand cultivation will be required between plants.

Pesticide Use

Very few pesticides are available for chemical-free production. Disease resistance will have to play a major role in chemical-free burley tobacco production; however, a few topical materials are available for surface control of plant diseases. The company purchasing your leaf may limit the use of topical materials, so be sure to check with the company. Insecticides, too, will be limited, but *Bacillus thuringiensis* can be used for control of budworms, hornworms, and loopers.

Sucker control was achieved with the use of vegetable oil. In our on-station experiments, about ¼ cup of corn oil was applied on each normal-sized plant. This amount however was too much for small plants, girdling the plant at the base (soil interface). In addition, some leaf drop occurred after application of the oil and before harvest on these small plants.

Special Thanks

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13. Burley Curing and Market Preparation

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As burley tobacco producers face increasingly higher input costs and the stresses of unfavorable weather-related production conditions and contract pricing, there is greater pressure to create a more profitable burley enterprise. Sound management decisions regarding curing and market preparation are more critical today than ever before. To lower costs yet maintain yield and quality during curing is somewhat out of each producer's control, but following a few simple rules outlined below can go a long way in curing the best quality crop under given conditions. Market preparation tasks, however, can be thought out and managed a little more easily to increase efficiency on a per-farm basis to save money and thereby increase net profits. Throughout this process, keep in mind that over half of the labor required to take 1 acre of tobacco from seed to sale begins with the takedown of cured tobacco. This chapter is a discussion of the curing and market preparation practices that are directed toward the goal of marketing a high-quality, profitable burley crop.

The Curing Process

Curing refers to the numerous chemical and physical changes that occur in tobacco leaves after harvest. The curing environment determines the nature of these changes and has a substantial impact on the quality and received price of cured tobacco. The curing environment primarily refers to temperature, relative humidity, and air exchange or ventilation.

The preferred curing environment for burley tobacco provides temperatures that stay within the range of 60 to 90°F, and a relative humidity that averages about 65 to 70 percent over any 24-hour period. In most seasons, the key to successful curing will be maintaining this desired relative humidity in the curing structure with enough ventilation to prevent stagnant air conditions. In many seasons, natural fall weather conditions provide acceptable conditions, without much management. But in unusually wet or unusually dry falls, the ability to control moisture (and, in some cases, temperature) inside the curing structure is critical to producing high-quality burley.

Controlled ventilation is the primary means of managing the curing environment. Stagnant, moist air contributes to *houseburn* or *barn rot* more than circulated, fresh, moist air. At the opposite extreme, excessively low relative humidity levels can result in rapid drying and undesirable leaf color and smoking characteristics. Furthermore, recent research results on leaf chemistry suggest that high humidity curing conditions increase the content of tobacco specific nitrosamines (TSNA) in cured burley leaf.

Curing Stages

Curing is a continuation of the ripening process that primarily involves nutrient starvation and moisture reduction. The curing process can be described in three stages:

The first is the yellowing stage. During yellowing, the leaf color slowly changes from shades of green to yellow, while the stems or midribs remain green. The yellowing stage generally lasts from one to three weeks, depending on the ripeness of the tobacco, the weather conditions, stick spacing in the barn, whether the tobacco was field-wilted, and the kind of curing structure used.

If the yellowing stage progresses too quickly (as a result of extended periods of low relative humidity, especially if accompanied by excessive ventilation), an undesirable leaf color will be set. This is generally a mottled or variegated bright color (often called *piebald*, *pawpaw*, or *K-tobacco*) if the temperatures are warm and a green color if the temperatures are cool during rapid drying. If the yellowing stage progresses too slowly (from high moisture, especially under poorly ventilated, stagnant air conditions), houseburn or barn rot will develop. Houseburn can reduce the weight and quality of the cured leaf and cause increased levels of TSNA.

The second stage of curing is the leaf-drying stage. During this period, the leaf lamina or webbing gradually changes from yellow to a dark color (typically brown, tan, or reddish brown).

The third and final stage is the stem-drying stage. During this stage, stems shrivel in size and lose most of their moisture. Once all the “fat stems” or “swelled stems” are dry, the curing process is essentially completed and stripping can begin. The curing process gradually proceeds from the ground leaves to the top leaves. Therefore, some overlapping of the three curing stages occurs from the bottom to the top leaves on the stalk.

Managing the Curing Environment for Quality and Yield

The ability to control moisture and air circulation (and in some cases temperature) inside the curing structure are critically important to producing burley tobacco of high physical and chemical qualities in years of unfavorable conditions. Housing and curing costs are affected by many risky variables, only some of which the producer can control directly. Besides lowering costs, a producer's major objective is to maintain the yield and quality of the uncured tobacco coming out of the field.

Controlled Ventilation

Controlled ventilation is the basic means of managing the curing environment. In conventional barns, as a rule of thumb, ventilators and doors should usually be opened during the day and closed in the late afternoon or early evening. However, if the tobacco is curing too fast due to dry weather (relative humidity is well below 65 percent for a 24-hour average), the barn should be closed during the day and opened at night. On the other hand, if the tobacco is curing too slowly due to high moisture levels (excessive humidity, prolonged rainy periods lasting more than 24 hours, or both), the barn must be kept open to provide ventilation. Stagnant moist air is more of a problem than circulated, fresh, moist air. In some extreme cases, circulation fans and supplemental heat will be required to prevent houseburn or barn rot.

Low Heat and Air Circulation

Low heat reduces the relative humidity without adversely affecting leaf color. Excessive heat can lower the relative humidity too much, resulting in rapid drying and undesirable leaf color. Supplemental heat in burley tobacco barns should be generated by vented stoves (ones that burn propane, LP gas, natural gas, or low-sulfur coke), but never by open fires that can smoke the tobacco. Fumes form the heat source should be vented outside the barn. Some ventilation will still be required when supplemental heat is used to allow moisture to escape from the barn. Otherwise, condensation is created that defeats the purpose of the additional heat. Adjust the stoves so the temperature at the lowest hanging tobacco directly above the stoves does not exceed about 85°F. Circulation fans are another way of controlling moisture in the curing structure during periods of prolonged rainy weather or excessively high daytime humidity. To be effective, air must move through the tobacco, rather than around it. Proper placement of fans and the manner in which tobacco is hung are critical to the effectiveness of fan ventilation.

Hanging Density and Side Covers

In traditional burley barns, stick spacing has normally varied from 6 to 12 inches depending on tier spacing and the degree of ventilation in the barn. Research at the University of Tennessee has shown that burley tobacco can be hung at higher densities in open-sided low-profile curing structures without increasing the danger of houseburn or barn rot. Higher densities mean lower barn cost per unit of cured tobacco.

In field-curing structures (Figure 13-1), the curing environment is controlled primarily by the hanging density (spacing between sticks) and by *side cover* management. Sticks can and should be spaced closer together in these structures than in conventional barns. An average spacing of 3½ to 4½ inches generally works well, depending on how large the tobacco is, how much wilting has occurred, and the prevailing weather conditions. Polyethylene covers should be placed over the structures soon after hanging. However, if the leaves are wet, allow them to dry before covering.

Figure 13-1. Two-rail field-curing structures

The *gable ends* of field-curing structures should always be open. The side covers should generally stay up or open during the yellowing and leaf-drying stages and then should be dropped for completion of curing. One exception to this rule of thumb occurs during prolonged periods of warm to hot temperatures and low relative humidity that last for several days or more. Under these conditions, the side covers should be lowered during yellowing and leaf drying to slow the curing process and to minimize undesirable variegated color. Once the side covers are lowered, close monitoring of the interior stalks of tobacco is necessary to detect potential houseburn conditions that require temporarily raising the covers. This management step is especially important for field structures that are three or more tiers wide.

Curing Structure

Using low-profile structures with good curing management appears to result in cured burley that is darker and redder than burley cured in conventional barns. This has been observed both in long-term research and by producer experience. Industry acceptance of well-managed burley cured in these structures has been quite good.

Open-sided low-profile barns and structures are good for curing but not for storing unstripped cured tobacco. The tobacco should be removed (stripped or packed down) from polyethylene-covered field-curing structures as soon after curing is completed as possible. Timely takedown will minimize leaf shatter, excess moisture damage to tip leaves, and the risk of sticks blowing out of the structure.

Figure 13-2. Two-tier low-profile barn

Housing and curing management practices must be customized and directed at preserving yield and quality in each curing structure because every structure and every crop are different. Each structure is somewhat unique in its curing characteristics and needs to be uniquely managed. Field-curing structures generally require more management, but also allow for better management of the curing environment than most conventional barns.

An often-asked question is, "Which barn or structure is best?" The answer is that no one barn or structure is necessarily the best. The fact that polyethylene-covered field-curing structures are the lowest cost, as a group, does not mean that a producer's whole crop should be cured in such structures; they are poor facilities for storing cured tobacco for extended periods because of weather risks. If a producer cannot strip tobacco as it cures, then a better facility with a good roof and perhaps some partial or complete side protection from the elements would be more appropriate than a plastic-covered field-curing structure for storing part of the unstripped, cured crop. For example, a conventional metal-covered, gable-roof, low-profile barn (Figure 13-2) would be a better choice for adding this weather protection. Also, a tall, enclosed, conventional barn (which one might already own) hung one or two tiers high at a higher density than normal (to get some of the labor and cost advantages of the low-profile approach) offers excellent weather protection for cured tobacco that will be stripped and graded later.

Many producers may conclude that it is best to use both low-cost structures that provide minimal weather protection as well as structures that are built better, but are more expensive to own and operate. They may decide that this approach would offer labor and time flexibility and help manage weather risks inherent in producing burley. In some cases, compromising on cost efficiency to gain flexibility, improve timeliness, and reduce risks can be justified as an excellent management strategy to preserve or even improve net income in an uncertain production environment.

Market Preparation

Market preparation practices are some of the key determinants of burley quality. Proper management of these practices contributes greatly to profitability because market preparation requires about half of the total labor in a burley crop. Maximizing the efficiency of one's market preparation system by keeping costs per pound of tobacco as low as practical is an important management strategy.

System is the key word. *System* means that all the various tasks associated with market preparation (such as takedown, transport, stripping, baling, bale handling and storage, stick removal, stick handling and storage, and stalk disposal) are linked together in ways that minimize unnecessary labor, such as wasted steps, downtime, handling the tobacco more times than necessary, long-distance carrying, inefficient space utilization, not having tobacco in order or case, and so on. A *market prep system* is an orderly, efficient flow of the entire market preparation process, very much like a factory assembly line.

Studies at the Research and Education Center in Greeneville, Tennessee, show that making the system efficient is actually more important than selecting the right system or the right stripping equipment. There is no magical piece of equipment that will guarantee efficiency in market preparation. Even stripping aids, such as the stripping wheel, the carousel, and the stripping chain conveyor, cannot guarantee improvements in efficiency. The conventional relay method of stripping-grading actually competes very well in efficiency with these semi-mechanized stripping aids when the system is made efficient by implementing a few key principles.

What are some of the key concepts involved in maximizing efficiency in market preparation while at least maintaining or even enhancing tobacco quality?

Key Concepts

Understand that there is no single correct method of efficient market preparation. The objective is to customize one's operation to make it as efficient and quality oriented as possible within the given conditions or current limitations.

Handle tobacco in bulk quantities. This applies to several steps in the process. Here are two examples: (a) Take down as much tobacco as possible when it is in proper order or case after the stalks are no longer green and the stems of the leaves are not longer "fat" to reduce the risk of heating and rot. Tobacco on the stick can be taken down on 5-foot by 8-foot flat wooden pallets, wagons, scaffold trailers, or other transportable devices that can be safely stored until stripping. (b) At stripping, workers should gather as many leaves in their hands and arms as practical before placement in the bale boxes, if using traditional 80-pound bales, to minimize worker motion and effort. If using the large flue-cured-style bale, bulk containers for stripped tobacco should be in easy reach of each worker so that tobacco can be directly dropped into them as it is stripped.

Organize the layout of the stripping area. Tobacco should be moved through the stripping/grading room in a logical, efficient manner that minimizes worker steps and stalk handling. For example, the "pile" of unstripped tobacco should be close to the stripping area, and the bale boxes/temporary storage containers should be no more than an arm's length from the people doing the stripping-grading. Storage containers should be easily movable to the baler or a temporary storage area for later baling, Storage areas and/or balers should be as close as possible to the stripping line, minimizing the time spent moving loose tobacco, or a mechanical means of moving the loose tobacco to the baler should be provided.

Wagons, trailers, sticks, pallets, stalks, and bales should not be moved against the flow. Use a one-way-in, one-way-out approach, like an assembly line.

Consider worker comfort. Floor cushions or pads, or slatted floors, can reduce fatigue and improve worker production in many cases. Minimize stooping, reaching, dust, and so forth. Provide heat if necessary to maintain a temperature of about 55 to 60°F. Adequate lighting over the stripping area can increase the accuracy and speed of grading. A comfortable work environment is a productive work environment.

If necessary, prioritize tasks. For example, some systems keep the stalks on the stick during stripping. In this case, consider waiting to remove the stalks from the sticks later when the tobacco is not in order or case, or when stripping is completed. This concept points to the value of the next principle.

Increase your control over when tobacco is in order or case. When relying on natural weather conditions to order or case tobacco, there are times in every stripping season when market preparation must be stopped simply because tobacco is too dry to handle. The value of large-quantity takedown has already been mentioned. In addition, having an ordering or casing room can greatly improve efficiency and timeliness in most operations. Humidifiers (commercial or homeowner types) placed in a tight room or building can bring tobacco placed on pallets, scaffold trailers, or wagons into workable order or case overnight if enough heat is provided to maintain a temperature of about 55°F.

This discussion is not to imply that other factors or principles associated with market preparation are unimportant. These, however, are clearly some of the key ingredients in improving efficiency. As crucial as efficiency is to the market preparation process, several other factors critical to product integrity and long-term market viability follow.

Big Bales

Recently, buyers have been accepting the delivery of burley tobacco in flue-cured sized bales that weigh 500 to 600 pounds. By facilitating the mechanical handling of tobacco in bulk and by allowing "tangled leaf" baling rather than the oriented-leaf baling required to keep small bales together, this system can save considerable labor. Preliminary University of Tennessee research indicates a 15 percent saving in stripping and baling labor. Some farmers report larger savings of up to 25 percent. The labor cost savings in this system have to be balanced against the increased investment required for a large baler, handling equipment, and stripping facility modifications. Nevertheless, it appears this system can in general be a profitable choice for growers who produce 20,000 to 30,000 pounds. Subsidies for purchase of balers and premiums paid for delivery in large bales by some buyers may make this option attractive to even smaller growers.

With big bales or small, however, the basic principles described above still hold true. Most of the labor savings from big bales can be lost by inefficient practices in other aspects of the market preparation system. One possible difference may be the value of stripping aids such as the wheel or conveyor type systems. Farmer experience indicates that these aids may offer more advantage with large bales because they eliminate the downtime needed to move loose leaves to boxes and orient them.

Grade Separation

Burley tobacco should be separated or sorted into three or four grades by stalk position, in accordance with buyer preferences. A cull or throw-out grade should also be established if the particular crop requires it. Tobacco should always be separated by stalk position. Price incentives certainly favor separation. It is the way quality tobacco has traditionally been handled, and it is insurance against discounts for, or outright rejection of, mixed-grade tobacco. Furthermore, proper grade separation helps sustain demand (short-term and long-term) for U.S. burley. Quality is the only market niche that U.S. tobacco has, and the lack of attention to this detail could further jeopardize the already falling market share of U.S. produced burley.

Moisture Content

Tobacco with excess moisture will spoil quickly. Current use of moisture testers and rejection of substantial amounts of excessively moist tobacco over the last four years are proof that buying companies are taking a tougher, more quality-conscious stand against excess moisture in burley tobacco. This approach makes sound business sense not only for the buying companies, but for producers as well. Selling burley with known moisture content in bales that weigh no more than company specifications allow should help sustain and perhaps improve the marketability of U.S. burley tobacco. Recent evaluations suggest that a moisture content of about 18 to 23 percent is acceptable. Contracts generally call for baled tobacco to contain no more than 23 to 24 percent moisture. Moisture has been a concern to many producers in the use of large bales. University of Tennessee tests indicate that moisture contents up to the 22 to 23% range are not a problem in big bales, and do not cause any more problems with heating or TSNA level in big bales than in small ones. But it is enough of a concern that some buyers seem to be a bit more strict on moisture in large bales than in traditional ones.

Product Uniformity and Integrity

As the focus on growing and selling a quality product increases and as buying companies hedge their liability risks by greater knowledge of the tobacco they buy, selling big bales, traditional farmer bales (80-90 pounds each) and market lots (piles) of uniform tobacco is important. Nonrepresentative display bales, bales of inferior tobacco mixed in a pile of better tobacco, and bales nested with inferior tobacco or non-tobacco-leaf substances (such as suckers and stalks) and other non-tobacco-related materials (NTRM)—all make for a non-uniform, lower-quality product that will increasingly be viewed as a liability against top dollar, future purchasing contracts, and market viability. Of particular concern are NTRM and illegal pesticide residues. NTRM increase the cost of processing and may reduce the quality of final products if undetected. Both NTRM and pesticide residues may pose liability problems. Tobacco companies are increasing their testing for pesticides, and are establishing increasingly strict standards for producers regarding both pesticides and NTRM.

Each producer has a stake in a continuing if not stronger demand for U.S. burley tobacco to help ensure a viable future for tobacco farming. Additional information on curing and market preparation is available at **http://tobaccoinfo.utk.edu**.

14. 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 people and water quality and 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.

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 11-1 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.

Resistance Mangement

Resistance management should also be considered when selecting pesticides. Pesticide mode of action (MOA) should be rotated when multiple treatments are required for insect pests. The Insecticide, Fungicide, and Herbicide Resistance Action Committees have developed groupings of pesticides with the same MOA. These IRAC, FRAC, and HRAC codes (insecticide, fungicide, and herbicide codes, respectively) are listed to help growers select rotational materials. One noteworthy resistance management restriction consists of the limitations on foliar applications of neonicotiniod insecticides (IRAC group 4A) to plants previously treated with a long-acting soil-applied systemic neonicotiniod. What this means practically is that, in most cases, acetamiprid (Assail), imidacloprid (Provado), and thiamethoxam (Actara) foliar treatments should not be applied to tobacco treated with Admire Pro (imidacloprid) or Platinum (thiamethoxam) in the greenhouse. See labels for details.

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 11-1. 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.

Protect People

The U.S. EPA's Worker Protection Standard (WPS) is a regulation that requires actions to be taken 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 know how to comply with its requirements. To plan effectively, you must also understand how compliance might affect your farming operation. The

WPS requires employers to provide for their workers and pesticide applicators in the following three areas:

1. Provide Training on Pesticide Safety

Information about the specific pesticides used on the farm must be provided. 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 and 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 be sure that workers are warned about treated areas (through oral warning, posting of field, or both) and that workers do not enter treated fields during restricted entry intervals (with some very specific exceptions). This may require careful scheduling of pesticide applications and field work so that they do not conflict. Personal protective equipment requirements vary by pesticide and may be different for applicator/handlers and mixer/loaders. Protective equipment is also required for entry into fields during the restricted-entry interval. Labels should be checked carefully for specific requirements. Restricted-entry intervals (generally 12, 24, or 48 hours) also vary, as stated on labels.

3. Provide Ways for Their 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 WPS, farmers should consult their county Cooperative Extension center or one of several publications available.

The following table lists products, registration numbers, common names, restricted entry intervals, and posting/notification requirements for the major pesticides and growth regulators used in tobacco. This will help you properly record and post pesticide use and plan field operations. The information in this table is presented as a reference only. Always read and follow label directions.

Disclaimer

The following information and worker protection standards are presented in good faith for your reference. This information does not take the place of the product label; changes to product label information can occur without notice. Always read and follow label directions.

Table 14-1. Water contamination potential and mammalian toxicity of commonly used tobacco pesticides

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

[a] Most common trade name, products containing these active ingredients may be labeled under other trades. Information provided only pertains to trade names listed, and other products containing the active ingredient listed may be registered on tobacco The inclusion or omission of a trade name should not be considered an endorsement or rejection of a product.

[b] Exception: If the product is soil-injected or soil-incorporated, the Worker Protection Standard, under certain circumstances, allows workers to enter the treated area if they will not contact anything that has been treated.

[c] Notification on Farms, Forests, and Nurseries: Refer to page 41, The Worker Protection Standard for Agricultural Pesticides — How to Comply. Unless the pesticide labeling requires both types of notification, notify workers either orally or by posting warning signs at entrances to treated areas. You must inform workers of which method of notification is being used.

Both Oral Warning and Posted Signs: 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, 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."

[d] Surface loss may occur when pesticides go into solution in water and run off the field in surface water. Potentials from the Natural Resources Conservation Service Pesticide Properties Database (http://www.wsi.nrcs.usda.gov/products/W2Q/pest/winpst.html#pst%20ppd). NA = not available.

[e] Surface loss may also occur when pesticides are adsorbed to soil or organic materials and washed out of the field. Potentials from the Natural Resources Conservation Service Pesticide Properties Database (http://www.wsi.nrcs.usda.gov/products/W2Q/pest/winpst.html#pst%20ppd). NA = not available.

[f] Leaching occurs when pesticides are moved downward in solution. Potentials from the Natural Resources Conservation Service Pesticide Properties Database (http://www.wsi.nrcs.usda.gov/products/W2Q/pest/winpst.html#pst%20ppd). NA = not available.

[g] LD50: 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 LD50 for mammals was found in the literature, the lowest found is shown here. Oral refers to toxicity through ingestion (Norway rat, unless otherwise specified), while dermal refers to toxicity by skin contact. Values are from material safety data sheets.

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

[h] Telone C-17 also contains chloropicrin.

[i] Fumigant regulations will change in 2010. Contact your cooperative extension agent or specialist for further information and follow label instructions carefully.

Table 14-1. continued

Common Name EPA Reg. No. Company Name	Trade Name(s)[a]	Signal Word	Re entry interval (REI)[b]	Worker notification[c]	Surface Loss Potential (Solution)[d]	Surface Loss Potential (Adsorbed)[e]	Leaching Potential[f]	IRAC, FRAC, or HRAC MOA Grouping	Mammalian LD_{50}[g]	
									Oral	Dermal
acephate *EPA Reg. No. 5481-8978* *Amvac*	*Orthene 97*	*Caution*	*24 hrs*	*Either*	*Intermediate*	*Low*	*Low*	*1B*	*1,030**	*10,250**
EPA Reg. No. 53883-132-66222 *Makhteshim Agan of North America, Inc*	*Acephate 90 WSB*	*Caution*	*24 hrs*	*Either*	*Intermediate*	*Low*	*Low*	*1B*	*1,030**	*>10,000*
acetamiprid *EPA Reg. No.8033-36-AA-70506* *United Phosphorus, Inc.*	*Assail 30 SG*	*Caution*	*12 hrs.*	*Either*	*Intermediate*	*Low*	*Intermediate*	*4A*	*805*	*>2,000*
acibenzolar-S-methyl *EPA Reg. No. 100-922* *Syngenta Crop Protection*	*Actigard*	*Caution*	*12 hrs.*	*Either*	*Intermediate*	*Low*	*Intermediate*	*P1*	*> 5,000*	*> 2,000*

Table 14-1. continued

Common Name EPA Reg. No. Company Name	Trade Name(s)[a]	Signal Word	Re entry interval (REI)[b]	Worker notification[c]	Surface Loss Potential (Solution)[d]	Surface Loss Potential (Adsorbed)[e]	Leaching Potential[f]	IRAC, FRAC, or HRAC MOA Grouping	Mammalian LD_{50}[g] Oral	Mammalian LD_{50}[g] Dermal
Bacillus thuringiensis subsp. aizawai EPA Reg. No. 70051-47 Certis USA, LLC	Agree WG	Caution	4 hrs.	Either	High	High	Low	11	>5,050	>2,020
EPA Reg. No. 73049-54 Valent BioSciences Corp.	Biobit HP	Caution	4 hrs	Either	High	High	Low	11	>5,000	>2,500 (rabbit)
Bacillus thuringiensis subsp. Kurstaki EPA Reg. No. 73049-39 Valent Agricultural Products	DiPel DF	Caution	4 hrs.	Either	High	High	Low	11	>5,050	>2,020
EPA Reg. No. 73049-17 Valent Agricultural Products	DiPel ES	Caution	4 hrs.	Either	High	High	Low	11	>5,050	>5,050 (rabbit)

Table 14-1. continued

Common Name EPA Reg. No. Company Name	Trade Name(s)[a]	Signal Word	Re entry interval (REI)[b]	Worker notification[c]	Surface Loss Potential (Solution)[d]	Surface Loss Potential (Adsorbed)[e]	Leaching Potential[f]	IRAC, FRAC, or HRAC MOA Grouping	Mammalian LD_{50}[g]	
									Oral	Dermal
bifenthrin EPA Reg. No. 279-3302 FMC Corporation	Capture LFR	Warning	12 hrs.	Either	Low	Low	Very Low	3	262	> 2,000
bifenthrin & imidacloprid EPA Reg. No. 279-3332 FMC Corporation	Brigadier	Warning	12 hrs.	Either	Low & High	Low & Intermediate	Very Low & High	3 & 4A	262 & 609	> 2,000 & > 2,000
Butralin EPA Reg. No. 33688-4-400 Chemtura	Butralin	Danger	12 hrs.	Either	High	High	Low	K1	>2,000	> 2,000 (rabbit)
C10 fatty alcohol EPA Reg. No. 19713-18 Drexel Chemical Corp.	Antak	Caution	24 hrs.	Either	Unknown	Unknown	Unknown	NA	>2,000	>2,000

Table 14-1. continued

Common Name EPA Reg. No. Company Name	Trade Name(s)[a]	Signal Word	Re entry interval (REI)[b]	Worker notification[c]	Surface Loss Potential (Solution)[d]	Surface Loss Potential (Adsorbed)[e]	Leaching Potential[f]	IRAC, FRAC, or HRAC MOA Grouping	Mammalian LD_{50}[g] Oral	Mammalian LD_{50}[g] Dermal
carbaryl EPA Reg. No. 264-333 Bayer CropScience	Sevin XLR Plus	Caution	12 hrs.	Either	Intermediate	Low	Low	1A	575	> 4,000
EPA Reg. No. 264-316 Bayer CropScience	Sevin 80S	Warning	12 hrs.	Either	Intermediate	Low	Low	1A	203	>5,000
EPA Reg. No. 264-349 Bayer CropScience	Sevin 4F	Caution	12 hrs.	Either	Intermediate	Low	Low	1A	699	> 4,000
carbofuran EPA Reg. No. 279-2876 FMC Corporation	Furadan 4F	Danger Poison	48 hrs.	Oral and Posted	High	Intermediate	High	1A	7.34	6,783 (rabbit)
EPA Reg. No. 279-3310 FMC Corporation	Furadan LFR	Danger Poison	48 hrs.	Oral and Posted	High	Intermediate	High	1A	7.34	6,783 (rabbit)

Table 14-1. continued

Common Name **EPA Reg. No.** **Company Name**	**Trade Name(s)[a]**	**Signal Word**	**Re entry interval (REI)[b]**	**Worker notification[c]**	**Surface Loss Potential (Solution)[d]**	**Surface Loss Potential (Adsorbed)[e]**	**Leaching Potential[f]**	**IRAC, FRAC, or HRAC MOA Grouping**	**Mammalian LD_{50}[g]**	
									Oral	**Dermal**
chloropicrin EPA Reg. No. 5785-17 Great Lakes Chemical Corp.	Chlor-O-Pic	Danger	48 hrs. and gas concentration less than 0.1 ppm	Oral and Posted	Intermediate	Low	Low	8B	NA	NA
									Inhalation danger	
chlorpyrifos EPA Reg. No. 62719-591 Dow AgroSciences	Lorsban Advanced	Warning	24 hrs	Oral and Posted	Low	Intermediate	Low	1B	495	>5,000
EPA Reg. No. 62719-34 Dow AgroSciences	Lorsban 15G	Caution	24 hrs	Oral and Posted	Low	Intermediate	Low	1B	1288	>5,000 (rabbit)
dichloropropene & chloropicrin EPA Reg. No. 62719-32 Dow AgroSciences	Telone II	Danger	5 days	Oral and Posted	Intermediate & Intermediate	Low & Low	High & Low	NA & 8B	NA	NA
									Inhalation danger	
dichloropropene EPA Reg. No. 62719-12 Dow AgroSciences	Telone C-17	Danger	5 days	Oral and Posted	Intermediate	Low	High	NA	NA	NA

Table 14-1. continued

Common Name EPA Reg. No. Company Name	Trade Name(s)[a]	Signal Word	Re entry interval (REI)[b]	Worker notification[c]	Surface Loss Potential (Solution)[d]	Surface Loss Potential (Adsorbed)[e]	Leaching Potential[f]	IRAC, FRAC, or HRAC MOA Grouping	Mammalian LD_{50}[g]	
									Oral	Dermal
dimethomorph EPA Reg. No. 241-410 BASF Corporation	Acrobat	Caution	12 hrs	Either	High	Intermediate	Intermediate	40	2,498	> 2,000
emamectin benzoate EPA Reg. No. 100-903 Syngenta Crop Protection	Denim	Danger	48 hrs.	Either	High	High	Intermediate	6	2,950	> 2,000 (rabbit)
ethoprop EPA Reg. No. 264-457 Bayer CropScience	Mocap 15 G	Danger Poison	48 hrs.	Oral and Posted	Intermediate	Low	High	1B	250 Inhaltion risk	> 2,000 (rabbit) Inhalation risk
etridiazole EPA Reg. No. 400-422 Chemtura	Terramaster 4EC	Danger	12 hrs.	Either	Intermediate	Intermediate	Low	14	1,600	3,600
fenamiphos EPA Reg. No. 264-731 Bayer CropScience	Nemacur 3	Danger Poison	48 hrs.	Oral and Posted	High	Intermediate	High	1B	10.6	71.5 (rabbit)

Table 14-1. continued

Common Name EPA Reg. No. Company Name	**Trade Name(s)[a]**	**Signal Word**	**Re entry interval (REI)[b]**	**Worker notification[c]**	**Surface Loss Potential (Solution)[d]**	**Surface Loss Potential (Adsorbed)[e]**	**Leaching Potential[f]**	**IRAC, FRAC, or HRAC MOA Grouping**	**Mammalian LD_{50}[g]**	
									Oral	**Dermal**
flubendiamide *EPA Reg. No. 264-1025 Bayer CropScience*	*Belt SC*	*Caution*	*12 hrs.*	*Either*	*Unavailable*	*Unavailable*	*Unavailable*	*28*	*> 2,000*	*> 4,000*
flumetralin *EPA Reg. No. 100-640 Syngenta Crop Protection*	*Prime+*	*Danger*	*24 hrs.*	*Either*	*Low*	*Intermediate*	*Low*	*NA*	*4,400*	*2,010 (rabbit)*
imidacloprid *EPA Reg. No. 264-827-ZA Bayer CropScience*	*Admire Pro*	*Caution*	*12 hrs.*	*Either*	*High*	*Intermediate*	*High*	*4A*	*609*	*> 2,000*
EPA Reg. No. 264-763 Bayer CropScience	*Provado 1.6 F*	*Caution*	*12 hrs.*	*Either*	*High*	*Intermediate*	*High*	*4A*	*4,143*	*> 2,000*
	Many generics	*See labels*			*High*	*Intermediate*	*High*	*4A*		
iron phosphate *EPA Reg. No. 67702-3-11656 Western Farm Service, Inc.*	*Sluggo*	*Caution*	*0*	*Either*	*High*	*Intermediate*	*High*	*4A*	*> 5,000*	*> 5,000*

Table 14-1. continued

Common Name EPA Reg. No. Company Name	Trade Name(s)[a]	Signal Word	Re entry interval (REI)[b]	Worker notification[c]	Surface Loss Potential (Solution)[d]	Surface Loss Potential (Adsorbed)[e]	Leaching Potential[f]	IRAC, FRAC, or HRAC MOA Grouping	Mammalian LD_{50}[g]	
									Oral	Dermal
lambda-cyhalothrin EPA Reg. No. 100-1112 Syngenta Crop Protection	Warrior	Warning	24 hrs.	Either	Low	Intermediate	Very Low	3	351	>2,000
EPA Reg. No. 100-1086 Syngenta Crop Protection	Karate	Warning	24 hrs.	Either	Low	Intermediate	Very Low	3	92.91	>2,000
maleic hydrazide EPA Reg. No. 400-84 Chemtura	Royal MH-30	Caution	12 hrs.	Either	Intermediate	Low	Low	NA	> 5,000	> 5,000
EPA Reg. No. 51873-9 Fair Products, Inc.	Fair-30	Caution	12 hrs.	Either	Intermediate	Low	Low	NA	> 5,000	> 5,000
	Many others	See label			Intermediate	Low	Low	NA	> 5,000	> 5,000

Table 14-1. continued

Common Name EPA Reg. No. Company Name	Trade Name(s)[a]	Signal Word	Re entry interval (REI)[b]	Worker notification[c]	Surface Loss Potential (Solution)[d]	Surface Loss Potential (Adsorbed)[e]	Leaching Potential[f]	IRAC, FRAC, or HRAC MOA Grouping	Mammalian LD_{50}[g]	
									Oral	Dermal
mancozeb EPA Reg. No. 2719-402 Dow AgroScience	Dithane DF Rainshield	Caution	24 hrs.	Either	High	High	Low	M3	> 5,000	> 5,000
mefenoxam EPA Reg. No. 100-801 Syngenta Crop Protection	Ridomil Gold	Caution	48 hrs.	Either	High	Intermediate	High	4	1,172	> 2,020
EPA Reg. No. 55146-73 Nufarm America's Inc.	Ultra Flourish	Warning	48 hrs.	Either	High	Intermediate	High	4	1,172	> 2,020
metaldehyde EPA Reg. No. 5480-507 AMVAC	Dealine Bullets	Caution	12 hrs.	Either	Intermediate	Low	Low	NA	283	> 5,000 (rabbit)

Table 14-1. continued

Common Name EPA Reg. No. Company Name	Trade Name(s)[a]	Signal Word	Re entry interval (REI)[b]	Worker notification[c]	Surface Loss Potential (Solution)[d]	Surface Loss Potential (Adsorbed)[e]	Leaching Potential[f]	IRAC, FRAC, or HRAC MOA Grouping	Mammalian LD_{50}[g]	
									Oral	Dermal
metam sodium EPA Reg. No. 5481-468 Amvac Chemical Corp.	Vapam HL	Poison	48 hrs.	Oral and Posted	Intermediate	Low	Intermediate	Z	812	> 2,020 (rabbit)
									Inhaltion danger	
methomyl EPA Reg. No. 352-384 Du Pont	Lannate LV	Danger Poison	48 hrs.	Either	Intermediate	Low	High	1A	49	> 2,000
napropamide EPA Reg. No. 70506-64 United Phosphorus Inc.	Devrinol 2 EC	Danger	12 hrs.	Either	High	Intermediate	Intermediate	K3	>5,000	>2,000 (rabbit)
oxamyl EPA Reg. No. 352-372 Du Pont	Vydate L	Danger	48 hrs.	Either	Intermediate	Low	Low	1A	9	>5,000

Table 14-1. continued

Common Name EPA Reg. No. Company Name	Trade Name(s)[a]	Signal Word	Re entry interval (REI)[b]	Worker notification[c]	Surface Loss Potential (Solution)[d]	Surface Loss Potential (Adsorbed)[e]	Leaching Potential[f]	IRAC, FRAC, or HRAC MOA Grouping	Mammalian LD_{50}[g]	
									Oral	Dermal
pendimethalin *EPA Reg. No. 241-337* *BASF Ag Products*	*Prowl 3.3 EC*	*Caution*	*24 hrs.*	*Either*	*Intermediate*	*High*	*Low*	*K1*	*3,956*	*>2,000*
EPA Reg. No. 241-418 *BASF Ag Products*	*Prowl H2O*	*Caution*	*24 hrs.*	*Either*	*Intermediate*	*High*	*Low*	*K1*	*> 5,000*	*> 5,000*
potassium salts of fatty acids *EPA Reg. No. 53219-6* *Dow AgroSciences*	*M-Pede*	*Warning*	*12 hrs.*	*Either*	*Unknown*	*Unknown*	*Unknown*	*Un*	*Unknown*	*Unknown*
pymetrozine *EPA Reg. No. 100-912* *Syngenta Crop Protection*	*Fulfill*	*Caution*	*12 hrs.*	*Either*	*Unknown*	*Unknown*	*Unknown*	*9B*	*> 5,000*	*> 2,000*
sethoxydim *EPA Reg. No. 7969-58-51036* *Micro Flo*	*Poast*	*Warning*	*12 hrs.*	*Either*	*Intermediate*	*Low*	*Low*	*A*	*4,286*	*> 4,000*

Table 14-1. continued

Common Name EPA Reg. No. Company Name	**Trade Name(s)[a]**	**Signal Word**	**Re entry interval (REI)[b]**	**Worker notification[c]**	**Surface Loss Potential (Solution)[d]**	**Surface Loss Potential (Adsorbed)[e]**	**Leaching Potential[f]**	**IRAC, FRAC, or HRAC MOA Grouping**	**Mammalian LD_{50}[g]**	
									Oral	**Dermal**
spinosad EPA Reg. No. 62719-267 Dow AgroSciences	Tracer	Caution	4 hrs.	Either	Low	Intermediate	Low	5	> 5,000	> 5,000 (rabbit)
sulfentrazone EPA Reg. No. 279-3220 FMC Corp.	Spartan Charge	Caution	12 hrs.	Either	High	Intermediate	High	E	5,000	> 5,050
thiamethoxam EPA Reg. No. 100-938 Syngenta Crop Protection	Actara	Caution	12 hrs.	Either	High	Intermediate	High	4A	> 5,000	> 2,000
EPA Reg. No. 100-1291 Syngenta Crop Protection	Platinum 75 SG	Caution	12 hrs.	Either	High	Intermediate	High	4A	> 5,000	> 5,000
EPA Reg. No. 100-939-51873 Fair Products, Inc.	T-Moxx	Caution	12 hrs.	Either	High	Intermediate	High	4A	> 5,000	> 5,000

15. Mechanization

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Burley mechanization efforts focus on both harvesting machines and cured-leaf removal systems to reduce the hard work and improve labor efficiency. The traditional harvesting of burley tobacco requires intensive hand labor, resulting in a significant cost to the grower. Also, many new burley growers are also flue-cured tobacco growers who depend heavily upon mechanization for harvesting. As more mechanization options are becoming available, growers can choose equipment that will work best for their particular acreage and location. Because the cost of the harvesting equipment can vary significantly, some devices will be better suited for larger growers. As growers and equipment manufacturers gain experience with existing and new machinery, improvements will be made to increase overall efficiencies. In this chapter we describe some of the new machinery to increase your awareness of recent developments in burley mechanization and commercially available equipment.

Commercial Burley Harvesters

Traditional harvesting requires spiking five to eight plants onto a stick and handling the plants and sticks. The 30- to 35-pound sticks are handled multiple times during loading and transporting from the field to the barn. Compared to traditional harvesting operations, commercial harvesters offer a major advantage—they require a limited number of workers to cut and remove the plants from the field. A tractor operator is required for the harvester, and two additional drivers are needed to transport the field trailers. The machines eliminate most of the drudgery and significantly reduce the harvesting time required per acre. As might be expected, the time required to hang the plants will be significantly greater than the time it takes to cut, notch, and load the plants in the field with any type of harvester. Based on feedback from a limited number of growers, 8 to 10 workers may be required to maintain a continuous harvesting operation when using the wire-frame curing structures.

The Kirpy Machine

The Kirpy machine is a unique burley harvester developed by a French equipment manufacturer (Figure 15-1). The harvester is designed to mount on a tractor's three-point hitch. It is powered by the tractor power take-off (PTO). The single-row machine uses a large diameter saw to cut the plant slightly above the ground. Once the stalk is cut, a modified steel chain with metal spikes grips the plant and conveys it in the upright position. The spikes penetrate the stalk and convey the plant as the chain travels along a sheet metal track. A notching saw is also incorporated that cuts a 45-degree notch at the base of the stalk, which is required to hang the plants onto any of the wire-frame curing structures. After notching, the plant is conveyed until it reaches the track end, where it is released onto a field trailer that is pulled adjacent to the harvester. The notching saw can also be disengaged or removed if the grower uses sticks for hanging the plants.

Suggested manufacturer capacity is approximately ¼- to ⅓-acre per hour, depending on plant population and tractor ground speed. In order for the plants to be conveyed in the upright position, the conveyor chain speed and tractor ground speed must be synchronized. Also, the conveyor track width should be properly adjusted to maintain the stalks in an upright position when conveyed. This ensures

Figure 15-1. Kirpy harvester

that the notch will be correctly aligned when the stalks pass through the notching saw. Plants that are leaning result in problems during the notching process and consequently will not hang properly on the curing structure.

The recommended tractor ground speeds are 0.6 to 1.0 miles per hour. Therefore, the tractor used to operate the harvester should be capable of maintaining a very slow ground speed to properly synchronize the conveyor speed. The conveyor speed can be adjusted with a needle valve incorporated in the hydraulic controls. The conveyor width can be manually adjusted for different sizes of tobacco, but the more uniform plant size and field conditions are, the better the machine performance will be. Contact your Extension agent for details concerning a U.S. distributor.

Marco Harvesters

A more sophisticated commercial harvester designed to incorporate the portable curing frames was built originally by Powell Manufacturing Co. and most recently by Marco Manufacturing. The harvester cuts the plant, cuts the 45-degree notch, and conveys the plant to workers on the machine who hang the plant onto the portable frames. The advantage of this system is that workers handle the plant only once until curing is completed. Due to the increased auto-

Figure 15-2. Marco burley harvester

mation, this harvester requires a greater investment than the carrier unit and single-row cutter-notcher and may only be cost effective for growers with many acres of burley. The frame cost and quantity required per acre, however, would be similar for both systems.

A smaller version of the burley harvester without the portable rack-handling mechanism was recently built by Marco Manufacturing (Figure 15-2). This machine is a tractor three-point-hitch-mounted harvester that cuts, notches, and positively conveys the plant utilizing a gripper or sticker chain. The plants are conveyed and discharged onto a field trailer that is pulled adjacent to the harvester. Although Figure 15-2 shows a wide flat-belt conveyor, this has been eliminated and replaced with another section of gripper chain. One advantage of the gripper chain is its ability to continuously accommodate different size stalks that may be encountered during operation. The harvester's self-contained hydraulic system is powered by the tractor PTO.

Field Trailers

With both types of commercial harvesters, the number of trailers required will depend on the trailer capacity. A small trailer of 16 feet or less will be filled quickly with loosely stacked plants. Some growers are using 40-foot cotton trailers for additional capacity. One solution developed by a local grower is to fabricate removable bulk handling bins that are incorporated onto the trailer. Instead of numerous trailers, only a few are needed and many bins are fabricated. The filled bins can be removed from the trailer in the field or at a central location, such as the curing structure. In terms of trailer capacity, the packing or loading density for uniform average-size plants is approximately four to five plants per square foot of area. The area is determined by the length of the trailer and the depth of the bulked plants. For example a 16-foot trailer with plants piled 3 feet deep would result in approximately 240 plants (16 times 3 times 5). Regardless of the capacity, the harvesters can load the trailers significantly faster than workers can unload them.

Plant Cutting and Notching Devices

The concept of notching the base of the plant to hang it from a wire grid system was developed some years ago in Maryland and exported to Europe. Carolina Industries manufactures a toolbar-mounted cutter-notcher based on a similar unit developed by the University of Kentucky (Figure 15-3). The single-row machine simultaneously cuts a 45-degree notch in the stalk near the base and cuts the plant down.

The notch depth is approximately half the diameter of the stalk. The notch is cut using a 7-inch and a 6.25-inch saw blade assembled together. Stacking the blades together, thereby doubling the thickness, results in a tapered notch that is widest on the stalk surface and narrower near the stalk center. The tapered notch allows the worker to hang the plant onto the wire with ease, but the notch grips the wire tightly enough to keep the stalk from bouncing off the wire during transport through the field. To cut the plant completely, a 10-inch saw blade was used. The cutter and notcher blades are driven by a single hydraulic motor powered by the tractor's remote hydraulic outputs.

Portable Notching Saw

A portable notching saw was developed at NC State University to assist growers who cut the plants manually or by some mechanical method other than the cut-and-notch machinery. Regardless of how the plants are cut, if the portable frames or high-tensile wire curing structures are to be utilized, a notch is required in each stalk. The portable notching saw is direct-driven by a hydraulic motor and uses the same blade assembly as on the cutter-notcher. This device can be mounted in any position and is operated from the tractor's remote hydraulics. A centering linkage is also incorporated into the notching saw that ensures the notch depth is correct regardless of the stalk

Figure 15-3. Carolina Industries cutter-notcher

diameter. An electric unit was also developed to operate from a 120-volt power source and eliminate the use of a tractor (Figure 15-4). The major difference is the notching saw blades are powered by a ¾-horsepower electric motor. The hydraulically operated portable notching saw is commercially available, but it can be fabricated locally if a grower has the resources. Contact your Extension agent for plans to build both portable notching saw configurations.

High-Tensile-Wire Curing Structures

Some growers are beginning to develop low-cost and low-maintenance field curing structures that utilize high-tensile wire for hanging and curing the plants. Various construction methods and materials are being used. All structures incorporate, as they should, some type of plastic cover to protect the tobacco from the wind and rain. Although weather conditions greatly affect the cure quality, growers can manage curing to some degree by raising and lowering the plastic, which controls the drying rate.

Most of the low-cost structures use single wire strands that span support posts (Figure 16-5). The wires are spaced across the structure in 6-inch increments, and the plants are typically spaced 6 inches apart along the wire. The resulting plant density is approximately four plants

Figure 15-4. Electric-motor-driven portable notching saw

per square foot, which is recommended for adequate ventilation. The length of these low-cost structures varies from 100 to several hundred feet, depending on the space availability. The height of the field structures should be sufficient to ensure the tip leaves are 6 to 12 inches above the ground.

When constructing these types of field structures, do not exceed the tensile strength of the wire. This is critical. Typically, 12.5 gauge high-tensile wire is used that has a wire diameter of approximately 0.095 inches and a tensile strength of 180,000 pounds per square inch (psi). The wire support-post spacing and amount of sag allowed will determine the tensile stress in each wire. For a given support-post spacing, the wire tension force increases as less wire sag is allowed under load. This tension force should not exceed the wire capacity, which is approximately 1,370 pounds for 12.5 gauge wire. Figure 16-6 is a plot of the wire sag at mid-span in relationship to the support-post spacing. The wire sag is the greatest at mid-span or half the distance between the posts. The green plants are assumed to weigh approximately 8 pounds, and a factor of safety of 2 is used. The factor of safety decreases the allowable tension force to 685 pounds (1,370 divided by 2).

The solid line in Figure 16-6 represents the wire sag for a given post spacing that results in a tension force of 685 pounds. Anything above the solid line is under-stressed and anything below is overstressed, which may result in exceeding the wire capacity. For example, if the

Figure 15-5. High-tensile-wire curing structure

support posts are spaced 12 feet apart, a wire sag of approximately 5 inches will result in a tension force of 685 pounds. In this example, a wire sag of greater than 5 inches would decrease the tension force, but a sag of less than 5 inches would over-stress the wire.

As you might suspect, the farther apart the support posts are spaced to maintain a given wire sag, the greater the strength required in the wire. Also, excessive wire sag can result in the plants sliding down the wire and bunching together, especially during periods of high wind. Experience in Kentucky recommends avoiding a wire sag greater than 4 inches. Plants that do not maintain the proper spacing may result in curing problems. Based on the graph, spans exceeding 12 feet are not recommended due to the tension force required to maintain a minimum amount of wire sag.

Another major concern of these types of field structures is bracing the end posts. The tension developed in each wire is transferred back to the end posts and supports. Typically, guy wires, brace members, or both are used to support the end post. The guy wires will need to resist the tension load developed by all the individual wires minus the load carried by the end post. The end-post load is not easily determined, and it is affected by many variables. Therefore, assume that the guy wires must be of adequate strength to carry the entire load.

Consider this example: A field structure that is 16 feet wide with a

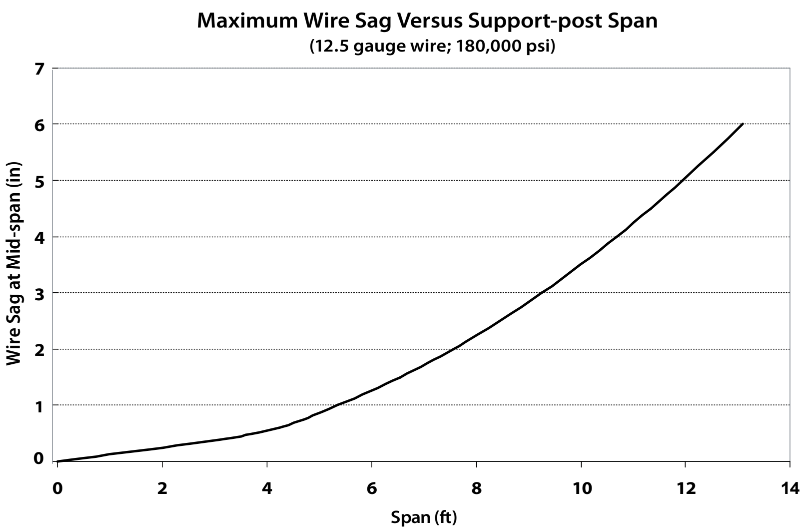

Figure 15-6. Mid-span wire sag versus support-post span

6-inch wire spacing supports 33 wires total. If the support posts are 12 feet apart with a mid-span wire sag of 5 inches, the tension force in each wire is approximately 685 pounds (Figure 16-6). The total load supported by the end posts and guy wires is approximately 22,605 pounds (685 times 33). This example demonstrates the large amount of force that can be exerted onto the end post. Also, the load exerted on the middle end post may be twice the load exerted on the outer posts. Therefore, the middle end post may need additional bracing. Fortunately, the load exerted on the support members will decrease as the plants dry.

Experience has shown that mobile home ground anchors may not be suitable for bracing the end posts. Mobile home anchors are typically rated at a holding capacity of a few thousand pounds. The industrial type screw anchors similar to those used to support utility poles are a better alternative. These larger-capacity anchors come in various rod diameters and lengths and may be installed by hand or machine. As an example, for a given soil type, the holding strength for an industrial screw anchor is approximately three to four times that of a mobile home anchor.

The soil type will have a great effect on the holding strength of any anchor used. Regardless of the anchor used, the angle measured between the guy wire and the ground should be minimized to decrease the tension load. As the angle increases, the tension load carried by the guy wires will increase accordingly. An angle of 45 degrees or less between the guy wire and the ground should be targeted. It is also recommended that the ground anchor be installed at the same angle as the guy wire so the anchor shaft is aligned with the guy wire load.

Cured-Leaf Removal Aids

Removing the cured leaves from the burley tobacco stalk is very labor intensive and accounts for approximately half of the total labor cost. The leaves are typically removed manually and segregated into different stalk positions for market preparation. To increase worker productivity and efficiency, a simple stripping aid was developed at NC State University based on similar devices developed by growers in Kentucky and Tennessee (Figure 15-7).

The stripping unit consists of a light steel frame and a conveyor with holders or cups for the stalks. The stalk holder allows a worker to use both hands to remove the leaves, which increases worker productivity. The conveyor frame height is also adjustable to minimize worker effort during removal of the tip leaves. Conveying the stalk past the stationary workers reduces both the time and physical effort required to remove the leaves. A variable speed electric motor drives the conveyor, which allows workers to vary the conveyor speed and consequently the stalk output rate. Although capacities can vary, a stripping unit should easily convey 10 to 12 stalks per minute. Such a simple leaf-removal aid can reduce the labor requirement by 50 percent. Some growers have developed their own aids using flue-cured stringing machines or other conveying equipment, but the concept is the same. Commercial units are available. If you are interested in fabricating your own device, contact your Extension agent for plans.

Figure 15-7. Stripping aid