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Extension Personnel Working with Burley Tobacco

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1. U.S. Tobacco Situation and Outlook

Blake Brown
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Tobacco Products

The U.S. Food and Drug Administration (FDA) continues to work on implementation of the Family Smoking Prevention and Tobacco Control Act. The FDA has published a final regulation requiring color graphics depicting smoking's negative health consequences to appear on cigarette packages. The FDA's Tobacco Products Scientific Advisory Committee has published recommendations that cigarettes not contain menthol flavorings. The new legislation had already banned other flavorings. It is still unknown what restrictions FDA will actually place on menthol and what their impact on tobacco will be. The Tobacco Products Scientific Advisory Committee is ready to begin examining the health consequences of dissolvable tobacco products and how they should be regulated. Related to the issue of dissolvable tobacco products is the question of how to regulate harm-reduced tobacco products. Recommendations on the use and marketing of harm-reduced products may have a substantial impact on the demand for tobacco because harm-reduced products likely will contain less tobacco per unit.

Cigarette excise taxes continue to climb. The average state excise tax per pack was $1.45 at the end of 2010, up from an average of $1.32 at the end of 2009. The federal excise tax per pack was raised from $0.39 to $1.01 in 2009. The average price per pack of cigarettes in the United States was $5.55 at the end of 2010, with state and federal excise taxes accounting for $2.46 of the price per pack.

As of July 1, 2011, 22 states had laws in place that completely banned smoking in nonhospitality workplaces, restaurants, and bars. Another 12 states have banned smoking in either restaurants and bars or the workplace. U.S. cigarette consumption decreased 5 percent per year in 2008 and 2009. From 2009 to 2010, cigarette consumption fell by more than 8 percent, to 307 billion pieces annually. However, data through the first seven months of 2011 reveal that both cigarette consumption and production had only decreased by about 2 percent in the United States, indicating that cigarette consumers may have adjusted to the relatively large price hikes of recent years.

Alternatively, U.S. smokeless consumption continues to increase, following trends established over the past two decades. Snuff production was up 6.5 percent last year, and production increased another 4.4 percent during the first seven months of 2011. Smoking restrictions, successful marketing of traditional products, the introduction of new products, and perceived lower health risks have collectively benefited the smokeless sector in recent years.

Flue-Cured Situation and Market Outlook

The 2011 U.S. flue-cured tobacco crop was characterized by extreme weather conditions that reduced both yields and quality. Large parts of eastern North Carolina east of Interstate 95 were in extreme drought conditions during much of the growing season. Hurricane Irene passed over eastern North Carolina early in the harvest season, dumping much-needed rain but also causing severe wind damage to much of the crop in eastern North Carolina, especially east of Interstate 95. The National Agricultural Statistics Service (NASS) of the U.S. Department of Agriculture (USDA) estimated North Carolina flue-cured yields at 1,550 pounds per acre on 160,000 harvested acres, down from a prehurricane August 1 estimate of 2,150 pounds per acre on 168,000 acres. North Carolina flue-cured production for 2011 was 248 million pounds.

Table 1-1. U.S. flue-cured tobacco production, 2004–2011 (weight in million pounds)

Year	*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*	*28.0*	*417.6*	*38.8*	*42.0*	*526.4*
2010	*N/A*	*27.4*	*348.6*	*36.0*	*39.9*	*451.9*
2011	*N/A*	*26.3*	*248.0*	*26.3*	*46.8*	*347.5*

Source: USDA, NASS. *Crop Production Report*. January 2012.

The rains from hurricane Irene helped some of the North Carolina piedmont flue-cured tobacco crop. The biggest concern for tobacco in piedmont North Carolina and southside Virginia was a late harvest and the danger of frost. Virginia's flue-cured crop for 2011 was estimated at 46.8 million pounds. The crops in Georgia and South Carolina were estimated at 26.3 million pounds each. U.S. flue-cured tobacco production for 2011 was 347.5 million pounds. U.S. flue-cured production in 2010 was 452 million pounds.

The 2011 Brazilian crop of flue-cured tobacco was reported to be more than 1.5 billion pounds (Universal Corporation, *World Leaf Production*, August 4, 2011). This is the largest Brazilian crop since 2005 and is 200 million pounds more than initial forecasts for the 2011 crop. With the U.S. crop initially expected to be 475 to 500 million pounds, excess supply of flue-cured tobacco was a concern. However, the reduction in the 2011 U.S. crop because of extreme weather has removed much excess supply from the global market.

Prices offered in contracts signed in spring 2011 were mostly flat to slightly higher than 2010 contract prices. A new potential buyer emerged in spring 2011 and signed contracts with numerous growers for reportedly more than 100 million pounds. For most growers, the amount signed with this buyer was a small portion of their total production. Unfortunately, this new buyer was not able to purchase the tobacco for which it had signed contracts. Because hurricane Irene had destroyed a large portion of the 2011 crop, demand from other buyers was sufficient to take any pounds growers had produced for the new buyer. In addition, another leaf dealer offered to honor the contracts growers had signed with the new buyer.

Prices received at harvest are quite variable depending on quality, particularly in light of the extent of storm damage. The reduction in supply due to hurricane Irene prompted at least one buyer to increase prices paid by $0.05 per pound. Farmers fortunate enough to have good-quality tobacco received premium prices.

Total use of U.S. flue-cured tobacco was down for the 2010 marketing year. Domestic use was up from the 2009 marketing year, but exports were down by more than 40 million pounds. The drop in exports for the 2010 marketing year is not surprising given that production for 2010 was down from 2009. However, the main factors driving exports down may have been the poor quality of much of the 2010 crop and the large supply of Brazilian tobacco that became available in early 2011 (the second half of the 2010 marketing year for U.S. flue-cured tobacco). Exports for the 2011 marketing year would have likely recovered if so much of the 2011 crop had not been lost to drought and hurricane Irene. Domestic use and exports will likely decrease again for the 2011 marketing year but less than the decline in production, because manufacturers will probably draw down stocks to partially offset low 2011 production.

Table 1-2. Flue-cured tobacco production, stocks, supply, and disappearance (farm sales, weight in million pounds)

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

Source: USDA, Agricultural Marketing Service. *Tobacco Stocks as of July 1, 2011*. TOB-215. September 2011.

Burley Situation and Market Outlook

Upon entering the 2011 growing season, U.S. burley farmers faced many of the same adverse demand conditions they experienced in 2010: declining domestic demand, excess world burley supply leading to slumping exports, and regulatory uncertainty on the domestic and international fronts. Aggregate burley contract volume was likely reduced again in 2011, but some buyers did boost contract volume for some growers. Despite excess world burley supply, high-quality stocks entering 2011 were fairly tight following the disastrous 2010 U.S. burley crop, along with subpar-quality crops in 2007 and 2008. Some companies may have boosted the contracts of their "better" quality growers to replenish depleted inventories, or there could have been a resurgence in the proportion of U.S. burley in domestic blends. Imports have plagued the U.S. burley industry for decades, and they continue to make up a large percentage of domestic blends. But disappearance data (Table 1-4) show that U.S. burley use has increased in recent years, even with declining domestic cigarette consumption.

Although domestic buyers have apparently demonstrated a renewed interest in U.S. burley (at least in the short term), the largest portion of the crop is purchased by the international market. Similar to U.S. flue-cured, the value of the dollar has kept the price of U.S. burley competitive in the world market in recent years. But a doubling of burley production in the African market from 2007 to 2009 flooded the international tobacco market, displacing U.S. burley around the globe the past couple of years. Plus, it appears that technological advances in cigarette manufacturing and uncertainty over potential flavoring bans are leading manufacturers and dealers worldwide to reduce their ideal desired inventory levels, to minimize storage costs and speculative risks. Consequently, U.S. burley exports have slumped by more than 50 percent since 2007, which has had devastating impacts on a crop that once sold nearly 75 percent of its production to international customers.

As a result of these and other adverse factors, U.S. burley acreage is forecast to shrink by 8 percent in 2011. Relative to last year, there will be 9,000 fewer acres in Kentucky, 1,000 more acres in Tennessee, and 400 more acres in Virginia. Burley acreage is also up in Pennsylvania, which has emerged as an important source of U.S. burley in the post-buyout era. It was speculated that North Carolina would expand burley acreage after quota restrictions were lifted, but relatively low yields and high production costs have prevented any expansion. Belt-wide yields for the 2011 burley crop are forecast to be below average because of excessive heat and dry conditions in parts of the burley belt. According to the USDA crop report, the U.S. burley crop was 172.3 million pounds in 2011, 9 percent lower than last year's crop of 188 million pounds.

Table 1-3. U.S. burley tobacco production, 2004 to 2011 (weight in million pounds)

Year	*Kentucky*	*Tennessee*	*Pennsylvania*	*North Carolina*	*Others*	*U.S. Total*
2004	*206.7*	*46.1*	*N/A*	*6.6*	*32.8*	*292.2*
2005	*143.5*	*34.0*	*4.8*	*5.0*	*16.1*	*203.4*
2006	*153.3*	*30.8*	*11.6*	*6.6*	*15.0*	*217.1*
2007	*154.0*	*20.8*	*10.8*	*6.6*	*15.2*	*207.4*
2008	*147.0*	*24.7*	*9.9*	*5.6*	*14.3*	*201.5*
2009	*161.3*	*26.9*	*9.4*	*6.3*	*11.0*	*214.9*
2010	*140.4*	*24.9*	*10.1*	*4.0*	*8.2*	*187.6*
2011	*128.0*	*22.5*	*11.0*	*3.6*	*7.5*	*172.6*

Source: USDA, NASS. *Crop Production Report*. January 2012.

The August 2011 production report of the Universal Leaf Tobacco Company estimates world burley production to be 2 percent higher in 2011, following a 9 percent reduction in 2010. According to the report, 2011 burley production in Brazil is up 30 percent, and African production is virtually flat from 2010 but 7 percent off its record crop in 2009. Despite the boost in Brazilian burley, high-quality burley stocks remain relatively flat in the world market, especially given that some industry representatives claim the September 2011 USDA estimate for U.S. burley may be too high.

On the demand side, domestic use of U.S. burley has surprisingly rebounded, despite declining U.S. cigarette consumption. Technological changes in cigarette manufacturing and the introduction of new tobacco products has likely reduced overall domestic burley use per cigarette, so U.S. burley use has evidently been gaining relative to imported burley in the U.S. market in recent years. But the extremely poor quality of the 2010 crop likely limited additional market share gains for U.S. burley in manufacturing U.S. cigarettes in 2011 and into 2012. On the international front, U.S. burley leaf exports continue to slump. Following the record high of nearly 260 million pounds in the 2006–2007 marketing year, U.S. burley exports fell to 116 million pounds in the 2009–2010 marketing year and will likely come near that level when the 2010–2011 data are finalized. Combining projections for domestic use and exports, U.S. burley disappearance likely fell below 200 million pounds for the 2010–2011 marketing year.

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

Marketing Year	*Beginning Stocks*	*Production*	*Total Supply*	*Ending Stocks*	*Total Use*	*Exports*	*Domestic Use*
2004–2005	*540.0*	*280.1*	*820.1*	*492.6*	*327.5*	*227.6*	*99.9*
2005–2006	*492.6*	*203.4*	*696.0*	*403.4*	*292.6*	*200.4*	*92.3*
2006–2007	*403.4*	*217.1*	*620.5*	*296.2*	*324.4*	*259.8*	*64.6*
2007–2008	*296.2*	*207.4*	*503.6*	*256.2*	*247.4*	*192.1*	*55.3*
2008–2009	*256.2*	*201.5*	*457.7*	*239.2*	*218.5*	*140.0*	*78.5*
2009–2010	*239.2*	*214.9*	*454.0*	*237.7*	*216.4*	*116.0*	*100.4*
2010–2011	*237.7*	*187.6*	*425.3*	*N/A*	*N/A*	*N/A*	*N/A*

Source: USDA, Agricultural Marketing Service. *Tobacco Stocks as of July 1, 2011*. TOB-215. September 2011.

Assuming that a decent curing season evolves, the structure of contract prices coupled with the stocks situation indicates that U.S. burley prices should rebound back into the $1.70s and 1.80s per pound for the upcoming marketing season, after the extremely poor-quality 2010 crop averaged $1.50 per pound, with many growers receiving less than $1.00 per pound for inferior leaf.

Burley's outlook beyond 2011 hinges critically on a multitude of uncertainties, including the following items:

• Will the U.S. burley export market rebound? This will be very dependent on what happens with respect to international flavoring and additive regulations, foreign burley production, exchange rates, and sales in the all-important Chinese market.

• What impact will future FDA policies have on domestic burley demand and required production practices?

• As tobacco regulations and public smoking restrictions expand, what will be the effect of new tobacco products, both with regard to consumer acceptance and product ingredients?

• How will growers balance labor cost and availability versus adoption of "affordable" mechanization?

• How will profitable alternative agricultural enterprises affect future U.S. burley production and the number of farmers growing the crop?

Dark Tobacco Situation and Market Outlook

The situation for U.S. dark tobacco growers is much different from what most other tobacco growers are experiencing. Dark continues to benefit from growing domestic snuff sales and limited foreign competition, which has resulted in profitable prices and an optimistic outlook for most U.S. dark tobacco growers in the post-buyout era. Following two straight years of supply adjustment, it appears that the industry once again is close to an acceptable supply/demand balance.

According to the USDA's October crop report, U.S. dark fire-cured acres are up nearly 7 percent in 2011, while dark air-cured acres are relatively flat from 2010. The USDA pegs total U.S. dark fired production at 52.4 million pounds, compared to 48.4 million pounds in 2010. For dark air-cured, the USDA is projecting a 2011 crop of 15.6 million pounds, up slightly from last year. Look for dark tobacco prices to remain near recent levels ($2.25 per pound for dark air-cured and $2.50 per pound for dark fire-cured) for the 2011–2012 marketing year.

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Table 1-5. Flue-cured tobacco—machine harvest—eastern North Carolina: 2012 estimated costs per acre

	Unit	Quantity	Price or Cost/Unit	Total Per Acre	Your Farm
1. Gross receipts					
Stalk position		Yield	Price/lb		
Lugs	lb	0.00	$0.00	$0.00	
Cutter	lb	0.00	$0.00	$0.00	
Leaf	lb	0.00	$0.00	$0.00	
Tips	lb	0.00	$0.00	$0.00	
Total receipts:				$0.00	
2. Variable costs					
Plants (greenhouse)	thou	6.20	$34.50	$213.90	
Multipurpose fumigation	gal	10.50	$17.13	$179.87	
Fertilizer					
8-8-24	cwt	5.00	$30.63	$153.15	
24s liquid	cwt	1.25	$14.13	$17.66	
Lime (prorated)	ton	0.33	$48.50	$16.01	
Herbicides	acre	1.00	$51.17	$51.17	
Insecticides	acre	1.00	$54.58	$54.58	
Sucker control	acre	1.00	$186.32	$186.32	
Hauling	lb	2500.00	$0.04	$100.00	
Cover crop	acre	1.00	$20.00	$20.00	
Curing fuel	gal	325.00	$1.75	$568.75	
Electricity	kwh	1580.00	$0.08	$126.40	
Crop insurance	$	1.00	$120.00	$120.00	
Baling supplies	$	2500.00	$0.003	$7.50	
Tractor/machinery	acre	1.00	$233.94	$233.94	
Labor					
Preharvest	hrs	46.25	$9.30	$430.13	
Harvest/baling	hrs	23.54	$9.30	$218.92	
Postharvest	hrs	9.00	$9.30	$83.70	
Interest on op. cap.	$	$553.30	5.0%	$27.67	
Total variable costs				$2,809.67	
3. Income above variable costs					
4. Fixed costs					
Tractor/machinery	acre	1.00	$224.03	$224.03	
Bulk barn	acre	1.00	$132.58	$132.58	
Green leaf box loading sys.	acre	1.00	$38.75	$38.75	
Baler	acre	1.00	$7.50	$7.50	
Total fixed costs				$402.86	
5. Total costs				$3,212.53	
6. Net returns to land, risk, and management					

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

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

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

Table 1-6. Flue-cured tobacco—machine harvest—piedmont North Carolina: 2012 estimated costs per acre

	Unit	Quantity	Price or Cost/Unit	Total per Acre	Your Farm
1. Gross receipts					
Stalk position		Yield	Price/lb		
Lugs	lb	0.00	$0.00	$0.00	
Cutter	lb	0.00	$0.00	$0.00	
Leaf	lb	0.00	$0.00	$0.00	
Tips	lb	0.00	$0.00	$0.00	
Total receipts				$0.00	
2. Variable costs					
Plants (greenhouse)	thou.	6.20	$34.50	$213.90	
Multipurpose fumigation	gal	10.50	$17.13	$179.87	
Fertilizer					
6-6-18	lb	665.00	$0.27	$179.55	
15.5-0-0	lb	193.00	$0.25	$48.25	
Lime (prorated)	ton	0.33	$48.50	$16.01	
Herbicides	acre	1.00	$51.17	$51.17	
Insecticides	acre	1.00	$62.65	$62.65	
Sucker control	acre	1.00	$186.32	$186.32	
Hauling	lb	2500.00	$0.04	$100.00	
Cover crop	acre	1.00	$20.00	$20.00	
Curing fuel	gal	325.00	$1.75	$568.75	
Electricity	kwh	1580.00	$0.08	$126.40	
Crop insurance	$	1.00	$120.00	$120.00	
Irrigation	cycle	3.00	$80.01	$240.03	
Baling supplies	$	2500.00	$0.003	$7.50	
Tractor/machinery	acre	1.00	$275.49	$275.49	
Labor					
Preharvest	hrs	46.25	$9.30	$430.13	
Harvest/baling	hrs	23.54	$9.30	$218.92	
Post harvest	hrs	9.00	$9.30	$83.70	
Interest on op. capital	$	$606.61	5.0%	$30.33	
Total variable costs				$3,158.97	
3. Income above variable costs					
4. Fixed costs					
Tractor/machinery	acre	1.00	$247.42	$247.42	
Bulk barn	acre	1.00	$132.58	$132.58	
Baler	acre	1.00	$7.50	$7.50	
Irrigation	acre	1.00	$67.08	$67.08	
Total fixed costs				$454.58	
5. Total costs				$3,613.55	
6. Net returns to land, risk, and management					

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

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

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

Table 1-7. Flue-cured tobacco—hand harvest—piedmont North Carolina: 2012 estimated costs per acre

	Unit	Quantity	Price/Cost per Unit	Total per Acre	Your Farm
1. Gross receipts					
Stalk position		Yield	Price/lb		
Lugs	lb	0.00	$0.00	$0.00	
Cutter	lb	0.00	$0.00	$0.00	
Leaf	lb	0.00	$0.00	$0.00	
Tips	lb	0.00	$0.00	$0.00	
Total receipts				$0.00	
2. Variable costs					
Plants (greenhouse)	thou	6.20	$34.50	$213.90	
Multipurpose fumigation	gal	10.50	$17.13	$179.87	
Fertilizer					
6-6-18	lb	665.00	$0.27	$179.55	
15.5-0-0	lb	193.00	$0.25	$48.25	
Lime (prorated)	ton	0.33	$48.50	$16.01	
Herbicides	acre	1.00	$51.17	$51.17	
Insecticides	acre	1.00	$62.65	$62.65	
Sucker control	acre	1.00	$186.32	$186.32	
Hauling	lb	2500.00	$0.04	$100.00	
Cover crop	acre	1.00	$20.00	$20.00	
Curing fuel	gal	325.00	$1.75	$568.75	
Electricity	kwh	1580.00	$0.08	$126.40	
Crop insurance	$	1.00	$120.00	$120.00	
Irrigation	cycle	3.00	$80.01	$240.03	
Baling supplies	$	2500.00	$0.003	$7.50	
Tractor/machinery	acre	1.00	$157.14	$157.14	
Labor					
Preharvest	hrs	46.25	$9.30	$430.13	
Harvest/bailing	hrs	59.60	$9.30	$554.28	
Postharvest	hrs	9.00	$9.30	$83.70	
Interest on op. capital	$	$547.43	5.0%	$27.37	
Total variable costs				$3,373.02	
3. Income above variable costs					
4. Fixed costs					
Tractor/machinery	acre	1.00	$98.63	$98.63	
Bulk barn	acre	1.00	$132.58	$132.58	
Baler	acre	1.00	$7.50	$7.50	
Irrigation	acre	1.00	$67.08	$67.08	
Total fixed costs:				$305.79	
5. Total costs				$3,678.81	
6. Net returns to land, risk, and management					

** Crop insurance: 65% based premium. No disaster subsidies.*
** Please note: This budget is for planning purposes only.*
Prepared by Gary Bullen and Loren Fisher, North Carolina State University, Department of Agricultural and Resource Economics.

2. Complying with North Carolina Farm Labor Regulations

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

Immigration

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

Since April 3, 2009, all employers are required to use the revised I-9 form available at the U.S. Citizenship and Immigration Services Web site. The new form has (Rev. 02/02/09) or a later date printed in the bottom right corner.

E-Verify is an Internet-based system for matching an employee's Social Security number with other I-9 information. E-Verify will become mandatory soon for many North Carolina businesses. E-Verify becomes mandatory on the following dates:10/1/12 for businesses that employ 500+ employees; 1/1/13 for businesses that employ 100+ employees;

and 7/1/13 for businesses that employ 25+ employees. Employers with seasonal temporary employees who work fewer than 90 days in a consecutive 12-month period are exempt. In most cases, employers who submit an employee's information to E-Verify will receive one of two types of feedback from the system: either the information is verified, or the system returns a tentative nonconfirmation (TNC). If an employer receives a TNC for an employee, the employer should follow the directions that E-Verify provides. E-Verify is not a replacement for the I-9 form and should not be used until after an employee has completed the I-9 form. E-Verify can be used only for new hires. Although use of the E-Verify system is voluntary, if an employer uses E-Verify for one new hire, the employer must continue to use it for *all* new hires. Many other rules, regulations, and requirements apply to E-Verify, and employers must understand them. Go to **www.uscis.gov** and select "E-Verify Home page" in the far right-hand column. Be sure to read all information on the E-Verify site, particularly the *E-Verify Quick Reference Guide* and *E-Verify User Manual for Employers* under "Manuals and Guides" and information on employees' rights under "For Employees."

Employment Discrimination

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

Taxes

Social Security and Medicare Taxes

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

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

In 2011 there was a temporary rate reduction for Social Security and Medicare taxes. As of this writing (February 2012) there was still debate about the reduced rates continuing or reverting. The Social Security rate will be 6.2 percent for both employee and employer portions. The maximum annual wage on which Social Security taxes must be paid was $106,800 for 2011 and will be $110,100 in 2012. 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 website: **www.ssa.gov**.

Income Taxes

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

Unemployment Taxes

Employers must pay federal and state unemployment tax if they paid cash wages of $20,000 or more for agricultural labor during any calendar quarter in the current or preceding year or if they employed at least 10 persons in agricultural labor for some portion of the day in 20 different weeks during the preceding calendar year. H2-A wages are considered for meeting the $20,000 wage test. This tax may not be deducted from the employee's salary. Federal unemployment tax is paid only on the first $7,000 of each employee's wages. The federal tax rate was 6.2 percent before June 30, 2011, and is now 6.0 percent. A credit of up to 5.4 percent is usually granted, depending on the situation. The credit is now down to 5.1 percent, making the effective tax rate 1.1 percent. This information is changing quickly, so employers should monitor rates frequently. North Carolina unemployment tax is paid only on the first $19,700 of each employee's wages in 2011. The state tax rate is between 0 percent and 6.84 percent, depending on the credit or debt ratio. The new-business starting rate is 1.2 percent.

For detailed information about federal unemployment taxes, contact the U.S. Internal Revenue Service. The IRS has 10 local offices in North Carolina. To find the nearest one, call (800) 829-4933 or visit **www.irs.gov**. For information about state income taxes, contact the North Carolina Department of Revenue, 501 North Wilmington St., Raleigh, NC 27604. Phone: (877) 252-3052. Web: **www.dor.state.nc.us**. You may also contact the Employment Security Commission of North Carolina, 700 Wade Ave., Raleigh, NC 27605. Phone: (919) 707-1170. The ESC has many regional offices. To find the nearest one, visit **www.ncesc.com**.

Workers' Compensation

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

Minimum Wage

The federal minimum wage is $7.25 per hour. 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.

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

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

Overtime

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

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

Child Labor Provisions

The minimum age for working in agriculture is 16 if the job is hazardous or is performed during school hours. Minors of age 14 or 15 may work in agriculture if the job is neither during school hours nor 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 aged 12 or 13 may be employed with their parents' written consent on a farm where their parents are also employed. Minors of any age may be employed at any time in any occupation on a farm owned and operated by their parents.

In North Carolina it is illegal to hire any youth younger than age 18 unless the youth and a parent or guardian have completed a youth employment certificate, a form provided by the North Carolina

Department of Labor. The employer must keep a copy of the properly signed and witnessed certificate on file. This certificate serves as an official statement of the child's age and will serve as a defense against accusations of some child-labor violations. To receive a youth employment certificate or further information, contact the North Carolina Department of Labor at (800) NCLABOR, or visit the department's website: **www.nclabor.com**.

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

As of December 7, 2011, significant changes to agricultural child labor regulations were being considered that may affect employment of your own child. Stay informed on this issue as it evolves.

Joint Employment

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

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

Vehicle Insurance

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

Farm Labor Contractors

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

Migrant Housing

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

Field Sanitation

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

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

Poster Requirement

Some North Carolina employers are required to place government posters in conspicuous places that explain employees' rights. If an employee is illiterate, the poster information must be read to the employee in a manner they can comprehend. These posters are available *free of charge* from the website listed below. There is no need to buy these *free* posters from companies trying to sell them. Not all operations will be covered by the same statutes, so the requirements vary by business. The following website tells which poster you are required to display: **http://www.dol.gov/oasam/programs/osdbu/sbrefa/poster/matrix.htm**.

New Hire Reporting

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

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

New Laws and Regulations

Many changes in labor law are being proposed at the time of this writing (November 2011). All producers are encouraged to stay informed about changes that may occur before this guide is published again.

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 Test.

The purpose of the Regional Minimum Standards Program is to ensure that varieties planted by growers are acceptable to the tobacco industry. Once a breeding line is genetically stable, it can be entered into the Regional 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. In 2011, burley OVT trials were conducted at the Upper Mountain Research Station (Laurel Springs), the Upper Piedmont Research Station (Reidsville), the Lower Coastal Plain Research Station (Kinston), 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 in chapter 9, "Disease Management"). 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”). 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.

Tables 3-1 through 3-5 display yield and grade index data from the North Carolina Official Variety Test.

Table 3-1. Performance of commercial varieties in the North Carolina Official Variety Test, combined across four locations, 2011

	Kinston, N.C.		*Rocky Mount, N.C.*		*Reidsville, N.C.*		*Laurel Springs, N.C.*	
Variety	*Yield (lb/a)*	*Grade Index*	*Yield (lb/a)*	*Grade Index*	*Yield (lb/a)*	*Grade Index*	*Yield (lb/a)*	*Grade Index*
NC 5 LC	2,704	77	2,522	66	2,541	79	2,987	69
NC 6 LC	3,002	79	2,586	68	2,293	77	3,198	73
NC 7 LC	2,620	78	2,618	72	2,287	80	3,103	72
KT 200 LC	2,656	75	2,889	70	1,980	76	2,890	75
KT 204 LC	2,690	74	2,639	63	2,420	77	2,934	68
KT 206 LC	2,466	76	2,577	70	1,905	79	3,232	68
KT 209 LC	2,525	78	2,659	70	1,891	79	3,035	69
KT 210 LC	2,272	78	2,385	72	2,202	81	3,008	68
TN 90 LC	2,310	76	2,618	73	2,291	76	2,626	67
TN 97 LC	2,464	78	2,502	66	2,129	77	3,004	71
HB 3307 LC	2,241	76	2,707	66	2,371	78	3,046	69
R 610 LC	2,671	76	2,557	76	2,492	78	3,109	75
R 630 LC	2,335	78	2,513	72	2,123	76	2,722	70
CC 812 LC	2,374	79	2,523	74	2,504	79	2,588	72

Table 3-2. Performance of commercial varieties in the North Carolina Official Variety Test at the Upper Coastal Plain Research Station, Rocky Mount, N.C., 2010–2011

	2010		2011		Two-Year Average	
Variety	Yield (lb/a)	Grade Index	Yield (lb/a)	Grade Index	Yield (lb/a)	Grade Index
NC 5 LC	2,054	81	2,522	66	2,288	74
NC 6 LC	1,967	75	2,586	68	2,277	72
NC 7 LC	2,134	76	2,618	72	2,376	74
KT 200 LC	1,777	74	2,889	70	2,333	72
KT 204 LC	2,020	78	2,639	63	2,330	71
KT 206 LC	2,083	82	2,577	70	2,330	76
KT 209 LC	1,718	76	2,659	70	2,189	73
KT 210 LC	1,872	79	2,385	72	2,129	76
TN 90 LC	1,893	79	2,618	73	2,256	76
TN 97 LC	1,776	78	2,502	66	2,139	72
HB 3307 LC	2,011	78	2,707	66	2,359	72
R 610 LC	1,952	80	2,557	76	2,255	78
R 630 LC	1,959	79	2,513	72	2,236	76
CC 812 LC	N/A	N/A	2,523	74	N/A	N/A

Table 3-3. Performance of commercial varieties in the North Carolina Official Variety Test at the Lower Coastal Plain Research Station, Kinston, N.C., 2010–2011

	2010		**2011**		**Two-Year Average**	
Variety	***Yield (lb/a)***	***Grade Index***	***Yield (lb/a)***	***Grade Index***	***Yield (lb/a)***	***Grade Index***
NC 5 LC	*2,246*	*56*	*2,704*	*77*	*2,475*	*67*
NC 6 LC	*2,329*	*59*	*3,002*	*79*	*2,666*	*69*
NC 7 LC	*2,306*	*60*	*2,620*	*78*	*2,463*	*69*
KT 200 LC	*2,270*	*54*	*2,656*	*75*	*2,463*	*65*
KT 204 LC	*2,306*	*57*	*2,690*	*74*	*2,498*	*66*
KT 206 LC	*2,339*	*58*	*2,466*	*76*	*2,403*	*67*
KT 209 LC	*1,903*	*45*	*2,525*	*78*	*2,214*	*62*
KT 210 LC	*1,941*	*60*	*2,272*	*78*	*2,107*	*69*
TN 90 LC	*2,281*	*57*	*2,310*	*76*	*2,296*	*67*
TN 97 LC	*2,298*	*59*	*2,464*	*78*	*2,381*	*69*
HB 3307 LC	*2,243*	*68*	*2,241*	*76*	*2,242*	*72*
R 610 LC	*2,084*	*60*	*2,671*	*76*	*2,378*	*68*
R 630 LC	*2,379*	*57*	*2,335*	*78*	*2,357*	*68*
CC 812 LC	*N/A*	*N/A*	*2,374*	*79*	*2,374*	*79*

Table 3-4. Performance of commercial varieties in the North Carolina Official Variety Test at the Upper Piedmont Research Station, Reidsville, N.C., 2010–2011

	2010		*2011*		*Two-Year Average*	
Variety	***Yield (lb/a)***	***Grade Index***	***Yield (lb/a)***	***Grade Index***	***Yield (lb/a)***	***Grade Index***
NC 5 LC	*2,341*	*74*	*2,541*	*79*	*2,441*	*77*
NC 6 LC	*2,377*	*76*	*2,293*	*77*	*2,335*	*77*
NC 7 LC	*2,303*	*74*	*2,287*	*80*	*2,295*	*77*
KT 200 LC	*2,208*	*73*	*1,980*	*76*	*2,094*	*75*
KT 204 LC	*2,421*	*74*	*2,420*	*77*	*2,421*	*76*
KT 206 LC	*2,220*	*67*	*1,905*	*79*	*2,063*	*73*
KT 209 LC	*2,323*	*77*	*1,891*	*79*	*2,107*	*78*
KT 210 LC	*2,298*	*75*	*2,202*	*81*	*2,250*	*78*
TN 90 LC	*2,300*	*73*	*2,291*	*76*	*2,296*	*75*
TN 97 LC	*2,044*	*75*	*2,129*	*77*	*2,215*	*75*
HB 3307 LC	*2,204*	*76*	*2,371*	*78*	*2,208*	*77*
R 610 LC	*2,293*	*76*	*2,492*	*78*	*2,348*	*77*
R 630 LC	*2,033*	*75*	*2,123*	*76*	*2,208*	*76*
CC 812 LC	*N/A*	*N/A*	*2,504*	*79*	*N/A*	*N/A*

Table 3-5. Performance of commercial varieties in the North Carolina Official Variety Test at the Upper Mountain Research Station, Laurel Springs, N.C., 2010–2011

	2010		2011		Two-Year Average	
Variety	Yield (lb/a)	Grade Index	Yield (lb/a)	Grade Index	Yield (lb/a)	Grade Index
NC 5 LC	3,364	78	2,987	69	3,176	74
NC 6 LC	3,438	78	3,198	73	3,318	76
NC 7 LC	3,374	77	3,103	72	3,239	75
KT 200 LC	3,220	74	2,890	75	3,055	75
KT 204 LC	3,601	78	2,934	68	3,268	73
KT 206 LC	3,923	78	3,232	68	3,578	73
KT 209 LC	3,884	76	3,035	69	3,460	73
KT 210 LC	3,427	78	3,008	68	3,218	73
TN 90 LC	3,338	76	2,626	67	2,982	72
TN 97 LC	3,769	78	3,004	71	3,387	75
HB 3307 LC	3,639	75	3,046	69	3,343	72
R 610 LC	3,275	78	3,109	75	3,192	77
R 630 LC	3,342	81	2,722	70	3,032	76
CC 812 LC	N/A	N/A	2,588	72	N/A	N/A

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 much attention to detail. 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°F 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 & 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 (without using soap) several times, and allow the water to run several minutes before collecting the sample. Forms and assistance are available from county Cooperative Extension centers.

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

Select a High-Quality Growing Medium

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

A glazed tray has been introduced with 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 will 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 whether disease incidence differs between plants produced in glazed trays and those produced in traditional trays.

Studies have measured the effects of cell density and volume on transplant production. Researchers compared the following four trays, which differed in cell density and volume, filled with three different growing media:

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 one year, and a traditional 288-cell tray with a cell volume of 18 cubic centimeters and a cell density of 122.5 cells per square foot in the next.
2. A shallow, glazed 288-cell tray with a cell volume of 8.6 cubic centimeters and a cell density of 122.5 cells per square foot.
3. A traditional 200-cell tray with a cell volume of 27 cubic centimeters and a 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 indicated 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, but there were no interactions between media and tray type. 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 has shown that even a three-day delay in emergence in 25 percent of the seedlings could reduce usability. Researchers seeded random cells within a tray three, five, seven, 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 that uniform emergence is important 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 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 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 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 caused by genetics, 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 state-specific 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.

Specialists have also observed differences in spiral root incidence according to brand of growing medium. However, a given brand of growing medium may cause more spiral roots than others in one year but not in the following year.

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 by 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°F to 60°F to conserve fuel usage.

Daytime temperatures of 80°F to 85°F are adequate for normal growth. Heat injury (browning of leaves or seedling death) has been observed when air temperatures inside the structure exceed 110°F.

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 half inch are directly related to the total amount of fertilizer applied (in the waterbed and in the medium). Therefore, it is better to use a medium with no fertilizer (or with only a minimal amount) than to use a highly charged medium.

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

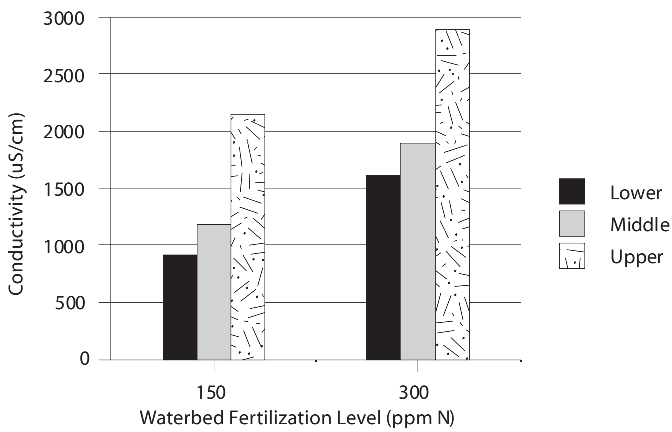
Salts should be monitored in the growing medium every 24 to 48 hours from seedling emergence until the plant roots grow into the waterbed. Collect a sample of the medium from the upper half inch of the cell from several trays. Then add twice as much distilled water as growing medium by volume (a 2:1 water-to-growing-medium dilution). Shake or stir the sample and wait two to three minutes before measuring the conductivity. Normal levels range from 500 to 1,000 microseimens (0.5 to 1 millimhos). Readings of 1,000 to 1,500 microseimens (1 to 1.5 millimhos) are moderately high, and readings above 1,500 microseimens are very high. Apply water from overhead to leach and dilute salts when: (1) conductivity readings are above 1,000 microseimens and plants are pale or stop growing, or (2) conductivity readings are 1,500 microseimens or above.

Fertilize Properly

Growers with fertilizer injection systems have been successful in using a constant application rate of 100 parts per million (ppm) nitrogen from fertilizers with ratios of 20-10-20, 16-4-16, 16-5-16, 15-5-15, or similar. 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 (ratio of 2-1-2, 3-1-3, or 4-1-4) for the first application. The same fertilizer or ammonium nitrate can be used for the second application. Higher application rates cause tender, succulent seedlings that are more susceptible to diseases. Also, high application rates promote fertilizer salts injury to seedlings as noted above. If high fertilizer salts levels are detected during the first four weeks after seeding (>1,000 microseimens in the medium from the upper half inch of the cell), apply water uniformly from overtop 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

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



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

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

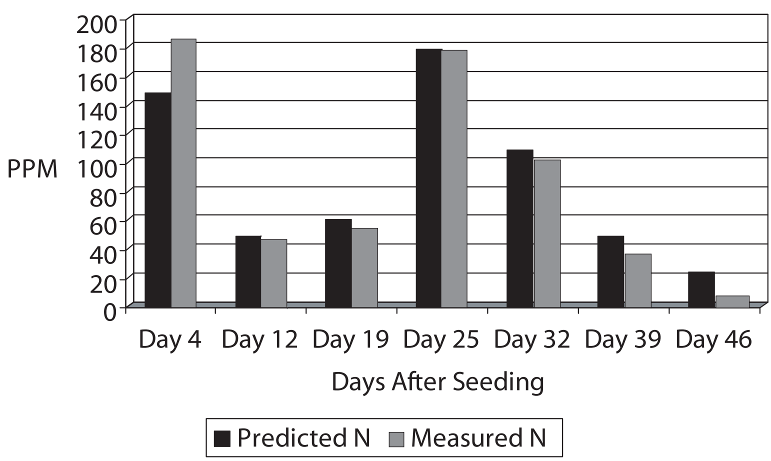
Phosphorus. Research at Clemson University has shown the need to limit phosphorus concentrations to 35 to 50 ppm in the waterbed. Applying excess phosphorus causes spindly transplants and leaves more phosphorus in the waterbed for disposal after transplant production. Therefore, 20-10-20 and 20-9-20 are better choices than 20-20-20 fertilizer. Other fertilizers, such as 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, overapplication 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 caused by boron deficiency has been observed in several float systems. In most cases, the water and the fertilizer did not contain any boron. If the water analysis indicates no boron, the best solution is to choose a fertilizer such as a 20-10-20 with a guaranteed micronutrient charge. 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

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



transplants with the water-soluble fertilizers typically used in float systems. However, growers may be required to use organic fertilizers during transplant production for USDA organic certification in the future. Studies were conducted to compare seedling production when using bat manure (8-4-1) and Peruvian seabird guano (13-8-2) to seedling production when using the standard water-soluble fertilizer 16-5-16.

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

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

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

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

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

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

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

Clip Properly

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

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

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

Current recommendations are to begin clipping at three- to five-day intervals when total plant height is 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 efficient use of fertilizer 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 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 from previous years. The only way to know for sure is to have the soil tested 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. Having soil tested regularly and following recommendations for lime application 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 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 residues of herbicide or growth regulator. *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 result from overapplication 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 or make foliar applications. 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 determine whether the spray was really needed.

More information on cold injury, boron deficiency, and boron toxicity, including photographs of these conditions, are available in the online 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, "Producing Healthy Transplants in a 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 they 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 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 via U.S. Postal Service 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 North Carolina Department of Agriculture & Consumer Services publication *Crop Fertilization Based on North Carolina Soil Tests*. Soil testing is a service of the department's Agronomic Division. 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:

Soil class. Soils are grouped into three classes in North Carolina: mineral (MIN), mineral-organic (MO), and organic (ORG). Classification is determined on the basis of 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%. Percentage 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. This value generally runs 3 percent or less 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 more. Also, as the organic matter content increases, the W/V declines.

CEC. This stands for *cation exchange capacity*, 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 ensuring 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 percentage indicates the proportion 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 is, and the less acidity is present to interfere with plant growth. A well-limed and fertilized soil will have a BS% of 80 or more.

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 greater.

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 less than 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 more, and Mg% should be between 10 and 20.

Mn-I, Zn-I, Cu-I, and S-I. Manganese (Mn), zinc (Zn), copper (Cu), and sulfur (S) are the remaining four elements that are routinely measured in soil samples. Manganese, zinc, and copper are micronutrients, and sulfur is a secondary nutrient. All four are expressed as index values, with 25 and greater being adequate for normal plant growth. On many tobacco soils, the Mn-I may be more than 100, a level that frequently results in manganese toxicity symptoms, especially if the pH is less than 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, which is 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 top-dressing the remainder 30 days after setting. Applying more than the recommended rates of nitrogen reduces efficiency and increases the risk of groundwater contamination.

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

	Percentage of Maximum Yield	
N Rate (lb/a)	***Yield Less Than 2,500 lb/a***	***Yield More Than 2,500 lb/a***
150	*91*	*75*
175	*99*	*84*
200	*100*	*94*
225	*99*	*97*
250	*98*	*100*

P_2O_5. The value in 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. The value in 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. Because 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 (lb/a)	Lb/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 are brief descriptions 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. However, triticale 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 it 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 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 slowly during the winter. Austrian winter pea also has a viney growth habit and a high nitrogen content, and it grows slowly during the winter, but it can frost-heave. Crimson clover has an upright growing habit and grows slowly 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 more nitrogen to the soil than small grains will 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 clover'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 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 North Carolina 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 could increase Granville wilt in flue-cured tobacco.

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 rows as narrow as recommended to help shade weeds. With current recommendations for wider rows to leave more space between plants and drive rows to

(Continued on page 57)

Table 7-1. Expected weed control from herbicides labeled for use in tobacco

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

Note: Ratings are based on average to good soil and weather conditions for herbicide performance and on proper application rate, technique, and timing.

E = *Excellent control: 90% or better.*
G = *Good control: 80%–90%.*
F = *Fair control: 60%–80%.*
P = *Poor control: 1%–59%.*
N = *No control.*
— = *Has not been tested.*

(Continued from page 55)

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 can 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 North Carolina Department of Environment and Natural Resources has shown that sediment is by far the largest cause 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:

- Efficiency increases 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.
- Hoeing is unnecessary.
- Herbicides provide good insurance against wet weather and cultivation problems, especially in clay soils. Most burley soils are very sticky when wet.

- Rotation opportunities are increased. With good control of nutsedge now possible, producers may be able to bring more land into a proper rotation.
- Fewer cultivations are needed, which saves money and reduces soil erosion.
- Spread of diseases is reduced, especially TMV and other viruses and black shank, and nematode populations are reduced.
- Yields are increased, generally by 150 to 450 pounds per acre.
- Harvest is simplified. Fields are cleaner of weeds for burley harvest.

Selecting and Applying Herbicides for Conventional Burley Tobacco

Certain herbicides may be applied before transplanting or within seven days after transplanting. 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. To properly select a herbicide, it is essential to correctly identify the weed (Table 7-1). 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 of application.

Preplant-Incorporated Herbicides

Preplant-incorporated (PPI) herbicides—those incorporated into the soil before transplanting—offer several advantages. Growers can tank-mix them with other chemicals to save one or more 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, tank-mixing two or more herbicides, and high rates of application 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 10, “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 the 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 half as deep as the disks run, whereas larger harrows incorporate approximately two-thirds as deep as the disks 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 PPI herbicide. Stunting of the crop from improper soil incorporation is most likely to occur with Tillam 6E and Devrinol tank-mixed, and then with Tillam 6E or Prowl; it 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. It does not control ragweed or hairy galinsoga.

Spartan and Spartan Charge

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

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

Conversion table for rate of Spartan 4F and Spartan Charge

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

Spartan 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 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 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 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 the past, 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 when Command was 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 any time after application; wheat, barley, rye, and oats can be planted after four months; corn and sorghum can be planted after 10 months; and sweet corn can be planted after 18 months.

The Spartan label also indicates that the product can be used as a 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, weed control from Spartan and Command applied PPI was as good as that from 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 that included Devrinol did not control certain weeds, as well as treatments that 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 control of annual grass, hairy galinsoga, and ragweed. 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 Postdirected with a Shield After Transplanting but Prior to Layby

Aim can be applied using a shielded hooded sprayer to emerged, actively growing weeds in the row middles prior to layby. Damage can result if spray solution contacts the tobacco plant. Do not apply Aim when conditions favor drift. Refer to the Aim label for specific recommendations regarding application precautions in tobacco. Aim is a contact herbicide that only controls some broadleaf weeds (Table 7-1) after emergence and while they are small (less than 3 to 4 inches for most weeds).

Herbicide Application Overtop up to 42 Days Before Harvest

Poast gives good control of most annual and perennial grasses when sprayed overtop tobacco and 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 nonphytotoxic oil concentrate. If a second application is needed for johnsongrass, use 1 pint per acre with the oil concentrate when 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 semidirected 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 half.

Poast can be very helpful in no-till burley tobacco because 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 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. 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.) Spartan has been evaluated for no-till burley not only in experiment-station tests but also in on-farm tests.

Experiments have compared no-till tobacco to conventional-till tobacco to determine what effect not tilling before planting and a good rye mulch had 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 an 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.

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 is as effective as tank-mixing 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 compared to conventionally tilled and transplanted tobacco. Growers are now interested in no-till burley because it is easier to meet conservation requirements where land for rotation is limited.

Here are current recommendations for 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 subsurface 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 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 a lot of biomass and chemically suppresses weeds. *Sow at a rate of three 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 just before transplanting if needed, 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 subsurface 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. 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 overtop 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. 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 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 disk-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. No-till crop production requires greater managerial ability, so 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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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, however. In fact, some insect problems may be greater in greenhouses than in beds. Many of the same pests can affect 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; 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 insulate pests 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 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 difficult to control. If possible, use greenhouses only for tobacco production. Otherwise, keep them empty as much as possible, especially just before beginning seeding tobacco.

Insecticides

Watch plants carefully, and treat them with an insecticide if insects threaten plant supply. Orthene 97 PE (or generic versions of acephate) may be used at ¾ tablespoon per 3 gallons of water for each 1,000 square feet of bed. 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, but not on, tobacco inside the greenhouse. Check with your county Extension agent or the *North Carolina Agricultural Chemicals Manual* for further information on available materials. Fire ants 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 cropland. Bait treatments typically provide longer-acting control than mound drenches, but baits must be applied when ants are actively foraging. The “potato chip test” can be used to determine whether it is warm enough for fire ants to forage. Briefly, place a potato chip or other salty snack, such as a cheese puff, near—not on top of—fire ant mounds. If ants find this bait within 30 minutes, they are actively foraging, and baits can applied.

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 crop that is more difficult to manage. If young plants are stunted or dying, check for wireworms. Dig up several plants, and check the underground stem for feeding scars and tunnels. In fields with a history of wireworm injury, a preplant soil insecticide or a higher rate of greenhouse-applied neonicotiniod insecticides may be justified.

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 because a rescue treatment is available, 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.

Managing Soil Insects

Step 1. Prepare fields as far ahead of transplanting as is practical to reduce the chance of cutworm problems. 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 at a given location in the past and the previous crop there 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 13, "Protecting People and the Environment When Using Pesticides," for toxicity information on tobacco insecticides.)

Whether you choose a contact insecticide or a systemic insecticide, 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, so apply them at least two weeks ahead of time, 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.

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 8-8). 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 thus 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 may also occur after topping and before harvest. Late-season beetles are often overlooked, but concern has grown about their impact on yield and quality. We are currently determining what, if any, impact late-season flea beetle feeding has on tobacco.

Budworms. Budworms occasionally tunnel in the stalk or leaf midribs, and they sometimes top plants. The most common budworm damage, however, is from feeding on newly developed 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.

Aphids. Aphids 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 green peach aphid (the species most common on North Carolina tobacco), transmit viral tobacco diseases such as etch, potato virus Y, and vein banding. It takes only a few seconds for a winged aphid to transmit the disease after landing on a plant, and 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 through conservation of beneficial insects, (3) preventive chemical treatments applied to the soil, and (4) insecticides applied after a problem develops (remedial treatment).

1. Cultural control. 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

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–.2 oz per 1,000 plants*	*Apply to tobacco in greenhouses or float beds one to three days before transplanting and wash off leaves immediately, OR apply in transplant water.*
Platinum	*0.27–0.43 oz per 1,000 plants*	

these practices (listed below) are important in good crop management as well. Also, most add little or nothing to the cost of production, and some may actually reduce costs.

• 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).

• Control pests such as aphids and flea beetles in the greenhouse to ensure they will not be taken 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.

• Consider planting as early as is 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.)

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

• 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 in hot, dry conditions. Early topping is important in controlling a difficult population of aphids or in preventing a low population from reaching damaging levels.

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

• 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.

• 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.

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

• 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, resulting in significant virus transmission. Destroy weeds or cover in adjacent areas four weeks or more before transplant.

2. Biological control. Beneficial insects are very important for controlling insect pests. 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 80 eggs will never hatch to damage your crop. Hornworms are attacked by a series of predators (including stilt bugs and paper wasps) and parasites (like *Cotesia congregata*, the wasp that forms white cocoons on the back of the hornworm) that often kill more than 90 percent of the worms. To make the most of these free, natural controls, follow these steps:

- Minimize or avoid using systemic insecticides that may reduce the populations of beneficial insects. Systemics are insecticides that are taken up by the plant and later kill insects feeding on the leaves or stems. Stilt bugs are especially sensitive to systemic insecticides.
- 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 natural enemies of tobacco pests.
- If an insecticide is necessary, consider the effect on natural enemies when choosing materials.

3. Preventive chemical treatments applied to the soil. Several soil-applied systemic insecticides are available. There are several reasons why 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, such as controlling wireworms or suppressing tomato spotted wilt infection.

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 seldom lasts for the entire season, 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 years with low levels of pests, 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 presents efficacy ratings for these insecticides and lists the pests for which they are recommended. Do not combine systemics targeted at the same insect pests. Using two chemicals that do similar jobs confers no advantage, increases costs, and makes crop damage more likely.

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

4. Remedial control. Remember that you can reduce your profit by applying remedial insecticides when they are not needed. In addition,

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	*N/A*	*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 they are NOT significantly different from each other.*

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*. North Carolina farmers have used thresholds successfully for many years.

When tobacco's per-pound value goes down, its economic threshold goes up. However, the value changes 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 will be even more conservative for lower-value tobacco. Cheaper tobacco deserves less protection, not more.

Following are some thresholds for typical tobacco pests:

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 are therefore not counted after this point. This threshold is very conservative. In recent tests on flue-cured tobacco, 100 percent infestation has not significantly lowered yields.

Tobacco hornworms: Treatment is justified when the equivalent of at least one worm larger than 1 inch without parasite cocoons is found

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

Insecticide	*Wireworm*	*Aphid*	*Flea Beetle*[a]
Admire	**	***	***
Capture	**	*NR*	*NR*
Lorsban	**	*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.*

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 that 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 for these insects. 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 half an inch) and 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 burrow a 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. Belt and Coragen are registered for tobacco splitworms, but efficacy data are limited. If a splitworm infestation occurs during the harvest period, growers may be able reduce populations by harvesting leaves with mines and following with insecticide sprays (this is not a recommendation to harvest unripe tobacco).

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 stops in fields of 4 to 8 acres. The pattern of stops is not critical, but stop once or more in each area of the field. Check the field borders, but do not concentrate on them. 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 fields. Insect levels may vary greatly, even among similar fields.

Choosing a Remedial Insecticide

No single 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 8-5 shows the effectiveness ratings for insecticide sprays against major leaf-feeding insects. Table 8-6 shows the results of four tests against budworms, and Table 8-7 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.

4. What are the hazards to the applicator and other workers? Do not take lightly the hazards that pesticide use can present 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 regulations.

5. What are the hazards to groundwater and surface water? Pesticides differ in their potential for leaching into groundwater or running off

Table 8-5. Effectiveness of foliar insecticides against insect pests

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

*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 become more effective against budworms as the season progresses.*

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

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

into surface water. You should consider these risks when choosing remedial and soil-applied insecticides (see chapter 13, "Protecting People and the Environment When 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 four to 48 hours.

Table 8-6. Effect of insecticides on budworms in N.C. field trials, 1998–2008

Insecticide[a]	*Reduction in Budworm Damage (%)*[b]	*Number of Trials*
Belt SC *3–4 fl oz/acre (2008)* *3 fl oz/acre (2009)*	*87*	*5*
Capture LFR *3.4 fl oz/acre*	*82*	*1*
Coragen, 3–7 fl oz, foliar applications	*80*	*5*
DiPel ES *1–2 pt/acre*	*51*	*9*
DiPel 10G, bait	*87*	*11*
Denim 0.16EC *8 oz/acre*	*84*	*9*
Lannate 2.4LV *1.5 pt/acre*	*52*	*5*
Orthene 97PE *0.77 lb/acre*	*56*	*18*
Tracer 4SC *1.5 oz/acre*	*79*	*20*
Warrior 1CS *2.5 oz/acre*	*73*	*7*

[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.*

7. Will the insecticide restrict time of harvest? All the commonly used insecticides in conventionally grown tobacco require growers to wait for a preset interval of time between application of insecticides and harvest. This period of time is called the preharvest interval (PHI). Sometimes this interval can be quite long, rendering 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 can be relatively harmful to beneficials.

Table 8-7. 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 lb	*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.

9. Do tobacco buyers have concerns about insecticide residues? Most farmers are aware of the concern many buyers have about maleic hydrazide residues. There is also concern about residues of acephate (Orthene) and pyrethroids. If growers chose to use insecticides containing pyrethroids (Capture 2EC, Capture LFR, Brigadier, Karate, Warrior, and others) for insect management, they must pay careful attention to the PHIs for these materials. Most of these PHIs preclude applications after layby. Because of exisiting residue concerns, endosulfan (Thiodan and others) is not recommended for use in tobacco and will no longer be labeled for tobacco after July 2012.

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, including pretransplant greenhouse or soil applications (as is often the case for hornworm and budworms), select a material with a different MOA from the one that was previously used. (See chapter 13 for information on IRAC codes and how to use them.)

Spray adjuvants. Adjuvants are materials added 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 not 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 eastward movement of burley tobacco production 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 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 nonburley varieties confirmed that commonly grown burley varieties may be more susceptible to TSWV than flue-cured varieties.

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

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

Insect	Insecticides and Formulations	Amount per Acre	Reentry Interval[a]	Remarks
Aphids	Acephate (Acephate 97UP)	¾ lb	24	Good coverage is essential with any product.
	Imidacloprid (Admire Pro and many generics)	0.7–1.4 fl oz	12	
	Lambda-cyhalothrin (Warrior) (Karate Xeon)	 2.5–3 oz 0.96–1.92 fl oz	24	Note long preharvest interval.
	Thiamethoxam (Actara 25WDG)	2–3 oz	12	
	Pymetrozine (Fulfill 50WG)	2¾ oz	12	
	Acetamiprid (Assail 30SG)	1.5–4 oz	12	
	Methomyl (Lannate 90SP) (Lannate 2.4LV)	 ½ lb 1½ pt	 48 48	Initial control is fair to good, but numbers rebound quickly.
Budworms	Spinosad (Tracer)	1.4–2 oz	4	Use one or three solid cone nozzles no more than 12 inches above the bud. Apply 25–50 gal water/acre with at least 40–60 lb pressure.
	Emamectin benzoate (Denim 0.16EC)	8 oz	48	
	Methomyl (Lannate 90SP) (Lannate 2.4 LV)	 ½ lb 1½ pt	 48 48	
	Lambda cyhalothrin (Warrior 1CS) (Karate Xeon)	 2.5–3 oz 0.96–1.92 fl oz	24	Do not use Warrior within 40 days of harvest.
	Acephate (Acephate 97UP)	¾ lb	24	

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

Table 8-8 (continued).

Insect	*Insecticides and Formulations*	*Amount per Acre*	*Reentry Interval*[a]	*Remarks*
Budworms (cont.)	Bacillus thuringiensis *(Agree)* *(Biobit HP)* *(Crymax)* *(Deliver)* *(DiPel ES)* *(DiPel DF)* *(Javelin WG)* *(Lepinox WDG)*	 *2 lb* *1 lb* *1–1½ lb* *1–1½ lb* *2 pt* *½–1 lb* *1–1¼ lb* *1–2 lb*	 *4* *4* *4* *4* *4* *4* *4* *12*	
	Chlorantroniliprole (rynaxypyr) *(Coragen)*	*3.5–7.5 fl oz*	*4*	
	Flubendiamide *(Belt SC)*	*2–3 fl oz*	*12*	*14-day preharvest interval.*
Cutworms	*Acephate* *(Acephate 97UP)*	*¾ lb*	*24*	*In late afternoon, apply in 25–50 gal water.*
	Flubendiamide *(Belt SC)*	*2–3 fl oz*	*12*	
	Chlorantroniliprole (rynaxypyr) *(Coragen)*	*3.5–7.5 fl oz*	*4*	
Flea beetles	*Acephate* *(Acephate 97UP)*	*½ lb*	*24*	*For best control with any product, spray entire plant.*
	Imidacloprid *(Admire Pro and many generics)*	*0.7–1.4 fl oz*	*12*	
	Thiamethoxam *(Actara 25WDG)*	*2–3 oz*	*12*	
	Methomyl *(Lannate 90SP)* *(Lannate 2.4LV)*	 *¼–½ lb* *1½ pt*	 *48* *48*	
Grasshoppers	*Acephate* *(Acephate 97UP)*	*½ lb*	*24*	

Table 8-8 (continued).

Insect	Insecticides and Formulations	Amount per Acre	Reentry Interval[a]	Remarks
Hornworms	*Acephate (Acephate 97UP)*	*½ lb*	*24*	*If applications are necessary during harvest, make them immediately after priming rather than before.*
	Spinosad (Tracer)	*1–1½ oz*	*4*	
	Methomyl *(Lannate 90SP)* *(Lannate 2.4LV)*	 *¼–½ lb* *¾–1½ pt*	 *48* *48*	
	Bacillus thuringiensis *(Agree)* *(Biobit HP)* *(Crymax)* *(Deliver)* *(DiPel DF)* *(DiPel ES)* *(Javelin WG)* *(Lepinox WDG)*	 *1–2 lb* *¼–½ lb* *½–1 lb* *½–1 lb* *¼–½ lb* *½–1 pt* *1/8–¼ lb* *1 lb*	 *4* *4* *4* *4* *4* *4* *4* *12*	
	Emamectin benzoate (Denim 0.16EC)	*8 oz*	*48*	*Denim has a 14-day preharvest interval.*
	Flubendiamide (Belt SC)	*2–3 fl oz*	*12*	*14-day preharvest interval.*
	Chlorantroniliprole (rynaxypyr) (Coragen)	*3.5–7.5 fl oz*	*4*	
Japanese beetles	*Imidacloprid (Admire Pro and many generics)*	*0.7–1.4 fl oz*	*12*	
	Lambda-cyhalothrin *(Warrior)* *(Karate Xeon)*	 *2.5–3 oz* *0.96–1.92 fl oz*	*24*	*Do not use Warrior within 40 days of harvest.*
	Thiamethoxam (Actara 25WDG)	*2–3 oz*	*12*	
	Acephate (Acephate 97UP)	*½ lb*	*24*	

Table 8-8 (continued).

Insect	***Insecticides and Formulations***	***Amount per Acre***	***Reentry Interval[a]***	***Remarks***
Loopers	Bacillus thuringiensis *(Agree)* *(Biobit HP)* *(Condor OF)* *(Crymax)* *(Deliver)* *(Dipel DF)* *(Dipel ES)* *(Javelin WG)* *(Lepinox WDG)*	 *2 lb* *1 lb* *1²/³ qt* *1–1½ lb* *1–1½ lb* *½–1 lb* *1–2 pt* *1 lb* *2 lb*	 *4* *4* *4* *4* *4* *4* *4* *4* *12*	*Good coverage, especially of lower leaves, is essential.*
	Flubendiamide *(Belt SC)*	*2–3 fl oz*	*12*	
	Chlorantroniliprole (rynaxypyr) *(Coragen)*	*3.5–7.5 fl oz*	*4*	
	Spinosad *(Tracer)*	*2–2.9 oz*	*4*	
	Acephate *(Acephate 97UP)*	*½ lb*	*24*	
Slugs	*Metaldehyde* *(Deadline Bullets)*	*12–40 lb*	*12*	*Apply at dusk. Do not put bait on plants.*
Splitworms	*Flubendiamide* *(Belt SC)*	*2–3 fl oz*	*12*	*14-day preharvest interval.*
	Chlorantroniliprole (rynaxypyr) *(Coragen)*	*3.5–7.5 fl oz*	*4*	
Stink bugs	*Bifenthrin* *(Capture LFR)*	*3.4–6.8 fl oz*	*12*	*Do not apply after layby.*
	Bifenthrin + imidacloprid *(Brigadier 2SC)*	*6.4 fl oz*	*12*	*Do not apply after layby.*
	Lambda-cyhalothrin *(Warrior 1CS)* *(Karate Xeon)*	 *2.5–3 oz* *0.96–1.92 fl oz*	*24*	*Do not use Warrior within 40 days of harvest.*

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 introduced each year from outside the region; the pathogen does not typically overwinter here. 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, requiring different management strategies. This chapter describes the most prevalent North Carolina burley tobacco diseases 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 can be an effective, 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.

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. The disease ratings of the newest burley cultivars are available at http://tobaccoinfo.utk.edu/PDFs/VarietyGuides/2011BurleyVarietyGuide.pdf.

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 that were 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 wa-ter-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. The disease is favored by moisture, so 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 because 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. By the time the disease is noticed, the pathogen has already spread. 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 catch-all 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 *Rhizoctonia solani* races that are different from those causing damping-off in plant beds and greenhouses. Symptoms begin as small, circular water-soaked spots on leaves, with a ring-like appearance when held up to a light source. The primary source of inoculum of this pathogen among seedlings is infested trays, so 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 percent formulation or the 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 because 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 crosswise, cover with plastic to seal, and release from the top of the stack 3 pounds of 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).

Terramaster 4EC has a federal label for 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 rate of 1.4 ounces per 100 gallons, because severe stunting may result. *Do not* make applications later than eight 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 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 that 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 9-1). 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. It also could have 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 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. If black shank was evident on this variety in the past, use a variety with moderate resistance to all races of the pathogen. 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 because 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 and applying the higher labeled rate of Ridomil Gold SL (2 to 3 pints per acre) or Ultra

Table 9-1. Fumigants for soilborne disease control

Disease	*Material*	*Amount per Acre*	*Waiting Period before Planting*	*Precautions*
Root-knot nematodes[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] *Nonfumigants such as ethoprop (Mocap 10G/15G/EC) and carbofuran (Furadan 4F) also are labeled for root-knot nematode. See the* 2012 North Carolina Agricultural Chemicals Manual.

Flourish (2 to 3 quarts per acre). *Note:* 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, so 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, 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.

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

	Resistance		Percentage of Plants with Black Shank					
			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, 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. Abbreviations used: High = high resistance; Mod = moderate resistance; Susc = susceptible.

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 in North, South, and Central America. In the United States, Granville wilt is only a problem in the traditional flue-cured areas of North and South Carolina. This disease causes wilting, stunting, and yellowing of foliage, and 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.

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

			Percentage of Plants with Black Shank					
	Resistance		Effect of Variety (No Ridomil)			Treated with Ridomil Gold		
Variety	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, 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. Abbreviations used: High = high resistance; Mod = moderate resistance; Susc = susceptible.

Root-Knot Nematodes

Root-knot nematodes are generally not a problem on burley tobacco in western or piedmont 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 9-1). 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 9-1). Multipurpose fumigants (Telone C-17 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 Telone II or with the multipurpose fumigants mentioned above. When using these materials, follow all directions and precautions carefully. Refer to Table 9-1 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 United States. 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 2011, the blue mold epidemic was the lightest on record. Only three reports came in from Pennsylvania and Massachusetts. No counties from North Carolina reported blue mold in 2001. The blue mold forecasting system at NC State University has been discontinued. 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. However, growers can do several things to reduce the risk from this very important disease.

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

Burley transplants. You should produce your own transplants or obtain 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 used Acrobat MZ (a prepackaged mixture of dimethomorph and mancozeb) to control blue mold for several years. Acrobat MZ has also been replaced with a liquid formulation of dimethomorph with the trade name 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 because of different methods of application and label restrictions. When blue mold threatens, tank mixes of Forum and Dithane DF Rainshield should be applied weekly any time between transplanting and topping (Table 9-4). 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. Because of 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.

Table 9-4. 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 (gal/acre)*	*Spray Volume for Backpack Mist Blowers (gal/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 and beyond (shoulder high)[a]	*7*	*30*	*100*	*50*

[a] Shoulder height until topping.

When blue mold warnings are issued for your area, begin weekly sprays with tank mixes of Forum and Dithane DF Rainshield using the rates 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 (Figure 9-2). Spray 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 for 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 damage.

Table 9-5. 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 a 0–5 scale: 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.*

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 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 9-1). 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. Contact your county Extension center for more information.

Variety resistance. North Carolina State University plant breeders have been selecting and breeding for resistance to blue mold for

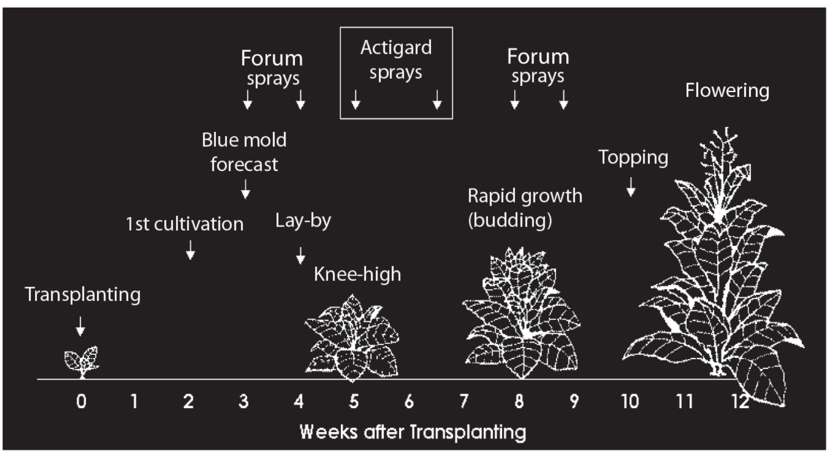

Figure 9-1. Burley growth and fungicide applications for blue mold. *This figure shows one possible strategy for using Forum and Actigard 50WG to manage blue mold. If blue mold is forecast the third week after transplanting, begin weekly sprays of Forum tank mixes. At week five (18-inch tobacco), make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

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 9-6). 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 9-7). As indicated by Table 9-7, 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 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.

Table 9-6. 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.

- 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.

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 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 reduce brown spot.

Target Spot

Target spot is a fungal disease caused by races of *Rhizoctonia solani* that are different from those causing soreshin. Because of weather

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.*

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 of 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 was labeled in 2006 to help control this disease on flue-cured and burley tobacco, because it provides superior control of target spot when applied once at lay-by (16 to 32 fluid ounces). In previous trials conducted by NC State University, the application of Quadris caused a phytotoxic reaction on burley tobacco by increasing weather flecking (see Table 9-5). 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 tactics 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 viruses 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 in 2007 was rather high due to dry weather conditions favoring thrips populations.

(Continued on page 109)

Table 9-7. 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 (lb/a)
					Nonsprayed				Acrobat MZ–Sprayed				
Variety	1996	1997	Avg.	Rank*	1996	1997	Avg.	Rank	1996	1997	Avg.	Rank	
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 to 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.

(Continued from page 107)

Tobacco vein mottling virus and tobacco etch virus are transmitted by aphids, and they 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, AMV, and the necrotic strain of PVY.

Disease Management in the Piedmont and Coastal Plain

Now burley is being grown in both the piedmont and the coastal plain by growers who traditionally have grown flue-cured tobacco. This situation created the need to investigate some of the most important diseases of tobacco—black shank and Granville wilt—under conditions prevailing in the nontraditional burley areas of North Carolina. Following is a brief summary of our investigations since 2006.

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. From 2006 through 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 9-8). 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. 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 9-9).

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.

Table 9-8. 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] The disease index was calculated as for the flue-cured varieties, so the disease indices for flue-cured and burley cultivars are directly comparable. 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 when the disease appeared. Higher indices reflect more disease.

[b] No ratings available.

4. Avoid root wounding.
5. Manage nematodes.
6. Fumigate in the fall or spring.

Several burley varieties are not resistant to Granville wilt (Table 9-9). However, when a fumigant is applied, burley mortality is reduced significantly (Table 9-9). Fumigant and variety effect vary, and both depend 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

Table 9-9. 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, three weeks after layby*	*60*	*57*	*29*	*16*
1 pt/acre	*Pretransplant, 1st cultivation, layby*	*7*	*2*	*3*	*2*

Note: 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.

Table 9-10. Fumigant effect on Granville wilt by variety

	Granville Wilt Rating[a]			
	Edgecombe County, 2006		*Franklin County, 2006*	
Variety	*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.

chemical for the disease. It is both useless and wasteful to attempt to control a disease by applying a material that is most effective for solving 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.

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). Online: www.ces.ncsu.edu/depts/pp/notes/Tobacco/tdin002/tdin002.htm

Black Shank (TDIN-004). Online: 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

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. 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 and first-flower stages can reduce yields. 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 improve 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 and may ask 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+, Drexalin Plus, 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 and 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, and you must also 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, both the leaves and 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 aggravate the situation, as does excess nitrogen.

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+, Drexalin Plus, 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 they 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 overtop, overall spray method.

Flumetralin may be tank-mixed with products containing MH. Mix 2 quarts of flumetralin with MH at half the rate to the full rate. The three-fourths 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 is 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 may be mixed with products containing MH. Check the label for proper application and mixing of this product.

Maleic Hydrazide (MH)

MH is a true systemic; that is, when sprayed on the leaves, it is absorbed and is 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 it 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. MH rates less than 2 gallons per acre can be very effective in controlling sucker growth, especially when used following contacts and/or in a tank mixture with a dinitroaniline (flumetralin or butralin). In addition, lower rates of MH are recommended to reduce MH residues in cured leaf. For a smaller amount of MH, 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 to create a coarse spray and 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 9 quarts of the product in 47.75 gallons of water.

For a smaller amount, use 1 pint 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 rundown 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+, Drexalin Plus, or Flupro) Tank Mix. The suggested concentration of flumetralin in a tank mix with MH is 2 quarts per acre of flumetralin with half the rate to the full rate of MH. Generally, lower MH rates can be used when MH is applied in combination with flumetralin, which can result in reduced MH residues. 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 rundown but also wets the upper leaves. A fine spray such as that used for MH alone may reduce stalk rundown 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 rundown 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 overtop, 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 rundown. 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 overtop at the button stage, then top the plants 24 hours later. See chapter 14, "Worker Protection Standards for Agricultural Pesticides Used in Tobacco Production," for restricted field-entry intervals for other tobacco pesticides. Approximately one week later, apply MH, Prime+, Drexalin Plus, Flupro, Butralin, or a tank mix of MH with Prime+, Drexalin Plus, Flupro, or Butralin. Using a 3 percent contact before applying systemic products substantially reduced sucker number and weight per acre in most previous tests.

Option II

Wait until all plants are in the elongated-button to early-flower stage, and apply MH, FST-7 or Leven-38, Prime+, Drexalin Plus, Flupro, Butralin, or a tank mix of MH with Prime+, Drexalin Plus, 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+, Drexalin Plus, Flupro, or Butralin down-stalk to the topped plants. Repeat the procedure as later plants reach this flower stage, being careful not to retreat 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 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 half rate of MH; reapplication of flumetralin or Butralin may increase the chance of stunting following crops.

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 10-1. 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 90°F. 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 60 (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 10-1. (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+, Drexalin Plus, 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, Drexalin Plus, 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 +, Drexalin Plus, or Flupro)	*½ to full rate MH + 2 qt flumetralin**	
Maleic hydrazide (MH) + Butralin	*Full rate MH + 2 qt Butralin**	

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

11. 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. This practice will provide around 40 pounds of nitrogen (N) and potassium (K) per acre and 5 pounds of phosphorous (P) per acre. Late-spring plowing will provide more nutrient uptake for small grains; however, decomposition will be more difficult because of 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 into ammonia in the plant, and eventually converting it to plant protein. Once plowed under, legumes should immediately begin decomposing and providing plant-available nitrogen, phosphorus, and potassium (75, 15, and 80 pounds per acre, respectively, for late-spring plowing). For more discussion of 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. A chemical analysis of the manure will provide information on the amount of available and total nutrients in the manure and tell how much additional fertilizer to apply. Additional information can be found online at http://www.ncagr.gov/agronomi/pdffiles/wflyer.pdf 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 through 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 through microbial activity requires oxygen and water. Although most soils contain sufficient water for microbial activity, having irrigation available (either overhead or trickle) will optimize organic material decomposition by soil microbes.

Experiments at both the Upper Mountain Research Station (Laurel Springs) and the Mountain Research Station (Waynesville) 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. Our experiments were located in upland sites, and with no rain late in the growing season, tobacco was considerably taller and produced higher yields in the irrigated treatment than in the nonirrigated treatment. These experiments conducted with adequate rainfall during the summer resulted in similar yields with and without irrigation.

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 bear a label printed with the amount of available nutrients confirmed by laboratory analysis. Soybean meal analyses give measurements close to 7 percent N, 1.2 percent P_2O_5, and 1.5 percent K_2O; cottonseed meal analyses give measurements close to 6 percent N, 3 percent P_2O_5, and 1.5 percent K_2O. 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 on-station experiments have given us important information on potential tobacco yield response resulting from use of these materials. Composted chicken manure gave us less tobacco yield than the other organic fertilizer materials. This was because of 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 because of immobilization (microbial activity that uses nitrogen when decomposing carbon material). All the other materials produced similar good tobacco yields. Organic materials decompose slowly, providing more plant nutrients late in the season when tobacco is growing rapidly. Consider three factors when choosing a fertilizer source: (1) whether the company buying your leaf allows growers to use the materials, (2) the availability of the materials selected, and (3) the cost of the plant nutrients inside the bag.

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.

In the past, 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. A new sucker control material, O-TAC, is a fatty alcohol product made from natural palm oil and is currently approved for chemical-free tobacco use.

Special Thanks

Special thanks to Anthony Cole, Department of Soil Science, NC State University; the staffs at the Upper Mountain Research Station and the Mountain Research Station; North Carolina Cooperative Extension Service agents; and regional agronomists from the North Carolina Department of Agriculture and Consumer Services who provided advice for our chemical-free burley tobacco production.

12. 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. Producers can only do so much to lower costs while maintaining yield and quality during curing, but following the few simple rules outlined below can go a long way toward curing the highest-quality crop under a given set of conditions. Market preparation tasks 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 more than half 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°F to 90°F and a relative humidity that averages about 65 to 75 percent over any 24-hour period. Humidity on the higher side of this range will give darker, redder leaf color. 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:

1. *Yellowing.* 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 (as a result of 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.

2. *Leaf-drying.* During this period, the leaf lamina or webbing gradually changes from yellow to a dark color (typically brown, tan, or reddish brown).

3. *Stem-drying.* 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

Controlling moisture and air circulation (and in some cases temperature) inside the curing structure is 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 acceptably high 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 (average relative humidity is well below 65 percent over a 24-hour period), 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). Never supply supplemental heat by open fires that can smoke the tobacco. Fumes from 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 that 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 12-1), 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 12-1. 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 in 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.

Housing and curing management practices to preserve yield and quality must be customized to each curing structure because every

Figure 12-2. Two-tier low-profile barn

structure and every crop are different. Each structure is somewhat unique in its curing characteristics and will need to be uniquely managed. Field-curing structures generally require more management, but they 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 cost less 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, 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 12-2) 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.

Key Concepts in Maximizing Efficiency While Maintaining Quality

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: (1) 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 no 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. (2) 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. Otherwise, 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, floor pads, and 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°F 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

An increasing proportion of burley tobacco is being marketed in flue-cured sized bales that weigh 600 to 700 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 research at the University of Tennessee indicates 15 percent savings 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. Some buyers are now assessing penalties on small bales, which may make the large bales attractive to even smaller growers.

Regardless of bale size, 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. This is the way higher-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 several 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. Research evaluations suggest that a moisture content of about 18 to 23 percent is acceptable. Contracts call for baled tobacco to contain no more than 20 to 24 percent moisture, depending on the buyer. Many producers have been concerned about moisture content in large bales. University of Tennessee tests indicate that moisture contents up to the 22 percent to 23 percent range are not a problem in big bales and do not cause any more problems with heating or TSNA levels 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, and some have established a maximum moisture limit of 20 percent.

Product Uniformity and Integrity

As the focus on growing and selling a quality product increases, and as buying companies hedge their liability risks by requiring more knowledge of the tobacco they buy, selling bales of clean, 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) make for a nonuniform, lower-quality product that is increasingly viewed as a liability against top-dollar sales, 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 production standards for both pesticides and NTRM. Contracts have been canceled in recent years due to unacceptable levels of NTRM and pesticides.

Each producer has a stake in maintaining buyer 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.

13. Protecting People and the Environment When Using Pesticides

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

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

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

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

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

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

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

Table 14-1 lists products, common names, registration numbers, manufacturers, signal words, restricted-entry intervals, and posting/notification requirements for the major pesticides and growth regulators used in tobacco. This should help you to properly record and post pesticide use and to plan field operations. **However, the information in this table is presented in good faith as a reference and is not an exhaustive list. This information does not take the place of the product label; changes to label information can occur without notice. Always read and follow label directions. The label on the container you are actually using must be followed, even if there has been a change on newer labels.**

Minimize Pesticide and Fertilizer Use Where Possible

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

Select Pesticides Carefully

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

A measurement called an LD_{50} is used to measure pesticide toxicity to humans and other mammals. The LD_{50} is the amount of a substance that will cause death in 50 percent of a target population (rats, mice, or rabbits are most commonly used). The lower the number, the more acutely 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, which includes the ability to cause diseases such as cancer. In general, it is best to choose the least toxic pesticide that will do the job. Use extreme caution with pesticides that have low LD_{50} ratings. Note that proper handling of pesticides (including the use of appropriate personal protective equipment) minimizes the risk of acute and chronic effects of all pesticides—even those with low LD_{50} values. Information on acute toxicity can be found in Table 14-1. Information on chronic toxicity can be found on Material Safety Data Sheets (MSDS) provided by your pesticide dealer. Both the pesticide label and the MSDS should be on hand when a pesticide is being used.

Apply Pesticides Carefully

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

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

Rotate Pesticide Modes of Action

Applying pesticides with the same mode of action (MOA) multiple times or successively can eventually result in pest resistance to these tools. To aid growers in rotating pesticide mode of action, three organizations have developed MOA categories. These codes are listed on newer pesticide labels: FRAC (Fungicide Resistance Action Committee), IRAC (Insecticide Resistance Action Committee), and HRAC (Herbicide Resistance Action Committee). When it becomes necessary to treat a tobacco pest with more than one insecticide application (for example, if multiple tobacco hornworm treatments are required per season), pesticides with different MOAs should be chosen for the applications. Note that pesticide trade names and active ingredients may share the same MOA; for example, acephate (Orthene) and carbaryl (Sevin) are both in IRAC group 1A. Therefore, following a Sevin application with an Orthene application does not represent a pesticide MOA rotation. To assist in chemical selection, FRAC, IRAC, and HRAC codes are listed in Table 13-1.

Minimize Soil Movement and Leaching

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

Pesticides commonly used on tobacco differ in their potential to contaminate surface water and groundwater. Predicting which pesticides may reach groundwater and where this is most likely to occur is very difficult because of differences in soil chemical and physical characteristics and in water table depth. Generally, rolling soils in the piedmont have more potential for surface water contamination through runoff, whereas the porous soils of the sandhills and coastal plain may be more susceptible to groundwater contamination through leaching. However, surface water contamination can occur even on slightly sloping soils in the coastal plain. The Natural Resources Conservation Service can help you determine the leaching and runoff potentials for your fields. There are also guidelines that help determine which pesticides may be at highest risk for runoff and leaching. Two guidelines for pesticides are *surface loss potential* and *leaching potential*. Surface loss potential is broken into two categories: the risk of a pesticide running out of a field in solution with surface water (rain, irrigation, or flooding) and the risk of a pesticide adhering (being adsorbed) to soil or organic material and washing out of the field as erosion. A high rating in either category means the pesticide has a high tendency to move off the field, while a low rating means the pesticide has a low potential to move. Leaching potential indicates the tendency of a pesticide to move in solution with water and leach below the root zone. The ratings of *very high*, *high*, *medium*, *low*, and *very low* describe the potential for leaching. These guidelines are based on knowledge of the chemical characteristics of different pesticides and are summarized in Table 13-1. (The symbol "NA" is used where information is not yet available.) These are general guidelines and should be interpreted as such. Most pesticides will move into either surface or groundwater supplies in at least one of the ways described above. For example, a material that is not very leachable will tend to be adsorbed to soil and move with erosion. Thus, your best choice will depend on the characteristics of the field and the measures you have taken to reduce the chance of runoff.

Protect Wells

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

- Ensure that wells are properly constructed and sealed.
- Do not mix or load pesticides within one hundred feet of a well.
- When filling spray tanks, be sure the hose or pipe is not at or below the surface of the water in the tank. Otherwise, it is possible to back-siphon the pesticide mixture directly into your water supply.
- Install back-flow prevention devices, and inspect them frequently.

Table 13-1. Environmental contamination potential and mammalian toxicity of commonly used tobacco pesticides

Changes to labels can occur at any time. This information does not take the place of the product label. Always read and follow label directions; it is the law.

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

[a] *Exception to Restricted Entry Interval: If a product is soil-injected or soil-incorporated, under certain circumstances, workers may enter the treated area if there will be no contact with anything that has been treated.*

[b] *Worker Notification: Unless the pesticide labeling requires both types of notification, notify workers EITHER orally OR by posting warning signs at entrances to treated areas (labeled "Either"). You must inform workers which method of notification is being used. Some pesticide labels require you to notify workers BOTH orally AND with signs posted at entrances to the treated area. If both types of notification are required ("Oral and Written"), the following statement will be in the "Directions for Use" section of the pesticide labeling under the heading Agricultural Use Requirements: "Notify workers of the application by warning them orally and by posting warning signs at entrances to treated areas."*

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

[d] *Surface loss may occur when pesticides go into solution in water and run off the field in surface water. Potentials by Natural Resources Conservation Service, 2004. NA = not available.*

[e] *Surface loss may also occur when pesticides are adsorbed to soil or organic materials and washed out of the field. Potentials by Natural Resources Conservation Service, 2004. NA = not available.*

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

[g] *LD_{50}: The dose (quantity) of a substance that will be lethal to 50 percent of the organisms in a specific test situation. It is expressed in the weight of the chemical (mg) per unit of body weight (kg). The lower the number, the more toxic the chemical. When more than one LD_{50} for mammals was found in the literature, the lowest found is shown here. "Oral" refers to toxicity through ingestion, while "dermal" refers to toxicity by skin contact. Values are from product MSDS.*

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

***** *= Technical material. Technical material (pure active ingredient) may be more or less toxic than the formulated material.*

NA = not available.

Common Name, EPA Reg. No. & Company Name (for first listed trade name)	Signal Word	Restricted Entry Interval (REI)[a]	Worker Notification[b]	Trade Name(s)[c]	Surface Loss Potential (solution)[d]	Surface Loss Potential (adsorbed)[e]	Leaching Potential[f]	FRAC, IRAC, or HRAC MOA Grouping	Mammalian LD_{50}[g] Oral	Dermal
Acephate EPA Reg. No. 51036-236 Micro Flo	Caution	24 hr	Either; all greenhouse applications must be posted	Acephate 75	Intermediate	Low	Low	1A	1,030*	10,250*
Acetamiprid EPA Reg. No. 8033-23-4581 Cerexagri	Caution	12 hr	Either	Assail	Intermediate	Low	Intermediate	4A	1,064	>2,000
Acibenzolar-S-methyl EPA Reg. No. 100-922 Syngenta Crop Protection	Caution	12 hr	Either	Actigard	Intermediate	Low	Intermediate	P	> 5,000	> 2,000
Bacillus thuringiensis EPA Reg. No. 73049-39 Valent Agricultural Products	Caution	4 hr	Either	Dipel DF	NA	NA	NA	11	> 5,050	> 2,020
Bifenthrin EPA Reg. No. 279-3302 FMC Corporation	Warning	12 hr	Either	Capture LFR	Low	Low	Low	3A	54.5	2,000

Common Name, EPA Reg. No. & Company Name (for first listed trade name)	Signal Word	Restricted Entry Interval (REI)[a]	Worker Notification[b]	Trade Name(s)[c]	Surface Loss Potential (solution)[d]	Surface Loss Potential (adsorbed)[e]	Leaching Potential[f]	FRAC, IRAC, or HRAC MOA Grouping	Mammalian LD_{50}[g]	
									Oral	Dermal
Butralin *EPA Reg. No. 33688-4-400* *Chemtura*	*Danger*	*12 hr*	*Either*	*Butralin*	*High*	*High*	*Low*	*K1*	*891*	*> 2,000*
Carbaryl *EPA Reg. No. 264-333* *Bayer CropScience*	*Warning*	*12 hr*	*Either*	*Sevin XLR Plus*	*Intermediate*	*Low*	*Low*	*1A*	*500*	*> 2,000*
Chlorantraniliprole (rynaxypyr) *EPA Reg. No. 352-729* *DuPont Crop Protection*	*NA*	*4 hr*	*Either*	*Coragen*	*Low*	*High*	*Very Low*	*28*	*>5,000*	*>5,000*
Chloropicrin *EPA Reg. No. 5785-17* *Great Lakes Chemical Corp.*	*Danger Poison*	*48 hr*	*Both*	*Chlor-O-Pic*	*Intermediate*	*Low*	*Low*	*8B*	*NA* *Inhalation danger*	*NA*
Chlorpyrifos *EPA Reg. No. 62719-591* *Dow AgroSciences*	*Warning*	*24 hr*	*Either*	*Lorsban*	*Low*	*Intermediate*	*Low*	*1B*	*96*	*2,000*

Common Name, EPA Reg. No. & Company Name (for first listed trade name)	Signal Word	Restricted Entry Interval (REI)[a]	Worker Notification[b]	Trade Name(s)[c]	Surface Loss Potential (solution)[d]	Surface Loss Potential (adsorbed)[e]	Leaching Potential[f]	FRAC, IRAC, or HRAC MOA Grouping	Mammalian LD_{50}[g]	
									Oral	Dermal
Dlomazone EPA Reg. No. 279-3158 FMC Corp.	Caution	12 hr	Either	Command	Intermediate	Low	Intermediate	F3	1,369*	> 2,000*
Dichloropropene EPA Reg. No. 62719-32 Dow AgroSciences	Warning	5 days	Oral and Written	Telone II, Telone C-17[f]	Intermediate	Low	High	8B	224 Inhalation danger	333
Dimethomorph EPA Reg. No. 241-410 BASF Corp.	Caution	12 hr	Either	Acrobat	High	Intermediate	Intermediate	40	3,900*	> 2,000*
Dimethomorph & mancozeb EPA Reg. No. 241-383 BASF Corp.	Caution	12 hr	Either	Acrobat MZ	High High	Intermediate High	Intermediate Low	40 M3	3,900* > 5,000	> 2,000* > 5,000
Emamectin benzoate EPA Reg. No. 100-903 Syngenta Crop Protection	Danger	48 hr	Either	Denim	NA	NA	NA	6	1,516	> 2,000

Common Name, EPA Reg. No. & Company Name (for first listed trade name)	Signal Word	Restricted Entry Interval (REI)[a]	Worker Notification[b]	Trade Name(s)[c]	Surface Loss Potential (solution)[d]	Surface Loss Potential (adsorbed)[e]	Leaching Potential[f]	FRAC, IRAC, or HRAC MOA Grouping	Mammalian LD_{50}[g]	
									Oral	Dermal
Ethephon EPA Reg. No. 264-418 Bayer CropScience	Danger	48 hr	Oral and Written	Prep, Super Boll, Mature XL	Low	Intermediate	Low		3,030	1,560
Ethoprop EPA Reg. No. 264-457 Bayer CropScience	Danger Poison	48 hr	Oral and Written	Mocap 15 G	Intermediate	Low	High	1B	16	2.4
Etridiazole EPA Reg. No. 400-422 Chemtura	Danger	12 hr	Either	Terramaster 4 EC	Intermediate	Intermediate	Low	14	1,077	> 5,000
Fenamiphos EPA Reg. No. 264-731 Bayer CropScience	Danger Poison	48 hr	Oral and Written	Nemacur	High	Intermediate	High	1B	10.6	71.5
Flubendiamide EPA Reg No. 264-1025 Bayer CropScience	Caution	12 hr	Either	Belt	High	High	Low	28	2,000	2,000
Flumetralin EPA Reg. No. 100-640 Syngenta Crop Protection	Danger	24 hr	Either	Prime+	Low	Intermediate	Low	NA	3,100	NA

Common Name, EPA Reg. No. & Company Name (for first listed trade name)	Signal Word	Restricted Entry Interval (REI)[a]	Worker Notification[b]	Trade Name(s)[c]	Surface Loss Potential (solution)[d]	Surface Loss Potential (adsorbed)[e]	Leaching Potential[f]	FRAC, IRAC, or HRAC MOA Grouping	Mammalian LD_{50}[g]	
									Oral	Dermal
Imidacloprid EPA Reg. No. 264-827 Bayer CropScience	Caution	12 hr	Either; all greenhouse applications must be posted	Admire, Provado, Nuprid, many others	High	Intermediate	High	4A	4,143	> 2,000
Lambda-cyhalothrin EPA Reg. No. 100-1112 Syngenta Crop Protection	Warning	24 hr	Either	Warrior	Low	Intermediate	Very Low	3A	351	>2,000
Maleic hydrazide EPA Reg. No. 400-84 Chemtura	Caution	12 hr	Either	Several (Royal MH-30 and many others)	Intermediate	Low	Low	NA	> 5,000	> 5,000
Mancozeb EPA Reg. No. 62719-402 Dow AgroScience	Caution	24 hr	Either	Dithane	High	High	Low	M3	> 5,000	> 5,000
Mefenoxam EPA Reg. No. 100-801 Syngenta Crop Protection	Caution	48 hr	Either	Ridomil Gold	High	Intermediate	High	4	1,172	> 2,020

Common Name, EPA Reg. No. & Company Name (for first listed trade name)	Signal Word	Restricted Entry Interval (REI)[a]	Worker Notification[b]	Trade Name(s)[c]	Surface Loss Potential (solution)[d]	Surface Loss Potential (adsorbed)[e]	Leaching Potential[f]	FRAC, IRAC, or HRAC MOA Grouping	Mammalian LD_{50}[g]	
									Oral	Dermal
Metaldehyde EPA Reg. No. 5481-507 AMVAC	*Caution*	*12 hrs*	*Either*	*Deadline Bullets*	*Intermediate*	*Low*	*Low*	*NA*	*283*	*NA*
Metam sodium EPA Reg. No. 5481-468 Amvac Chemical Corp.	*Danger*	*48 hr*	*Oral and Written*	*Vapam*	*Intermediate*	*Low*	*Intermediate*	*Z*	*1,891* *Inhalation danger*	*> 3,074*
Methomyl EPA Reg. No. 352-384 DuPont	*Danger Poison*	*48 hr*	*Either*	*Lannate LV*	*Intermediate*	*Low*	*High*	*1A*	*17*	*5,880*
Napropamide EPA Reg. No. 70506-64 United Phosphorus Inc.	*Danger*	*12 hr*	*Either*	*Devrinol 2 EC*	*High*	*Intermediate*	*Intermediate*	*K3*	*4,640*	*NA*
Oxamyl EPA Reg. No. 352-372 DuPont	*Danger Poison*	*48 hr*	*Either*	*Vydate L*	*Intermediate*	*Low*	*Low*	*1A*	*5.4**	*2,960**

Common Name, EPA Reg. No. & Company Name (for first listed trade name)	Signal Word	Restricted Entry Interval (REI)[a]	Worker Notification[b]	Trade Name(s)[c]	Surface Loss Potential (solution)[d]	Surface Loss Potential (adsorbed)[e]	Leaching Potential[f]	FRAC, IRAC, or HRAC MOA Grouping	Mammalian LD_{50}[g]	
									Oral	Dermal
Pendimethalin EPA Reg. No. 241-337 BASF Ag Products	Caution	24 hr	Either	Prowl 3.3	Intermediate	High	Low	K1	3,956	2,200
Pymetrozine EPA Reg. No. 100-912 Syngenta Crop Protection	Caution	12 hr	Either	Fulfill	NA	NA	NA	9B	> 5,000	> 5,000
Sethoxydim EPA Reg. No. 7969-58-51036 Micro Flo	Warning	12 hr	Either	Poast	Intermediate	Low	Low	A	3,200	> 5,000
Spinosad EPA Reg. No. 62719-267 Dow AgroSciences	Caution	4 hr	Either	Tracer	Low	Intermediate	Low	5	> 5,000	NA
Sulfentrazone EPA Reg. No. 279-3220 FMC Corp.	Caution	12 hr	Either	Spartan	High	Intermediate	High	E	2,855*	> 2,000*
Thiamethoxam EPA Reg. No. 100-939 Syngenta Crop Protection	Caution	12 hr	Either; all greenhouse applications must be posted	Platinum, T-Moxx, Actara	High	Intermediate	High	4A	> 5,000	> 2,000

14. 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. As mechanization options become available, growers can choose the equipment that will work best for their particular acreage and location. Because the cost of harvesting equipment can vary significantly, some devices will be better suited for larger growers. This chapter describes the relevant commercially available equipment.

Commercial Burley Harvesters

Traditional harvesting requires spiking five to eight plants onto a stick and handling the plants and sticks. The sticks, which weigh 30 to 35 pounds, 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. Harvester 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, eight to 10 workers may be required to maintain a continuous harvesting operation when using wire-frame curing structures.

The Kirpy Machine

The Kirpy machine is a unique burley harvester developed by a French equipment manufacturer (Figure 14-1). The harvester is mounted on the three-point hitch and 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. 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 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 ground speeds are 0.6 to 1.0 mile 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

Figure 14-1. Kirpy harvester.

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's performance will be. Contact your Extension agent for details concerning a U.S. distributor.

Marco Harvesters

A more sophisticated commercial harvester designed to incorporate portable curing frames was built originally by Powell Manufacturing Company 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 automation, this harvester requires a greater investment than the carrier unit and single-row cutter-notcher, and it 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 built by Marco Manufacturing (Figure 14-2). This machine is a tractor three-point-hitch-mounted harvester that

Figure 14-2. Marco burley harvester.

cuts, notches, and positively conveys the plant by using 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 the different sizes of 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—16 feet long 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 hold approximately 240 plants (16 × 3 × 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 14-3). 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 saw blade 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 is 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 using some mechanical method other than cut-and-notch machinery. Regardless of how the plants are cut, if portable frames or high-tensile-wire curing structures are to be used, 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 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 that the notch depth is correct regardless of the stalk diameter. An electric unit was also developed to operate from a 120-volt power source and eliminate the use of a tractor (Figure 14-4). The major difference is that 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

Figure 14-3. Carolina Industries cutter-notcher.

locally if a grower has the resources. Contact your Extension agent to obtain 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 use high-tensile wire for hanging and curing the plants. These growers are using various construction methods and materials. All such structures necessarily incorporate some type of plastic cover to protect the tobacco from wind and rain. Although weather conditions greatly affect cure quality, growers can manage curing to some degree by raising and lowering the plastic, which controls the drying rate.

Most of these low-cost structures use single wire strands that span support posts (Figure 14-5). 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 per square foot, which is recommended for adequate ventilation. The length of these low-cost structures varies from 100 feet to several hundred feet, depending on the space availability. The height of the field structures should be sufficient to ensure that the tip leaves are suspended 6 to 12 inches above the ground.

Figure 14-4. Electric-motor-driven portable notching saw.

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 14-6 is a plot of the wire sag at mid span in relationship to the support-post spacing. The wire sag is the greatest at midspan 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 15-6 represents the wire sag for a given post spacing that results in a tension force of approximately 685 pounds. Anything above the solid line, is understressed and anything below is overstressed, which may result in exceeding the wire capacity. For example, if the 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 more than 5 inches would decrease the tension force, but a sag of less than 5 inches would overstress the wire.

Figure 14-5. High-tensile-wire curing structure.

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 of more than 4 inches. A failure to maintain proper spacing between plants 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 6-inch wire spacing supports 33 wires total. If the support posts are 12 feet apart with a midspan wire sag of 5 inches, the tension force in each wire is approximately 685 pounds (Figure 14-6). The total load supported by the end posts and guy wires is approximately 22,605

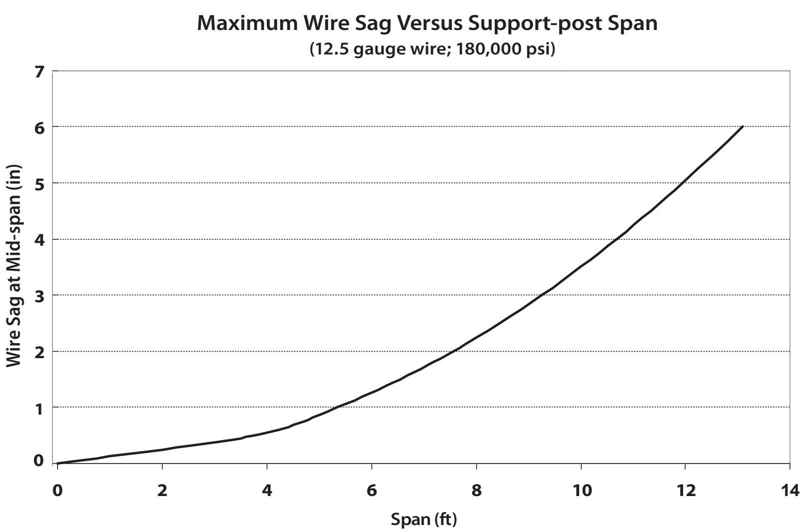

Figure 14-6. Mid-span wire sag versus support-post span.

pounds (685 times 33). This example demonstrates the large amount of force that can be exerted on 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. 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 strong 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 that 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 14-7).

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 the 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.

Figure 14-7. Stripping aid.