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UK COOPERATIVE EXTENSION SERVICE
UNIVERSITY OF KENTUCKY—COLLEGE OF AGRICULTURE

2008 Kentucky

TOBACCO
Production Guide

AGRICULTURE & NATURAL RESOURCES • FAMILY & CONSUMER SCIENCES
4-H/YOUTH DEVELOPMENT • COMMUNITY & ECONOMIC DEVELOPMENT

2008 Kentucky

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Introduction

Gary Palmer

The 2007 tobacco growing season started out dry in many areas and, other than a few sporadic rains, remained dry throughout the season. Areas with relatively poor soils were hit hardest along with late crops. Crops transplanted into fields that were turned late or where wheat or other crops were harvested prior to tillage were hardest hit. Many suffered from poor stands unless transplant quality was high, transplants were set deep or transplant water was sufficient for a good start. Differences in transplanting depth were often seen at harvest, where shallow set tobacco remained stunted from a poor start. Growers reported seeing differences between the carousel-type transplanter and the older finger setter, which tends to set deeper. However, finger setters require a good quality transplant for them to work successfully. In variety tests conducted at UK's Coldstream Farm and on farms, slight differences in transplant quality were magnified by the extreme drought in 2007 resulting in stand loss and stunting in plants from all but the best transplants.

August is the month when tobacco needs rainfall to expand and produce a high-yielding crop. Unfortunately most of the state received only 1-2 inches of rainfall during August. Dry conditions prevailed on through the curing season producing a quick-cured crop with undesirable characteristics. Variegated or pie-bald tobacco was not necessarily the problem, but the overall color tended to be bright due to low humidity and quick curing conditions.

Black shank was ever present in many fields, but blue mold was not a significant threat due to the dry weather. New experimental varieties that will be available for 2008 show improvement for black shank control over current varieties.

Target spot was not as severe as in 2006 due to extreme drought conditions, but it remains a disease of concern for the future.

Weed pressure was high with more weed problems early due to the influence of dry conditions on herbicide performance. Some herbicides like Spartan have what is referred to as reach back potential, and fields receiving even moderate rainfall allowed the chemical to become active and control weeds that had developed. In a few cases, areas like ends of rows or turn rows that received too high a rate of Spartan developed crop injury after rainfall.

Sucker pressure was average, with those using a combination of MH and either Prime+ or Butralin reporting good to excellent control.

Timely and deep transplanting, adequate ground preparation and production of quality transplants can reduce some of the effects from drought. This publication is designed to provide the latest information for the production of high yielding, good quality tobacco. Contact your County Extension Service for more information and other supporting materials and publications.

Tobacco Economics in the Post-Buyout Era

Will Snell, Laura Powers and Greg Halich

The economic landscape for tobacco production in the post-buyout era has been different compared to what growers experienced during the decades of the federal tobacco program. No longer do growers benefit from the price support system which assured a minimum price for their tobacco, a guaranteed buyer, and minimal price volatility within and across marketing seasons. However, growers are not faced with production (quota) constraints and the extra cost of renting in additional production rights, along with quota instability and all the uncertainty that existed with regards to the continued existence of the former federal tobacco program.

The movement to production contracts by most growers has had the tendency to reduce some of the risks, but also adds new risks. Contracting growers have a legal agreement with a buyer which states the company will purchase their crop (as long as they fulfill contracting terms), along with a pre-marketing price schedule for a given set of grades/qualities established and determined solely by the contracting company. However, the post-buyout marketing environment requires growers to pay more attention to various quality-enhancing production and management practices (e.g., chemical/fertilizer applications, disease control, curing management, market preparation) as there is no longer a market where the government, through the cooperatives, purchases tobacco rejected by the companies. Furthermore, contracting growers under the current marketing environment do not have access to a third party to settle any grade disputes.

Presently, the existence of a few remaining auction markets provide an alternative system for those growers who opt to not be bound by a contract or as an outlet for contracted tobacco rejected by the tobacco companies. However, these markets do not guarantee a buyer or an established set of prices predetermined prior to marketing. Grower prices and buyer acceptance of tobacco under both systems should be fairly consistent and favorable during periods of short supplies relative to demand. However, when supplies become ample relative to demand, growers will experience more price volatility as buyers become more selective in their purchases. Excess supplies across marketing seasons will induce buyers to consider various options such as lowering contract prices, decreasing contract volume, eliminating contract growers, and/or a reduction in participation in the auction marketing system.

More competitive prices and the potential for improved quality during the post-buyout era should make U.S. tobacco more attractive in the domestic and international marketplace. Despite continued declines in U.S. cigarette consumption, domestic burley use has risen in the post-buyout era as manufacturers respond favorably to more competitive U.S. burley prices by using a higher percentage of U.S. burley in their blends. Outside the U.S., improved competitiveness of U.S. leaf, continued political and economic instability in some competing tobacco producing nations, along with the potential growth in sales of American-blended cigarettes in some traditional and emerging markets should allow U.S. burley exports to remain relatively strong. However, the ability to take advantage of both domestic and international demand opportunities in the post-buyout era will hinge critically on the ability of the U.S. burley tobacco industry to provide adequate supplies. Alternatively, dark tobacco growers should continue to benefit from a sustained expansion in domestic smokeless tobacco consumption, limited off-shore competition, and favorable price incentives offered by smokeless tobacco manufacturers. One wildcard in the dark tobacco outlook is how the entry of cigarette manufacturers in the smokeless tobacco sector may affect leaf production and marketing requirements.

In summary, the marketing environment in the post-buyout era provides opportunities and challenges for both burley and dark tobacco growers. The former federal tobacco program tended to minimize growers' price risk and generally insured profitability on a per pound basis (assuming a good quality crop), but subjected farmers to much quota and income instability in order to balance supply and demand. Income for Kentucky tobacco farmers will now have to be earned in a marketing environment characterized by a concentrated group of buyers with market power and against very competitive tobacco producers from other countries and from other traditional and nontraditional growing areas in the United States. Consequently Kentucky tobacco growers will have to pay a lot more attention to cost-cutting measures (along with quality) if they are going to survive and prosper in the post-buyout era. Thus, it becomes critically important that producers not only maintain detailed production records on their cost of production, but also understand how to develop and interpret tobacco budgets.

Budgeting and Production Economics

Economists generally classify production expenses into two categories: variable and fixed. Variable expenses are those costs which are incurred directly with the production of the crop (e.g. fertilizer, chemicals, labor) and that depend on the scale of production for a particular year. If no production occurs, these expenses will be zero. Fixed expenses are more commonly referred to as overhead expenses which do not vary with the level of production (e.g. barns, equipment, taxes, insurance). If no production occurs, these expenses will still be incurred. However in developing enterprise budgets, economists spread the cost of fixed expenses over time and across enterprises that use the particular input in the farming operation. In addition to accounting for variable and fixed expenses, economists also place an economic value on the land and operator labor as an opportunity cost to reflect that if the producer was not growing tobacco they can use their land and labor for the production of other crops or employ their labor in non-farming employment opportunities. Enterprise budgets are generally divided into several categories including:

- Gross Revenue—estimated average price per pound times the expected yield per acre
- Total Variable Costs—an aggregation of all expenses that vary with the level of production
- Returns Above Variable Costs—gross revenue less total variable costs

- Total Fixed Costs—an aggregation of total overhead expenses
- Returns to Operator Labor and Management—gross revenue less total variable costs less total fixed costs
- Operator Labor—an estimated value of the operator's labor
- Returns Above All Costs—returns to operator labor and management less operator labor

The University of Kentucky's tobacco production budgets are located online at www.uky.edu/Ag/TobaccoEcon/mgmt.html, or may be obtained at the local county extension office. The budgets are meant to serve as a guide (but not a rule) to assist producers in determining their own anticipated returns and costs of production. Consequently, growers are strongly encouraged to incorporate their own input costs into the budget and observe how sensitive economic returns are to changing yields, input costs, market prices, etc.

In reviewing post-buyout tobacco budgets one will notice two of the major traditional costs for producing tobacco have been eliminated with the changes in tobacco policy and marketing. The termination of the program erased the cost of quota and the switch toward contracting has eliminated marketing costs for most growers. Energy costs in recent years have soared, but as the diagram below illustrates, energy-based inputs such as fertilizer, chemicals and fuel comprise a relatively small component of total production costs. The two factors that have the greatest effect on tobacco production costs on a per pound basis are yield and labor.

Yield

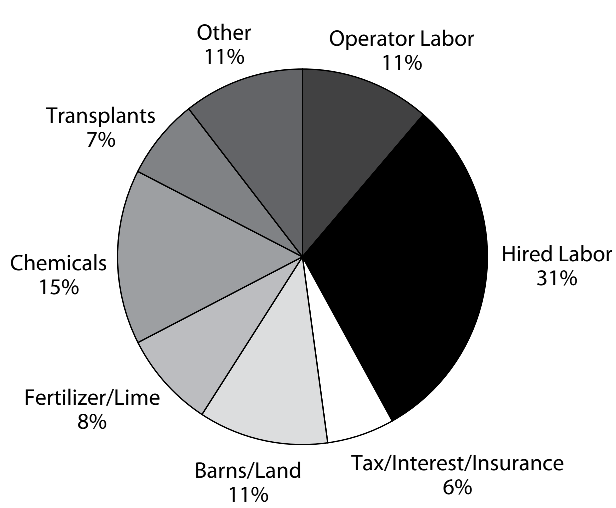
Burley tobacco yields trended upwards during most of the 1960s as growers responded to the acreage program by attempting to maximize their yields on a per acre basis. However since the adoption of the poundage program in the early 1970s, burley tobacco yields have exhibited a downward trend due to a variety of reasons, including increased disease pressure and challenging weather-related growing conditions. Over the past two decades burley tobacco yields in Kentucky averaged around 2,100 pounds per acre. Current budgets and price schedules indicate that 2,100 pounds per acre is close to the "break-even" yield, given an average cost structure. Obviously under the current price and cost environment, burley growers will either have to achieve yields above our historical average or find ways to reduce costs in order to survive in a more competitive market. Average yields should tend to increase in the post-buyout era as the profit potential for relatively low-yielding producers will force many of these producers to exit. Perhaps more important than yield per acre, the current labor situation may cause producers to be more concerned about yield per plant. While yield per plant is affected by variety selection and plant population, growers should strive for around 0.33 pounds of cured leaf per plant or better. Burley growers averaging 0.25 pounds of cured leaf per plant (implying a yield of less than 2000 pounds per acre) will find it difficult to survive in the current cost/price environment.

Dark tobacco yields have been exhibiting the opposite trend as burley with many producers averaging well over 3000 pounds per acre in recent years. Consequently, dark tobacco growers have been able to achieve 0.6 pounds per plant or better given their smaller plant populations and improving yields per acre. Undoubtedly increasing yields, coupled with relatively smaller post-buyout price adjustments have enabled dark tobacco production to remain profitable for most growers in the early post-buyout era.

Labor

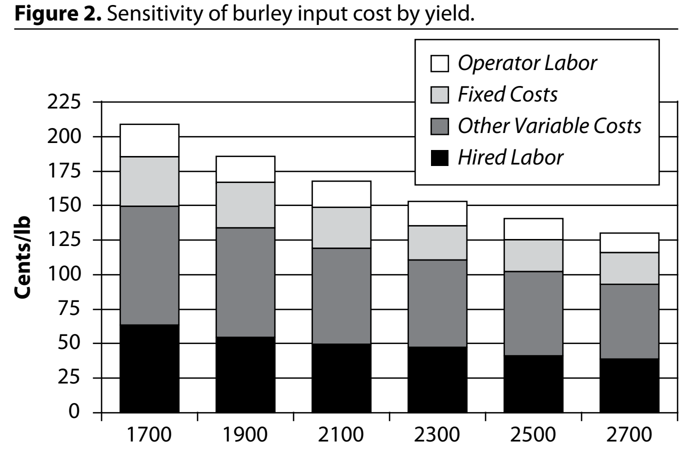
The most challenging factor affecting most tobacco farmers today is labor. Labor saving technologies for tobacco have been studied and implemented for decades, but tobacco still remains a very labor intensive crop. Tobacco production studies have generally indicated that despite some gains in labor efficiency over the years, it still takes around 200 hours of labor to grow an acre of burley tobacco, with dark tobaccos requiring 300 or more hours per acre. A lot of attention is generally focused on harvesting labor (approximately 45–55 hours/A), but market preparation requires the largest portion of labor hours (approximately 80–90 hours/A) in burley tobacco production. Historically,

Figure 1. Distribution of burley costs.



Source: *UK Burley Budget*

Figure 2. Sensitivity of burley input cost by yield.



Source: *UK Burley Budget*

tobacco budgets have generally indicated that labor accounts for nearly 50% of production expenses for burley tobacco and over 50% for dark tobacco. However, these percentages may be conservative given the escalating cost of hired labor in recent years. Consequently growers, tobacco companies, and engineers continue to study and monitor various labor saving technologies (e.g. larger bale size, more efficient stripping systems, mechanical harvesters, alternative curing structures, varying barn designs) to enhance U.S. burley competitiveness. As with any capital investment, producers are encouraged to evaluate the additional costs versus the anticipated benefits of adopting such labor saving technologies over the expected useful life of the asset.

While the cost of labor is a major concern, a greater concern among many tobacco farmers is access to laborers. Due to a very limited supply of domestic laborers willing to work in tobacco, farmers have become increasingly dependent on migrant laborers which may currently account for 75% or more of the total labor hours in tobacco production. However, immigration issues (e.g. border control of illegal labor, terrorism concerns) and competition for migrant laborers from the non-farming sector has dramatically reduced the supply of seasonal workers available in recent years. Consequently, farm organizations and policy makers in tobacco-producing states have sought national immigration reform legislation to allow for a guest worker program that will lead to an adequate supply of legal/affordable labor.

The Immigration Reform and Control Act authorizes the lawful admission of temporary, nonimmigrant workers (H-2A workers) to perform agricultural labor of a temporary or seasonal nature (10 month annual maximum). Rules and regulations regarding the hiring of legal labor are complex but manageable for informed growers. Some (but not all) of the major guidelines of the program are summarized below:

- All employers who hire temporary workers must file a labor certification application with the U.S. Department of Labor. An authorized agent or association may file an application on behalf of an employer.
- Employers must make an effort to hire U.S. workers and show that hiring migrant laborers will not adversely affect the wages of U.S. workers in similar positions.
- Employers must pay H-2A workers the same as U.S. workers and the wage must be the greater of the minimum wage, the adverse effect wage rate (AEWR) or the prevailing hourly wage rate for a given crop/area.
- Workers must be guaranteed employment for at least three-fourths of the workdays in the work contract.

Farmers who employ H-2A workers must provide:

- Reimbursed transportation and subsistence expenses for all workers for their travel expenses to the United States (after completion of 50% of the contract time period), provide transportation from the employees' housing to the worksite, and travel expenses back to the worker's area of residence at the end of the work contract.
- Free and approved housing, which will be inspected annually according to specific federal, state, and local standards and codes.
- Either three meals a day or kitchen facilities for workers to prepare their own meals. If providing meals, then the employer can deduct a federally approved amount from the employee's paycheck if outlined in the work contract.
- A copy of the work contract or job clearance order which includes the contract period, work dates/times, job duties, rate of pay, and other significant conditions of employment.
- Workers compensation insurance.
- Tools and supplies to complete assigned work.
- Detailed accurate record keeping is vital to document all employment activities/issues for this program! Records must be maintained for three years.

Several fact sheets on the Department of Labor's website are useful in understanding the basic guidelines. These include:

- H2 A General Fact Sheet: www.dol.gov/esa/regs/compliance/whd/whdfs26.htm
- H2A Compliance Review: www.dol.gov/esa/regs/compliance/whd/h2A.htm

Other relevant employer information for the H-2A program, including a link to an online application processing system for H-2A workers, can be found at www.uky.edu/Ag/TobaccoEcon.

In Kentucky, the Department for Workforce Investment: Office of Employment & Training Office (274 East Main Street, 2W-A, Frankfort, Ky.) is available to assist growers with the H-2A program. Information from this office is available online at http://oet.ky.gov, or by contacting Jeff Gatewood (Jeff.Gatewood@ky.gov) or Henry Gross (HenryC.Gross@ky.gov), or by calling 502-564-7456.

Growers who plan to use migrant labor are strongly encouraged to become well-educated (either on their own or by working with a reputable labor association) on the rules and regulations of using migrant laborers. Given recent attention to illegal immigration issues nationwide, fines for employing illegal workers or by not following labor/housing requirements have increased in recent months.

Finally, concerns over the labor situation have prompted several legislative proposals in Congress. Growers are encouraged to provide input and closely monitor the situation for changes that could affect the supply of labor and the general requirements outlined above.

Conclusions

Tobacco growers and tobacco companies are adjusting to the changing marketplace in the post-buyout era. During the early years of the post-buyout era, use of U.S. burley has exceeded production. But increasing input costs and frustrations over the labor situation may constrain additional acreage expansion in future years without further price incentives. Higher prices could provide the supplies to expand the dwindling domestic use, but could have adverse effects on the growing export market. Consolidation in the number of growers will likely continue with production continuing to shift to the areas that can consistently produce the quality attributes demanded by the companies at the lowest cost. While the future for those remaining in the sector remains very uncertain, production and cash receipts for the Kentucky tobacco sector do have the potential to expand in future years (in response to demand opportunities) if growers are encouraged (through manufacturer price incentives) to remain in production, and most importantly, the labor situation shows some signs of stabilizing or improving.

Selecting Burley Tobacco Varieties for 2008

Gary Palmer, Bob Pearce, and Andy Bailey

Variety selection is important to minimize disease incidence and severity and to suit the growth characteristics desired by individual producers. With contracting the norm for marketing tobacco, needs of the contracting companies must be considered. Most companies may want tobacco produced from screened seeds only. Others may require that the variety carry the LC logo designating that the tobacco came from seed screened to a specific standard. This seed screening process is intended to help reduce the possible accumulation of tobacco-specific nitrosamines (TSNA) during curing and storage of cured tobacco. The level of screening in private varieties listed below could not be determined at the time this publication was written.

Black shank incidence throughout the burley growing regions makes variety selection for resistance extremely important and the degree of resistance can be an issue in areas where black shank pressure is high. The specific resistance offered by a variety may make a difference in areas where race 0 or race 1 may be high. In many cases, chemicals containing mefenoxam (Ridomil Gold or Ultra Flourish) may be necessary to achieve the best results under heavy black shank pressure (See Chemicals for Disease Management section for best use guidelines). In addition to disease resistance, characteristics like handling, stalk diameter, drought and excess moisture tolerance, growth habits and, of course, yield and quality are important traits to look for in a variety.

The number of varieties with high resistance to black root rot makes variety selection for this disease easy. As the amount of legume forages, like alfalfa, has increased, rotation to fields with such a history is common. Selection of root rot resistant varieties reduces the risk of developing this disease when rotating to a high-risk area.

Many new high yielding varieties are available to producers. However, some may be difficult to handle if not managed properly. Some producers may want to rethink their choices for 2008 and consider drought tolerance as part of the selection process along with handling characteristics as major factors to consider when selecting a variety. However, producers must consider that weather patterns change from year to year. Therefore, selection should be based on disease incidence with other characteristics considered secondary. For example, HB 04P is the most drought tolerant variety available, but it is not a choice many can use due to lack of black shank resistance.

Variety Descriptions

TN 90 LC is still a popular burley tobacco variety accounting for a significant number of acres in Kentucky and the U.S. in general. Released in 1990, TN 90 LC offers a broad range of important characteristics. Originally thought of as a substitute for TN 86 LC, TN 90 LC became a popular variety due to tolerance or partial resistance to blue mold, small stalk diameter, upright growth characteristics (ease of handling) and good cured leaf color. Although not as high yielding as some other varieties including TN 86 LC, TN 90 LC can produce a respectable yield with the potential to reach 3200 lb/A. New varieties like KT 204 LC and KT 206 LC threaten to take much of the current TN 90 LC acreage due to improvements in disease resistance and yield.

Like TN 86 LC, TN 90 LC yields vary more than most varieties from location to location. In addition to blue mold tolerance, it has level 4 resistance to both races of black shank and high root rot resistance. Its lack of Fusarium wilt resistance has caused some concern, but that is not an issue for many producers.

TN 86 LC still has a loyal following, but quality issues prompted many producers to switch away from this variety. TN 86 LC has a tendency to germinate slow, grow slow early in the season and cure slow, leaving undesirable variegated patterns on the cured leaf. It is higher yielding than TN 90 LC reaching 3300 lb/A under ideal conditions and may perform slightly better than TN 90 LC under the same level of black shank pressure. It is an upright variety to the point that row coverage may not be complete at harvest. TN 86 LC should be avoided in all but the best curing barns. Varieties like KT 204 LC and KT 206 LC are superior to TN 86 LC in many areas.

KT 206 LC is the newest variety released jointly by the University of Kentucky and the University of Tennessee and once again offers some improvement over KT 204 LC. KT 206 LC has a good disease package and the best black shank resistance currently available. It has a 10 level to race 0 of the black shank pathogen, indicating no black shank symptoms expected in fields with only race 0, and a 7 level to race 1. With most counties now reporting the presence of race 1 in combination with race 0, KT 206 LC is expected to provide good black shank tolerance. In areas with heavy race 1 black shank pressure, products containing mefenoxam (Ridomil Gold or Ultra Flourish) are still recommended for KT 206 LC. (See Chemicals for Disease Management section). KT 206 LC performed extremely well during the drought of 2007. It is expected to have a potential yield of 3400-3500 lb/A. Average yields should reach 2800-2900 lb/A.

Figure 1. Burley tobacco variety trial, Woodford Co.—Rusty Thompson Farm.

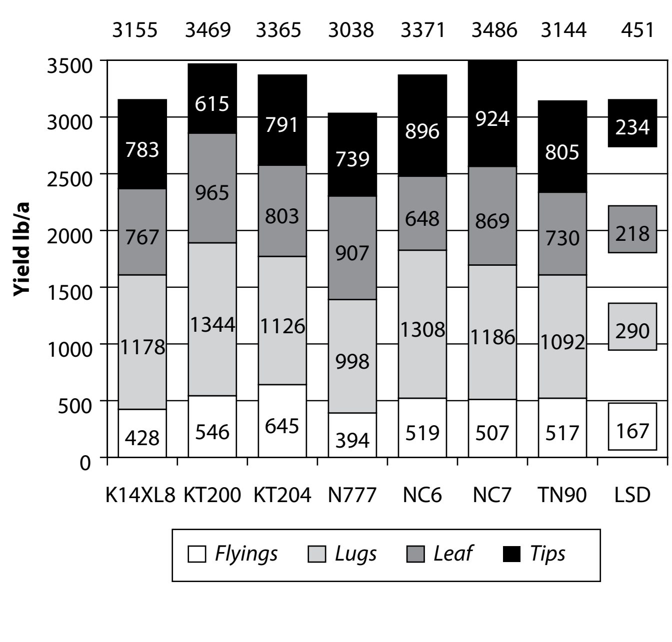
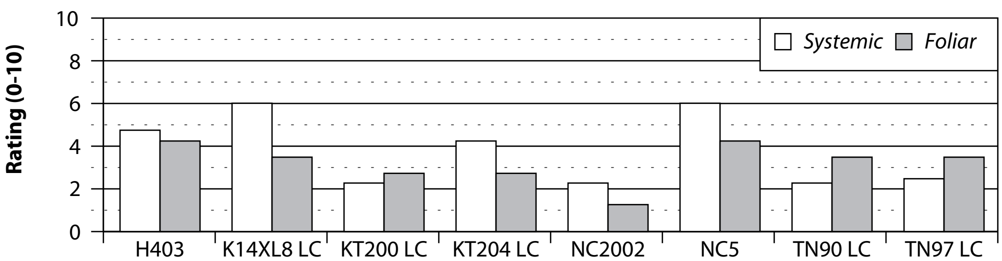


Figure 2. Systemic and foliar blue mold incidence—Menifee County.



KT 204 LC offers some improvements over that of KT 200 LC, but may not perform as well as KT 206 LC. While it still has the great disease package offered by KT 200 LC, it may actually fare better under heavy black shank pressure (both races). It is not as late maturing as KT 200 LC, a common complaint from farmers who grow KT 200 LC. It does not have as large of a stalk as KT 200 LC, which should improve handling. It is not as tolerant to blue mold as KT 200 LC or TN 90 LC, but not as susceptible as Hybrid 403. Quality is expected to be better than that of KT 200 LC with yields that can reach 3400–3500 lb/A under ideal conditions. KT 204 LC tends to grow slow early in the season which may discourage producers initially, but its growth in the later part of the season is impressive. KT 204 LC reverts to normal growth during the later part of the season due to the development of a good root system even though top growth may be slowed initially. KT 204 LC does not tolerate drought and black shank resistance may not hold up well during dry seasons. Target spot incidence has been high for KT 204 LC. However, the extent of the susceptibility is not known at this time.

KT 200 LC continues to have a loyal following, but may lose out to KT 204 LC and KT 206 LC in many cases. It has a similar disease resistance package to TN 90, but should tolerate black shank pressure much better TN 90 LC, but less so than either KT 204 LC or KT 206 LC. It has level-six resistance to both races of the black shank pathogen. It has tolerance to blue mold similar to that of TN 90 LC. Yields have been excellent and can reach close to 3400-3500 lb/. Some producers like KT 200 LC, but others were disillusioned with its large stalk and plant size and its late maturity and quality issues. It has a high green stalk weight which may discourage growers. Many who tried KT 200 LC for the first time in 2004 or 2006 were disillusioned with the size of the variety which was enhanced by high rainfall late in the season. Its late maturing nature was not a problem in 2006 due to labor shortages that forced late harvest anyway. KT 200 LC has a dark green color while growing in the field and may have more of a tendency to cure green if not allowed to mature prior to harvest. Growers should top this variety early and let it stand 4-5 weeks before harvest to minimize a potential green cure.

KY 14 x L8 LC is dropping in popularity due to increased incidence of race 1 black shank and the extra management required to produce high yields and good quality. It is an early maturing, short, spreading type of tobacco. Leaves droop to the extent that leaf breakage can be excessive under certain conditions. In addition, leaves appear to be more brittle than most varieties making KY 14 x L8 LC a poor choice for mechanical harvest or for farmers using laborers that may not take precautions during harvest. It has fewer leaves than most varieties, but compensates by producing larger leaves. Stalk diameter is small to medium. Yields average over 3000 lb per acre and may reach 3300 lb/A under ideal conditions. Quality can be excellent under proper management. Delayed topping increases sucker development and may make control more difficult. KY 14 x L8 LC initiates sucker growth sooner than most other varieties making early topping a must. Best results are achieved when 14 x L8 LC is harvested at three to four weeks after topping. Delayed harvest may increase sucker control problems and reduce cured leaf quality. KY 14 x L8 LC has high resistance to race 0 of the black shank pathogen, but no resistance to race 1. The presence of race 1 many areas has forced producers to abandon KY 14 X L8 LC in favor of varieties with resistance to both races. Damage by the virus complex can be severe where virus pressure is high and blue mold incidence may be higher for than in most varieties. KY 14 x L8 LC may yield poorly if planted in an area with high root rot pressure. Many tobacco growers are realizing that KY 14 x L8 LC no longer serves their needs as it once did. Hopefully most growers will realize this fact prior to suffering major loses from race 1 black shank. KY 14 x L8 LC also has moderate resistance to Fusarium wilt.

HB 04P LC, a hybrid variety from F.W. Rickard Seed, has excellent drought tolerance as demonstrated by its performance in 2002, 2005, 2006, and especially 2007, but also performed well under wet conditions in 2003 and 2004. HB 04P LC is resistant to black root-rot and mosaic, but has no resistance to black shank. It has medium maturity and is similar to NC BH129 LC for its resistance to the virus complex. It has large leaves and an average-sized stalk diameter. HB 04P LC has a yield potential of approximately 3300-3400 lb/A. Cured leaf quality is generally good. With a yield close to that of KT 200 LC or Hybrid 403 LC, it may be a better choice for those who do not like the late maturity of KT 200 LC or need the black shank resistance that KT 200 LC offers. It also offers more rotational choices than Hybrid 403 LC due to its root rot resistance. This variety is also well suited for hill top, non-irrigated crops that may be prone to drought.

Hybrid 403 LC remains one of the top yielding burley tobacco varieties after several years on the market. Producers who wish to grow Hybrid 403 LC, which has no resistance to black shank or black root rot, need to avoid fields with a history of black shank and rotations that might favor root rot development including continual tobacco production or any legume crop such as alfalfa, clovers or soybeans. A darker green variety in the field, Hybrid 403 LC has a higher incidence of blue mold than most varieties when conditions favor this disease. Producers tend to like how this variety handles, especially at housing time. The ratio of cured leaf yield to green weight at harvest tends to be higher than in most other varieties. It has a yield potential in the absence of disease pressure of approximately 3500 lb/A. Some newer varieties with higher yield potentials and better disease packages are challenging the popularity of Hybrid 403 LC.

NC BH129 LC has been one of the most consistent yielding varieties regardless of weather or soil conditions. With a 3200 lb/A yield potential, this variety has performed well for many producers. It has high resistance to black root rot, but low black shank resistance. NC BH129 LC is a tall variety with more space between leaves than most other varieties. It produces very high cured leaf quality with the exception of color, which tends to be bright. Early topping significantly improves color in this variety. Its medium to early maturity makes it a good choice when coupled with a late maturing variety for scheduling labor. Lack of adequate black shank resistance limits the use of this variety.

R 630 LC is an early maturing variety with a yield potential around 3000 lb/A. While unable to yield with some of the newer varieties, it still has a good yield potential. Even though it has the same level 4 rating for both races of black shank as R 610 LC, some trials indicate that it may fair better in black shank fields. R 630 LC's drought tolerance may be part of the reason why. R 610 LC can develop significant stress during a drought with the potential for heavy leaf loss or burn. While R 630 LC shares a similar name, maturity, and yield potential to that of R 610 LC, the similarities end there. It has high resistance to black root rot, a disease that often afflicts R 610 LC. Viruses have caused serious losses in R 610 LC in some areas, but R 630 LC has resistance to the virus complex. While R 630 LC leaf quality may not be quite as good as that of R 610 LC, no other variety can make that claim either.

R7-12 LC is a late maturing variety with a high yield potential that may reach past the 3400 lb/A mark. Although it has no black shank resistance, it does have high black root rot resistance, which will make it suitable for more locations than Hybrid 403 LC. It has wide upright leaves, medium stalk diameter, and a good cured leaf color and quality.

N 126 is a medium maturity variety with a yield potential of 3200 lb/A. It has very little disease resistance and yields would suffer if it is grown where disease pressure is high. Avoid fields with a history of root rot or black shank when growing this variety. N 126's other strong point besides yield is its dark cured leaf color, which makes it stand out at the market. N 126 has a relatively small stalk diameter making handling potentially easier than big stalk varieties.

N 7371 LC is a new variety released by Newton Seeds Inc. Early indications are that resistance to black shank early may be fair, but preliminary tests indicate that the resistance does not hold up later in the season. However, results may vary depending on the predominant black shank race. N 7371 LC is a late maturing variety with a high number of long but narrow leaves and is a high yielding, good quality variety. Topping may be slower than comparable varieties due to the smaller upright leaves in the top of the plant at topping time.

TN 97 LC is a medium to late, high yielding variety with a yield potential that can reach 3400 lb/A. Its potential as a black shank resistant variety has not lived up to expectations. It does have black root rot resistance and resistance to the virus complex. It appears to be more susceptible to drought than many other varieties making it more suitable where irrigation is possible. Its susceptibility to drought may decrease its perceived resistance to black shank. A variety like TN 97 LC handles the excess moisture of a year like 2003 better than most other varieties.

NC 2000 is a late maturing, blue mold resistant variety. It has very little resistance to other major diseases like black shank or black root rot. It has one of the lowest yield potentials of all of the varieties currently available at approximately 2600 lb/A. Its usefulness is limited to those producers whose tobacco suffers a high degree of damage from blue mold annually, but is not exposed to black shank.

NC 2002 is a blue mold resistant variety. It has very little resistance to other major diseases like black shank or black root rot. It is a higher yielding variety than NC 2000 with a yield potential of approximately 3000 lb/A under ideal conditions and no disease pressure.

NC 3, a medium, late maturing variety, may surpass the yield of NC BH129 LC by 100 lb/A, but disease resistance is similar. It does have virus resistance, although NC BH129 LC should show some tolerance also. NC 3 is also a consistent variety and may produce a better color at curing than NC BH129 LC.

NC 5 is a variety with good potential for control of black shank. It has very high resistance to race 0 black shank like that of 14 x L8, but also has a medium level of resistance to race 1, which 14 x L8 does not have. It has high resistance to black root rot and the virus complex, but does not have Fusarium wilt resistance. It is medium to late in maturity. Yields may reach 3200 lb/A under ideal conditions, but its yields cannot compete with higher yielding varieties.

NC 6 is a medium-late maturity with high yield potential and good leaf quality. Yields are expected to reach 3400–3500 lb/A under ideal growing conditions. NC 6 is a big robust variety with a large stalk size. Plant size can be big at harvest and handling may be difficult if plant population drops below 7500 plants per acre, 42" x 20" plant spacing. It has high resistance to race 0 black shank, but low-to-medium resistance to race 1 black shank. It also has resistance to black root rot and the virus complex. In addition, it has resistance to Southern root knot nematode, but is susceptible to Fusarium wilt.

NC 7 has high resistance to race 0 black shank, and low-to-medium resistance to race 1. Otherwise, NC 7 has a good disease resistance package including resistance to black root rot, Fusarium wilt, tobacco mosaic virus, and wildfire. It has a big, robust growth habit with a large stalk diameter. Handling may be difficult under conditions that increase plant size (plant populations under 7500 plants per acre). It has some unique resistance that may not be significant in Kentucky, including resistance to root knot nematode and tobacco cyst nematode. Yields are expected to reach 3500 lb/A under ideal conditions and quality is expected to be good. Avoid areas where race 1 incidence is high. NC 7 may be the best current solution where Fusarium wilt incidence is high. However, if race 1 black shank pressure is expected to be high (common in many fields around Kentucky), chemicals containing mefenoxam (Ridomil Gold or Ultra Flourish) may need to be applied up to three times to achieve best results.

These and other varieties could help to improve disease control and improve yield and quality. Other varieties not listed here may produce equal results, if selections meet disease resistance and management needs. Look for 2007 yield results as they become available at www.uky.edu/ag/tobacco/.

Characteristics of Major Dark Tobacco Varieties

Andy Bailey

Agronomic characteristics of dark tobacco varieties may vary between years and locations. The following descriptions are based on observations and results from replicated variety trials conducted under different environments across western Kentucky and Tennessee over the past several years. Yield potentials listed are an average across several trials and seasons and actual yields may vary from those listed. The disease resistance indicated can be expected if disease pressure is present. (See Figure 1.)

Little Crittenden is typically an air-cured variety but also performs well as a fire-cured variety. It has medium to late maturity with fair yield potential (3000 lbs/A) and excellent cured leaf quality. Little Crittenden has a semi-erect growth habit with long leaves that have considerable crinkle and fairly coarse texture. It has very good curing characteristics similar to the Madoles. Little Crittenden has no disease resistance.

Narrowleaf Madole LC is still the most popular dark tobacco variety grown. It can be used as a fire-cured or air-cured variety and has medium maturity with excellent yield (3200 lbs/A) and cured leaf quality. It is known for its good curing characteristics. Narrowleaf Madole has a very prostrate growth habit with long, drooping leaves and a smooth leaf texture. Narrowleaf Madole can typically remain in the field longer after topping than any other variety before harvesting. However, it is somewhat more prone to leaf breakage at harvest due to its prostrate nature. It generally does not perform well when transplanted early (prior to May 15th) when cool, damp conditions commonly occur. Narrowleaf Madole has no disease resistance.

TR Madole is typically used as a fire-cured variety. It has early to medium maturity and excellent yield (3200 lbs/A) and cured leaf quality characteristics. It has a very prostrate growth habit and is an easy-curing variety similar to Narrowleaf Madole. TR Madole has very characteristic rounded top leaves with a smooth, open textured leaf surface which makes it well suited to cigar-wrapper style markets. TR Madole has no disease resistance.

KY 160 is an air-cured variety with medium maturity and relatively low yield potential (2600 lbs/A) but excellent cured leaf quality. It has a semi-erect growth habit with long, narrow leaves and very smooth leaf texture. KY 160 has high resistance to tobacco mosaic virus.

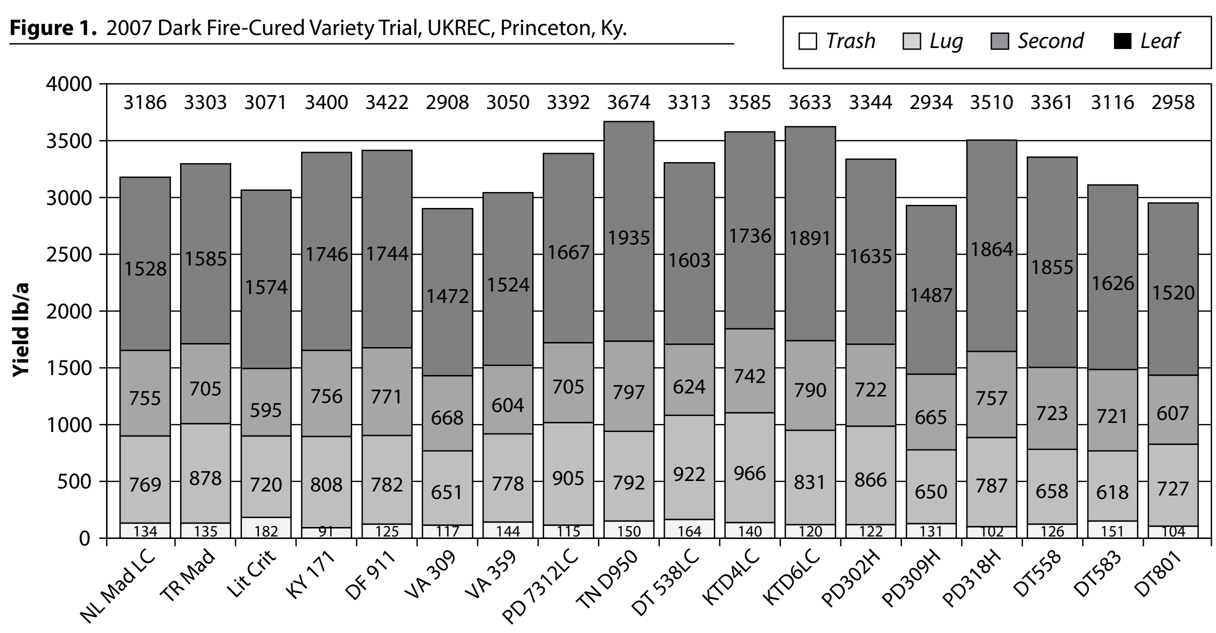
KY 171 is an air-cured or fire-cured variety with medium maturity and very good yield (3100 lbs/A) and cured leaf quality. It has a semi-erect growth habit with coarse leaf texture and good curing characteristics. KY 171 has high resistance to black root rot and tobacco mosaic virus, medium resistance to Fusarium wilt, and performs better than many other varieties when transplanted early (prior to May 15th).

DF 911 is typically used as a fire-cured variety but may also work relatively well as an air-cured variety. It has medium maturity and excellent yield potential (3300 lbs/A). DF 911 has a prostrate growth habit somewhat similar to Madoles but has a larger stalk size than most other dark tobacco varieties. Cured leaf quality is typically lower than most other varieties, as the leaf face tends to cure to a dark brown while the back of the leaf cures to a light tan. DF 911 has high resistance to black root rot, wildfire, and tobacco mosaic virus.

DT 508 is typically used as a fire-cured variety and has very good yield (3200 lbs/A) and quality characteristics. It has a prostrate growth habit with medium maturity. DT 508 has medium resistance to race 0 and race 1 black shank and medium resistance to Fusarium wilt.

DT 518 is typically used as a fire-cured variety. Similar to DT 508, it has very good yield (3200 lbs/A) and quality characteristics, prostrate growth habit, and medium maturity. DT 518 has medium resistance to black root rot and medium resistance to race 0 and race 1 black shank.

Figure 1. 2007 Dark Fire-Cured Variety Trial, UKREC, Princeton, Ky.



DT 592 is typically used as a fire-cured variety. It has good yield (3000 lbs/A) and quality characteristics and has a growth habit similar to Narrowleaf Madole. It has a larger stalk than most other varieties, with stalk size similar to DF 911. Like Narrowleaf Madole, it is somewhat more prone to leaf breakage at harvest than other varieties. DT 592 has medium resistance to black root rot and low-medium resistance to black shank race 0 and race 1.

DT 538LC is typically used as a fire-cured variety but may also work well as an air-cured variety. It has excellent yield (3400 lbs/A) and very good cured leaf quality. It has medium maturity with a semi-erect growth habit and fairly coarse leaf texture. It has good black shank resistance similar to KT D4LC (medium resistance to race 0 and race 1).

VA 309 can be used as an air-cured or fire-cured variety. It has early to medium maturity with fair yield (3000 lbs/A) and cured leaf quality characteristics. VA 309 has a semi-erect growth habit with a fairly smooth leaf texture. It has low-medium resistance to race 0 and race 1 black shank, and medium resistance to black root rot.

VA 359 can be used as an air-cured or fire-cured variety. It has early to medium maturity and good yield potential (3100 lbs/A). It has an erect growth habit with leaves lighter in color than most other varieties. VA 359 has excellent cured leaf quality characteristics and cures to a light brown color. VA 359 has low resistance to race 0 and race 1 black shank.

TN D950 is a fire-cured variety with early maturity and a very prostrate growth habit. It has excellent yield potential (3200 lbs/A) but typically produces only fair cured leaf quality. Leaves of TN D950 have a fairly smooth texture and are darker green, containing more chlorophyll (green leaf pigment) than most other dark tobacco varieties and therefore may require earlier firing and more firing to help drive green out of the cured leaf. TN D950 has medium resistance to race 0 and race 1 black shank (slightly lower than DT 538LC, KT D4LC, and KT D6LC), and high resistance to black root rot, tobacco mosaic virus, and wildfire.

KT D4LC was developed as a fire-cured variety but has also performed relatively well as an air-cured variety. KT D4LC has the highest yield potential of any dark tobacco variety currently available (3600 lbs/A). It has a very erect growth habit with medium maturity and leaves light in color similar to VA 359. Spacing between leaves is closer than most other varieties and it typically will have 3 to 4 more leaves than other varieties topped to the same height on the stalk. It has a coarse leaf texture with cured leaf quality that is usually lower than most other varieties but better than TN D950. It has medium resistance to race 0 and race 1 black shank (similar to DT 538LC). KT D4LC has no resistance to black root rot, tobacco mosaic virus, or wildfire.

KT D6LC is a hybrid of KT D4LC x TN D950. It is a fire-cured variety with medium maturity, semi-erect growth habit, and fairly smooth leaf texture. KT D6LC has excellent yield potential (3400 lbs/A) and higher cured leaf quality than KT D4LC or TN D950. It has good resistance to race 0 and race 1 black shank (medium, but slightly lower than KT D4LC or DT538LC), and high resistance to black root rot, tobacco mosaic virus, and wildfire.

KT D8LC is a new variety for 2008 released by the Kentucky-Tennessee breeding program. KT D8LC is very similar to KT D4LC, and will perform well as a fire-cured variety and may be a better air-cured variety than KT D4LC. KT D8LC has the same disease resistance package as KT D4LC, with medium resistance to race 0 and race 1 black shank but no resistance to black root rot, tobacco mosaic virus, or wildfire. KT D8LC has a very erect growth habit with medium maturity. Leaf number, color, and texture for KT D8LC are very similar to KT D4LC. KT D8LC has excellent yield potential (3500 lbs/A).

PD 7312LC is a hybrid of KY 171 x Narrowleaf Madole developed by Rickard Seed. It has medium maturity, excellent yield (3200 lbs/A), and very good cured leaf quality. PD 7312LC can be used as a fire-cured or air-cured variety, and performs well as an early-transplanted variety (prior to May 15th). It has high resistance to black root rot and tobacco mosaic virus and medium resistance to Fusarium wilt, but no black shank resistance.

PD 7302LC is a new hybrid for 2008 developed by Rickard Seed. PD 7302LC has medium maturity with excellent resistance to race 0 black shank but no resistance to race 1 black shank. It also has high resistance to black root rot and tobacco mosaic virus. PD 7302LC can be used as a fire-cured or air-cured variety. It has a slightly upright growth habit, with excellent yield (3300 lbs/A) and excellent curing characteristics.

PD 7309LC is another new hybrid for 2008 developed by Rickard Seed. PD 7309LC has medium maturity with excellent resistance to race 0 black shank. It is not resistant to race 1 black shank, black root rot, or tobacco mosaic virus. It is a slightly more prostrate variety than PD 7302LC with excellent yield (3400 lbs/A) and curing characteristics. PD 7309LC can be used as a fire-cured or air-cured variety.

Management of Tobacco Float Systems

Bob Pearce, Gary Palmer, Andy Bailey, Kenny Seebold, and Lee Townsend

What is the value of a tobacco transplant? The typical market value of finished transplants is in the range of $38–$45 per one thousand plants. However the true value of a quality transplant lies in its potential to produce a high yield at the end of the growing season. Poor field management can result in low yields from good quality transplants, but good field management cannot always rescue poor quality transplants.

Most tobacco growers have the knowledge and skills necessary to grow good quality transplants, but many do not have the time to do the job right. For some the best decision may be to purchase transplants and allow someone else to absorb the risks of transplant production. Growers who derive a significant portion of their farm income from transplant sales tend to spend more time managing their float facilities than growers who grow transplants only for their own use. This does not mean that purchased plants are always better quality than you can grow yourself. Transplant buyers should consider carefully the reputation of the transplant producer, ask questions about their management practices, and carefully inspect transplants upon delivery.

There are risks associated with transporting transplants over long distances. Transplants may be infected with a disease even though they appear healthy at the time of delivery. One example of this principle is with the potential for blue mold on transplants grown in the Deep South. Blue mold does not overwinter in Kentucky, and is typically spread into our area on wind currents from southwestern source areas. When infected transplants are brought in, blue mold "hot spots" can develop rapidly and greatly accelerate the problem, costing growers money in lost production and increased control measures. If you choose to purchase transplants consider working with a local producer to minimize the risk of introducing disease and to help stimulate the local farm economy, or buy plants produced in areas north of Kentucky (where blue mold is unlikely to be present).

For growers who choose to produce their own transplants there are three general systems to consider: 1) Plug and transfer in unheated outdoor float beds, 2) Direct seeding in unheated outdoor float beds, and 3) Direct seeding in heated greenhouses. Each of these systems has its advantages and disadvantages, but all can be used to produce quality transplants. Table 1 shows a relative comparison of these three systems. Some growers may utilize more than one system; for example seeding in a heated greenhouse and moving plants to an unheated bed after germination.

Table 1. Relative advantages and disadvantages of tobacco float systems.

Characteristic	Plug and Transfer	Direct Seed	
		Outside	Greenhouse
Labor requirement	High	Medium	Low
Cost per plant	Medium	Low	High
Target usable plants (%)	95	80	90
Management intensity	Medium	High	High
Risk of plant loss	Medium	High	Medium
Risk of introduced disease	High	Low	Low
Uniformity of plants	High	Low	Medium
Degree of grower control	Medium	Low	High
Time to usable plants (weeks)	3 to 4*	8 to 10	7 to 9

** Weeks after plugging*

Tray Selection

Most trays used in tobacco float systems are made of polystyrene and manufacturers control the density of the tray by the amount of material injected into the mold. Higher density trays tend to be more durable and have a longer useful life than low density trays, but they also tend to be more expensive. In some cases an inexpensive low density tray may be desired for those who sell finished plants and have difficulty getting trays returned, or are concerned about potential disease problems with returned trays. Some problems have been reported with roots growing into the walls of low density trays, making it difficult to remove the plants.

Some trays have been described as "glazed"; these have been manufactured by a process that seals the inner surfaces of the cells. Data from greenhouse trials with new trays have shown little difference in transplant production in glazed or unglazed trays (Table 2), although glazed trays may be slightly easier to clean and sanitize due to the sealed surface in contact with the plant roots.

Yet another choice in tray design appeared on the market in 2006. A "shallow" tray has the same length and width as a regular tray but is only 1.5 inches deep as compared to the 2.5 inch depth of a regular tray. In limited testing the shallow trays had fewer dry cells, slightly lower germination, and slightly more spiral roots than regular trays (Table 2). In the end there was no difference in the production of usable transplants. The field performance of plants produced in shallow trays has not been systematically tested so we do not know if the smaller root volume will have adverse effects on the establishment and growth of the transplants. The advantages of the shallow trays are reduced amount of soil-less media needed and reduced space needed for tray storage.

Table 2. Greenhouse performance of float trays.

Tray type	Dry Cells (%)	Germination (%)	Spiral Root (%)	Usable Plants (%)
2004 data				
Regular	--	96.0	6.1	89.8
"Glazed"	--	96.5	6.1	91.0
LSD 0.05*		NS	NS	1.1
2006 data				
Regular	0.8	97.4	1.9	91.4
Shallow	0.1	96.7	2.8	91.0
LSD 0.05*	0.3	0.5	0.6	NS

** Small differences between treatments that are less than this are not considered to be real differences due to the treatment, but are thought to be due to random error and normal variability in plant growth.*

The choice of cell number per tray comes down to maximizing the number of plants produced per unit area, while still producing healthy plants of sufficient size for easy handling. The outside dimensions of most float trays are approximately the same, so as the number of cells increases, the cell volume generally decreases. However, the depth of the tray and cell design can influence cell volume. In general, as the cell volume decreases, so does the optimum finished plant size. Smaller plants are not a problem for growers using carousel setters, but those with finger-type setters may have difficulty setting smaller plants deep enough. There are some slight variations in tray dimensions from one manufacturer to another. Be sure that the tray selected matches the dibble board and seeder to be used.

Some float plant producers try to maximize plant production per unit area as a means of lowering overhead production costs. High cell number trays (338 and higher) have been used successfully to do this by some greenhouse operators, but more time and a greater level of management are needed to grow transplants at these higher densities. Disease management is also more difficult with high cell numbers, requiring better environmental control, more frequent clipping, and diligent spray programs. For most tobacco producers with limited greenhouse experience, a 242 or 288 cell tray is a good compromise.

Trays with lower cell numbers are recommended for transplant production in outside beds. The lack of environmental control and infrequent clipping of outside beds makes the use of high density trays a risky venture. Since the cost of outdoor bed space is relatively inexpensive compared to a greenhouse, there is not as much pressure to produce the maximum number of plants per square foot.

Tray Sanitation and Care

A good sanitation program is critical for consistent success in the float system. For many of the diseases that are a problem in float plants, sanitation is the first line of defense. Sanitation of trays is difficult because of the porous nature of polystyrene. As the trays age they become more porous, and with each successive use, more roots grow into the tray. This allows pathogenic organisms to become embedded deep in the tray where they are difficult to reach with sanitizing agents.

Trays should be rinsed off immediately after transplanting to remove any media, plant debris or field soil. Some of the organisms that cause diseases in the float system are common soil inhabitants, and field pathogens. So, after trays have been used to grow a crop of transplants and been to the field for transplanting, they may be contaminated.

Trays may be disinfected prior to storage or just before seeding in the spring. They should be stored indoors out of direct sunlight. Do not store trays in a greenhouse where UV light and heat will cause deterioration and damage. If trays have been sanitized prior to storage, store them in such a way as to avoid recontamination. Take appropriate steps to protect trays from damage due to the nesting activity of small rodents and birds.

Disinfectants available are: Steam, chlorinebleach, and quaternary ammonium chloride salts. None of these have been totally effective in killing all the pathogens. Each has positive and negative points, as discussed below.

In our studies, steam has been the most effective disinfectant. It consistently does the best job of killing the range of pathogens found in Kentucky. Steam sterilization of trays is especially recommended for commercial transplant producers. Steaming at 170-180°F for 30 minutes has been successful, but lower temperatures and longer times may also be used. The cost of using steam to sterilize trays, however, is high and some trays will be damaged by steaming. Thus, the biggest problem with steaming at the farm level is insufficient control steam to reach and maintain the recommended temperature range for the prescribed period of time without damaging the trays.

Chlorine bleach solutions have given a high level of control, but, overall, are not as effective as steam. We have found little benefit of using more than 1 part bleach to 9 parts water (10% solution). Any commercially available bleach can be used to make the sterilizing solution, but avoid concentrated formulations. Industrial-type bleaches cost more and don't add any additional benefit, as mentioned above. Bleaches work best when the trays are washed with soapy water, dipped several times into clean 10% solution, and covered with a tarp to keep them wet overnight with the bleaching solution. Afterwards, the bleach solution should be washed from the trays with clean water or water plus a quaternary ammonium chloride salts, as listed below, followed by aeration to eliminate the chlorine and salts of chlorine. Without proper aeration and postwashes, salt residues can cause serious problems, especially with older trays that tend to soak up more materials. Worker safety issues are also important with bleach. It is critical that the bleach solution remain below pH 6.8 and that a new solution be made up every 2 hrs, or whenever it becomes dirty, whichever comes first. Organic matter deactivates bleach quickly.

Quaternary ammonium chloride salts are marketed under such trade names as Greenshield, Physan, and Prevent as solutions containing 20% ammonium chloride. While many growers use them, our tests indicate that they are not as effective as some believe. Their greatest benefit is in the final wash and on exposed surfaces in the greenhouse. In all our tests, they have always provided some control, as compared to using soap washes only, but have always been inferior to any of the above mentioned methods.

Water Quality

Water quality for tobacco float plants has not been a big problem in Kentucky when using a fertilizer that is well suited for the float system. However, there are a few things to keep in mind. Never use untreated surface water for tobacco float beds. Surface water may contain high levels of disease-causing organisms. Water from most municipal and county water systems has been found to be suitable for use in the float system. In a few water districts, the alkalinity levels have been found to be above acceptable levels.

Water from private wells occasionally has higher than desired levels of alkalinity, with about 15-20% of the wells tested requiring the addition of acid to reduce the alkalinity to a manageable range for float plant production. Rarely are there cases where water quality problems are severe enough to warrant switching to a different water source. A preliminary check of water quality can be made with a conductivity meter and swimming pool test strips that measure pH and alkalinity. Conductivity readings above 1.2 microsiemens/centimeter (µs/cm) or alkalinity above 180 ppm suggest the need for a complete water analysis. For more information on water quality for float beds see AGR-164, *Water Quality Guidelines for Tobacco Float Systems.*

Media Selection and Tray Filling and Seeding

The three basic components of soil-less media used in the float system are peat moss, perlite, and vermiculite. Peat is the brown material that is used in all the media to provide water and nutrient holding capacity. Vermiculite is the shiny, flaky material, and perlite is the white material used in some media. Different brands of media have varying amounts of these components. Some have only peat and vermiculite, others have only peat and perlite, and still others have all three ingredients. Research to date has not indicated any particular combination of ingredients or brand of media to be consistently superior to the others (Table 3). Year to year variability within the same brand of media can be quite high, so there is a need to continually check and adjust tray filling and seeding procedures each year.

Careful attention to tray filling procedures will minimize the occurrence of dry cells and spiral roots. Dry cells occur when the media bridges and does not reach the bottom of the tray, or when a portion of the media sifts out the bottom of the tray. When this happens water does not wick and the seed in that cell will not germinate. A few dry cells (1% or less) should be considered normal. It is a good idea to check a few trays during tray filling to make sure that a plug of media is in the small hole at the bottom of the tray. If bridging of media is a consistent problem try pouring it through a coarse mesh screen to remove stick and clumps. If media is falling out the bottom of trays you may need to add one or two quarts of water to each bag of media prior to tray filling. Wait 24 hours, if possible, to allow time for moisture to adjust evenly.

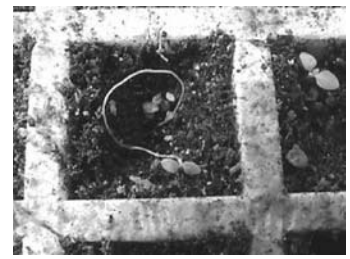
Each year there are a few cases where large groups of trays fail to wick up after a reasonable period of time. Many of these cases have been traced back to the use of media left over from the previous year. During storage the media dries out and the wetting agents tend to break down over time causing the media to be difficult to rewet. The use of left over media should be avoided if possible, however if it is known that the media is old, try adding two or three quarts of water per bag at least a day before seeding. It is also a good idea to record the lot numbers (if legible) off any bags of media used as they can be very helpful in tracking down the source of problems.

Table 3. Production of usable burley tobacco transplants in selected soilless media in a tobacco float system.

	Usable Plants (%)		
Brand of Media	**2006**	**2005**	**2004**
Beltwide All Peat	89.9	90.1	--
Burley Gold	88.2	90.5	95.1
Carolina Choice	93.3	90.8	90.1
Carolina Silver	92.6	91.5	90.7
Kentucky Paydirt	90.4	92.3	--
Metromix Ag-lite	94.2	88.1	--
Southern States	92.4	92.2	88.0
Southern States w coir	88.1	--	91.2
Speedling fortified	90.8	88.5	91.4
Sunshine LT-5	92.0	91.3	90.7
LSD 0.05*	2.2	2.6	2.0

* *Small differences between treatments that are less than this are not considered to be real differences due to the treatment, but are thought to be due to random error and normal variability in plant growth.*

Figure 1. Spiral root of a burley tobacco transplant.



Spiral root is a term used to describe a germinating float plant in which the emerging root does not grow down into the media, but instead grows on the surface often looping around the plant (Figure 1). It is thought to be the result of physical damage to the root tip as the root attempts to break out of the seed and pellet. Whether or not a particular plant will have spiral root is determined by a complex interaction between the variety, the seed/pellet, media properties, and weather conditions. Table 4 shows the influence variety and seed source on spiral root occurrence in dark tobacco. Similar results have been observed in burley tobacco with the variety KY14 x L8 having a higher incidence of spiral root than other varieties.

Table 4. Effect of seed source and variety on spiral rooting at 21 days after seeding.

	Seed Source			
	Rickard	*Workman*	*Newton*	**Seed Source**
Variety	**% Spiral Rooting**			**LSD 0.05**
Narrowleaf Madole	11.2	5.4	4.9	3.1
KY 171	1.0	1.4	2.0	0.9
KT D4LC	4.3	4.4	2.6	3.4
LSD 0.05 (variety)	2.0	2.9	2.9	

The incidence of spiral root has decreased during the last two growing seasons, due in part to changes made to the pellets by some tobacco seed companies. Nevertheless, spiral root can still be a problem that results in a significant reduction in usable plants. To minimize spiral rooting avoid packing media tightly into the trays. Trays should be allowed to fill by gravity without additional pressure applied to the top of the tray.

After the trays are filled a small indentation or "dibble" should be made in the surface of the media. Research has shown that seed germination is much more consistent in dibbled trays than in non-dibbled trays. The dibble board or rolling dibbler should be matched to the brand of tray such that the dibble mark is as close as possible to the center of each cell. The dibble should be ½–¾ inches deep, with relatively smooth sides to allow the seed to roll to the bottom of the dibble. Handle the trays with care after dibbling to avoid collapsing the dibble prior to seeding.

Like the dibbler, the seeder should be matched to the brand of tray that you have. There are slight differences in the dimensions of trays from different manufacturers. If the seeder is not matched to the tray, seeds may be placed near the edge of the cell where they are less likely to germinate. After seeding, examine the trays to ensure that there is only one seed in each cell. The seed should be near the center of the cell, and at the bottom of the dibble. Seeds that fall outside of the dibble or on the side of the dibble mark are more likely to experience problems with germination or spiral root.

If spiral roots are consistently a problem, a light covering of media over the seed may be considered. A light dusting is all that is needed; the tops of the seed should remain visible. Research by Danny Peek in Virginia has suggested that in many cases all that is needed is just a bump on the tray after seeding to settle the seed and gently collapse the dibble around the seed. Often growers who seed at one location and then move trays by wagon or truck to the greenhouse report fewer problems with spiral root, due most likely to the shaking of the tray while transporting.

Primed Seed

Seed priming is a process in which seeds are pre-germinated under controlled conditions before being dried back down and pelleted. The desired effect of using primed seed is to reduce time to germination and improve uniformity. Research has shown that primed seed germinate about 2 days earlier than unprimed seed sown at the same time. In the controlled environment of a greenhouse the final germination at 14 days is not usually different between primed and unprimed seed. In outside float beds primed seed may be advantageous because they tend to germinate more uniformly than unprimed seeds at cooler temperatures.

Fertilizer Selection and Use

Choose a fertilizer that is suitable for use in the float system. Many water soluble fertilizers sold at garden shops do not contain the proper balance of nutrients in the right form for tobacco transplants. Specifically, avoid fertilizers which have a high proportion of nitrogen in the form of urea. Look for a fertilizer with mostly nitrate nitrogen and little or no urea. In the float system urea is converted to nitrite which is toxic to plants. Information about the nitrogen source should be on the product label. If it is not there, don't buy that product for the float system.

Research has shown that tobacco transplants do not need a high level of phosphate. Some research even suggests that there is a better balance of top and root growth if phosphate levels are kept lower. Look for a fertilizer with low phosphate like 20-10-20, 15-5-15, 20-5-20, 16-4-16, etc.

Fertilizer can be added to float water just at seeding or within 7–10 days after seeding. The advantage of fertilizing at seeding is convenience in that the fertilizer can be dissolved in a bucket, poured in to the bed and mixed easily. The disadvantage is that salts can build up at the media surface during hot, sunny conditions. As built up water evaporates from the media surface the fertilizer salts can be wicked up and deposited where they may cause damage to the germinating seed.

Delaying the addition of fertilizer until a few days after seeding minimizes the risk of salts damage to young seedlings. Many producers have built simple distribution systems with PVC pipe or hoses to help mix fertilizers and chemicals throughout large float beds without having to remove trays. The distribution systems are typically connected to small submersible pumps that can be lowered into a bucket of dissolved fertilizer. The addition of fertilizer should not be delayed by more than 7–10 day after seeding, or a lag in plant growth may result.

Over-fertilization of float plants is a common mistake. The recommended level of fertilization is no more than 100 parts per million nitrogen. This is equivalent to 4.2 lb of 20-10-20 per 1000 gal of water. To determine the gallons of water in a float bed use the following formula:

  Number of trays the bed holds
x depth of water in inches
x 1.64
= gallons of water.

When transplants are not developing fast enough, some growers are tempted to add more fertilizer to push the plants along. At high rates of fertilizer, plant growth will be very lush, making the plants susceptible to bacterial soft rots, Pythium root rot, and collar rot. Under-fertilized plants grow more slowly and are more susceptible to such diseases as target spot.

The incidence of improper fertilization can be reduced by investing in a conductivity meter and monitoring the salt concentration on a regular basis. A conductivity meter measures how easy it is to pass a current through a solution. The higher the salt content of the solution the greater the current. Conductivity meters need to be calibrated periodically to insure proper operation. Check the instructions that came with the meter or visit your local County Extension Office for help calibrating. To use the meter, measure the reading of your water source prior to fertilization. Most water sources have a conductivity of between 0.1 and 0.5 µs/cm before fertilization. However, salt levels above 0.9 µs/cm may become too salty for optimum plant growth after fertilizing. Older meters may read in 100 µS/cm and therefore would read between 1.0 and 5.0 100 µS/cm. Meters that read in ppm dissolved solids are discouraged due to difficulty in determining the corresponding increase expected after fertilizing.

After testing the water, calculate the amount of fertilizer needed for the bed. Add the fertilizer to the bed and mix thoroughly before reading again. The reading should go up by 0.5 to 0.9 units, depending on the type of fertilizer used. For the most commonly used 20-10-20 formulations, the reading increases by 0.3 units for every 50 ppm N added. The reading obtained after fertilization should be the target level. If the reading falls below the target, add more fertilizer. If it is above the target add water to dilute the fertilizer and avoid problems with over-fertilization. Many water soluble fertilizers now have charts on the label to help you interpret conductivity readings.

Climate Control

Temperature Management

Pelleted seeds germinate best around 70–75°F. However, a fluctuation from cool night temperatures and warm daytime temperatures may be beneficial for optimum plant growth. While cooler temperatures tend to slow germination and growth, higher temperatures are risky. Temperatures that exceed 90°F may prevent germination and predispose plants to cold damage. Primed seed which tend to germinate quicker than regular pelleted seed may also tend to tolerate cooler temperatures better. A good rule of thumb is that if it's too hot to work in a greenhouse it's too hot for the plants. Temperature in excess of 100°F may be unavoidable on hot, sunny days, but every attempt should be made to manage the ventilation to reduce the length of time that plants are exposed to excessive heat. Plants exposed to excessive high temperatures may suffer more damage during cool nights or when exposed to outside air when greenhouses and float beds are ventilated during the day.

Cold damage can result when plants that have been exposed to high temperature are then exposed to cold air. Symptoms of cold damage are usually visible within two or three days and include an upward cupping of the leaf tips, constricted regions of the leaves, and a distinct yellowing of the bud. Once the bud has been damaged it no longer can suppress the development of suckers. While the bud usually recovers from this damage and re-establishes control over the suckers, the sucker buds have already been initiated. They may begin to grow again if the plant is subjected to further stress. That stress often occurs after transplanting when the sucker buds begin to develop into ground suckers. Maintaining an even temperature that doesn't fluctuate too drastically can help reduce ground sucker problems. In severe cases plants may produce ground suckers that are not suppressed and that grow into multiple stalks from a single plant. Such plants will be difficult to harvest and produce low yield and poor quality tobacco.

Accurate measurement is important for good control of temperature. Thermostats and thermometers exposed to direct sunlight will give false readings. Both devices should be shielded for accurate readings. Thermostats should not be located too close to doors and end walls or positioned too high above plant level. The most accurate results are obtained from shielded thermostats with forced air movement across the sensors.

Fans for ventilation are rated in CFM's or cubic feet per minute. Typically a greenhouse used for tobacco float plant production in Kentucky should have enough fan power to exchange ¾ –1 times the volume of air in a greenhouse per minute. Two fans allow for the fans to be staged so that the first comes on at a lower temperature than the second. Fans with more than one speed are more expensive, but allow the speed to increase as the air temperature inside the greenhouse increases.

Shutters are designed to complement fans and should be located at the opposite end of the greenhouse and should have an opening equal to or 1¼–1½ times the size of the fan. Motorized type shutters are best and should be on a thermostat set at a 2-3 degree cooler setting than the fans so that they open prior to the fans. Alternatively, fans may be set on an 8–10 sec delay which will accomplish the same thing. To reduce cold injury damage locate fans and shutters 3 feet above plant levels to minimize drafts and to improve mixing of cooler air with the warmer air inside the greenhouse. Baffles can be used inside to deflect cool, incoming air upward and away from the plants.

Side curtains are dependent on natural air movement for good ventilation. Although they are cheaper to install and operate than fans they do present some risk. A cool, rainy morning may rapidly change to a sunny day. If no one is available to make sure curtains are lowered plant damage can occur within minutes after the sun comes out. It is important to have someone at or near the greenhouse to lower curtains when needed. Automated curtains are an option, but may offer less precise operation than fans. Many greenhouses in Kentucky have both fans and curtains which offer the most control of the growing environment. A side curtain should, at its maximum, provide one foot of vertical opening per 10 ft of greenhouse width. A typical 36 ft wide greenhouse may have only a 3 foot side curtain that will drop 2 feet, but may have 1 foot of plastic hanging down over the side providing only 1 foot of effective ventilation. A best system would have a 5 foot side wall that could be open to 3½–4 feet to meet the required guideline for ventilation.

For more information please see ID-131, *Basics for Heating and Cooling Greenhouses for Tobacco Transplant Production.*

Humidity Management

Humidity can cause numerous problems inside a greenhouse or float system. As the warm moist air comes in contact with cool surfaces such as greenhouse plastic, support pipes and float bed covers, it condenses as droplets that can dislodge and fall to the trays disturbing seeds and seedlings, and can knock soil out of cells resulting in stand loss. Some foliar diseases may be favored by high humidity. High humidity can also reduce the longevity of some metal components such as heaters and supports by promoting the development of rust. In greenhouses, the best control of condensation and moisture is through the proper control of ventilation and heating.

Excessive humidity is more common in greenhouses than in outdoor float beds due to more ventilation in outdoor beds. Sources of humidity include evaporation from the float beds, transpiration as water moves through a plant's system and into the air, and the release of moisture during the combustion of natural or LP gas. Non-vented heaters will generate more humidity than vented heater because all of the heat, fumes and water vapor are released into the greenhouse. Ventilation is essential for greenhouses with non-vented heating systems, but is also a good idea for vented systems.

While ventilation seems counterproductive to keeping a greenhouse heated, ventilation replaces some of the warm moist air with cooler, less humid air. Warm air can hold a lot more moisture than cooler air, a concept that can aid in regulating humidity.

Regulation of humidity can begin as the sun goes down in the evening. Turning a fan on manually pushes warm humid air out replacing it with cooler less humid air. The exchange of air can reduce problems that tend to escalate during the cooler part of the day. This process will take only a few minutes of fan time to complete. However, producers are reluctant to use this method due to the cost of reheating the cooler air. The benefits can outweigh the cost during cooler weather periods by reducing the damage caused by condensation collecting and falling from the inner surface of the greenhouse onto trays.

An exchange of air at day break can be used in combination with the exchange at night. Ventilation at this time is almost essential. Fans are safer than side curtains due to possible cold injury from side curtains. Fans should be switched on manually for a few minutes. If only one of two fans is used for this procedure then more time may be needed. As cooler air enters the greenhouse and comes in contact with the warm moist air, fog may form, but should dissipate quickly. Once the humid air has been exchanged, the fans should be switched off and set to come on automatically when the air temperature reaches a set point. Later in the day when outside temperatures rise, side curtains, if available, can be lowered to improve ventilation.

Other methods may be used to protect plants from the damage caused by dripping, but they do little to control the cause of condensation, or reduce disease potential. Building the greenhouse or bed with a steeper pitch will reduce problems because the condensation that forms will have a greater tendency to roll off the sides rather than drip. Some growers use bed covers at the plant level to protect plant from dripping. With this method three common problems occur: (1) the plants get too hot, (2) they don't get enough light and have a tendency to elongate or stretch, and (3) plants may become attached to the cover and may be pulled from the trays as the covers are removed. The plant level covers should be removed as soon as the plants are big enough to protect the cell from damage (about dime size). There are also some commercial materials available that can be sprayed on interior surfaces of greenhouses reducing surface tension to help water roll off the sides rather than drip. Some growers with outside beds have taped vinyl corner molding to the undersides of their bows to help channel condensation away from the trays.

Circulation Fans

Circulation fans are primarily designed for one purpose, to circulate heat and air. This prevents the formation of hot and cold zones which could influence plant growth in those areas. Circulations fans should be located approximately 40-50 feet apart and one-fourth of the house width from each sidewall and halfway between plant level and the roof. A slight downward angle will improve air circulation near the plant. Fans pointed down too severely can increase evaporation on the tray surface and may potentially increase salt accumulation at the soil surface affecting germination and plant growth. An elliptical pattern across several trays and in front of a fan is generally an indication that a circulation fan is positioned at too steep of an angle.

Clipping

Proper clipping of float plants helps to toughen the plants, promotes uniformity, increases stem diameter, and aids in disease control. When done properly, clipping does not slow the growth of plants, nor does it contribute to early blooming or ground sucker formation.

The first clipping is usually the most beneficial and direct seeded float plants should be clipped the first time when the plant buds are approximately 1.5–2 inches above the tray surface. Plants will start to leave the tray growing away from the tray surface. The first clipping should remove approximately ½–1 inch of leaf material. The first clipping promotes uniformity, particularly in outside direct seeded beds where germination is often uneven. Smaller plants may not be clipped the first time, but will benefit from more sunlight and less competition from plants that were taller prior to clipping. After the first clipping, plants should be clipped every 5–7 days depending on growth rate. At each clipping, remove no more than ½–1 inch of leaf material. Three to five clippings may be necessary to achieve the best plant quality. Seldom are more than five clippings necessary. However, plants produced in trays with smaller cells (338) may require more clipping. Plants that need to be held for some length of time prior to transplanting can be clipped an additional time to help manage plant size and slow plant growth. Hard clipping (removing more than 1 inch of leaf material) should be avoided unless plant growth needs to be controlled. Plants should never be clipped so severely that buds are damaged. Transplants with buds removed may yield much less than non-injured plants.

Plugged plants should be clipped for the first time approximately 1–2 weeks after plugging (as soon as the roots have established). The same guidelines apply to clipping plugs as apply to direct seeded plants. Plugged plants should only require two or three clippings, unless setting is delayed.

When clipping plants, sanitation of the clipping equipment must be done to avoid spreading diseases. When done properly, clipping actually aids in disease control by opening up the plant canopy to allow for greater light penetration and improved air circulation around the plants. The mower and surrounding frame should be thoroughly cleaned after each use and sprayed with a disinfecting solution of 10% bleach or a commercial greenhouse disinfectant. If left on metal surfaces, bleach will promote rust, so rinse all surfaces after 10 minutes of contact time.

The key to effective clipping of float plants is to make a clean cut and remove the clipped material from the area. To accomplish this use a sharp blade and adjust the mowers speed so that the clipped material is lifted off the plants and deposited in the bagger. A high blade speed will result in the material being ground to a pulp and being deposited back on the trays, thereby increasing the likelihood for diseases. A dull blade may tear the leaf which may not promote proper healing. A relatively low blade speed with a sharp blade works best. Although some vacuum is necessary to push clipped leaves into a leaf catcher, a high vacuum may pull plants from the trays or suck the trays up into the blade. Dispose of clippings in an area well away from the greenhouse to prevent disease development that could spread to healthy plants in the float bed. Gasoline powered reel type mowers have been used successfully for clipping plants, since this type of mower tends to make a clean cut producing large pieces of intact leaf and deposits them in a catcher with little or no grinding. However, rotary mowers may be easier to adjust and maintain. An improperly maintained or adjusted mower may result in improper clipping that could injury plants, reduce vigor and promote disease development.

Pest Control in Tobacco Float Beds

EPA has ruled that outside float beds are considered as mini-greenhouses for the purposes of chemical pest control options. This means that only chemicals labeled for use on tobacco in greenhouses can be used on outside float beds. Chemicals that are labeled have specific instructions concerning the contamination of float water. This limits the chemical options available for controlling diseases and insects in these systems.

The first line of defense in controlling pests is exclusion of the pest. A good sanitation program will not eliminate pests from the system, but it will reduce their numbers and reduce the likelihood that they will cause economic loss. In addition to disinfection of trays, a good sanitation program includes removing weeds from around the bed area, and the cleaning of equipment used in and around the beds. Locate the float site away from tobacco fields, barns, and stripping rooms to reduce the chance of carrying disease over from one crop year to the next.

Management of Insect Pests

A variety of insects and other organisms that live naturally in water or moist organic matter can cause problems in the float system. Moist media, algae and organisms that can grow float water provide ideal conditions and food for fungus gnats and shore flies. Pillbugs, and even dung beetles, can burrow into media while slugs and cutworms feed on developing plants. While some are harmless, others eat or uproot seedlings and can destroy many plants before they are noticed.

Flies and Gnats

Fungus Gnats. Occasionally, fungus gnat larvae can be serious pests in greenhouses. The legless white larvae with distinct black heads are scavengers that live in and feed on decaying organic matter. Occasionally, they will feed on root hairs, enter the roots, or even attack the stem or crown of the plant. Infested plants generally lack vigor and may begin to wilt.

Fungus gnats are small (1/8 inch) black flies with long legs and antennae, tiny heads, and one pair of clear wings. Females lay tiny ribbons of tiny yellowish white eggs in the growing media that hatch in about 4 days. The larvae feed for about 14 days and then pupate in drier surface media. Adults live about a week. Under greenhouse conditions, they can complete a generation in 3–4 weeks.

Shore Flies. Shore flies also are small gnats but have short antennae, heavier, darker bodies and a pair of smoky wings with several distinct clear spots. They are good fliers and can be seen resting on most any surface. The life cycle is similar to that of the fungus gnat. The yellow to brown larvae are up to 1/4 inch long and have no apparent head. Both larvae and adults feed mostly on algae growing on media, or other surfaces. Sometimes they will bore directly into the bases of small plants. Plants damaged by them will break easily at the soil surface. The adults may spread soil pathogens inside the greenhouse.

Bloodworms. Bloodworms are the striking red worms that live free in float water with lots of algae growth; they do not live in the media. The red color comes from hemoglobin, the same oxygen-carrying material present in our blood. Hemoglobin allows this insect to develop in still, stagnant water. These gnat larvae have chewing mouthparts and generally feed on algae or other organic matter in the water. They may be found in plant roots that grow through the bottoms of float trays but do not feed on them.

These insects are close relatives of the mosquito but the adults (gnats) do not have sucking mouthparts and are not blood feeders.

Reducing Fly/Gnat Problems

Eliminate standing puddles around the area and provide good drainage around the greenhouse or float beds. Have a minimum amount of exposed water surface in the float bed, float empty trays to fill the bed so open water is not available. This is where mosquitoes and many gnats lay their eggs.

Regularly clip grass along bed margins so these areas can dry quickly.

Excessively wet potting mixtures in trays are attractive to egg laying fungus gnats. Algal growth on the surface will attract shore flies. Keep moisture content optimum for plant growth but not above that level.

Yellow sticky cards (available from greenhouse supply stores) can be tacked to pot stakes or suspended in the area to monitor for buildup of gnats. An early insecticide treatment will be more effective than one applied when fly numbers are very high.

Foliar sprays of acephate (Orthene, etc.) can be used to reduce numbers of adults to some extent but do not get to larvae in the media so new adults will continue to be produced.

Slugs

Slugs can cause serious damage to float plants. They are active very early in the spring and can chew up small plants as they just begin to grow. Slugs can enter from overgrown areas around the bed or may come from under plastic bed liners. Slugs feed at night or during overcast days and hide in cool, moist places during sunny days. They rasp leaves and tender stems, producing holes or scars on the leaf surface. They leave behind silvery slime trails as they move.

Reducing Slug Problems. Sanitation is very important for slug control. Keep the area around float beds free of plant debris (leaves, pulled weeds, etc.), old boards, bricks, or stones that provide cool moist hiding places for slugs. Frequent clipping of plants along the outside margin of the beds will let the area dry out so it is less attractive to slugs. Metaldehyde bait pellets can be distributed along these areas, too. It is best manage slugs before they get to the trays. Insecticides are not effective against slugs.

Cutworms

The variegated cutworm has caused serious problems in a low percentage of float systems most every year. The adult (a moth) flies in mid-March and lay clusters of about 60 eggs on the stems or leaves of low-growing plants. The smooth pale gray to light brown larvae have a row of pale spots down the center of their backs. They feed for about 3-1/2 weeks and are about 1.6 inches long when full grown. Since they occur in clusters, entire trays of plants can be chewed up in a short time. The cutworms hide during the day in tray media and feed at night. When monitoring for these insects look for cut plants or leaves with large sections removed.

Infestations often begin in trays along outer walls and spread in a circular pattern from there. Feeding by small cutworms appears as notches along leaf margins and is easy to overlook. Feeding rate increases dramatically as the larvae grow, so extensive damage can seem to appear overnight. In fact, the cutworms are there usually for about 2 weeks before they eat enough to be noticed.

Reducing Cutworm Problems. Keep outside bed margins trimmed so plant growth is not attractive to moths.

- Keep doors closed or screened at night when moths are flying.
- Check trays along bed margins regularly for feeding damage to leaves. This is a good way to detect problems early.
- Foliar sprays of acephate (Orthene, etc.) or sprays of Bt insecticides (Dipel, etc.) will kill cutworms.

Pillbugs

Pillbugs are scavengers that feed mainly on decaying organic matter. They occasionally feed lightly on young plants but the damage seldom is significant. They do churn up and burrow into plant media, uprooting and killing small seedlings. Once in trays, it is difficult to control them. Their armored body protects them from insecticide spray droplets.

Pillbugs can only survive in humid air so they hide under objects during the day. They are common under plastic, boards, stones, other items resting on damp ground. They will congregate in grassy or overgrown areas, too.

Clean-up and regular mowing along the outside of bed structures will remove hiding places and allow areas to dry. Old plastic liners provide cover for pillbugs and should be removed. Pillbugs will leave for better conditions.

Leave a few small pieces of plywood on the ground and check under them regularly for accumulations of pillbugs or slugs. If many are found, the area can be sprayed with an insecticide before they enter trays.

Tobacco Aphids/Green Peach Aphids

Tobacco aphids or green peach aphids can begin to build up when covers are removed or sides are opened to let plants begin to harden off before transplant. Infestations start as winged aphids settle on plants and begin to deposit small numbers of live young. The initial infestation consists of a few aphids on scattered plants but these insects are fast reproducers and numbers can increase rapidly.

Since aphids are sap feeders, there are no holes in the leaves or distinct symptoms to attract attention. Begin checking random trays for aphids about 7–10 days after plants are uncovered and continue to check a few trays each week until transplant time. Look in the undersides of leaves for colonies.

Acephate (Orthene, etc.) can be used for aphid control in greenhouses and outdoor float systems. Catch infestations before they become too large to control effectively and direct sprays to the undersides of the leaves.

Thrips

Thrips are slender, tiny (1/25") long light brown to black insects. They feed by rasping the plant leaf surface and sucking up the exuding sap. Heavily infested leaves have a speckled or silvery appearance. Thrips feeding can damage the growing point and cause stunted, unthrifty plants, but they also can carry tomato spotted wilt / impatiens necrotic spot virus.

Thrips infestations are rare in outdoor float systems but could be a significant problem in greenhouse systems where at least some plants are kept year-round. They can be carried into the greenhouse on contaminated plant material or fly in during the summer and continue to breed throughout the winter.

Blue sticky cards, available from greenhouse suppliers, can be used to monitor thrips and to assess control efforts. Control of established infestations is difficult and usually requires several insecticidal sprays at regular intervals.

Prevention of infestations through the use of screens on ventilators, inspection of new material entering the greenhouse, and weed control in the greenhouse will help to manage thrips.

Cultural Controls are Essential

Cultural controls are the primary defense against pest infestations. Good practices include:

- Keep doors, screens and ventilators in good repair.
- Use clean or sterile media.
- Clean soil from tools, flats and other equipment.
- Maintain a clean, closely mowed area around the greenhouse or float beds.
- Eliminate pools of standing water on floors. Algal and moss growth in these areas can be sources of fungus gnat and shore fly problems.
- Dispose of trash, boards and old plant debris in the area.
- Remove all plants and any plant debris, clean the greenhouse thoroughly after each production cycle.
- If possible, allow greenhouse to freeze in winter to eliminate tender insects like whiteflies.
- Avoid over watering and promote good ventilation to minimize wet areas conducive to fly breeding.

Management of Diseases

General Information

The introduction of the float system revolutionized the way we produce tobacco transplants in Kentucky and other tobacco-growing areas around the United States. The float system offers a number of advantages over the traditional plant bed but also creates ideal conditions for some important diseases of tobacco transplants. High moisture in this virtually hydroponic system favors infection of roots and leaves by a number of plant pathogens, as does the dense plant population.

Prevention is the most important part of disease management in tobacco float beds, or any other production system for that matter. We put more emphasis on prevention in the float system, though, because of the disease-conducive environment and the relative lack of fungicide tools that we can use to prevent disease or slow disease spread once it begins.

The major diseases encountered in production of transplants in the float system are Pythium root rot, target spot, Sclerotinia collar rot, blue mold and black leg. Less common are anthracnose, damping-off (Pythium and Rhizoctonia), Botrytis gray mold, angular leaf spot, and virus diseases (such as tobacco mosaic). As mentioned earlier, careful management of the environment and good sanitation are key considerations. The following is a summary of recommended practices for control of diseases commonly encountered in the float system. Tables of recommended fungicides (Table 5) and relative effectiveness of cultural chemical practices against common diseases (Table 6) have been included at the end of this section.

Exclude Pathogens from Transplant Facilities

Avoid the introduction of plant pathogens into the float system. Water from ponds or creeks can harbor fungi like Pythium or the black shank pathogen that can wreak havoc in the float system. Keep soil out of float bays—this can also cause pathogens such as Pythium to be introduced into the system. Keep trays out of contact with soil as well. Control weeds in and around the greenhouse or outdoor bed, since these can harbor a number of plant pathogens that can move, on the air or by insects, onto tobacco seedlings. If purchasing plugs (plug-and-transfer system), consider plants from a local or northern source. Southern-produced plugs are at risk for exposure to the blue mold pathogen in areas where they are grown, and have been linked to serious outbreaks of blue mold in previous seasons (2006, for example). These same considerations are valid if you are buying finished plants to set in the field. Do not grow transplants near vegetable fields, and do not grow ornamentals or vegetables in the same facilities where tobacco seedlings are being produced. Ornamentals and vegetables can harbor pathogens that can attack tobacco.

Make Sanitation a Routine Practice

Sanitize old trays as recommended, or use new trays. New trays will all but eliminate carrying diseases over between crops of transplants. New trays will not harbor plant pathogens, but re-used trays pose more of a risk and this risk increases as trays age. There is no guaranteed, foolproof way to sanitize used trays; however, we do have methods that will significantly reduce survival of plant pathogens on trays. Refer to the section on tray sanitation for more information. Dispose of unused or diseased plants promptly and properly. Bury or burn plants, or place them in cull piles located at least 100 yards from float beds or tobacco fields. This is especially important in the management of Sclerotinia collar rot. Remove clippings and debris to prevent buildup of material that can favor development of collar rot or black leg (bacterial soft rot). Don't mow plants if diseases such as black leg are active, as this will spread disease from infected to healthy seedlings. If blue mold is found in float beds, destroy all plants immediately, even if only a small number actually show symptoms of disease. Plants with no symptoms in float beds where sporulating plants are found are likely infected with the blue mold pathogen but have yet to develop symptoms. Given time, disease will develop on these plants as well. Sanitize equipment (mowers, for example), tools, and other items (shoes, hands) that will come into contact with plants or float water. Use a 10% bleach solution for equipment and shoes, and antimicrobial soap for hands to prevent the introduction of pathogens.

Create an Unfavorable Environment for Plant Pathogens

Maintain good air movement through the use of side vents and fans, and keep water levels high enough for float trays to clear the side boards of the bays, which allows for better movement of air (water level may be kept low initially when plants are small to prevent cold injury and raised as plants grow). Long periods of leaf wetness favor most diseases encountered in the float system. Good airflow promotes rapid drying of foliage, creating less favorable conditions for diseases such as target spot, collar rot, blue mold, and black leg. Minimize the potential for water to splash between trays. Avoid overhead irrigation, fix leaks in roofs, and apply fungicides early in the day so that foliage dries quickly. Temperature control is critical as well—excess heat can lead to problems with target spot and black leg, while cooler temperatures favor collar rot and blue mold. Don't over-pack media into cells when seeding, as this leads to excessively wet conditions in the tray, favoring the development of disease. Older trays tend to water-log easily, causing media to become saturated. Trays with high cell counts (338) not only require more management, but the dense foliage may favor disease development.

Minimize Plant Stress

Keep your transplants as stress-free as possible. Avoid temperature extremes and keep fertilizer levels within recommended ranges. Plants that are under- or over-fertilized are more susceptible to diseases in general. For example, target spot is much more likely to develop if nitrogen levels are below 50 ppm for extended periods of time, while black leg is generally seen when nitrogen is consistently above 150 ppm. Excess nitrogen also leads to rapid, rank growth of transplants. New, succulent growth is more disease-prone, and also takes longer to dry out. When clipping plants, avoid the buildup of leaf matter on float trays. Some pathogens, particularly Sclerotinia and bacteria that cause soft rots and black leg, can use leaf debris as a food base to become established and then spread in the float system. Clip properly (see section on clipping) to minimize stress and also the volume of clippings, and use a well-sharpened blade to promote rapid healing of wounds. Make sure that plants dry quickly after mowing.

Table 5. Guide to chemicals available for control of tobacco diseases 2008—transplant production.

Product(s)	Product Rate Per Application[a]	Product Rate Per Season	Target Diseases	Label Notes
Agricultural Streptomycin	100-200 ppm	no limit	wildfire	Apply in 3-5 gal/1000 sq. ft.
Agri-Mycin 17	1-2 tsp/gal H_2O		blue mold	
Aliette WDG	0.5 lb/50 gal H_2O	1.2 lb per 1000 sq. ft.	blue mold	Apply 3 gal of solution per 1000 sq. ft. on small plants; increase to a maximum of 12 gal as plants grow.
Dithane DF	0.5 lb/100 gal H_2O	no limit	blue mold anthracnose damping-off	Apply 3-12 gal/1000 sq. ft. as a fine spray. Begin when plants are dime-sized or larger.
Milk: Whole/Skim	5 gal/100 gal H_2O	no limit	tobacco mosaic virus (plant-to-plant spread)	Apply to plants at least 24 h prior to handling. Mix will treat 100 sq. yd.
Milk: Dry	5 lb/100 gal H_2O			
Terramaster 4 EC	1.0-1.4 fl oz/100 gal H_2O	2.8 fl oz	damping-off (Pythium spp.) root rot (Pythium spp.)	Apply to float-bed water no earlier than 2 weeks after seeding. Additional applications can be made at 3-week intervals. Use high rate for curative treatments; begin no sooner than 3 weeks after seeding. Do not apply later than 8 weeks after seeding.

[a] *Rate range of product. In general, use higher rates when disease pressure is high. Refer to product label for application information, restrictions, and warnings.*

Table 6. Relative effectiveness of recommended practices for management of diseases of tobacco transplants.

Recommended Practice	Pythium Root Rot	Pythium Damping-off	Target Spot (Rhizoctonia)	Rhizoctonia Damping-off/Soreshin	Collar Rot (Sclerotinia)	Blue Mold	Black Leg/ Bacterial Soft Rot	Anthracnose	Botrytis Gray Mold	Angular Leaf Spot	Virus Diseases	Algae
Use new/sterilized trays	+++[a]	+++	+++	+++	+	-	-	+	-	-	-	+++
Use municipal water to fill bays	++	++	+	+	-	-	+	-	-	-	-	++
Sanitize equipment, shoes, hands, etc.	++	++	+	+	-	-	++	+	+	-	+++	-
Avoid contact of trays with soil	+++	+++	++	++	-	-	+	+	+	-	-	+
Maintain air movement	-	+	+++	+	+++	+++	+++	+++	+++	+++	-	-
Fungicides[b]	+++	+++	++	++	-	++	+	++	+	+	-	+
Maintain proper fertility[c]	+	++	+++	+	++	+	+++	+	+	+	-	+++
Temperature control	+	+	++	+	+	+	++	++	+	+	-	+
Minimize splashing	-	+	++	+	-	-	++	+++	+	++	-	-
Proper clipping[d]	-	-	++	+	++	+	++	++	+	+	-	-
Avoid buildup of leaf clippings in trays	-	+	+	++	++	-	++	+	++	-	-	-
Dispose of diseased plants properly	-	-	+	+	++	++	++	+	+	+	-	-
Weed control in/around float system	-	-	+	+	+	-	++	++	+	++	++	-
Insect control	-	-	-	-	-	-	+	+	+	-	++	+
Avoid out-of-state transplants	-	-	-	-	-	+++	-	-	-	-	+	-
Avoid tobacco use when handling plants	-	-	-	-	-	-	-	-	-	-	++	-

[a] *- = no effect on disease management, + = minimally effective, ++ = moderately effective, +++ = highly effective.*
[b] *Preventive applications only (made before symptoms appear).*
[c] *Based upon a recommended range of 75-100 ppm of nitrogen.*
[d] *Clip using a well-sharpened blade under conditions that promote rapid drying of foliage.*

Apply Fungicides Wisely

Relatively few fungicide products are labeled for use on tobacco in the float system, and only Pythium root, blue mold, and target spot/damping-off are targeted by these products. The remaining diseases can be managed only by cultural practices.

Fungicides can be effective in a disease management program, but applications must be made in a timely way for best results. For example, it is possible to get good-to-excellent control of Pythium root rot (PRR) with Terramaster 4EC, but only if the material is applied preventively. Make the first application 2-3 weeks after seeding, or when roots first enter the water. A second treatment can be made 3 weeks after the first, and a final application (if needed) can be made two weeks after the second treatment. Do not apply Terramaster later than 8 weeks after seeding; make sure that the product is mixed thoroughly in float bays to minimize the risk of phytotoxicity. "Rescue" applications of Terramaster (see Table 5 for rates) in systems with active PRR will halt further development of disease and symptomatic seedlings will likely recover. However, the higher rates of Terramaster used in rescue treatments increase the risk of phytotoxicity AND recuperating plants may still harbor Pythium that can weaken them and neighboring plants later in the season (and increase their susceptibility to black shank and Fusarium wilt). Terramaster will burn the roots of tobacco seedlings, but plants quickly recover. Stress from root burn is minimized if Terramaster is applied when roots first enter the float water, and is greatest if the fungicide is applied to seedlings with extensive root systems. Severe root burn can lead to stunting and delayed development of seedlings—reason enough to begin applications of Terramaster early.

Dithane DF is a widely used fungicide that is labeled for target spot, damping-off (Rhizoctonia), and blue mold. Dithane DF provides reasonable control of target spot and because it is a protectant-type fungicide (not systemic, and has no curative activity), it should be applied at the first signs of disease at the latest (see Table 5 for rates). Use 3 gal of spray material per 1000 sq. ft., applied as a fine spray to improve coverage, while plants are small, and increase gradually to 6 to 12 gal as plants grow to transplantable size. Be sure sufficient water is used to wet the base of the stems with runoff to increase the control potential of damping off. Avoid contamination of the floatwater during treatment. Do not apply this fungicide to plants smaller than dime-size to avoid damage. Producers with a history of problems with target spot should consider routine application of Dithane DF, beginning when plants are dime-sized and continuing on a 5-10 day schedule, depending upon age of transplants and weather conditions. For control of blue mold, Dithane DF must be in place before plants become infected. Because of the fast-moving, explosive nature of blue mold in the float system, applications made after the first signs of disease have little chance slowing the disease down to manageable levels. Refer to Cooperative Extension office, local press and radio, and UK extension specialists for guidance on when to treat for blue mold. You can also visit the Kentucky Tobacco Disease Information page (http://www.uky.edu/Ag/kpn/kyblue/kyblue.htm) for up-to-the minute reports on blue mold and other diseases. Apply Dithane DF more frequently to rapidly growing plants, if conditions are warm, humid and overcast, or if target spot is present.

Other products that can be used in the float system include Aliette WDG (blue mold), agricultural streptomycin (blue mold, angular leaf spot/wildfire), and milk (tobacco mosaic virus). Apply Aliette or streptomycin to plants dime-sized or larger in a manner similar to Dithane DF (see Table 5 for rates). Do not allow either Aliette or streptomycin to contaminate float water, as serious injury to plants can occur. Keep in mind, too, that products that specifically prohibit use in greenhouses cannot be applied to tobacco in the float system, since the EPA considers float beds to be mini-greenhouses. Only products labeled for tobacco can be used—do not apply products intended for greenhouse ornamentals or bedding plants to tobacco. Producers can use existing stocks of materials that are no longer labeled for tobacco (Ferbam Granuflo, Carbamate, Terramaster 35WP) so long as a copy of the original product label is possessed by the grower. Follow all label directions and take special care to protect workers from exposure to pesticides.

Develop an Integrated Plan to Manage Diseases

Disease-free transplants pay dividends down the road because they are more vigorous and less prone to attack by pathogens in the field. Use a management strategy that integrates management of the environment, sanitation, and fungicides to get the best possible control of diseases in the float system and produce the best transplants that you can. While it may not be possible to avoid diseases completely, integrated management practices will reduce the impact of diseases in the float system greatly.

Special Considerations for Outside Direct Seeded Float Beds

Production of tobacco transplants in outside direct seeded beds is inherently more risky than greenhouse production or plug and transfer. Though the cost of transplants is lower in direct seeded outside beds the chances of plant loss are greater. Although results are related to the uncertainty of the weather, the risk of plant loss can be reduced by good preparation and management.

Construction of an outside float bed doesn't have to be complicated. However, a few details can make construction easier. A level spot is essential because water will find the level. Having a deep end and a shallow end can result in fertilizers settling to the low end and, as water evaporates, trays may be stranded without water on the shallow end.

The float bed area must be free of debris that could potentially punch a hole in the plastic liner. Sand spread evenly within the bed area provides a good foundation.

Bed framing made from 2 x 6's or 2 X 8's is sufficient to construct a float bed. Most float trays are slightly smaller than 14" x 27". However, using these measurements to calculate the dimensions should provide the extra room need to assure a good fit, but to ensure that the fit is not too tight.

Six mil plastic is more forgiving and preferred over thinner plastic. The plastic should be draped over the framing and pushed into corners prior to filling with water. The addition of water to the bed will complete the forming of the plastic to the sides and only then should the plastic be tacked to the frames. Stapling through plastic strapping materials makes a more secure attachment of the plastic lining to the frames. The bed should be no wider than can be covered by a conventional cover stretched over bows. Bows should be 2–4 feet apart and can be constructed of metal or PVC pipe, but need to be strong enough to support the wet weight of the cover. Bows spaced wider apart will need to be stronger than those spaced closer together. Allowing some head space over the plant aids ventilation.

Covering materials are most commonly made from either spun-bonded polypropylene (Reemay covers) or spun-bonded Polyethylene (Continental covers). Both provide some protection from the cold and rain. However, temperatures can fall below the outside temperature inside the beds during the night. The most plausible explanation is that evaporative cooling inside the bed is responsible for the drop in temperature. Outside beds may not be suitable much earlier than the middle of April unless supplemental heat is used. Heat can be obtained from 150-watt light bulbs placed at each bow or every other bow depending on the degree of heat need anticipated. If any electrical appliances or equipment are used near the float bed, a ground fault interrupt (GFI) should be installed at the outlet or in line.

Plastic covers can help reduce rain damage to freshly seeded trays and trays where plants have not cover the cell. However, failure to remove the plastic when the sun comes out can damage seeds and kill plants very quickly. While a clear cover heats up inside quicker, a black plastic left on for an extended period of time during rainy weather can cause plants to stretch. Once plants stretch they will not recover.

Plugged plants and greenhouse grown plants are more susceptible to rapid changes in temperature and should have at least two days to acclimate in an outside bed prior to a cold snap. Newly plugged plants are also susceptible to wind damage which can desiccate plants. Normal plant bed covers are usually sufficient to protect plants. Once new roots become established (two days are usually sufficient), wind is less of a problem.

Field Selection, Tillage, and Fertilization

Bob Pearce and Greg Schwab

Field Site Selection

Ideally, sites for tobacco production should be chosen 2–3 years in advance of planting. This allows you to observe the site and take note of any problem areas such as poor drainage, low fertility, and specific types of weeds common in that field. Several factors need to be considered when selecting sites for tobacco including soil properties, rotational requirements, and proximity to curing facilities or irrigation.

The roots of a tobacco plant are very sensitive to the aeration conditions in the soil. In saturated soils tobacco roots begin to die within 6–8 hours with significant root loss occurring in as little as 12–24 hours. This is why tobacco plants "flop" after heavy rainfall events. Tobacco grows best in soils with good internal drainage that helps to keep excess water away from the roots. Of course tobacco also needs some water to grow and a soil with a good water holding capacity is an advantage during the short term dry spells that are common during summer in Kentucky. The best soils for tobacco production in Kentucky tend to be well structured silt loam or silty clay loam soils.

Tobacco can be produced successfully on heavier soils and somewhat poorly drained soils, but extra precautions are needed to avoid compaction. Such soils generally warm up and dry out much more slowly in the spring, so planting often must be delayed. Such soils should not be tilled when wet to avoid creating compaction and further reductions in drainage.

A good rotation scheme is a key element to maintaining the long term productivity of fields used for tobacco production. Continuous tillage and production of tobacco can result in losses of soil organic matter, weakened soil structure, and severe soil erosion, all leading to declining productivity over time. Rotation planning includes cover crops between tobacco crops, and other crops grown in place of tobacco in some years.

The benefits of using winter cover crops are well documented. Winter cover crops protect the soil from erosion losses, scavenge left over nutrients from the soil, and add organic matter to soil when they are plowed under or killed in the spring. Winter cereal grains such as wheat and rye are the most commonly used cover crops in tobacco production. These grains when planted in September or October make good growth by early winter to help reduce soil erosion, and grow very rapidly in spring as the weather warms. Winter grains should be plowed under or killed in early spring no later than when they are heading. Waiting too long can result in nutrients being tied up by the cover crop, significant reductions in soil moisture during dry springs, and in some cases organic matter toxicity to the tobacco crop. Organic matter toxicity can occur when a heavy cover crop is plowed under just before transplanting. The breakdown of the cover crops reduces oxygen in the root zone and may result in the production of organic compounds that are toxic to roots. Affected tobacco plants are yellowed and stunted, but usually recover in two to three weeks.

Winter legumes such as vetch or crimson clover may also be used as cover crops either alone or in combination with a winter cereal. They do not produce as much growth in the fall but have the potential to supply additional nitrogen. In practice the amount of nitrogen contributed by legume cover crops has been found to be relatively small due to the fact that they typically scavenge remaining N from the tobacco crop rather than fixing N from the atmosphere.

The benefits of crop rotation for reducing certain diseases is well known (see pest management section), however rotation also has significant agronomic benefits. The ideal rotation for tobacco in Kentucky would be one in which tobacco is grown on a specific site for no more than two years in a row, after which a sod or sod/legume crop is planted and maintained for at least four years before returning to tobacco production. The advantage of this rotation is that the sod crop helps to restore the organic matter and soil structure lost during tobacco production. Unfortunately, many tobacco growers do not have sufficient land resources to maintain a rotation of this length. Shorter rotations away from tobacco are very beneficial from a disease standpoint and at least slow the degradation of soil structure compared to continuous tobacco production. Some rotation even if it is short is better than no rotation.

Rotation to other row crops such as corn or soybean can also be beneficial to tobacco, but less so than a rotation which includes sod crops. In row crop rotations precautions should be observed to minimize the potential carry over of herbicides and to follow rotational guidelines on pesticide labels. A reduction in corn yields following tobacco has been reported by some growers.

The proximity of the site to curing facilities is an obvious, but often overlooked selection criterion. A large amount of time and money can be wasted transporting tobacco, and often crews, between the field and the curing barn. Consider placing new barns in an area that can be accessed from several tobacco production fields so that a good plan of rotation can be established.

Conventional Tillage

The typical tillage scenario for tobacco production usually involves moldboard plowing in late winter often followed by smoothing with a heavy drag and 2–4 diskings prior to transplanting. Some growers may use a power tiller in place of the disk to break-up clods and produce a smooth seed bed. Compared to most other crops currently grown in Kentucky, the level of tillage used for tobacco is intense. Tillage in tobacco production is useful to help with weed control, incorporate cover crops, reduce compaction, improve aeration, and incorporate fertilizers and chemicals. However, excessive tillage or tillage under the wrong conditions can create compaction and lead to soil loss due to erosion.

All soils consist of the solid particles that make up the soil and the gaps or spaces, called pores, between the solids. In an uncompacted soil the pores make up about 50% of the soil volume and are well distributed between small pores and large pores. Smaller pores are generally filled with water, while the large pores may fill with water during a rain event, but quickly drain and are usually filled with air. This balance of air and water is beneficial for root growth. When a soil becomes compacted there is a significant reduction in volume and a loss of pore space with the large size pores being lost more readily than the small pores. Compacted soils tend to waterlog more easily resulting in less favorable conditions for root growth and compaction also presents a physical barrier that limits root growth.

Tillage contributes to soil compaction in at least two ways. Tillage destroys soil organic matter and weakens soil structure making the soil less able to resist the physical forces of compaction. The more intense the tillage or the longer tillage has been practiced the weaker the soil will become. Tillage implements such as plows and disks exert tremendous pressures on the soil at points of contact. So even though tillage may seem to fluff up the soil at the surface, often compaction is taking place at the bottom of the tillage implement. Power tillers can exert tremendous pressure at the point where tines contact the soil resulting in compaction. The use of these implements to increase drying of wet soils for transplanting, compounds the problems and may lead to poor season long plant performance. Power tillers may do more damage to soil structure in one pass than several diskings. Tillage induced compaction generally occurs from 4 to 8 inches below the surface depending upon the tillage implement used. Silt loam soils are most susceptible to tillage induced compaction when tilled at soil moisture contents of about 14%.

Naturally occurring compacted zones are also found in some soils, more commonly in Western Kentucky. These compacted areas are typically found deeper than tillage compaction and may range in depth from 12–30 inches or more. The degree to which they adversely affect tobacco production depends upon the depth and severity of compaction.

The above ground signs of a soil compaction problem are difficult to recognize and are often mistaken for other problems. These signs can include stunted growth, multiple nutrient deficiencies, and reduced drought tolerance due to limited root growth. If soil compaction is suspected the best way to identify it is by digging up and examining roots. The root system of a normal tobacco plant should be roughly bowl shaped with a horizontal spread approximately 2–3 inches wider than the leaf spread. The presence of flat spots or areas with little or no roots suggests that compaction may be a problem.

Compaction in fields may also be characterized with the use of a soil probe or a device specifically designed to measure compaction called a penetrometer. The penetrometer is a pointed rod with a tee-handle attached and a gauge for reading the pressure required to push the rod into the soil. It is important to note the depth at which the compacted layer begins and the overall thickness of the compacted layer so that appropriate remediation procedures can be planned.

Table 1. Effect of in-row subsoiling on the yield of burley and dark tobacco.

Soil type	Compaction	Conventional	Subsoiled
Loring	Moderate	2626	3333
Vicksburg	Moderate	1924	2448
Grenada	Moderate	1473	1691
Loring	Severe	2463	3450
Grenada	Slight	2755	2799
Tilsit	Slight-Mod	2012	2158
Loring	Moderate	2365	2679
Avg.		2200 A	2605 B

Data from Lloyd Murdock and others, 1986.

The best management for dealing with tillage induced compaction is to avoid it. This means not working ground that is too wet and avoiding overworking. The potential for compaction can be lessened by practicing rotation which adds organic matter to the soil and strengthens soil structure. Using less intensive tillage implements like chisel plows and field cultivators can also help. Deep tillage to break-up compaction should only be used when the compacted layer has been confirmed and should only be used to the depth of that layer. Deeper tillage does little to improve growth and results in excessive fuel use.

Shallow in-row tillage has been shown to be an effective means of reducing the negative effects of compaction on tobacco in some Western Kentucky soils (Table 1). In these studies the compacted layer was measured using a penetrometer and the depth and thickness of the layer determined. The degree of compaction was characterized as slight, moderate or severe. In all cases where moderate or severe compaction existed there was a positive benefit from in-row "sub-soiling." Where compaction was only slight, no benefit from sub-soiling was observed. In-row sub-soiling is a relatively easy and inexpensive way to deal with shallow compaction in tobacco as long as the tillage is done when the soil is relatively dry. In-row sub-soiling under wet soil conditions can lead to the development of an air cavity under the roots of young transplants.

Most tobacco production in Kentucky is on fields with at least some slope, and much of it on slopes of 6% or more. When these fields are tilled they are extremely vulnerable to erosion losses for at least 2–3 months during the spring and early summer when strong storms with heavy rainfall are common. Gullies to the depth of plowing are a common site in tobacco fields (Figure 1). Losses can be minimized by waiting until just before transplanting to do secondary tillage operations and by planting rows of tobacco across the slope rather than up and down the slope. Leaving the tractor tracks in place until the first cultivation can increase surface roughness, thus lessening the velocity of water runoff water and soil erosion. Alternatively some growers may want to consider some form of conservation tillage.

Figure 1. Severe gully erosion in conventionally prepared tobacco field.

Conservation Tillage

Despite the fact Kentucky is known nationally as a leader in the development of conservation tillage for row crop production the adoption of such methods for tobacco has be relatively slow. Traditionally, tobacco growers have used intensive tillage to care for this high value crop and many still believe that tobacco must be cultivated for good growth. There are other reasons that tobacco growers have been slow to adopt conservation tillage including: 1) a lack of appropriate transplanters, 2) limited weed control options and 3) uncertainty over the future levels of tobacco production. Some of these issues have been partially addressed such that some growers now consider conservation tillage to be a feasible option for tobacco production.

The principal advantage of conservation tillage is a reduction in soil erosion losses, however there are other advantages for the grower as well. The mulch layer on the soil holds in moisture and may help reduce stress during periods of short term drought. Additionally, the mulch layer may help to keep the leaf cleaner by reducing mud splash on cut tobacco during late season rain storms. Fewer heavy tillage trips means less time and less fuel use than for conventional tobacco production. Conservation tillage includes: no-till in which the soil is not worked prior to transplanting, minimum-till in which the soil is worked in such a way to leave 30 to 50% of the residue on the surface, and strip-till where a 10–12 inch wide band is tilled before transplanting. Each system has its advantages and disadvantages which the tobacco grower must consider.

No-till tobacco is really a form of strip-tillage in which the tillage and transplanting functions both occur in one operation. Considerable modifications must be made to the transplanter for successful no-till planting. Figure 2 shows an example of the modifications required. At a minimum a no-till transplanter needs a wavy coulter in front to cut residue, a sub-surface tillage shank to till the root zone and pull the unit into the ground, and modified press wheels to close the planting trench. Some growers have added row cleaners to assist in moving residue away from the row allowing easier planting. Costs for modifying transplanters range from $300–$600 per row depending on how much fabrication the grower is able to do themselves.

No-till tobacco works best on medium textured soil (silt loam to sandy loams). Tobacco can be grown no-till in clay ground, but you must be patient and wait for the soil to dry sufficiently before transplanting. One of the persistent myths about no-till tobacco is that you can set it when you would not be able to get on conventional ground. In fact, experience has shown you may need to wait two or three days longer before

Figure 2. Modifications to a transplanter for no-till transplanting of tobacco.

setting no-till. Even though the ground may be firm enough to support equipment, the mulch layer slows the drying rate at the surface. Transplanting in ground that is too wet can lead to compaction of the trench sidewall which restricts root growth and may suppress growth and yield potential.

Minimum or strip-till may be better on heavy clay ground since some of the surface residue is incorporated allowing the soil to warm-up and dry out quicker. These methods require additional tillage passes leaving the soil more vulnerable to erosion than in no-till. Growers using strip tillage are able to transplant using their normal transplanter. However, they often have one or more modified tillage implements matched to the row spacing and number of rows of the transplanter to prepare the 10–12 inch wide planting band.

A good cover crop or previous crop residue is an essential part of successful conservation tillage tobacco production. The cover crop or residue helps to reduce soil erosion losses and conserve water in the soil much like mulch in the garden. Tobacco growers have been successful planting no-till tobacco in winter grain cover crops, sod, and row crop residues.

One of the keys to success when planting no-till tobacco into a small grain is timing the kill of the cover crop. The initial burn-down of winter small grains should be made when the cover is approximately 6 to 8 inches tall. This allows a sufficient buildup of residue while limiting the production of straw that complicates transplanting. Research has shown that tobacco transplants grew better and yielded more when the cover crop was killed at least 30 days prior to transplanting. The initial burn-down should be made with a product containing glyphosate, a follow-up treatment with a paraquat containing product may be made within a few days of transplanting when residual weed control products are applied.

Sod crops should also be burned down at least 4–6 weeks prior to transplanting. This allows sufficient time for the root mass to break down so that the soil will crumble and fill around the plant root ball. Some growers prefer to burn down a sod in the late fall and plant a cover crop to be burned down the following spring. Elimination of a sod that includes alfalfa can be particularly difficult due to the persistence of the alfalfa crowns. To eliminate alfalfa stands to prepare for no-till tobacco may require an application of burn down in the fall and a follow-up in the spring. Even then we have seen some volunteer alfalfa in no-tobacco fields.

What to Use for Burn-down?

Because no-till tobacco is a relatively small use crop, there are very few products labeled specifically for this use. However many glyphosate containing products have a statement on the label that allows the products to be used 30–35 days prior to planting of crops not specifically listed on the label. Be sure to check the label of the specific product that will be used. Some products containing paraquat (Gramoxone Inteon) have been labeled specifically for use on no-till tobacco. Growers must take care to obtain a copy of the supplemental label specifically for this use as it does not appear on the label normally included with the product.

There are labeled weed control products that work well for no-till tobacco, but "rescue" options are very limited so it is best to choose sites with as low a weed potential as possible. Winter pastures, feed lot areas, and areas with sparse cover often make poor sites for no-till tobacco due to large amounts of weed seed in the soil and/or established populations of perennial weeds. Perennial weeds and vines should be controlled during the rotation prior to growing no-till tobacco.

Spartan should be a part of any weed control program for conservation-till tobacco. Research has demonstrated that this product provides more consistent control in the absence of tillage than other herbicide options. Either Prowl or Command can be tank mixed with Spartan for improved control of certain weeds and grasses. However the most consistent control has been achieved by applying Spartan 7–10 days prior to transplanting then making an application of Command within 7 days after transplanting. The post-transplant application of Command helps to control weeds in the strips of soil disturbed by the transplanting operation. In all cases the highest labeled rate for the soil type is recommended when used in conservation tillage.

Poast can be used over tobacco for control of annual and perennial grasses including Johnsongrass. In cases where weed control has been poor due to environmental conditions some growers have used mechanical means such as lawn mowers and cultivators to control weeds in conservation-till tobacco.

Once the in the ground the crop can be treated just like conventional tobacco. Thus far there have been no additional problems with insect or disease pests when compared with conventional tobacco

Fertilization of Tobacco

Tobacco fields should be soil tested at least 6–12 months before planting to allow time for the application of lime and to plan for any nutrient deficiencies that may be identified. Limestone should be applied in the fall and thoroughly mixed with the soil one to two years ahead of the crop. If applied in the spring before transplanting, or if more than 4 T limestone/A are applied, plow one-half down and disc in the other half for soils with water pH below 6.0.

Nitrogen fertilization rates (see Table 2) depend primarily on the field cropping history and soil drainage class. Rotation to other crops is strongly recommended after two or more years of burley tobacco production in the same field. More frequent rotation may be necessary when growing dark tobacco or burley tobacco varieties with low levels of disease resistance.

All commonly available N sources can be used satisfactorily on tobacco, particularly on well-drained soils where a good liming program is followed and soil pH is maintained in the range of 6.0–6.6. If soil pH is moderately to strongly acid (pH 6.0 or less) and no lime is applied, using a nonacid-forming source of N (sodium nitrate, calcium nitrate, or sodium-potassium nitrate) will lower the risk of manganese toxicity. Use these sources (or ammonium nitrate or potassium nitrate) for sidedressing, because nitrate is more mobile in soil than ammonium nitrogen. If tobacco is grown on sandy soils or soils that tend to waterlog, using ammonium sources (urea, ammonium nitrate, ammoniated phosphates, ammonium sulfate, nitrogen solutions) will lower the risk of leaching and denitrification losses.

Table 2. Nitrogen recommendations for burley and dark tobacco.

	Well Drained Soil (lb N/A)	Moderately Well Drained Soil (lb N/A)
Low N levels: following tobacco or row crops	225-250	250-275
Medium N levels: first-year tobacco following a grass or grass-legume sod	200-225	225-250
High N levels: first-year tobacco following legume sod or legume cover crop	150-175	175-200

The entire nitrogen requirement can be applied pre-plant broadcast on well drained soils. However, Kentucky often has large rainfall amounts during April and May, so applying the broadcast nitrogen as near to transplanting as possible will significantly lessen the chances for losses of applied nitrogen. Apply the nitrogen after plowing and disc into the surface soil. Because losses of fertilizer nitrogen can occur on sandy soils or soils with poor drainage, it is helpful to split nitrogen applications on these soils, applying one-third of the nitrogen before transplanting and the remaining nitrogen two or three weeks after transplanting. The use of poorly drained or somewhat poorly drained soils for tobacco production is not recommended.

Further efficiencies in nitrogen use, decreased manganese toxicity, and increased early growth can be obtained by banding most of the nitrogen (sidedress) after transplanting. These bands should be applied 10–12 inches to the side of the row in either one or two bands and at depths of 4–5 inches. All the nitrogen should be banded at 0–10 days after transplanting or in two applications, two-thirds at 0–10 days and one-third at four or five weeks after transplanting. If one third or more of the total nitrogen is applied after transplanting the rate from Table 2 should be reduced by 15–25 lb N per acre.

Phosphorus (P) and potassium (K) fertilizer additions should be determined by soil testing. Based on soil test results, apply the recommended amounts indicated in Table 3. Recommendations in Table 3 apply only to soil test results obtained using the Melich 3 extraction procedure as used by the University of Kentucky Regulatory Services soil testing laboratory. If you have soil tests performed at another lab please refer to their charts and tables for appropriate recommendations. Results from soil tests run at the University of Kentucky show that approximately 70% of the tobacco fields in Kentucky test very high in P and need no additional P to grow a crop. Almost 30% of tobacco fields do not need additional K for the current crop year. Growers are encouraged to take full advantage of the soil nutrients to help reduce their fertilizer expense.

Spring applications of chloride-containing fertilizers such as muriate of potash at rates greater than 50 lb of chloride per acre lead to excessive levels of chloride in the cured burley tobacco leaf. High chloride levels lead to increased curing and storage problems, decreased combustibility of the leaf, and, ultimately, greatly reduced quality and usability of the cured leaf. Consequently, sulfate of potash should be the major potassium fertilizer used on tobacco fields after January 1.

Animal manures are also known to contain chloride in concentrations high enough to reduce the quality of cured tobacco. Chloride in excess of 1% in cured tobacco leaf is considered unacceptable by the tobacco industry. Cattle and swine manure applications should be limited to no more than 10 tons per acre. Poultry manures should not be applied in the year tobacco is grown. Fall applications of poultry littler should not exceed 4 tons per acre on ground where tobacco will be planted the following spring. Fall manure applications should be made only when a living cover crop will be present to take up and recycle some of the available N. Excessive rates of manure or manure used in conjunction with chloride-containing fertilizers may result in unacceptable chloride levels in the cured leaf.

Molybdenum (Mo) is recommended for use on burley tobacco either as a broadcast soil application or as a mixture in transplant setter water when the soil pH is below 6.6. Research and field trials have shown that setter water applications are equally as effective as broadcast applications for supplying molybdenum to the crop. Molybdenum can be purchased in dry solid form or as a liquid. Either source is satisfactory when molybdenum is needed.

For broadcast field applications, apply at the rate of 1 lb of sodium molybdate (6.4 oz of molybdenum) per acre. Dissolve this amount of dry sodium molybdate (or 2 gal of 2.5% Mo liquid product) in 20–40 gal of water and spray uniformly over each acre. Apply before transplanting and disc into the soil. Because sodium molybdate is compatible with many herbicides used on tobacco, it can be applied with herbicides normally applied as a spray in water. Combining the two chemicals can result in savings in application costs because only one trip over the field is necessary. It is recommended that not more than 2 lb of sodium molybdate (12.8 oz of molybdenum) per acre be used during a five-year period.

For transplant applications, use 0.25 to 0.50 lb sodium molybdate (1.6–3.2 oz of molybdenum) per acre. If dry sodium molybdate is used, divide the total recommended amount (0.25–0.50 lb/A) equally among the number of barrels of water used per acre. For example, if 2 barrels of water per acre are used, add one half of the total recommended amount to each barrel, and fill the barrel with water. Adding the dry material before filling the barrel will aid in dissolving and mixing. If a 2 .5% liquid source of molybdenum is used with 2 barrels of setter water per acre, add 1–2 qt of the liquid product per barrel before filling the barrel with water.

The need for iron, copper, and zinc in tobacco has not been shown for Kentucky soils. Improper rates could result in toxicity to the plant so they are not generally recommended on tobacco. Some isolated cases of suspected boron deficiency have been observed in recent years; however recommendations are being made on a case by case basis.

Table 3. Phosphate and potash recommendations (Lb/A), tobacco.

Burley and Dark		**Burley**		**Dark**	
Test Result: P	**P_2O_5 Needed**	**Test Result: K**	**K_2O Needed**	**Test Result: K**	**K_2O Needed**
Very high		*Very high*		*Very high*	
> 80	0	> 450	0	> 450	0
High		*High*		*High*	
73-80	30	424-450	30	398-450	30
71-72	40	417-423	40	383-397	40
68-70	50	409-416	50	368-382	50
66-67	60	402-408	60	353-367	60
64-65	70	394-401	70	338-352	70
62-63	80	387-393	80	323-337	80
58-61	90	379-386	90	308-322	90
		372-378	100	296-307	100
		364-371	110		
		357-363	120		
		349-356	130		
		342-348	140		
		334-341	150		
		327-333	160		
		319-326	170		
		312-318	180		
		304-311	190		
Medium		*Medium*		*Medium*	
54-57	100	296-303	200	286-295	110
50-53	110	286-295	210	276-285	120
46-49	120	276-285	220	266-275	130
41-45	130	266-275	230	256-265	140
37-40	140	256-265	240	246-255	150
33-36	150	246-255	250	236-245	160
29-32	160	236-245	260	226-235	170
		226-235	270	216-225	180
		216-225	280	206-215	190
		206-215	290		
Low		*Low*		*Low*	
25-28	170	195-205	300	195-205	200
22-24	180	184-194	310	184-194	210
18-21	190	173-183	320	173-183	220
14-17	200	162-172	330	162-172	230
11-13	210	151-161	340	151-161	240
7-10	220	140-150	350	140-150	250
		129-139	360	129-139	260
		118-128	370	118-128	270
		107-117	380	107-117	280
		96-106	390	96-106	290
Very Low		*Very Low*		*Very Low*	
< 7	230	< 96	400	< 96	300

Pest Management

Kenny Seebold, J.D. Green, and Lee Townsend

Tobacco diseases cause significant losses in yield and quality each year in Kentucky, resulting in lost revenue to growers. The extent of losses varies from year to year and farm to farm, depending upon the weather and diseases present. Tobacco is threatened by disease from seeding until harvest (and even during the curing process). The most common diseases encountered in field production of burley and dark tobacco are black shank, blue mold, target spot, frogeye, brown spot, soreshin, Fusarium wilt, black root rot, angular leaf spot (wildfire), virus diseases (virus complex, tobacco mosaic, alfalfa mosaic, ringspot, tomato spotted wilt), and bacterial stalk rot (hollow stalk). Diseases such as brown spot and black root rot are found infrequently in burley tobacco but are more common to dark tobacco, while blue mold appears more often on burley. Resistance to black root rot in many burley varieties has reduced the importance of this disease in recent years; however, dark varieties generally lack resistance to black root rot. As with transplant diseases, discussed earlier in this guide, the key to success in controlling diseases during field production is prevention. In almost every case, it is far easier to prevent disease than to stop it after an epidemic has gained momentum. And even if an outbreak of disease is brought under control through some type of rescue treatment (of which few are available for tobacco), yield losses can occur and quality of the crop can be affected. The latter is especially important for dark tobacco due to the low tolerance of manufacturers for leaf spots and other disease-related damage.

Implementing a preventive disease management program means that control measures have to be carried out or in place before disease appears, and this requires planning ahead. Field selection, picking varieties, and choice of fungicides that will be used are decisions that should be made well in advance of seeding transplants to ensure availability of land, seed, and chemicals. Choosing the practices to be implemented requires knowledge of field history (previous crops, prevalent diseases, field characteristics) and an awareness of the diseases that affect tobacco. The following are recommended practices and tips for managing tobacco diseases in the field.

General Considerations

Take full advantage of resources to monitor and manage disease. During the growing season, check crops regularly for signs and symptoms of diseases. Where preventive programs aren't in place, best control of diseases will be achieved if action is taken early in an outbreak. Consult your county Extension agent if you are unsure of what is affecting your crop. He or she can help get a correct diagnosis through the UK Plant Disease Diagnosis laboratories located in Lexington or Princeton. Tobacco-related publications from the UK Cooperative Extension service are available at your local county Extension office. You can access information online that can help with identification of disease problems. The Kentucky Tobacco Disease Information page (http://www.uky.edu/Ag/kpn/kyblue/kyblue.htm) features up-to-date information on tobacco diseases and recommended controls, as well as advisories on current disease problems (such as blue mold).

Avoid areas with histories of severe disease problems. One of the best ways to keep a particular disease from affecting a crop is to not plant tobacco in areas where problems have occurred in the past. This can be an effective way to manage black shank, Fusarium wilt, and black root rot. Locating fields away from areas with large, unmanaged populations of weeds can help minimize problems with a number of insect-transmitted plant viruses, such as alfalfa mosaic and tomato spotted wilt. In areas with a history of problems with aphid-transmitted viruses, planting tobacco early will ensure that the crop is older and less susceptible when aphid populations begin to grow. However, early plantings may suffer from black root rot. On the other hand, planting later to avoid early-season activity by thrips may reduce losses to tomato spotted wilt.

Exclude plant pathogens from the field. Keep plant pathogens out of "clean" fields by sanitizing equipment (especially if you share equipment or farm in several different areas) and shoes, and by limiting animals' access to fields. This can help reduce the introduction and spread of pathogens that cause black shank and Fusarium wilt. Don't discard stalks from fields with black shank and other diseases in clean fields or near sources of surface water (streams, ponds, etc.) to avoid introduction. Use locally-produced transplants or those grown north of Kentucky to avoid problems with blue mold. Plants produced in the Deep South may become exposed to blue mold at their source, and their importation into Kentucky could start an outbreak early in the season.

Go to the field with healthy transplants; don't set plants with severe Pythium root rot or other diseases. Diseased plants tend to take longer to establish and are more likely to be affected by black shank and soreshin. Do not set plants that have blue mold—destroy them immediately. Such plants will die, or if they survive they will not thrive and can serve as a source of spores for an outbreak in surrounding fields. Avoid tobacco use during setting to prevent the transmission of tobacco mosaic virus.

Rotate to non-related crops. Crop rotation is a highly effective tool for preventing and managing diseases, particularly those that are soilborne (including nematodes) or carry over in crop debris. Regular rotation away from tobacco and related crops deprives pathogens of their preferred source of food, which slows their buildup or causes their numbers to decline over time. Typically speaking, the effectiveness of rotation improves as the length of time away from tobacco is increased. Three to five years out of tobacco after a one- to two-year period in tobacco should provide good control of soilborne diseases for most growers. Do not follow tobacco with tobacco if black shank, black root rot, or Fusarium wilt are observed in a field.

Although less than ideal, even short rotational intervals are usually beneficial and certainly better than not rotating. Short rotations can be used to reduce disease pressure in fields after a serious disease outbreak, although longer intervals between susceptible crops, as discussed earlier, are recommended.

Table 1. Relative levels of resistance to disease in burley varieties.

Variety	Black Shank[a] Race 0	Black Shank[a] Race 1	Black Root Rot[b]	Virus Complex[c]	TMV	Fusarium Wilt
KY 14 × L8 LC	10	0	M	S	R	6
KY 907 LC	2	2	H	R	R	1
KT 200 LC[e(L)]	6	6	H	R	R	0
KT 204 LC	7	7	H	R	R	1
KT 206 LC[e(M)]	10	7	H	R	R	-
NC BH 129	1	1	H	S	R	1
NC 3[d]	2	2	H	R	R	1
NC 4	2	2	H	R	R	6
NC 5[d]	10	4	H	R	R	0
NC 6[d]	10	3	H	R	R	0
NC 7	10	3	H	R	R	5
NC 2000[e(H)]	0	0	L	S	R	1
NC 2002[e(H)]	0	0	L	S	R	0
TN 86 LC	4	4	H	R	S	0
TN 90 LC[e(L)]	4	4	H	R	R	0
TN 97 LC	4	4	H	R	R	0
Hybrid 403 LC	0	0	M	S	R	6
Hybrid 404 LC	0	0	H	S	R	-
Hybrid 501 LC	5	5	H	S	R	4
N-126	0	0	M	S	R	3
N-777 LC	2	2	M	S	S	0
N-7371 LC	3*	3*	-	-	-	-
NBH 98	2	2	M	S	R	3
HB 04P LC	0	0	H	S	R	0
HB 3307P LC	10	3	H	R	R	-
R 610 LC	4	4	M	S	-	3
R 630 LC	3	3	M	R	R	4
R7-11	0	0	M	S	R	6
R7-12 LC	0	0	H	S	R	4

[a] *Black shank and Fusarium wilt resistance scored on a 0-10 scale where 0=no resistance and 10=high resistance.*
[b] *L=low resistance, M=medium resistance, H=high resistance.*
[c] *S=susceptible to virus complex or TMV, R=high level of resistance.*
[d] *Variety with resistance to root-knot nematode.*
[e] *Variety with partial resistance to blue mold. L=low resistance, M=medium resistance, H=high resistance.*
* *Rating based upon a limited number of trials.*
\- *No data available.*

Unfortunately, rotation is not effective against all diseases. Diseases caused by pathogens that don't overwinter in soil or on plant debris, like blue mold, are not affected by crop rotation.

Plant disease-resistant varieties. Select varieties with resistance to the diseases that you anticipate to be a problem. Using resistant varieties is one of the least expensive management practices—the cost is built into the price of the seed. Burley varieties are available with good resistance to diseases such as black shank, blue mold, Fusarium wilt, virus complex, tobacco mosaic, and black root rot (Table 1). Look at the entire resistance "package" when choosing a variety, as levels of resistance to individual diseases can vary and may not be appropriate for some fields. For example, NC 2002 has good resistance to blue mold, but no resistance to black shank and would be a poor choice to plant in areas where black shank has been a problem. Varieties such as TN 86 and TN 90 have moderate resistance to black shank and none to Fusarium wilt.

Select and prepare sites properly. Do not set plants into saturated soils or in areas that tend to accumulate water. Choose a site that is well-drained to avoid soil saturation and problems with black shank. Install ditches or drain tiles if needed to promote good soil drainage. Select sites that are not excessively shaded and have good air movement to suppress diseases like target spot and blue mold. Do not plant tobacco adjacent to areas where vegetables are produced, as many vegetable crops (especially tomatoes and peppers) can harbor viruses that can be moved into tobacco by insect vectors. By the same token, don't plant tomatoes or peppers in tobacco fields.

Plow cover crops early. This practice will ensure that plant matter decomposes thoroughly before setting time. Soreshin and black root rot can be problems in fields with high levels of partially decomposed organic matter. Heavily manured fields may also have higher severity of black root rot. Turn tobacco roots and stubble under soon after harvest to promote decomposition and a more rapid decline of soilborne pathogens.

Manage soil fertility and pH. Keep pH within recommended ranges during the growing season. Allow pH to drop somewhat during rotational periods to promote rapid decline of *Phytophthora* (black shank) populations in soil. Do not overfertilize, as this favors development of blue mold and black root rot; however, low nitrogen levels can contribute to severe outbreaks of target spot., so be sure to recommended amounts of nitrogen fertilizers for optimal crop production.

Harvest in a timely manner and manage barns correctly. Overmature tobacco is more prone to leaf spotting diseases such as brown spot. Manage humidity levels in barns to avoid houseburn and barn rots.

Use fungicides correctly. Timely and accurate application of fungicides is essential for best performance. The following are some general guidelines for successful use of fungicides to manage diseases of tobacco.

- Do not use products that are not approved for tobacco. By the same token, don't use tobacco-approved products in ways that are not outlined in the products' labels. Pay attention to safety precautions and observe guidelines for resistance management.
- Apply fungicides preventively or at the latest when first symptoms of disease appear. Most products labeled for tobacco are protectants and must be in place before the arrival of the pathogen to suppress infection. Applications made after a disease has become established will take longer to bring the epidemic under control, or worse may not be successful at all. Maintain recommended application intervals while disease threatens or the weather favors disease. Applying fungicides with a specific mode of action, such as Quadris or Acrobat, when high levels of disease are present could lead to the development of resistance in certain plant pathogens. This is yet another reason to think preventively when using fungicides.
- Use an application volume that gives the best coverage of plants. For most fungicides, this amount will change as the crop grows. In general use 20 gallons per acre early (when plants are small) and increase to as much as 100 gallons per acre for applications made at topping or afterward. Spray pressure should be between 40 and 100 psi, and use hollow-cone nozzles for best effect. As the crop grows, configure your sprayer, if possible, with one nozzle centered over the row and multiple nozzles on drop extensions to allow for good coverage in the middle and lower canopy.
- Calibrate your sprayer for accurate delivery. This will ensure the crop receives neither too little fungicide (poor disease control) nor too much (extra cost and potential injury). Clean

nozzles regularly, and change them as they become worn. This is an extra expense that will pay for itself in the long run. When purchasing nozzles, consider ceramic or stainless-steel tips. These types of nozzles are more expensive than their brass counterparts but are more durable and less prone to wear.

Common Diseases and their Management

Angular leaf spot & wildfire. These bacterial diseases are occasionally important in Kentucky and do not cause significant losses in most years. Crop rotation and good sanitation practices can be useful in suppression of angular leaf spot and wildfire. The majority of burley varieties are resistant to wildfire, but not angular leaf spot; however, many dark varieties are very susceptible to this disease. Refer to Table 2 for a listing of dark tobacco varieties with good resistance to wildfire. Use of chemicals to manage these diseases is rarely necessary; however, agricultural streptomycin (Table 4) can be applied preventively at 100 ppm (8 oz/100 gal) or after symptoms first appear at 200 ppm (16 oz/100 gal). Continue applications while conditions favor disease (typically warm and wet weather).

Black shank. Black shank is by far the most important disease of burley and dark tobacco in Kentucky. Use good sanitary practices to prevent introduction and spread of the pathogen. Once introduced into a field, the black shank pathogen *(Phytophthora nicotianae)* can never be eradicated completely. Crop rotation is a key consideration in both prevention and management of black shank. Simply put, there's no better tool for managing black shank. The black shank pathogen survives and reproduces mainly on tobacco, so continuous planting of tobacco will lead to increased populations over time. Rotation slows the buildup of *P. nicotianae* and other pathogens in field by depriving them of their preferred host. Rotation away from tobacco for even a year will significantly reduce disease; however, rotations of 3-5 years have the greatest impact on black shank. A number of crops serve as good rotation partners with tobacco, although grass sods seem to reduce populations of *P. nicotianae* to a greater degree than other crops. Legumes and vegetables may promote the buildup of other soilborne pathogens responsible for diseases like sore shin, damping-off, and black root rot.

Table 2. Relative levels of resistance[a] to disease in dark tobacco varieties.

Variety	Black Shank Race 0	Black Shank Race 1	Black Root Rot	Wildfire	TMV	Fusarium Wilt
NL Madole	S	S	S	S	S	S
TR Madole	S	S	S	S	S	S
Little Crittenden	S	S	S	S	S	S
DF 911	S	S	H	H	H	S
KY 160	S	S	S	S	H	S
KY 171	S	S	H	S	H	M
DT 508	M	M	-	-	-	M
DT 518	M	M	M	-	-	-
DT 592	LM	LM	M	-	-	-
DT 538LC	M	M	-	-	-	-
VA 309	LM	LM	M	-	-	-
VA 359	L	L	-	-	-	-
TN D950	M	M	H	H	H	-
KT D4LC	M	M	S	S	S	-
KT D6LC	M	M	H	H	H	-
KT D8LC	M	M	S	S	S	-
PD 7312LC	S	S	H	-	H	M
PD 7302LC	H	S	H	-	H	-
PD 7309LC	H	S	S	-	S	-

[a] *S=completely susceptible, L=low resistance, M=medium resistance, H=high resistance- No data available.*

Field location is an important consideration—avoid planting in fields that are down-slope from areas that have had black shank in the past or those that could receive runoff from infested fields. Steps should be taken to minimize soil saturation, since these conditions favor infection by *P. nicotianae*. Eliminate areas in fields were water stands, or install tiles to improve drainage. Keep in mind that, if irrigating, water from ponds, rivers, or creeks could be contaminated with the black shank pathogen and using water from these sources could result in severe problems with black shank in the future.

Using a resistant variety is an excellent tool for managing black shank, particularly if other practices (good rotation, fungicides) are employed. In Kentucky, we deal primarily with two races of *P. nicotianae* on tobacco, race 0 and race 1. Historically, race 0 tended to be the predominant strain present in most fields of burley tobacco, but extensive use of certain varieties ('L8' hybrids) over time has led to many areas having a mixture of race 0 and race 1.

Burley varieties are available with varying degrees of resistance to both races of the black shank pathogen (Table 1). However, no variety is completely resistant to black shank. These varieties can be placed into three groups: completely susceptible, partially resistant to races 0 and 1, and those with "near-immunity" to race 0 (10 on the UK rating scale). No variety possesses "near-immunity" to race 1. Generally speaking, 'Hybrid 403,' 'HB04P,' 'NC 2002,' and 'R7-11' are examples of varieties with no resistance to black shank. Partial resistance ranges from low (1-3 on the rating scale) for varieties like 'NCBH 129' and 'NC 3' to moderate (4-6 on the rating scale) for 'TN 86,' 'TN 90,' or 'KT 200' or high (7 on the rating scale) for 'KT 204.' Varieties such as 'KY 14 × L8,' 'HB 3307P LC,' 'NC 5,' 'NC 6,' and 'NC 7' have near-immunity to race 0, owing to their genetic makeup, but low to no resistance to race 1. However, 'KT 206,' which will be available in 2008, has near-immunity to race 0 plus high resistance (7 on the rating scale) to race 1, and is partially resistant to blue mold. Growers of dark tobacco will find that resistance to black shank is limited in these varieties, although 'KT D4,' 'KT D6,' and 'KT D8' do have moderate levels of resistance to both races of *P. nicotianae* (Table 2).

So which variety should you pick? To answer this, one must consider rotational history of a field along with the presence or absence of black shank if tobacco was part of the rotation. Choose a variety with little or no resistance (0-3 on the rating scale) if planting into fields with no history of disease or where good rotation has been practiced. Varieties with "near-immunity" to race 0 of *P. nicotianae* are practical if populations of race 1 are not present. Without time-consuming tests, though, it is difficult to say which race of the black shank pathogen is present in a field. The safest bet is to assume that both races are present in fields known to be prone to black shank and use varieties with moderate-to-high levels of resistance to race 1 (4-8 on the rating scale) in conjunction with rotation and fungicides.

For suppression of black shank, use products containing mefenoxam (Ridomil Gold or Ultra Flourish) in conjunction with resistant varieties (4 or better on the rating scale) and crop rotation (Table 3). In most cases, mefenoxam will not provide acceptable control of black shank if applied to varieties with little or no resistance to black shank. Good soil moisture is needed for best performance of mefenoxam products against black shank because uptake by roots is required for best control of disease. Where black shank has been severe, consider making a pre-plant application at 1-2 pt/A of Ridomil Gold or 1-2 qt of Ultra Flourish per acre prior to transplanting. Use a volume of water or fertilizer sufficient for good soil coverage and incorporate into the top 2-4 inches of soil by disking or irrigation. Under light-to-moderate disease pressure, apply mefenoxam within 1-2 weeks of transplanting. For extended control of black shank, make a supplemental application (1 pt of Ridomil or 1 qt of Ultra Flourish) of mefenoxam at layby OR at 1st cultivation and again at layby. These applications should be directed toward the soil and incorporated immediately by cultivation. Avoid "over-the-top" applications of mefenoxam later in the season, since any chemical intercepted by tobacco leaves will not be taken up by the roots thereby reducing the effectiveness of the treatment. Do not make supplemental applications if more than 1 pt of Ridomil Gold was used at planting. Do not exceed the equivalent of 1.5 lb a.i./A of mefenoxam per season(3 pt of Ridomil Gold or 3 qt of Ultra Flourish).

Black root rot. Once one of the most destructive diseases of burley tobacco in Kentucky, black root is now only a sporadic problem. Resistance to black root rot in many burley varieties has reduced the importance of this disease in recent years; however, dark varieties generally lack resistance to black root rot. Despite the decreased importance of black root rot, *Thielaviopsis basicola* is present in soils in many parts of Kentucky and could pose problems to producers who do not rotate routinely or plant varieties with little or no resistance to this disease.

Use good sanitary practices to avoid introduction of *T. basicola*. Once introduced into a field, the black root rot pathogen can persist in soil for a number of years. This disease can be managed successfully through an integrated approach that includes crop rotation and resistant varieties (Tables 1 & 2). Do not follow leguminous crops (snap beans, soybeans, clover, alfalfa) with tobacco. By-products from decomposition of rye and barley residues are also believed to increase the susceptibility of tobacco to the black root rot fungus, making these crops a risky choice for cover crops in areas with a history of the disease. Avoid planting in cool soils and excessive use of lime (keep soil pH between 6.0 and 6.4 on burley). Black root rot can be aggravated by high amounts of undecomposed organic matter. Incorporate manure and cover crops early in the spring to permit as much decomposition as possible before transplanting. Soil fumigants are labeled for suppression of black root rot (Table 3), but their use may not be practical for many producers.

Blue mold. Blue mold has caused serious losses in Kentucky in certain years when cool and rainy conditions have prevailed, particularly early in the season. The blue mold pathogen, *Peronospora tabacina,* does not overwinter normally in Kentucky and requires a living host to survive. When tobacco is killed by frosts or freezes in late fall, surviving *P. tabacina* is eliminated as well. Epidemics of blue mold in Kentucky begin generally from introductions of *P. tabacina* from areas outside the state where *P. tabacina* is present year-round. In rare cases, the blue mold pathogen may overwinter in Kentucky on tobacco in protected environments (old float beds or greenhouses) – this is a key reason to ensure that unused tobacco is destroyed after transplanting in the spring. Management of blue mold should begin with the use of transplants that are free of the disease; avoid transplants produced out-of-state (particularly the Deep South). If planting into areas which are prone to blue mold, select a variety with partial resistance to blue mold (Table 1). Two varieties, 'NC 2000' and 'NC 2002' have moderate-to-high resistance to blue mold, while 'KT 206' and 'TN 90' have low-to-moderate resistance. Be mindful that some of these varieties may not be resistant to other diseases present in fields around Kentucky.

Chemicals registered for control of blue mold in Kentucky are listed in Table 4. Fungicides are good, but not perfect, tools

Table 3. Guide to chemicals available for control of tobacco diseases 2008—soil application (field).

	Product Rate Per			
Fumigants	**Application[a]**	**Season**	**Target Diseases**	**Label Notes**
Chloropicrin	60-100 lb/A (broadcast)	--	black root rot, black shank	Inject to 8-in. depth. Apply when soil temperatures are >55°F and moisture levels are adequate. Apply a minimum of 3 weeks before setting transplants.
	150-500 lb/A (broadcast)	--	sore shin, nematodes, Fusarium wilt, bacterial wilt	
Telone C-17	10.8-17.1 gal/A (broadcast)	--	bacterial wilt, black root rot	Inject to 8-in. depth. Apply when soil temperatures are >55°F and moisture levels are adequate. Apply a minimum of 3 weeks before setting transplants.
Telone C-35	13-20.5 gal/A (broadcast)	--	black shank, nematodes	

		Product Rate Per			
Non-fumigants		**Application[a]**	**Season**	**Target Diseases**	**Label Notes**
Ridomil Gold EC	preplant only	1-2 pt	3 pt	black shank	Incorporate into the top 2-4 in. of soil after application by disking or cultivation.
	preplant + layby	1 pt + 1 pt			
	preplant + 1st cultivation + layby	1 pt + 1 pt + 1 pt			
Ridomil Gold SL	preplant only	1-2 pt	3 pt	black shank	Incorporate into the top 2-4 in. of soil after application by disking or cultivation.
	preplant + layby	1 pt + 1 pt			
	preplant + 1st cultivation + layby	1 pt + 1 pt + 1 pt			
Ultra Flourish	preplant only	1-2 qt	3 qt	black shank	Incorporate into the top 2-4 in. of soil after application by disking or cultivation.
	preplant + layby	1 qt + 1 qt			
	preplant + 1st cultivation + layby	1 qt + 1 qt + 1 qt			

[a] *Rate range of product. In general, use the highest labeled rates when disease pressure is high. Refer to product label for application information, restrictions, and warnings.*

Table 4. Guide to chemicals available for control of tobacco diseases in the field, 2008—foliar applications.

Chemical	Product Rate Per Application[a]	Product Rate Per Season	PHI[b] (days)	Target Diseases	Label Notes
Agricultural streptomycin Agri-Mycin 17 Firewall	100-200 ppm (4-8 oz/50 gal H_2O)	no limit	0	wildfire, angular leaf spot, blue mold	
Acrobat 50WP	2-8 oz	32 oz	0	blue mold	Increase rate and application volume (20-100 gal/A) as crop size increases. According to the product label, Acrobat must be tank-mixed with a product registered for control of blue mold, such as Dithane DF, for resistance management. Neither mefenoxam (Ridomil Gold / Ultra Flourish) nor Actigard are permitted as tank-mix partners for Acrobat.
Actigard 50WG	0.5 oz	1.5 oz (3 apps.)	21	blue mold	Begin applications when plants are >18 inches[c] in height. Actigard must be applied 4-5 days prior to infection to allow for activation of plant defense compounds. Do not apply to plants that are stressed from drought or other environmental factors. Make up to 3 applications on a 10-day schedule. Apply in a minimum of 20 gal/A.
Dithane DF	1.5-2 lb	no limit	30	blue mold, anthracnose	Apply on weekly schedule; discontinue sprays when blue mold threat no longer exists. Note: some buyers have expressed concern over residues of Dithane on tobacco. Use this product only as needed.
Aliette WDG	2.5-4 lb	20 lb	3	blue mold	Make first application immediately after transplanting; continue on a 7-10 day schedule. Use a minimum spray volume of 20 gal/A; increase by 20 gal/A weekly to a maximum of 100 gal/A.
Forum	2-8 fl oz	30 fl oz	0	blue mold	See notes for Acrobat.
Quadris 2.08SC	6-12 fl oz	31.2 fl oz	0	target spot, frogeye, blue mold	Do not apply curatively (when disease is present). Begin applications before symptoms appear. Continue sprays on a 7-14 day schedule (use a shorter spray interval when conditions favor disease. If blue mold is present in the field, apply Acrobat or Forum, tank-mixed with Dithane, prior to using Quadris. Do not make back to back sprays. Alternate with different fungicide labeled for tobacco. Can be used up to the day of harvest; however, due to a lack of post-topping options for product rotation, make only one application after topping.

[a] Rate range of product PER ACRE. In general, use the highest labeled rates when disease pressure is high. Refer to product label for application information, restrictions, and warnings.[b] Pre-harvest interval[c] Actigard can be applied to dark tobacco varieties at the 12-inch stage.

for managing blue mold if used properly. Begin fungicide applications for blue mold control when the disease is forecasted to threaten your area or has been found nearby. Contact your county Extension agent for disease advisories, or visit the Kentucky Tobacco Disease Information page (http://www.uky.edu/Ag/kpn/kyblue/kyblue.htm). Once blue mold has been reported or threatens an area, fungicides should be applied at regular intervals as long as conditions favor development of blue mold to minimize losses.

Quadris received a full (Section 3) label in 2006 for control of blue mold, frogeye, and target spot. While not as effective against blue mold as Acrobat (or Forum) + Dithane, our results indicate that Quadris provides consistent and effective control of blue mold if applied regularly on a preventive basis. Keep in mind that Quadris is a protectant fungicide, and has limited systemic activity. Do not make curative applications of Quadris! Applications of this product should begin before symptoms are observed in the field when blue mold threatens. If blue mold is present in a field, apply Acrobat or Forum tank-mixed with Dithane and follow with Quadris 7-10 days later. Make sure to not make back-to-back applications of Quadris; rotate to another fungicide or program (Dithane or Acrobat/Forum + Dithane) after each application of Quadris. Good coverage is critical to getting good disease control with this product – the use of drop nozzles is recommended. Quadris can be applied up to the day of harvest, making this material a good option for post-topping control of other leaf spotting diseases. In certain cases, injury in the form of flecking has been associated with the use of Quadris on tobacco and has been severe; however, significant loss of yield or quality is extremely rare in Kentucky.

Other options for blue mold include Acrobat 50W or Forum, Dithane DF, Aliette WDG, and Actigard. Forum, introduced by BASF in 2006, is a liquid formulation of dimethomorph, the same active ingredient found in Acrobat 50WP. The liquid formulation should be easier to measure and mix than Acrobat 50WP, and will eventually be the only dimethomorph-based product on the market. According to the Acrobat and Forum labels, these products must be tank-mixed with another blue mold fungicide for management of resistance; Dithane DF works well in this role. As with Quadris, good coverage is very important to get best results with Acrobat or Forum, and the application volume and rate must be increased as the crop increases in size (Table 4).

Actigard remains one of our best options for blue mold control. This is a systemic product that functions by inducing plant defenses and is thus not a true fungicide. Coverage is not as critical with Actigard as with other fungicides, so this product may be applied with standard broadcast-type equipment and will still give good control of blue mold. Activation of host defenses takes several days for full protection, so Actigard should be applied 4-5 days before tobacco is exposed to the blue mold pathogen. If infection threatens before the 4-5 day activation period, Actigard can be tank-mixed with another fungicide to protect plants during this critical time. A second application made 10 days after the first has been shown to provide good protection against blue mold up to topping time. Do not apply Actigard to burley tobacco until plants are greater than 18 inches tall (12 inches for dark tobacco) to avoid serious injury. Use another fungicide if blue mold threatens tobacco less than the recommended height to protect until Actigard can be applied. Do not apply Actigard if plants are stressed from drought or other environmental factors, as severe injury could occur.

Bayer CropScience received a label in 2006 for Aliette WDG on tobacco for control of blue mold only. The first application of Aliette should be made immediately after transplanting and subsequent sprays can be made on a 7-to10-day schedule. Aliette should not be tank-mixed with copper compounds, surfactants or foliar fertilizers, and the pH of the spray solution should not be less than 6.0. Our experience with Aliette in Kentucky is limited at this time; however, results suggest that this product does not suppress blue mold as effectively as other labeled options.

Ridomil Gold is labeled for control of blue mold, but should not be relied upon to manage this disease. Resistance to mefenoxam (Ridomil Gold and Ultra Flourish) is widespread in populations of the blue mold pathogen, making Ridomil a risky choice.

Brown spot and ragged leaf spot. These diseases tend to be problematic on burley and dark tobacco later in the season, and rarely cause economic losses. Proper rotation, deep-turning of crop residues, wider plant spacings, and timely harvesting can help prevent problems with brown spot and ragged leaf spot. In burley, some varieties are reported to have partial resistance to brown spot ('KY 14×L8,' 'NC 7'). We have no fungicides for the moment to manage brown spot and ragged leaf spot. A fungicide program that contains Dithane DF and Quadris may provide some suppression of these diseases.

Frogeye and target spot. Frogeye, caused by *Cercospora nicotianae,* is a problem on maturing tobacco and causes few problems on burley unless infections take place immediately before cutting. In these cases, green spots can appear that will affect the quality (and lower the value) of the tobacco. Late-season infections on dark tobacco can cause economic losses due to decreased quality. Target spot, caused by *Thanatephorus cucumeris,* has become increasingly prevalent in Kentucky, and has caused yield reductions of 50% or more in some areas of the state. High humidity and moderate temperatures favor this disease, making target spot a serious problem in fields that are shaded or have poor air drainage. Target spot tends to worsen as the crop grows. When the row middles close, significant shading occurs in the lower canopy and humidity increases, favoring development of target spot.

Cultural practices recommended for management of brown spot will also help control target spot and frogeye. Additionally, do not under- nor over-fertilize tobacco. Low nitrogen fertility can predispose tobacco to infection by the target spot pathogen, as can the presence of lush growth brought on by excessive nitrogen.

Quadris is the only labeled option for management of frogeye and target spot (Table 4). Research over the past three years has shown that where target spot has been historically severe, 1-2 applications of Quadris made at 8-12 fl oz/A, beginning when plants are between 24-36 inches tall, will provide significant control of target spot. Early applications prevent buildup of the target spot pathogen, suppressing disease later in the season; however, a mid- to late-season application may be required to protect tobacco between topping and harvest. Where disease severity is low, a single application made early (before the canopy closes between rows) may be as effective against target spot as 2-3 applications made at 2-3 week intervals. Greater levels of disease will require at least two applications of Quadris to get good control of disease and improved yield. Growers with recurring losses to target spot should consider applying Quadris to their crops. Dithane is also suppressive to target spot, as is Actigard; however, these materials will not provide acceptable control of target spot if levels of disease are high. As mentioned previously (see section on blue mold), do not make back-to-back applications of Quadris – always rotate to different fungicide product after Quadris is applied. In the case of frogeye and target spot, the only effective choice will be Dithane DF.

Fusarium wilt. Caused by *Fusarium oxysporum* f.sp. *nicotianae,* this soilborne disease can cause significant losses, particularly in fields with a history of disease or poor rotations. Warm conditions favor development of Fusarium wilt, and severity of disease can be aggravated by drought. Many of the practices that are useful in combating black shank can be helpful in managing Fusarium wilt. Practice thorough sanitation to avoid introduction of the pathogen into "clean" fields. Crop rotation is equally important as a preventive measure. In fields that have experience severe outbreaks of the disease, long (5+ years) rotations may be needed to reduce damage to economically acceptable levels, due to the persistent nature of *F. oxysporum* in soil. For some, avoidance of fields with a history of severe Fusarium wilt may be the best plan if at all possible. Certain varieties of burley tobacco have moderate resistance to Fusarium wilt, including 'KY 14×L8' and 'NC 7.' Unfortunately, many of the varieties that are most effective against black shank ('TN 90,' 'KT 200,' 'KT 204,' and 'KT 206') are extremely susceptible to Fusarium wilt. When dealing with both black shank and Fusarium wilt in the same field, 'NC 7' appears to be the best choice at this time.

Hollow stalk. This disease is caused by the same bacterium, Erwinia carotovora subsp. carotovora, that causes black leg on transplants, and is typically found after topping. Warm and humid conditions favor development of hollow stalk. To reduce incidence of this disease, ensure that crops are not over-fertilized. Minimize mechanical and chemical wounding during topping and sucker control operations, and don't top during rainy or overcast conditions, or if plants are wet. Chemical control of hollow stalk is not possible.

Virus diseases. Diseases caused by viruses are common in Kentucky, and their severity depends upon the year and also the varieties being grown. Chemical control of virus diseases is not possible. Host resistance can be effective against many virus diseases of tobacco (see Tables 1 & 2). Control of insect vectors gives variable (and unpredictable) levels of control of aphid-transmitted viruses or TSWV (thrips). Weed control in and around fields can be helpful, as weeds serve as reservoirs of certain diseases; don't plant tobacco near vegetables for the same reason. Tobacco surrounded by, or planted adjacent to corn, soybeans, or other small grains will have less problems with aphid-transmitted diseases, as the insects "lose" the virus as they feed on these crops before moving onto tobacco.

Chemicals for Disease Control

Fumigants. Several fumigants are registered for use on tobacco for preplant suppression of soilborne pathogens and nematodes in Kentucky, but should be considered a measure of last resort. Nematodes have not been a serious problem in Kentucky, and the use of products such as Telone C-17 or C-35 is not warranted under most circumstances due to high material costs and expensive custom application. Chloropicrin used as a pre-plant soil treatment will reduce populations of *P. nicotianae, Rhizoctonia, Fusarium, Pythium,* and *Thielaviopsis,* giving fair control of disease. As with soil nematicides, chloropicrin is expensive and must be applied with specialized equipment and will not be an economically viable choice for most producers.

Tables 3 and 4 list labeled chemicals that are available to growers in Kentucky for use in the production of burley and dark tobacco in 2008. As always, read all product labels carefully and follow all directions provided by the manufacturers. Each product has specific use directions that should be followed to minimize the risk of damage to the crop and to maximize the effectiveness of the product. Information provided in the tables is meant to serve as a general set of guidelines to aid in product selection but is not intended to replace product labels.

Weed Control

Weeds can impact tobacco production by reducing yield and interfering with crop harvest. Many of the common weed problems in tobacco are summer annuals such as foxtails, pigweeds, lambsquarters, and annual morningglories. In addition, some perennials such as johnsongrass, honeyvine milkweed and yellow nutsedge can be particularly troublesome in some tobacco fields. In locations where troublesome weeds are difficult to control it may become necessary to choose an alternative field site to grow tobacco. Table 5 is a guide to the relative response of selected weeds to various herbicides available for use in tobacco.

Land preparation practices such as moldboard plowing and disking are beneficial for initial weed control by destroying early season weeds that have emerged before transplanting. Field cultivation and hand-hoeing are also traditional methods used for obtaining good weed control post-transplant. In more recent years effective herbicide control options have decreased the need for mechanical control method. A foliar burndown herbicide also allows production of tobacco by conservation tillage methods. Specific herbicide options that are currently recommended for use on tobacco fields are discussed in Table 6.

Table 5. Guide to the relative response of weeds to herbicides.[1]

	Crabgrass	Fall Panicum	Foxtails	Johnsongrass (seedling)	Johnsongrass (rhizome)	Shattercane (Wild Cane)	Yellow Nutsedge	Black Nightshade	Cocklebur	Galinsoga, Hairy	Jimsonweed	Lambsquarters	Morningglory	Pigweeds	Common Ragweed	Ragweed, Giant (Horseweed)	Smartweed	Velvetleaf
Command	**G**	**G**	**G**	F	P	F	P	P	F	F	F	**G**	P	P	**G**	F	F	**G**
Devrinol	**G**	**G**	**G**	F	P	P	P	P	N	F	N	F	N	F	F	N	P	P
Prowl	**G**	**G**	**G**	**G**	P	F	N	N	N	P	N	**G**	P	**G**	P	N	F	F
Spartan	F	F	F	P	P	P	**G**	**G**	F	F	**G**	**G**	**G**	**G**	P	P	**G**	F
Spartan + Command	**G**	**G**	**G**	F	P	F	**G**	**G**	F	**G**	**G**	**G**	**G**	**G**	**G**	F	**G**	**G**
Poast	**G**	**G**	**G**	**G**	F	**G**	N	N	N	N	N	N	N	N	N	N	N	N

G = Good F = Fair P = Poor N = None - No Data Available

[1] *This table should be used only as a guide for comparing the relative effectiveness of herbicides to a particular weed. Under extreme environmental conditions, the herbicide may perform better or worse than indicated in the table. If a grower is getting satisfactory results under his conditions, he should not necessarily change products as a result of the information in the table.*

Table 6. Herbicides recommended for use in tobacco fields.

Herbicide	Weeds Controlled	Remarks and Limitations
Before Transplanting—Burndown Herbicides for Use in Conservation Tillage		
Gramoxone Inteon 2S 2.4 to 3.75 pt/A (*paraquat* 0.6 to 0.94 lb ai/A) + Non-Ionic Surfactant 2 pt/100 gal or Crop Oil Concentrate 1 gal/100 gal	Annual grasses and broadleaf type weeds that have emerged or for burndown of cover crops. Apply when weeds and cover crop are actively growing and between 1" to 6" in height. Vegetation 6" or taller may not be effectively controlled.	*A copy of the supplemental label should be in the hands of the applicator at time of application.* Apply as a broadcast treatment during the early spring but prior to transplanting tobacco. Use the higher rate on dense populations and/or on larger or harder to control weeds. Weeds and grasses emerging after application will not be controlled. A maximum of 2 applications may be made. Gramoxone may be tank-mixed with other registered tobacco herbicides for improved burndown. Do not graze treated areas or feed treated cover crops to livestock.
Before Transplanting—Soil-applied Herbicides		
Devrinol 50DF 2 lb/A or **Devrinol 2EC** 2 qt/A (*napropamide* 1 lb ai/A)	Crabgrass, fall panicum, foxtails.	Apply before transplanting and incorporate immediately, preferably in same operation. Follow incorporation directions on label. To avoid injury to crops not specified on the label, do not plant rotational crops until 12 months after the last DEVRINOL application.
Prowl 3.3EC 3 to 3.6 pt/A (*pendimethalin* 1.25 to 1.5 lb ai/A) or **Prowl H_2O** 3 pt/A (*pendimethalin* 1.4 lb ai/A)	Crabgrass, fall panicum, foxtails, lambsquarters, pigweeds.	Apply to prepared soil surface up to 60 days prior to transplanting. Incorporate within 7 days after application within the top 1 to 2 inches of soil. Consult incorporation directions on label. Emerged weeds will not be controlled. Tobacco plants growing under stress conditions (cold/wet or hot/dry weather) may be injured where PROWL is used. Wheat or barley may be planted 120 days after application, unless small grains will be planted in a no-tillage system.
Command 3ME 2 to 2.67 pt/A (*clomazone* 0.75 to 1 lb ai/A)	Crabgrass, fall panicum, foxtails, jimsonweed, lambsquarters, common ragweed, velvetleaf.	Apply COMMAND 3ME as a soil-applied treatment prior to transplanting or over-the-top of tobacco plants immediately, or up to 7 days after transplanting, but prior to emergence of weeds. Off-site movement of spray drift or vapors of COMMAND can cause foliar whitening or yellowing of nearby sensitive plants. Consult label for spray drift precautions and required setbacks when applied near sensitive crops and other plants. Tobacco plants growing under stressed conditions (cold/wet weather) may show temporary symptoms of whitening or yellowing. COMMAND may be tank mixed with other herbicides registered for use in tobacco to broaden the weed control spectrum or with other tobacco pesticides. Cover crops may be planted anytime, but foliar whitening, yellowing, and/or stand reductions may occur in some areas. Do not graze or harvest for food or feed cover crops planted less than 9 months after treatment. When COMMAND 3ME is applied alone, rotational crops which may be planted include soybeans, peppers, or pumpkins anytime; field corn, popcorn, sorghum, cucurbits, or tomatoes (transplanted) after 9 months; sweet corn, cabbage, or wheat after 12 months; and barley, alfalfa, or forage grasses after 16 months following application. See label for rotation guidelines for other crops and when tank mixed with other herbicides.
Spartan 4F 8 to 12 fl.oz/A (*sulfentrazone* 0.25 to 0.375 lb ai/A)	Black nightshade, jimsonweed, lambsquarters, morningglories, pigweeds, smartweed, yellow nutsedge.	Use the higher rate of SPARTAN when weed pressure is heavy with morningglory or yellow nutsedge. Apply from 14 days before up to 12 hours prior to transplanting tobacco as a soil surface treatment or preplant incorporated (less than 2 inches deep). Perform all cultural practices for land preparation, fertilizer/fungicide incorporation, etc. prior to application of SPARTAN. If the soil must be worked after application, but prior to transplanting, do not disturb the soil to a depth greater than 2 inches. Temporary stunting or yellowing of tobacco and localized leaf burns may be observed under some conditions with this treatment. Unacceptable crop injury can occur if applied post-transplant. *Spartan may be impregnated on dry bulk fertilizers (consult label). Proper mixing and uniform spreading of the impregnated fertilizer mixture on the soil surface is required for good weed control and to avoid crop injury.* Rotational crops which may be planted include soybeans or sunflowers anytime; wheat, barley, or rye after 4 months; field corn after 10 months; alfalfa and oats after 12 months; and popcorn, sweet corn, and sorghum (for rates above 8 oz/A) after 18 months. See label for rotation guidelines with other crops.
After Transplanting—Postemergence Herbicides		
Poast 1.5E 1.5 pt/A (*sethoxydim* 0.28 lb ai/A) + Oil Concentrate 2 pt/A	Crabgrass, fall panicum, foxtails, johnsongrass, shattercane.	*A copy of the supplemental label should be in the hands of the applicator at time of application.* POAST herbicide provides selective postemergence control of annual and perennial grasses. Apply any time from transplanting up to 7 weeks after transplanting tobacco, but avoid applications within 42 days of harvest. For adequate control ensure good spray coverage using a spray volume from 5 to 20 GPA (gallons per acre). Do not cultivate within 5 days before of 7days after applying POAST. For rhizome johnsongrass more than one application may be needed. Make the first application of POAST (1.5 pt/A) when johnsongrass plants are 20 to 25 inches; followed by a second application of POAST (1 pt/A) when regrowth is 12 inches. A maximum of 4 pt/A of POAST can be applied per season to tobacco. As a spot treatment, prepare a 1% to 1.5% solution (1.3 oz/gal to 2 oz/gal) of POAST plus a 1% solution of Oil Concentrate (1.3 oz/A) and apply to the grass foliage on a spray-to-wet basis. Do not apply more than 4 pt/A per season to tobacco, including POAST applied to seedbeds.

Insect Control

A variety of insect pests can attack tobacco from transplant until harvest. Most reduce yield directly by feeding on plant leaves. However, sap-feeding by aphids causes more subtle injury by reducing plant vigor and growth. They also may introduce and spread plant viruses in the crop. Tobacco insect pests are potential pests at relatively predictable times during the growing season. Field checks and use of treatment guidelines allow early detection and assessment of problems so that sound pest management decisions can be made.

Pre-Transplant: Soil Applications

Pre-plant Insecticides	Rate/Acre	Labeled Pests
Capture LFR (17.15%) (bifenthrin)	3.4 to 6.8 fl oz	Cutworms, white grubs, wireworms
Di-Syston 15% G Di-Syston 8 E	13.5 to 26.7 lbs 4 pts	Aphids, flea beetles
Furadan 4F * (carbofuran)	1 gallon	Flea beetles
Lorsban 15%G (chlorpyrifos) Lorsban 4E	13.5 to 20 lbs 2 to 3 qts	Cutworms, wireworms
Mocap 10% G (ethoprop) or Mocap 15%G Mocap 6 EC	20 lbs 13 lbs See label 1-1/3 qts	Wireworms only for G Wireworms only for G From 2 weeks before transplant up to transplant
Di-Syston 15% G	27 lbs	Wireworms only

Broadcast and incorporate spray or granules according to label instructions immediately before transplant.

Transplant: Tray Drench Applications

Acephate 75 SP or **Orthene 75 SP** can be used at the rate of 1 lb per acre in the transplant water to provide 3 to 4 weeks of control of flea beetles, cutworms and thrips. **Orthene 97** is used at the rate of 3/4 lb per acre. Using more than the label rate may result in plant damage. Orthene 97 has a 2ee label for a transplant water tank mix with Admire. See the label for more information.

Admire Pro 4F, Belay, and **Platinum** are systemic insecticides that are labeled for application as a drench to float trays or flats prior to transplant. Most rates are expressed as fluid ounces per 1,000 plants. Agitate or mix the insecticide frequently to keep it from settling in the tank. The plants should be watered from above after application to wash the insecticide from the foliage into the potting soil-less media. Failure to wash the insecticide from the foliage may result in reduced control. Adverse growing conditions may cause a delay in the uptake of the product into the plants and delay control.

Tray Drench Applications

Insecticide	Rate	Comment
Admire 2F	1 fl oz/1,000 plants	Aphids, flea beetles
	1.4 to 2.8 fl oz/1,000 plants	Wireworms
Admire Pro 4F	0.5 fl oz/1,000 plants	Aphids, flea beetles
	0.6 to 1.2 fl oz/1,000 plants	Wireworms
Orthene 97	3/4 lb/A	Flea beetles, cutworms
Acephate 75 SP Orthene 75S	1 lb/A	
Belay 16 WSG	5 oz/A	Flea beetles
	10 oz/A	Aphids
Platinum 2 SC	0.8 to 1.3 fl oz/1,000 plants	Aphids, flea beetles
	1.3 fl oz/1,000 plants	Wireworms

Transplant: Water Applications

For application equipment which has minimal agitation, such as tobacco transplanters, give proper attention to mixing. Keep the water suspension agitated or mix regularly to avoid settling in the transplant tank. Adverse growing conditions may cause a delay in the uptake of Admire into the plants and a delay in control.

Premix **Orthene 97** in water to form a slurry before putting it into the transplant water tank. If premixing is not done, allow time for the product to dissolve. Use of more than the label rate may result in some plant damage. Orthene 97 has a 2ee label for a transplant water tank mix with Admire. See the label for more information.

Water Applications

Insecticide	Rate	Comment
Admire 2F	1.4 fl oz/1,000 plants	Aphids, flea beetles
	1.4 to 2.8 fl oz/1,000 plants	Wireworms
Admire Pro (42.8%)	0.6 fl oz/1,000 plants	Aphids, flea beetles
	0.8 to 1.2 fl oz/1,000 plants	Wireworms
Orthene 97	3/4 lb/A	Flea beetles, cutworms
Acephate 75 SP Orthene 75S	1 lb/A	
Belay 16 WSG	5 to 10 oz/A	Flea beetles
	10 oz/A	Aphids
Platinum 2 SC	0.8 to 1.3 fl oz/1,000 plants	Aphids, flea beetles
	1.3 fl oz/1,000 plants	Wireworms
Capture LFR	5.3 to 8.5 fl oz	Cutworms, wireworms

Foliar Treatments for Tobacco Fields

The numbers of tobacco pests or infested plants in a field determines whether a control measure is justified. The actual numbers can vary due to a variety of factors, such as weather, natural enemies, and transplant date. Early set fields are prone to attack by flea beetles and tobacco budworms, while late-set fields are at greater risk to tobacco aphids.

Careful field monitoring is necessary to determine whether or not an insecticide application will provide an economic return through yield or quality protection.

The treatment guidelines listed in Table 7 allow proper timing of insecticide applications. Weekly field scouting is necessary to collect the information needed to use them. Check at least 100 plants per field—10 groups of ten or 5 groups of 20 up to 5 acres. Add two locations for each additional 5 acres of field size. Pick your locations randomly. Examine the plants carefully for damage or live insects. Record your counts, calculate the average, and compare them to the table values. Keep these counts so that you can look for trends in insect numbers during the season.

Table 7. Insect management calendar—treatment guidelines for key tobacco insect pests.

Insect	Treatment Guidelines
1-4 weeks after transplant	
Cutworms	Five or more freshly cut plants per 100 plants checked.
Flea Beetles	Three or more beetles per plant on new transplants, 10 or more beetles on 2-4 week old plants, 60 or more beetles on plants more than four weeks old.
3-8 weeks after transplant	
Aphids	Colonies of 50 or more aphids on at least one upper leaf of 20% of the plants from three weeks after transplant until topping.
Budworms	Five or more budworms per 50 plants from three weeks after transplant until one week before topping.
3 weeks before, and through topping	
Hornworms	Five or more hornworms (1" or longer) per 50 plants from three weeks after transplant until harvest. Do not count hornworms with white cocoons on their backs.

Tobacco Aphids

Tobacco aphids may infest tobacco plant beds but populations are usually highest following the flight of winged aphids into fields in mid- to late June. Winged aphid adults descend into fields and to deposit live young on scattered plants across fields. Their offspring will mature in 7–10 days and begin to give birth to 60–70 live young. Aphid numbers increase gradually at first but by 6–8 weeks after transplant they are increasing rapidly; populations of aphids are usually highest in mid-to-late-June. Fields not receiving a preventive treatment at transplant should be checked weekly by examining the bud area of 10 consecutive plants in at least 5 locations for colonies (clusters) of aphids on the undersides of leaves, especially in shaded areas of the field. *An insecticide application is recommended if aphid colonies are found on 20% or more of the plants that are examined.* Thorough coverage with sprays directed to the underside of leaves at the top of the plant is essential to obtain satisfactory aphid control.

Budworms

Budworms feed in the buds of young tobacco plants causing rounded holes in developing leaves. Tobacco plants may be topped by these pests resulting in early sucker growth. Infestations tend to be greatest in the earliest-set fields in an area. Moths lay single eggs so infestations are scattered randomly over a field. Examine the bud area carefully for the black ground pepper-like droppings, small holes, or the caterpillars. Damage will increase as the caterpillars feed and grow. If the bud is destroyed, the plant will be forced to develop new terminal growth. Direct leaf damage and stunting can reduce yields significantly. Examine the buds for feeding damage and the small green to black worms. *Treat if there are 5 or more live budworms (less than 1-1/4 inches long) per 50 plants, and topping is at least one week away.* Do not count the plant as infested if you cannot find a budworm. *Bacillus thuringiensis* baits have given excellent control of this insect in flue-cured areas but there are no efficient ways to apply baits to large acreages. Bt sprays are most effective if applied when larvae are small and feeding actively. Use the highest labeled rates for heavy populations.

Hornworms

Hornworms eat large amounts of tobacco foliage. They first appear in June and are active throughout the remainder of the growing season. Weekly field checks will allow detection of infestations that would benefit from treatment. Examine the upper third of the plant for holes or hornworms hanging from the underside of leaves. Examine the entire plant for signs of damage and live worms. *Treat if there are 5 or more hornworms (1" or longer) per 50 plants, and topping is at least one week away.* Treatments applied before most worms exceed 1-1/2 inches in length will greatly reduce yield loss. Hornworms with white egg-like cocoons on their back are parasitized by a small wasp. These worms will not contribute to yield loss. By late August or early September as much as 90% of the hornworm population may be parasitized.

Check fields for hornworms about one week before harvest. Hornworms pose the greatest threat at the end of the growing season. They are voracious eaters and can continue to feed on harvested tobacco after it is taken to the curing structure. Apply a short residue insecticide if necessary to prevent taking significant numbers of this pest to the barn. There are no treatments to control hornworms effectively on housed tobacco.

Table 8. Tobacco aphid control.

Insecticides	Rate/A	Harvest Interval (Days)
Acephate 75 SP Orthene 75 SP	2/3 lb to 1 lb	3
Orthene 97	3/4 lb	
Actara 25% WDG	2 to 3 oz	14
Assail 30 G	1.5 to 4.0 oz	7
Assail 70 WP	0.6 to 1.7 oz	
Capture LFR	3.4 to 8.5 fl oz	Do not apply later than layby
Fulfill 50 WDG	2.75 oz	14
Endosulfan 3E	2/3 to 1-1/3 qt	5*
Lannate 90 SP[1]	½ lb	14
Provado 1.6 F	2 to 4 fl oz	14

** Application of products containing endosulfan within 28 days of harvest can lead to increased residue on the crop. Do not spray in the heat of the day. Contracts offered by certain buyers may prohibit the use of endosulfan; do not apply endosulfan if your contract expressly prohibits these products.*
[1] *Restricted use pesticide.*

Table 9. Budworm control.

Insecticides	Rate/A	Harvest Interval (Days)
Acephate 75 SPOrthene 75 SP	1 lb	3
Orthene 97	3/4 lb	
Agree WG (3.8% Bt aizawai)	1 to 2 lb	0
Biobit HP (6.4% Bt kurstaki)	½ to 1 lb	0
Biobit F (6.4% Bt kurstaki)	1 to 4 pt	
Capture LFR	3.4 to 8.5 fl oz	Do not apply later than layby
Denim 0.16 EC[1]	8 to 12 fl oz	14
Dipel 10 G	5 to 10 lb	0
Dipel DF	1/2 to 1 lb	0
Dipel ES	1 to 2 pt	
Endosulfan 3E	2/3 to 1-1/3 qt	5*
Lannate SP[1]	½ lb	14
Lepinox WDG	1 to 2 lb	0
Sevin 80S	1-1/4 lb	0
Tracer 4SC*	1.4 to 2.9 fl oz*	3
Warrior 1 CS[1]	1.9 to 3.8 fl oz	40
XenTari DF	½ to 2 lb	0

** Application of products containing endosulfan within 28 days of harvest can lead to increased residue on the crop. Do not spray in the heat of the day. Contracts offered by certain buyers may prohibit the use of endosulfan; do not apply endosulfan if your contract expressly prohibits these products.*
[1] *Restricted use pesticide.*

Table 10. Hornworm control.

Insecticides	Rate/A	Harvest Interval (Days)
Acephate 75 SP Orthene 75 SP	2/3 lb	3
Orthene 97	½ lb	
Agree WG (3.8% Bt aizawai)	1 to 2 lb	0
Biobit HP (6.4% (Bt kurstaki)	½ to 1 lb	0
Biobit F (6.4% (Bt kurstaki)	1 to 4 pt	
Capture LFR	3.4 to 8.5 fl oz	Do not apply later than layby
Denim 0.16 EC[1]	8 to 12 fl oz	14
Dipel 10 G	5 to 10 lb	0
Dipel DF	1/2 to 1 lb	0
Dipel ES	½ to 1 pt	
Endosulfan 3E	2/3 to 1-1/3 qt	5*
Javelin WG	1/8 to 1-1/4 lb	0
Lannate SP[1]	½ lb	14
Lepinox WDG	1 to 2 lb	0
Sevin 80S	1-1/4 lb	0
Tracer 4SC*	1.4 to 2.9 fl oz*	3
Warrior 1 CS[1]	1.9 to 3.8 fl oz	40
XenTari DF	½ to 2 lb	0

** Application of products containing endosulfan within 28 days of harvest can lead to increased residue on the crop. Do not spray in the heat of the day. Contracts offered by certain buyers may prohibit the use of endosulfan; do not apply endosulfan if your contract expressly prohibits these products.*
[1] *Restricted use pesticide.*

Flea Beetles

Tobacco flea beetles are present in every field each season. Damage tends to be most severe in fields that are set first, especially following a mild winter when beetle survival is greatest. Flea beetles move frequently, chewing small round holes (shot holes) in the leaves. Extensive damage can occur when beetles feed in the bud of the plant. This injury can add to transplant stress and slow plant establishment. Flea beetles can be controlled with systemic insecticides applied in the transplant water or by a foliar spray if a preventive treatment was not used. An average of 3 or more beetles per plant is enough to cause significant damage. *Treat if there are 3 or more beetles per plant during the first 2 weeks after transplant. Established plants rarely need protection from this insect.*

Occasional Pests

Some feeding by incidental pests, such as Japanese beetles and stink bugs, may be seen but usually are not severe enough to cause economic damage.

Cutworms may be present in tobacco fields because of early season weed growth. Often these insects are relatively large by the time tobacco is set in the field. Cutworms feed at the base of transplants and can cut them off at ground level. Moths are active in March and April, laying their eggs on low, spreading weeds. Damage potential is highest in late-set fields where there has been a flush of winter annual weeds. Cutworms will begin to feed on the weeds and switch to transplants when the weed growth is removed.

Soil insecticides used for cutworm or wireworm control should be applied at least one to two weeks before transplant and immediately disked into the top 2"–4" of soil. A soil insecticide should be used when going into established sod. Liquid formulations are more toxic to handlers than are granular formulations.

A foliar spray should be applied if 5 or more cut plants are found per 100 plants checked. Orthene 97 at 3/4 lb (Orthene 75S at 1 lb) or Warrior 1 CS (a restricted use pesticide) at 1.92–3.84 fl oz per acre can be used as a broadcast spray. Proxol 80S, applied in a 12" band over the row can be used as a rescue treatment. Rescue treatments are generally less effective when damage is confined to the underground portion of the plant.

Grasshoppers usually remain in hayfields and along waterways but under dry conditions they may move from these into tobacco. Treatment of field borders to prevent mass migration into the field should be considered. When selecting an insecticide for this use consider the possibility of residues and time from application to cutting or grazing of hay. *Treat when grasshoppers are active along field margins, or if 10 or more grasshoppers are found per 50 plants.*

Japanese beetles and green June beetles can be found on tobacco. Japanese beetles occasionally feed on the plants but green June beetles do not. The damage usually appears worse than it actually is. Sevin 80 S may be used for control at 1-1/4–2-1/2 lb/A if Japanese beetles are causing significant damage. Actara 25% WDG, Orthene 97 and Warrior 1 CS (a restricted use pesticide) are labeled for Japanese beetle control. Provado 1.6 F can be used at the rate of 4 fl oz per acre.

Stink bugs can feed on tobacco and cause the wilting or collapse of individual leaves which can become scalded. Generally the symptoms do not show until a day or two after feeding. The damage usually appears worse than it actually is. Acephate 75 SP, Orthene 75S and Orthene 97, several products containing endosulfan (Phaser and Thiodan) and Warrior 1 CS (a restricted use pesticide) are labeled for stink bug control. Treatment is not justified unless stink bugs are found in the field.

Table 11. Flea beetle control.

Insecticides	Rate/A Small Plants	Rate/A Large Plants	Harvest Interval (days)
Acephate 75 SP Orthene 75 SP	2/3 lb	1 lb	3
Orthene 97	½ lb	½ lb	
Actara 25% WDG	2 to 3 oz	2 to 3 oz	14
Capture LFR	3.4 to 8.5 fl oz	3.4 to 8.5 fl oz	Do not apply later than layby
Endosulfan 3E	2/3 qt	1-1/3 qt	5*
Lannate 90 SP[1]	½ lb	½ lb	14
Provado 1.6 F	4 fl oz	4 fl oz	14
Sevin 80S	1-1/4 lb	2-1/2 lb	0
Carbaryl 4L	1 qt	2 qt	
Warrior 1 CS[1]	1.92 to 3.84 fl oz	1.92 to 3.84 fl oz	40

** Application of products containing endosulfan within 28 days of harvest can lead to increased residue on the crop. Do not spray in the heat of the day. Contracts offered by certain buyers may prohibit the use of endosulfan; do not apply endosulfan if your contract expressly prohibits these products.*

[1] *Restricted use pesticide.*

Table 12. Grasshopper control.

Insecticides	Rate/A Small Plants	Rate/A Large Plants	Harvest Interval (days)
Acephate 75 SP Orthene 75 SP	1/3 lb	2/3 lb	3
Orthene 97	1/4 lb	½ lb	
Capture LFR	3.4 to 8.5 fl oz	3.4 to 8.5 fl oz	Do not apply later than layby
Endosulfan 3E	2/3 qt	1-1/3 qt	5*
Lannate 90 SP1	½ lb	½ lb	14
Warrior 1 CS1	1.92 to 3.84 fl oz	1.92 to 3.84 fl oz	40

** Application of products containing endosulfan within 28 days of harvest can lead to increased residue on the crop. Do not spray in the heat of the day. Contracts offered by certain buyers may prohibit the use of endosulfan; do not apply endosulfan if your contract expressly prohibits these products.*

[1] *Restricted use pesticide.*

Appendix 1: Information Summary Table for Tobacco Insecticides

This table is provided for a quick comparison of insecticides labeled on tobacco. Insecticides are listed alphabetically by pesticide common name (usually present in the active ingredients section of the product label). One or more brand names are included along with the Restricted Entry Interval (REI) and Mode of Action Group number.

Use pesticide products only in accordance with their labels and with the Worker Protection Standard. Do not enter or allow worker entry into treated areas during the restricted entry interval. Check the label for Personal Protective Equipment required for early entry to treated areas that is permitted under the Worker Protection Standard and involves contact with anything that has been treated, such as plants, soil, or water.

Mode of Action Group

A numerical classification system has been developed to make it easy to recognize the modes of action of insecticide products. Insecticides with the same mode of action belong to groups with unique numbers. Selection of a labeled product from a different number category (different mode of action) will help to slow down the development of resistance to either group. For example, alternate use of pyrethroid insecticides and pyrethrins sprays (Category 3) with labeled organophosphate insecticides (Category 1B). Always avoid tank mixing products with the same mode of action. These Mode of Action Group codes are on many pesticide labels and have been developed by the Insecticide Resistance Action Committee (IRAC).

Common Name	Brand Name	Restricted Entry Interval (hours)[1]	Mode of Action Group
Acephate	Acephate Bracket Orthene	24	1B
Acetamiprid	Assail 30 G Assail 70 WP	12	4A
Bt aizawai	Agree WG Xentari DF	4	11B1
Bt kurstaki	Dipel DF Javelin WG Lepinox WDG, etc.	4	11B2
Carbaryl	Sevin XLR Plus	12	1A
Carbofuran	Furadan 4F[4]	48[3]	1A
Chlorpyrifos	Lorsban 15 G Govern Nufos Warhawk Whirlwind Yuma	24[2]	1B
Clothianidin	Belay 16 WSG	12	4A
lambda-Cyhalothrin	Warrior[4] Silencer[4] Taiga[4]	24	3
Disulfoton	Di-Syston 15 G[4]	48[2]	1B
Emamectin benzoate	Denim EC[4]	48	6
Endosulfan	Endosulfan EC	24	2A
Ethoprop	Mocap 15G[4]	48[2]	1B
Imidacloprid	Admire 2F Admire Pro Alias Couraze Pasada 1.6F Provado 1.6F	12[2]	4A
Methomyl	Lannate[4]	48	1A
Pymetrozine	Fullfil	12	9B
Spinosad	Tracer	4	5
Thiamethoxam	Actara Platinum	12	4A

[1] *For use in storage bins no reentry is allowed. See label for details.*
[2] *If the product is soil-injected or soil incorporated, the Worker Protection Standard, under certain circumstances, allows workers to enter the treated area if there will be no contact with anything that has been treated.*
[3] *Exceptions apply for corn, sunflowers, and sorghum. See label for details.*
[4] *Restricted use pesticide.*

Appendix 2. WPS Checklist

Prepared by Lee Townsend, Extension Entomologist

This information was prepared to help farmers comply with WPS. It does not cover all details of the requirements. Sources and costs of signs and equipment are given as educational examples, only. Prices vary with source and quantities purchased. See the WPS section of the label for product-specific instructions.

Notification

Signs for Posting

All greenhouse applications require posting. Some labels require field posting. Posting must be done before application and remain until 30 days after REI expires. Signs must be visible from all entrances into treated areas.

- ☐ WPS Safety Poster
  Gempler P928 .... $ 3.85
- ☐ Nearest Medical Facility Sign (or make your own)
  Gempler X1584 .... $ 8.60
- ☐ Reusable Pesticide Application Poster (or make your own; see the example below)
  Gempler P942 .... $ 7.35
- ☐ Corrugated WPS Sign
  Gempler 2256........ $ 2.75

Oral Notification

- ☐ Inform workers of treated areas before application or before they begin work, tell them not to enter treated areas during the REI. Some pesticide labels require both oral warnings and posting of treated areas.

Labeling

- ☐ Pesticide handlers must understand all labeling information for the pesticides they are using and must have access to labeling.

Clean-up

Decontamination

- ☐ Decontamination facilities must be located within ¼ mile of workers/handlers. Maintained for 7 to 30 days after REI applies (see label).

Washing

- ☐ Workers must have access to water to wash hands, soap, single use towels. Washing facilities must not be located in the area being treated or under REI.
- ☐ Handlers must have access to water to wash entire body, soap, single use towels, clean towels. These supplies must also be provided where personal protective equipment is removed and in mix/load area. Supplies must be enclosed.

Personal Protective Equipment (PPE)

Employer must provide and maintain clean PPE required by label and pesticide-free area to store and put on and take off equipment. Dispose of heavily contaminated PPE as hazardous waste. Check the label for specific PPE needed for mixing, loading, and application.

- ☐ Chemical resistant gloves (15 mil unlined nitrile)
  Gempler 10212 (36 pair) $79.95
- ☐ Unhooded DuPont Tyvek Coverall
  Gempler TC .... $ 5.70 each
- ☐ Low-cost Anti-Fog Chemical Splash Goggles
  Gempler 10507 .... $ 3.95
- ☐ Moldex Pesticide Respirator
  Gempler G80002........ $ 25.20
  Replacement cartridges
  Gempler G8100PR .... $ 11.15/pair

Emergency Assistance

Act promptly if any worker/handler may be poisoned.

- ☐ Provide transportation to medical facility.
- ☐ Supply medical personnel with product name, EPA registration number, and active ingredient(s). Describe pesticide use and give details about exposure.

Training

Valid for 5 years if records or EPA card is available. Certified pesticide applicators do not need WPS training and can perform WPS training. Training aids are available from CES office.

- ☐ Workers need basic training before they begin and complete training within 5 days. A worker is anyone who does tasks such as harvesting, weeding, or watering.
- ☐ Handlers mix, load, transfer or apply pesticides. They also may do many other specific tasks, such as incorporating soil-applied pesticides, clean PPE and dispose of pesticide containers.
- ☐ WPS Training Receipt
  Gempler G95003 (worker)
  Gempler G95004 (handler) .... $ 7.85/50

Example pesticide application poster: *If you choose to make your own poster, be sure to include the following categories.*

Field Location and Description	Product Name and EPA Registration Number	Active Ingredient(s) in Product	Time and Date of Application	Restricted Entry Interval

Topping, Sucker Control, and Harvest Management for Burley and Dark Tobacco

Andy Bailey, Gary Palmer, and Bob Pearce

Introduction

The emergence of the flower bud in a tobacco crop signals the first stage in the maturity of the crop. Flower buds must be removed and subsequent suckers controlled to allow the crop to reach its full yield and quality potential at harvest. Timely topping and sucker control practices also allow more efficient harvest when the crop reaches full maturity.

Topping

Topping is the removal of the flower bud along with some of the uppermost leaves in order to stimulate growth and development of upper leaves. Plants left untopped or topped late will exert more energy into flower and seed production rather than leaf production and substantial yield losses can occur. Topping removes the dominant influence of the terminal bud over lateral buds or "suckers," stimulating vigorous sucker growth that must be controlled. Topping also stimulates root growth, which increases nicotine production in the roots and translocation to the leaves. Secondary plant products that accumulate in the leaves to improve quality and smoking characteristics also increase at topping. Topped tobacco is much less prone to being blown over since the plant is less top heavy and root growth is enhanced.

Early topping reduces the populations of insects such as aphids and budworms that are attracted to the terminal bud and flower. Early topping is also easier than later topping since stalk tissue is softer and much easier to break. Later topping takes more time, both in the removal of the flower and suckers that may have to be removed. Unless knives or clippers are used, tobacco topped late usually results in bruised, ragged stalks that are more susceptible to diseases like bacterial soft rot (hollow stalk).

Most important, tobacco should be topped at a stage and height that will maximize yield and quality and satisfy the preferences of the buyer.

Topping Burley Tobacco

Bloom Stage. Research has shown that topping burley tobacco at 10–25% bloom generally provides the best yield and quality. This means that 10–25% of the plants have one open flower. Bloom stage at topping may also depend on the length of time the tobacco will remain in the field before harvest. Yield of burley tobacco topped at 75% bloom may be similar or better than tobacco topped at 10–25% bloom if harvested at 3 weeks after topping, whereas tobacco topped to 10–25% bloom and harvested 6 weeks after topping may have improved yield but lower quality.

Late maturing varieties like TN 86LC and KT 200LC tend to respond well to bud topping while bud topping may reduce yields in other varieties. Specific varieties may need early topping to produce their best quality. Varieties like TN 86 tend to produce flashy, poorer quality tobacco. Other varieties may also have a tendency to produce a lighter, thinner bodied tobacco. These varieties are more likely to develop better quality if topped early. Early topping will not affect yields if other factors such as harvest time after topping remain constant.

Leaf Number. Optimum leaf number for burley tobacco at topping is generally 22–24 leaves. Several marketing contracts now encourage that there be a true tip grade (T) and topping to this height allows the plant to produce a true tip. Yield effects of topping height are also dependent on timing of harvest. Tobacco topped to 24 leaves tends to yield slightly more than tobacco topped to 20 leaves. Too many extra leaves increases stripping labor and may increase the incidence of houseburn in old barns that have less space between tiers. Extra leaves beyond 24 leaves do not necessarily mean extra yield. Therefore, extra leaves usually mean smaller leaves. Root development dictates leaf production potential. Topping to the right number of leaves may require a slightly later topping time in order to produce tips. However, delays beyond 75% bloom will be counterproductive. A balance must be found between extra labor required to produce those leaves and the yield per acre and premium for tips at the market.

Topping Dark Tobacco

Bloom Stage. Dark tobacco can generally be topped anytime between the elongated bud stage and 50% bloom without causing a significant impact on yield. Dark tobacco crops can be more irregular than burley crops with wide variations in bloom stage at the time of topping. It is not uncommon for some plants to have open flowers while other plants are at the early bud or even pre-bud stage. For this reason, it may be advisable to make two toppings. Attempting to make one topping on irregular crops lowers the yield potential of smaller plants. Increased yield incurred by allowing smaller plants to catch up usually compensates for extra labor required in making two toppings.

Leaf Number. Dark tobacco should be topped to 16–18 leaves. Topping to this height maximizes yield potential and allows a distinct characterization of lug, second, and leaf grades that are desired by the industry. Lower topping to 12–14 leaves does make tobacco easier to handle on the stick during housing and may cure better in older barns with narrow tier spacing, but also results in mostly lug and leaf with little or no true seconds. Plants topped to 12–14 leaves do compensate somewhat by producing larger leaves, but yield is still reduced by 200 lb/A or more compared to tobacco topped to 16–18 leaves.

Sucker Control for Burley and Dark Tobacco

Many of the benefits in topping at the appropriate bloom stage and leaf number are lost if suckers are not controlled. Suckers grow vigorously immediately after topping and can severely reduce yield and quality if not controlled effectively. Three types of chemicals are available for controlling sucker growth on tobacco:

- Contacts—these chemicals are not absorbed by plants and must have direct contact with suckers and leaf axils where they physically burn tender suckers.
- Local systemics—these chemicals must also have direct contact with leaf axils, but are absorbed into the plant at the leaf axil area and retard sucker growth by inhibiting cell division.
- Systemics—these chemicals do not have to come into direct contact with suckers and are absorbed by the plant and move to leaf axil areas where they retard sucker growth by inhibiting cell division.

In addition, some products (FST-7®, Leven-38® and others) are mixtures of two of these chemical types. (See Table 1 and Figure 1.)

Table 1. Sucker control and sucker fresh weight data, 2006 regional burley sucker control trial, UKREC, Princeton, Ky.

Treatment (gal/A)	% Sucker Control	Sucker Fresh Wt/A (lbs)
Royal MH-30 (2 gal/A)	95 a	781 d
Royal MH-30 (1.5 gal/A)	94 a	1010 d
Royal MH-30 (1.5) + Flupro (0.5)	93 a	1126 d
Royal MH-30 (1.5) + Butralin (0.5)	94 a	847 d
Royal MH-30 (1.5) + Prime+ (0.5)	91 a	1220 d
Royal MH-30 (1) + Butralin (0.5) + Royal TacM (2 gal)	84 b	2543 c
Royal TacM (2) OT fb Butralin (0.5) + Royal TacM (2) SRD	77 c	3938 d
Royal TacM (2) (5 weekly applications)	73 c	5446 a
LSD(0.05)	5.5	1185

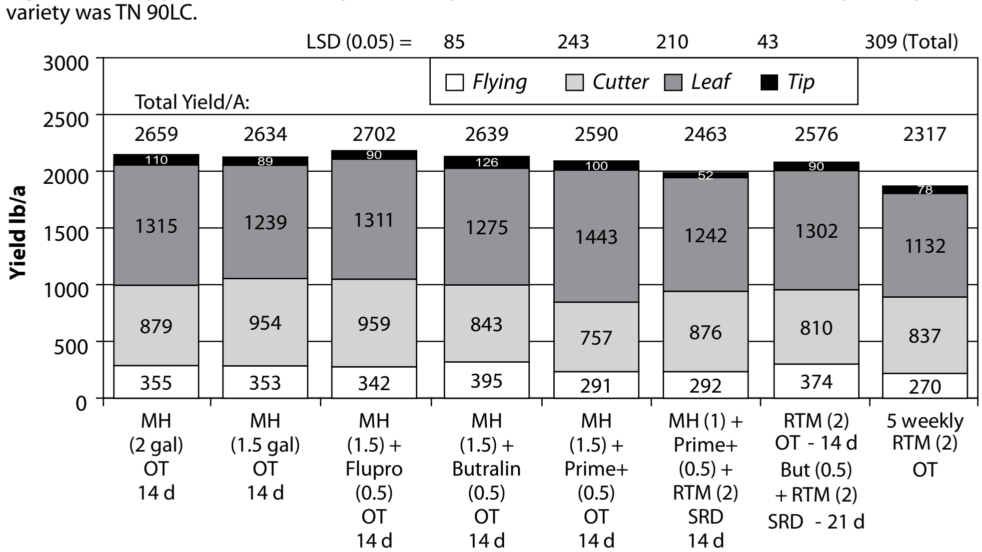
Contacts

Contact chemicals contain fatty alcohols as the active ingredient and form a milky-white emulsion when mixed with water at the proper dilution. Contact chemicals are available under many trade names such as Off Shoot T®, Royal TacM®, Fair 85®, Sucker Plucker®, and others. In University trials, all of these products have performed similarly when used under the same conditions. Fatty alcohols burn suckers shorter than 1 inch long on contact and sucker buds should turn brown or black within 1–2 hours after application. Fatty alcohols are rain fast at one hour after application and can be applied immediately before topping or within one day after topping. Contact chemicals will control suckers for 5–10 days. Any suckers longer than 1 inch will not be fully controlled and should be removed prior to applying fatty alcohols. Contacts should be applied so that the materials run down the stalk and come into direct contact with all leaf axils. Missed suckers are common with contacts applied to crooked or leaning tobacco, so it is a good practice to straighten crooked tobacco before application if possible. The proportion of fatty alcohol to water is critical to the effectiveness of these chemicals. If the concentration is too weak, suckers will not be controlled and if it is too strong, the suckers, leaves, and leaf axil will be burned and leaf loss could occur. A 3–5% solution is suggested on labels for contact chemicals. General recommendations are 3–4% solution for burley tobacco and 4–5% solution for dark tobacco, with the lower concentration used in initial applications and the higher concentration used in follow-up applications. For powered spray equipment, use 1.5–2.5 gal of contact chemical in 50 gal of total spray solution per acre (3–5% solution). For stalk rundown applications with backpack or hand sprayers, a 3–5% solution is 12–19 oz of contact chemical per 3 gal of total spray solution. Use of agitation is recommended since the fatty alcohols are lighter than water and will float on the water in the spray tank. Fatty alcohols should be added to the spray tank while adding water to promote dispersal. Avoid using cold water when mixing as these products may not totally disperse.

Local Systemics

Butralin®, Prime+®, and Flupro® are the local systemic products currently available. Butralin and flumetralin (Prime+ and Flupro) are the active ingredients in these products. All three belong to a family of chemicals called dinitroanalines and have similar use recommendations. When properly mixed with water, Butralin makes an orange emulsion while Prime+ and Flupro make a yellow emulsion. Application of local systemics should be made similarly to contacts, so that the chemical runs down the stalk and contacts every leaf axil. Suckers longer than 1 inch should be removed prior to application. Local systemics do not burn suckers like contacts but rather stop sucker growth, with suckers remaining as a pale greenish-yellow tissue for several weeks after application depending on whether the

Figure 1. Burley yield from 2006 Regional Burley Sucker Control Trial, UKREC, Princeton, Ky. Burley variety was TN 90LC.



application was made to dark tobacco or burley. Applications of local systemics can be made with powered spray equipment or with backpack or hand sprayers. Local systemics generally require 3 hours without rain after application to be effective. The activity of local systemics in stopping cell division can also cause distortion of small, upper leaves that come into contact with the chemical. For this reason, applications of local systemics should be delayed until upper leaves are at least 8 inches long. If upper leaves are less than 8 inches long and manual stalk rundown applications are made, direct the spray below these smaller leaves. If a local systemic is being applied alone, a rate of 1 gal/A should be used (1 gal per 50 gal total spray solution or 8 oz [½ pint] per 3 gal spray solution). Local systemics, particularly those that contain flumetralin, are much more persistent in the soil than other sucker control chemicals and severe damage can occur to subsequent crops, particularly grasses. For this reason, care should be taken not to use excessive amounts of these products. If manual stalk rundown applications are made with droplines, backpack or hand sprayers, care should be taken to prevent pooling of the solution at the base of the stalk. Use only enough solution to wet the stalk and suckers on each plant. Reduced rates of local systemics can be used if tank mixed with contacts or systemic products. Use 3 qt local systemic per acre when tank mixing with contacts and 2 qt per acre when tank mixing with systemic sucker control products.

Systemics

Maleic hydrazide (MH) is the only true systemic product available for sucker control in tobacco. Since it is absorbed through the leaves and moves to actively growing sucker buds, it does not have to directly contact leaf axils to be effective. However, good soil moisture at the time of application is required to allow adequate absorption by leaves. Similar to other types of chemicals, MH does not control larger suckers and these should be removed prior to application. MH should be applied with power spray equipment, as plant-to-plant stalk rundown applications do not allow enough absorption into the plant to be effective. Absorption into the plant is also enhanced by using nozzles that produce coarse spray droplets as opposed to fine mist nozzles. Similar to local systemics, MH retards the growth of small upper leaves and plants should be topped to a leaf no smaller than 6 inches long before MH is applied. MH used alone can be applied at a rate of 1.5–2 gal per 50 gal of total spray solution per acre. MH is most effective if no rain occurs within 12 hours after application. If significant rainfall occurs within 3 hours after application, reapply at the full application rate. If rainfall occurs between 3 and 6 hours after application, reapply at one half of the full application rate on the following day. There is also an increased chance of leaf burning from MH if applied on bright, sunny days where the temperature is above 90°F. Optimum time to apply MH is on overcast or hazy days or in the morning after dew dries on hot, clear days. MH is more active in controlling sucker growth than other chemicals and the most effective sucker control programs include an MH application. However, there has been some concern in the industry about the harmful effects of excessive MH residue on cured leaf and major efforts have been made to reduce or even eliminate MH residues on burley tobacco. An effective way to reduce MH residues without compromising sucker control is to use the lower 1.5 gal/A rate of MH in combination with 2 qt per acre of a local systemic applied with coarse nozzles. This combination spray controls suckers as well as the full 2 gal/A MH rate and reduces MH residues.

FST-7 and Leven-38

FST-7 and Leven-38 are prepackaged mixtures of MH and the contact n-decanol. Since both contain less MH (0.66 lb/gal) than that in other MH products, the application rate is 3 gal/A. They should be applied as a coarse spray with powered spray equipment at a spray volume of 50 gal/A to cover the top third to half of the plant, allowing the solution to run down the stalk to the bottom of each plant. Since the active ingredients in both products tend to separate in the container, make sure the container is well mixed and shaken before adding to the spray tank. Constant agitation in the spray tank should be used with FST-7, Leven-38, and all other sucker control products.

Application Methods for Sucker Control Chemicals

Four methods of application are currently being used to apply sucker control products to tobacco: power spray equipment, drop lines, backpack or hand sprayers, and jugs.

Powered Spray Equipment for High clearance Over-the-top Application

Use of powered spray equipment is the most labor efficient method of applying sucker control products, as this method typically requires only one person and many acres can be covered in a day. Any type of sucker control product can be applied through power spray equipment, although adequate coverage to achieve the best control generally requires high volume spray output and straight, uniform tobacco. Coverage is the key to success with any sucker control application. Thorough coverage of all leaf axils requires a minimum of 50 gal/A spray volume and coverage may improve on many crops as spray volume is increased to 60 or 70 gal/A. Pressure should be 20–30 psi.

Nozzle Arrangement

Broadcast applications and applications directed to the tobacco row are two types of nozzle arrangements that can be used. Broadcast or "straight boom" arrangements using 20 inch nozzle spacing provide even coverage over the row and the row middle. Applications directed to the tobacco row involve multiple (3 or more) nozzles per row. This method usually involves a nozzle placed directly over the row and two nozzles placed on either side of the row and directed at a slight angle into the row. Broadcast applications usually provide the best coverage if tobacco is leaning or if row spacing is inconsistent, while directed applications may be preferred if tobacco is straight and row spacing is consistent. Even a slight misalignment of nozzles over each tobacco row with the directed method can result in poor sucker control on those plants. Spraying only 2 or 4 rows at a time instead of using the entire boom can improve alignment with the tobacco.

Nozzle Selection

Nozzles that allow high output and produce coarse spray droplets are preferred for all applications. Coarse droplets tend to penetrate through leaves and reach all leaf axils down the stalk better than fine droplets. Nozzles such as TG-3, TG-4, TG-5, and TG-6 or their equivalents are commonly used with powered spray equipment for over-the-top applications. The 3-nozzle arrangement used for directed applications may be a TG-5 over the row and TG-3's on each side directed toward the row. Other combinations may also be effective. Broadcast applications can be made with all TG-3's or all TG-5's. Use TG-3's for more hilly terrain where traveling speeds are in the 2 ½–3½ mph range. For flatter ground where speed can be increased to 4–5 mph, use TG-5's or equivalent.

Dropline Applications

Dropline applications involve a high-clearance sprayer with hoses for each row attached to the boom with a spray trigger and coarse nozzle attached to the end of each hose that can be operated by a worker walking behind the sprayer. Droplines are used with plant-to-plant stalk rundown applications of contacts and local systemics. This method provides more direct sucker contact and generally provides better control than over-the-top applications, but is labor intensive and requires a slower pace to accommodate workers. The speed of the sprayer can only be as fast as the slowest worker. Practice may be required for workers to become accustomed to the appropriate rate of application, particularly on crooked tobacco that may require directing the application to several areas on the stalk. On tall tobacco, missed suckers can be common in the top of the plant, but misses are less common than in other methods. 0.5–0.75 oz of spray solution should be applied to each plant, with care taken to avoid applying excessive amounts that will pool on the ground at the bottom of the plant. Product rates per acre are the same for any application method, although volume of spray solution required for dropline applications will be 20–40 gal/A, significantly less that volume used in over-the-top applications. Droplines work well for local systemic applications to plants with upper leaves smaller than 6–8 inches since the applicator can direct the spray below these smaller upper leaves. Where applications are directed below small upper leaves, a second sucker control application should be made to those plants within 7 days to cover leaf axils of upper leaves. Although slow and labor intensive, dropline methods are very effective in sucker control programs that do not include MH. Personal protective equipment (PPE) must be employed when using this application method. Refer to Appendix 2 (Pest Management section) for more information.

Backpack and Hand Sprayer Applications

Backpack and hand sprayer applications are similar to dropline application methods in that each worker applies 0.5–0.75 oz of spray solution to the top of each plant to run down the stalk. The backpack or hand sprayer consists of a small, 2–3 gal spray tank and a wand attachment that can be fitted with a coarse spray nozzle. This method may have an advantage over the dropline method in that each worker is independent of others and speed is not dictated by the slowest worker. Small acreage growers using plant-to-plant stalk rundown applications prefer this method. Refer to Appendix 2 in the Pest Management section for PPE requirements.

Jug Applications

Jug applications involve adding the chemical to a gallon jug with water and pouring 0.5–0.75 oz of solution down the stalk of each plant. One gallon of spray solution should treat 170–256 plants. Although the jug method is the simplest of all methods, it is more difficult to apply consistent amounts to each plant. Some small acreage growers may still prefer the jug method. Refer to Appendix 2 in the Pest Management section for PPE requirements.

Sucker Control Strategies for Burley Tobacco

Uniform Crops

For most crops that are uniform and can be topped one time, use 1.5 gal/A MH with 2 qt/A of Prime+, Butralin, or Flupro as an over-the-top application with power spray equipment. Top tobacco at 10–25% bloom and remove all suckers longer than 1 inch. Spray applications can be made within 1 day before or after topping. If upper leaves will be less than 8 inches long at topping, apply a contact at topping and then follow with 1.5 gal/A MH plus 2 qt/A local systemic 7 days later.

Uneven Crops

The most common cause of sucker escapes is a delay in topping until suckers have reached a size that is difficult to control. Tobacco topped later than 50% bloom can have suckers that are more than 1 inch long. These suckers will escape control if not removed by hand at topping, and a second application to these suckers will also result in poor control. This situation commonly occurs in uneven crops. One solution is to make 2 toppings. However, the best solution may depend on the degree of unevenness. Three strategies for uneven crops are:

If the crop is not drastically uneven, the best approach may be to top all plants leaving a small leaf (approximately 6-8") at the top of plants that have not bloomed. Treat the entire crop with 1.5 gal/A of MH (regular concentrate) and 0.5 gal/A of Prime+ or Butralin. Use coarse nozzles only. To reduce labor, some producers may elect to top only those plants with a bud or bloom and spray the entire crop with the combination above allowing the spray material to chemically top those plants in the pre-bud stage.

In uneven crops that will require 2 toppings at 7 days apart, top plants that reach the elongated bud to early flower stage and apply a contact over-the-top to the entire field using power spray equipment. Apply 1.5 gal/A MH plus 2 qt/A local systemic after the second and final topping.

In extremely uneven crops that will require more than 2 toppings or 2 toppings more than 7 days apart, top plants that are ready and apply contacts every 5–7 days or at each topping using power spray equipment over-the-top, or apply a local systemic as a plant-to-plant stalk rundown application only to topped plants at each topping. Prime+ is the local systemic of choice in this situation as it generally provides longer control than other local systemics. If a local systemic is used, do not retreat plants that have already been treated at a previous topping. At the final topping, apply 1.5 gal/A MH over-the-top using power spray equipment.

MH-free Burley Tobacco

Certain buying companies have offered price incentives for burley tobacco that has not received MH. Although burley tobacco can be grown without MH, labor requirements may be greater and sucker control may be reduced in programs that do not include MH. If sucker control is adequate, some improvement in yield and cured leaf color can be seen in MH-free crops. Crops that have not received MH may also stay in the field longer before harvest. Alternative management and application techniques may need to be employed with MH-free tobacco. The most consistent method for producing MH-free tobacco is to use contacts and local systemics in plant-to-plant stalk rundown applications with droplines or backpack/hand sprayers. As discussed previously, this requires much more labor and time and multiple applications are usually needed. Good yields and sucker control can be achieved in MH-free tobacco using over-the-top applications from power spray equipment, but achieving adequate coverage on all leaf axils can be difficult. For the best chances of success, use multiple contact applications (at least 2) every 7 days beginning at topping followed by a single local systemic application at 1 gal/A either alone or preferably tank-mixed with a contact.

Sucker Control Strategies for Dark Tobacco

Although sucker control strategies for dark tobacco are similar to those in burley, achieving effective sucker control is usually more difficult in dark tobacco. Sucker growth after topping is generally more vigorous than in burley and ground suckers are more common. Dark tobacco is much more prone to blowing over and becoming crooked than burley. Also, dark tobacco typically stays in the field for a longer period between topping and harvest, requiring extended sucker control. The prostrate structure and leaf arrangement of dark tobacco is also not as conducive to achieving good coverage on all leaf axils. Some buyers of dark tobacco have also discouraged the use of MH in the past, except in situations of blow over where stalk rundown is nearly impossible. MH used at topping or at high rates can cause severe upper leaf discoloration and distortion. For these reasons, plant-to-plant stalk rundown applications of contacts and local systemics with droplines or backpack/handsprayers are much more common in dark tobacco. As discussed previously, dark tobacco crops are rarely uniform enough to allow one topping over the entire field.

Plant-to-plant Stalk Rundown Applications

A typical sucker control strategy for dark tobacco is to top plants that are ready (elongated bud to early bloom) and apply a contact at 4% solution (2 gal per 50 gal total solution) to the entire field as a plant-to-plant stalk rundown application. Top the rest of the crop within 7 days if possible and apply either a tank-mix of a contact at 4% solution with a local systemic at 3 qt per 50 gal, or a local systemic alone at 1 gal per 50 gal. The contact/local systemic tank-mix allows a slightly lower rate of the local systemic to be used. Although any local systemic can be used, Prime+ gives slightly longer sucker control than other local systemics. If more than 2 toppings are required, apply a contact every 7 days and follow with a local systemic or contact/local systemic tank-mix application at the final topping. If a local systemic is applied to plants that have not been topped or have upper leaves less than 6 inches long, direct the application below these smaller leaves. Another strategy is to apply a local systemic or contact/local systemic tank-mix at each topping. With this strategy, only treat plants that have just been topped and do not retreat plants at later toppings.

Over-the-top Applications with Power Spray Equipment

Although plant-to-plant stalk rundown applications are more common in dark tobacco, success can be achieved with over-the-top applications. Coverage on all leaf axils will be more difficult on dark tobacco, and higher spray volumes can improve coverage. Spray volumes of 60–70 gal per acre are recommended for contact and local systemic applications. Dark tobacco that is straight is rare, and crooked tobacco is usually the cause of missed suckers with over-the-top or plant-to-plant applications. If tobacco leans due to wind, try to straighten the tobacco before it grows crooked if possible, as this will improve coverage in over-the-top applications. If tobacco is relatively straight, directed applications with 3 nozzles per row will provide better coverage than broadcast, straight boom applications on dark tobacco. A good strategy for over-the-top applications is to apply a contact at 4% solution at the first topping and again 7 days later. Follow with a local systemic at 1 gal/A or contact/local systemic tank-mix as described previously. Since more suckers will escape control with over-the-top applications to dark tobacco, including an MH application is recommended.

Use of MH in Dark Tobacco

Although MH use in dark tobacco has been discouraged in the past, buying companies have become more lenient on its use in recent years. The key to avoiding discoloration and distortion of upper leaves is to not apply MH at topping. Allow at least 7 days after the final topping before applying MH. Application rate is also important. Five to 6 qt (1.25–1.5 gal) per acre is recommended. Rates lower than 5 qt/A will provide marginal sucker control and rates higher than 6 qt/A may cause upper leaf discoloration, even when applied at 7 days after topping. Recommended MH programs for over-the-top applications to dark tobacco are to apply a contact at the first topping and every 7 days through the last topping. Seven days after the final topping, apply 5–6 qt/A MH alone or tank mixed with 2 qt/A of a local systemic. If one topping can be made, apply a contact and follow with MH or MH/local systemic tank mix 7 days later. Be sure to top down to at least a 6-inch leaf.

Harvest Management for Burley and Dark Tobacco

One of the most important management decisions in producing high quality burley or dark tobacco is deciding when to cut. Maturity of the crop should be the primary consideration, although weather conditions and the availability of labor are also influential factors. Tobacco cut at maturity but not allowed to become overripe will be easier to cure and have better cured leaf quality than immature or over-mature tobacco.

Burley Tobacco

Burley tobacco should be allowed to ripen until nearly all of the upper leaves show a distinct yellow color. Stalks and main leaf stems will lose much of their original greenish color and take on a cream-to-white appearance. This usually occurs between 3 and 5 weeks after topping, depending on variety and environmental conditions. Many growers hesitate to allow upper leaves to ripen for fear of losing lower leaves. However, added growth of upper leaves usually more than compensates for any loss of lower leaves. Harvesting at 6 weeks after topping usually does not increase yield and may decrease leaf quality.

If possible, try to schedule burley harvest when at least a few days of fair weather are expected. Burley tobacco can be cut and put on sticks ("speared" or "spiked") in the same operation. Do not put more than six plants on a stick unless plants are extremely small. Tobacco can then be left on the standing stick in the field to wilt before being picked up for housing. Tobacco that is adequately field wilted will be lighter and easier to handle and house (up to 20% less fresh weight), and will incur less leaf loss and bruising. Tobacco that sunburns or has light frost damage may require a few (3-4) days of sunlight to remove chlorophyll staining. It is especially important not to let harvested tobacco get excessively wet and muddy in the field and it should not be left standing in the field longer than 4 days, even if weather conditions are good.

Burley tobacco can be loaded onto flat bed wagons or scaffold wagons for transport from the field. Flat bed wagons can be used if tobacco will be housed immediately. Tobacco loaded onto scaffold wagons can remain on the wagon for additional wilting prior to housing if needed. While loading, tobacco can be regulated on sticks so that plants are spaced equally apart and leaves hang straight down the stalk. Some producers prefer to regulate tobacco when housing.

Good housing practices are essential for high quality cured tobacco. Good cured leaf can be obtained in conventional curing barns or in outdoor curing structures if proper management is used. In conventional curing barns, all available space should be uniformly filled as air does not circulate well through tobacco in partially filled barns. Sticks should be spaced at least 7-8 inches apart on the tier rail in conventional barns to allow air movement between sticks. Insure that plants are spaced equally on sticks and leaves are shaken out to hang down the stalk if this was not done at loading in the field. Fill each bent in the barn completely from top to bottom. If possible, fill the entire barn in the same time period as greener tobacco does not cure as well when hung with partially cured tobacco. Tip leaves should hang between sticks of lower tiers and not overlap.

Burley tobacco can usually be hung at higher densities in open-sided, low-profile outdoor curing structures without increased risks of houseburn or barn rot. Burley tobacco hung on these structures should have a stick spacing of 4–6 inches. Since natural airflow is greater in these structures than in conventional barns, closer stick spacing helps to prevent the tobacco from drying too fast and setting undesirable colors in the cured leaf.

Dark Tobacco

Similar to burley tobacco, dark tobacco that is allowed to ripen before harvest will cure much more easily and with a better color. Dark tobacco does not show distinctive yellowness in the field at maturity like burley and is therefore more difficult to estimate ripeness. Dark tobacco is ready for harvest when leaves begin to show a very faint yellow cast. At this stage, the upper leaves will be thick and oily and will crack readily when doubled between the fingers. Depending on variety and environmental conditions, this usually occurs between 5 and 7 weeks after topping. An exception is TN D950, an early-maturing variety that is typically ready for harvest between 4 and 5 weeks after topping.

Dark tobacco that is ripe when harvested will have brittle leaves that will break and bruise easily. For this reason, dark tobacco should not be cut and put on sticks in the same operation as is typically done in burley. Due to its more prostrate leaf structure, dark tobacco should be carefully cut, with caution being taken not to break lower leaves, and allowed to wilt in place or "fall" before being put on sticks. Depending on temperature and sunlight intensity, this wilting period may take anywhere from 30 minutes to several hours. Tobacco cut late in the day can be left to wilt overnight if there is no chance of rain that will leave the tobacco excessively wet or muddy. Once tobacco is flexible enough to be put on sticks, it should be spiked and picked up as soon as possible. Dark tobacco is very susceptible to sunburn. Caution should be taken to not cut more tobacco than can be spiked and loaded in a day. Many growers may pile the tobacco after initial wilting in groups of six plants to make spiking easier and temporarily reduce the risk of sunburn. No more than six plants should be put on a stick, and five plants per stick works better for large tobacco. Whether the tobacco is spiked from piles or directly from the ground, it should not be allowed to stay in the field for more than a few hours before being picked up and loaded. When loading, space plants equally on sticks and shake leaves so that they hang straight down the stalk.

Scaffold wagons are the preferred means of loading and transporting dark tobacco. Scaffolded tobacco is less likely to sunburn and can remain on the wagons for several days of additional wilting before housing if wagons are placed in shade or are covered with shade cloth.

Dark tobacco housed in newer barns with wider tier spacing should have a stick spacing of at least 8–9 inches. In older barns with narrow tier spacing, place sticks at least 12 inches apart. Narrow tier spacing in older barns may only accommodate tobacco topped to 12 or 14 leaves, whereas wider tier spacing in newer barns will accommodate tobacco topped to the current market standard of 16–18 leaves. Use alternating placement on tier rails so that tobacco does not overlap tobacco on lower tiers, or only hang tobacco on every other tier if barns space allows.

For dark fire-cured and dark air-cured tobacco, fill the entire barn in the same time period as tobacco will not cure as well when housed at different stages. Fill each bent of the barn from top to bottom, ensuring that plants are spaced evenly on sticks and leaves hang straight down the stalk. Due to increased risk of weather damage, the use of outdoor curing structures for dark air-cured tobacco is not currently recommended.

Facilities and Curing

George Duncan, Larry Wells, and John Wilhoit

Conventional Barn Renovation and Remodeling

In the post-buyout era of tobacco production, curing facilities are becoming a limiting factor for producers wanting to expand their production. With the high cost of new barns, the renovation and remodeling of existing barns could be an economic advantage. Many curing barns remain that are generally in good structural condition. With some remodeling, they can often be improved to make housing easier and/or to aid the curing process. Here are a few possibilities:

Good burley curing requires lots of natural air. Be sure ventilator doors or equivalent openings equal 1/4–1/3 the barn side wall area and are positioned to permit natural ventilation air to enter and go through the hanging tobacco. Keep the vent doors in good repair so they can be opened and closed as required to regulate ventilation and manage the cure. Whenever possible, remove such obstructions as trees, bushes, and hay stacked in attached sheds that block prevailing winds.

Install full-width driveway doors to accommodate wagon access and increase housing efficiency. An amazing number of people still hand tobacco from the driveway across to the sheds and up into the barn, which takes an extra worker or two and costly labor hours.

Consider optional fans where natural ventilation is inadequate. Supplemental fan circulation and/or ventilation can help wilt big green tobacco, aid curing of tightly housed tobacco in humid weather or aid air movement in barns having poor ventilation. See available publications on the selection, installation and use of fans in tobacco barns.

Many producers have found that in older barns, where tiers are only 3–3 ½ ft apart vertically, better curing results when tobacco is housed on every other tier rail. This eliminates overlapping and produces better air movement. Sticks can usually be placed closer together when the plants do not overlap, thus compensating in barn capacity for the omitted tiers, provided the tier rails are not overloaded causing the tiers to break..

Structurally sound conventional barns can be modified for 2-3-tier air-cure housing, cable hoist, or portable frame housing for labor-saving benefits. Specific details of these procedures are contained in other publications.

What Type of Tobacco Barn or Curing Facility Should You Build?

There are several options for new tobacco barn construction as well as field curing structures. An important decision is to build the most suitable facility for present and future production methods. With labor becoming more scarce and costly, laborsaving features are a must. Rising material and construction costs continue to increase the initial investment costs. An air-cure tobacco barn (burley or dark) is the largest single investment required in the normal tobacco production system. Trends toward mechanization affect whether a facility can be modified, will become obsolete soon, or is needed at all. Partially enclosed barns and plastic covered field curing structures are alternatives for lower cost tobacco housing and curing. However, more management of field curing structures may be required for proper curing.

Producers considering a new facility should certainly not favor the historic tall, labor-intensive barns from the past era of plentiful low-cost labor and inexpensive homegrown lumber. Likewise, builders should not contend that they could only build barns of that type.

Considerations

When planning new curing facilities, producers should consider these options:

- the basic three- or four-tier barn designs, or two-tier economy designs, or one-tier field structures in which tobacco housing can be accomplished with smaller crew size and less total labor;
- alternative designs that use portable frames or cable-hoist mechanical handling and housing that can save over half the housing labor;
- structures that permit other possible farm uses of the facility during the non-curing season, such as machinery and supply storage or animal shelters; and
- future modifications for different tobacco housing and curing methods or other farm enterprises, as these methods could change significantly in the future.

Designs and Plans

Over three dozen designs and plans are currently available on the Biosystems and Agricultural Engineering Department (BAE) web site: www.bae.uky.edu/ext/tobacco. Some general groupings are:

- Three-tier and four-tier air-cure, 32, 40 or 48 ft wide, post-pier or pole-type construction, wood, or metal siding.
- Two- or three-tier forced-air, 32 or 40 ft wide, wood or metal siding, pole-type construction.
- Open-interior air-cure barn with portable curing frames handled by tractor forklift.
- Two-tier partially enclosed air-cure barn, pole-type construction.
- Cable-hoist mechanical housing system for new or modified air-cure barns.
- Thirty-foot wide machine shed with removable tier rails for small air-cure barn, pole-type construction.
- One-tier plastic-covered field curing structure with manual or mechanized housing
- Stripping rooms attached to barns or free-standing, especially layouts for the new big bale operations

Facility Design and Location

A barn should be located in an open, well-drained area with the broad side facing the direction of the prevailing wind to provide the best cross-ventilation.

The best location is on a high point on the farmstead. Width is the most important dimension affecting ventilation since width determines the distance the air must move as it passes through the facility and the amount of tobacco the air must pass through.

Most traditional barns have been 40 ft wide and as long as needed to hold the desired amount of tobacco. Other designs are 32- and 48-ft wide. Lumber of sound quality and proper strength capabilities should be used for construction as shown in typical plans. For labor saving in housing, the 'sheds' should have driveway doors so transport vehicles can pass under the tier rails for efficient handing of tobacco up into the tiers. Ventilator openings should be openable doors or panels, generally vertical in orientation, equivalent in area to at least ¼–1/3 of the side wall area. Some barns are being built with metal siding and do not have adequate side wall ventilation. Inadequate ventilation will result in 'houseburn' during humid weather or with tightly spaced tobacco.

Lower cost plastic-covered field structures can use untreated wood for reduced life or preservative treated for longer life. Various wooden and wire strung designs exist for stick harvested or notched plant hanging and curing. High tensile wire field structures are of particular importance with the plant-notching mechanical harvesters increasingly being used in larger operations because there is no practical way to use barns for hanging notched plants (see section Update on Burley Harvest Stripping Mechanization). Careless and haphazard construction, including failure to adequately anchor high tensile wire, can result in failure of these field structures when fully loaded with harvested tobacco, so it is important to build them strong.

Investment Costs and Labor Efficiency

Curing facility initial costs can range from $700-$1200 per acre capacity for simple field curing structures with plastic covers to $6000 and more per acre capacity for conventional air cure barns. Useful life of these structures can vary from 7-10 years for low cost field structures to 40-50 years or more for well-built barns. Labor requirements for hanging tobacco in these facilities (not including harvesting and hauling) can vary from approximately 12 worker-hours per acre of capacity up to 30-35 wkr-hrs/A.

The amortized value of construction cost and labor for these facilities over their useful life is estimated at approximately 8-12 cents per pound of cured tobacco per year. The annual costs per pound of cured tobacco are even greater to repay short-term construction loans.

Air Curing Burley Tobacco

One of the most important features of any tobacco curing facility is to provide for management and an environment for proper curing of the tobacco. The process of air curing burley and dark tobacco changes the tobacco leaf's chemical and physical properties from the green and yellowish stages to tan and brown aromatic leaf for processing. Most of the changes occur during the first four weeks of curing (approximately two weeks for yellowing, two weeks for browning) and alter many compounds in the green leaf.

Burley's quality is influenced by moisture and temperature conditions inside the curing facility during the curing period. For several decades the best conditions for curing burley have been cited from Jeffrey (1940) as a daily temperature range from 60–90°F and a daily relative humidity average of 65–70 percent. The study was based on an airflow of 15 feet/minute (1/6 mile per hour velocity) through the tobacco in the test chambers. These conditions were for tobacco grown and cured in the 1940s which was a very thin, buff colored leaf referred to as "white burley." The changes in varieties, fertility and cultural practices of the last couple of decades as well as buyer preferences have resulted in a darker brown to red color, thicker leaf now being favored. Recent barn and chamber studies have indicated that steady or daily average relative humidity in the 72-75 percent range produce the quality of tobacco leaves currently desired by the industry, thus a higher daily average humidity than that of the historic study.

During the normal Kentucky late August through September tobacco curing season, the outdoor temperature seldom goes above 90°F or below 60°F for any great length of time. Relative humidity can dwell near 100 percent during heavy dew or foggy nights and briefly may drop below 40-50 percent in the heat of the day, thus averaging around the 70-75 percent. The cooler October temperatures can often go below 60°F for an entire day and/or several consecutive evening periods with humidity ranging from 25-30 percent in day time to not over 70-80 percent in evening hours, resulting in daily averages of 45-55 percent. Extensive curing studies by Walton et. al. (1971, 1973) on the effect of several combinations of low and high temperatures and relative humidity on the quality of burley can be summarized as follows:

- Low temperatures result in green leaf, regardless of the relative humidity and airflow. The chemical conversions are too slow because of the low temperature. However, the drying rate does determine the degree of green cast in the leaf. The higher the drying rate, the greener the cured leaf.
- Low humidity and moderate temperature results in greenish or mottled leaf.
- Low humidity and high temperature (75°F and above) causes "pie-bald" (yellowish) leaf.
- High humidity and moderate-to-high temperature for extended periods is "house burning" weather. Houseburn results in a dark leaf with excessive loss in dry weight. The excessive weight loss is primarily caused by the action of microorganisms that cause soft rot.

Temperature determines the undesirable colors that prevail in the cured leaf during improper curing; however, it is the relative humidity (if airflow is adequate) that determines the degree of damage incurred. Walton et al. (1973) showed that the greater the departure from the optimum relative humidity range, the greater the damage to the quality of the tobacco.

The main control of the curing process is affected by spacing of the tobacco in the curing facility and management of the drying rate. Spacing can vary from 5-6 inches between plants or sticks for one and two tier facilities to 7-10 inches for 3-5 tier barns with tobacco overlapping on close tier rails. Control of the drying rate is done primarily by operating the ventilators, plastic covering, or other air control means to regulate the ventilation rates.

Barns should be located in open areas and broadside to the prevailing wind for maximum natural ventilation when ventilator doors are open. Ventilators should be sized to provide one-fourth to one-third of the wall area in openings. Fans can be used in barns to improve circulation and fresh air exchange through the tobacco for improved curing (see separate section). Also, not operating fans in a proper installation can reduce air exchange and maintain better humidity conditions during drier weather.

The conditions inside the barn generally follow the conditions outside the barn depending on the quantity of air movement and buffering action of the tobacco mass. The average temperature inside the barn will be slightly lower than outside because of evaporative cooling during drying stage and the average relative humidity inside will be higher than outside under most conditions of adequate ventilation. A good way to determine the conditions inside the barn and tobacco is to purchase a couple of commercial digital temperature and humidity instruments for $25-$39 each. Hang these up in the tobacco mass (but not directly against a moist leaf) to sense and record the environmental conditions. These instruments store maximum and minimum data readings which can be viewed to see the past cycle of conditions and reset as desired. The accuracy of relative humidity measurement is generally plus or minus 3 percent, which is reasonable for the price.

One-tier field curing structures with plastic covering normally have plentiful air movement through the tobacco, thus curing as well as the natural weather provides. Such structures should be placed downwind from fence rows or similar wooded areas to give protection from strong winds that can damage the plastic covering and tobacco. Plastic or other covering should be applied over the hanging tobacco before a significant rainfall and maintained throughout the cure for protection from rain and wind damage.

Dark Air-Cured Tobacco

Dark air-cured tobacco is cured essentially the same as burley, but because of the heavier body of dark tobacco, it is more prone to sweat, house burn, and mold. Under warm conditions (mean daytime temperatures >80°F and mean nighttime temperatures >60°F), barn doors and ventilators should be open during the early stages of curing to promote airflow through the tobacco. If warm, moist weather conditions prevail after housing, it may be necessary to use some type of heat to aid the curing process. Heat may also be necessary following late harvests if cool (mean daytime temperatures <65°F), dry conditions persist after housing. Heat sources that can be used include gas burners, coke stoves, or even small wood fires using dry sycamore wood. For dark air-cured tobacco, it is extremely important that these heat sources be virtually smoke-free so as not to leave any, or very little, smoke residue on the leaves. Barn temperatures during heating should be kept low (not exceeding 90°F), as too much heat can cause excessive drying (Bailey 2006a). Growers should be aware that the use of heat in dark air-cured tobacco can be of benefit in the situations described above, but heat in dark air curing is not a necessity that should be used in every situation.

Dark Fire-Cured Tobacco

The fire-curing process for dark tobacco can be broken down into four phases:

- Yellowing
- Color setting
- Drying
- Finishing

Yellowing. The degree of yellowing that occurs in the tobacco before fires are started will affect the color of the cured leaf. Tobacco should be allowed to yellow as much as possible without heat, managing ventilators carefully to prevent house burn and sweating. Firing should begin when yellowing is nearly complete (yellow spots appear or the majority of the leaf lamina has reached a solid yellow color). This usually occurs between five and eight days after housing. Initial fires should not exceed 100°F. Fires that are too hot too soon will cause "bluing" of the tobacco, which results in a crude, green color that will remain after curing is completed. Top ventilators are usually left open during this phase of curing and fires are mostly smoke with low heat.

Color Setting. When yellowing is completed and the entire leaf lamina is a solid yellow color, temperatures are increased with additional fires to set leaf color. Ventilators are usually closed, and temperatures should be kept between 100°F and 115°F. These conditions should be maintained until the leaf shows a solid brown color. Depending on tightness of the barn and weather conditions, this may be done with one firing or may take several firings over a 7- to 14-day period. Ventilators should be opened completely between firings to allow the tobacco to obtain some order before re-firing. When the tobacco has a clear, solid brown face and the stems are dried and browned for ½–2/3 of the way up the leaf, it is time to complete drying.

Drying. Tobacco is brought in order, ventilators opened, and heat increased until the midribs are completely dried down and darkened. Heat during the drying phase should not exceed 130°F. When drying is complete, there should be very little or no green pigment left in the stalks, tobacco should shatter when touched, and there should be no puffiness in the leaf midrib near the stalk. Puffy stems that remain after the drying phase will not easily be dried down during the final finishing phase.

Finishing. After the midribs and stalks are dried and darkened, temperatures are reduced to no more than 120°F, and smoke volume is maximized to add "finish" to the leaf surface. The finishing phase usually requires one to two slow firings over a 10- to 14-day period but may vary depending on the amount of finish desired by the buyer. Tobacco takes finish much better when in order, so ventilators should be opened for several nights prior to finishing to allow moisture to enter the barn. Finishing fires should contain minimal slabs and heavy sawdust to maximize smoke with little or no ventilation. The sawdust, barn floor, and walls may be dampened to produce a moist smoke that will help keep the tobacco in order longer to increase finish.

Firing Materials and Methods

Hardwood slabs and sawdust are the traditional firing materials used for dark fire-cured tobacco. Seasoned hardwood materials are preferable since they tend to burn more slowly and evenly than softer types of wood. Materials such as sulfur or salt should not be used in the yellowing or drying phases, and other materials such as molasses or brown sugar should not be used during the finishing phase in an attempt to increase finish in the cured leaf. Where these materials are used, the result may be tobacco that is excessively sticky and difficult to handle or not usable by the industry because of off-flavor.

Initial fires during yellowing and color-setting phases usually consist of slabs being placed in narrow rows on the floor of the barn and covered completely with sawdust, except for a small opening exposing slabs on alternating ends of each row where fires are started. Slabs should be overlapped so that fires will burn continuously to the end of each row. Later firings during the drying phase require increased heat, and slabs may be stacked higher and in wider rows or placed solid throughout the floor of the barn with sawdust covering the slabs.

Fires may be started on both ends of each row or at several locations. Finishing fires usually have minimal slabs placed either in rows or solid with increased amounts of sawdust to produce maximum smoke volume. Hardwood chips may also be used in combination with sawdust during later firings to help fires burn more slowly with increased smoke volume (Bailey 2006b).

Using Fans in Conventional Barns

High volume ventilation fans can be used in conventional barns to aid air circulation and improving curing. Here are some guidelines for using fans effectively.

When using fans to aid curing, make the air pass through the tobacco rather than just circulate around the driveway or gable space. You also need to move enough air to justify your effort in using the fans.

Most fans in the gable end of conventional barns are too small to do much more than short-circuit air through nearby wall and eave cracks. Fans at ground level in driveways or doorways need to have means (boards, etc.) to direct and/or deflect air up through the tobacco for more effective results.

The most efficient and effective method of using fans in conventional barns with numerous openings around the eave, walls and doors is to place good quality, belt-driven ventilation fans horizontally in the center, bottom rail of every other bent. This pulls any humid, stagnant air through the mass of tobacco from above and around the fan and blows it directly downward toward the ground. Thus, air is moved through the central core of the tobacco where moisture problems generally occur first. Sticks of tobacco are omitted directly above the fan and plants are moved sufficiently away from the sides to prevent damage by the fan. Leave the side ventilators or other doors open to allow the ground-level moist air to migrate out of the barn and fresh drier air to come in around the eave, through the sidewall vents and move through the tobacco.

For beneficial curing results, fan capacity should be 12,000–18,000 cu ft/minute of 0.1 inch static pressure-rated airflow for every 2 bents of 32 to 40-ft wide barn. This means good quality fans of 42 or 48-inch diameter; ½, or ¾ hp should be suitable for the above circulation method in conventional barns, depending on barn size, amount of tobacco, and the effectiveness of air movement you desire (see separate publication for more details).

Operate the fans continuously (24 hours a day) during rainy or humid weather and/or daily during the first 2 or 3 weeks of curing when the tobacco is still green or yellow and contains turgid stalks and stems. After about 3 weeks, the fans may be operated only during the day to dry the tobacco as needed and turned off at night to avoid bringing in moist air. Time clocks can be installed to automatically power the fans on and off daily.

Don't operate the fans during cool, dry weather (below 50–60°F and below 60-65 percent relative humidity) when the tobacco still has green or yellow color in the leaves, as over drying and off-colors can result.

When planning to use the electrically powered fans in conventional barns, check the existing electric wiring and service entrance components carefully. Many barns have been wired for only driveway or stripping-room lights and do not have enough electrical capacity to operate fan motors. Damaged and burned-out wiring or motors can quickly result from insufficient electrical service capacity. Have a local electrician or utility company representative help you check your electric circuits.

Tobacco Stripping Rooms

A good stripping room is very helpful for the stripping and market preparation tasks for most producers. Some producers strip early in the fall in the barn driveways using wagons for the stripping work area. Others can get by with temporarily enclosing a portion of the barn with plastic, tarps, etc., and using an improvised or fold-up work bench and portable vented heater or stove. Or, they can haul the un-stripped tobacco to a more suitable location. The advent of the big baler for burley baling requires greater space for the baler, a supply of unstripped tobacco, and accumulation of the stripped tobacco. As a baler is being filled with 500-600 lb of one tobacco grade, the additional leaf grades stripped from the plants must be accumulated. Such storage can only be avoided by operating multiple balers at a greater cost.

Heated workshops or garages can serve as temporary stripping areas. Likewise, any permanent stripping room can also serve as a workshop or storage area the rest of the year if suitably arranged and conveniently located. Features to be considered for a stripping facility include:

- Work bench of proper width and height (see below), or appropriate mechanical stripping aid;
- Overhead lighting;
- Adequate space for workers bringing in stalk tobacco, for baling equipment, and for removing the bare stalks;
- Doorways large enough to accommodate the tobacco handling and personnel passage needs;
- Heating equipment (with proper exhaust venting) for warmth in cold weather; and
- Electricity for the lights and other power equipment needs.

Blueprints are available from the BAE web site show typical construction of traditional stripping rooms. Over 20 possible layouts of larger stripping rooms for the big baler operation are also shown on the web site. Benches should be 32-36 inches high and 48-60 inches wide for one side stripping, or double width for workers on both sides. The top surface should be slatted wood or heavy wire mesh with ½-inch crack openings that allow fine particles of trash and debris to fall through.

Overhead lights should be multiple-tube fluorescent fixtures with a reflector shield, protective mesh grid and equal numbers of cool white and daylight type tubes per fixture. These tubes provide a rather good economical light source to see the tobacco color and grade qualities when stripping. Special lights with a more balanced daylight spectrum and quality of light are options.

Leaflet 293, "Improving Light Conditions for Stripping Tobacco," is a publication on the BAE web site describing various details of lighting and color features for stripping rooms. Other details of space, doorways, heating, and construction can be obtained from the blueprint plans.

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Stripping and Preparation of Tobacco for Market

George Duncan, Gary Palmer, and Andy Bailey

The market preparation phase of tobacco production involves the removal of cured tobacco from the curing facility, temporary bulking, removal of leaves from the stalk (stripping), sorting by physical characteristics and packaging in conventional small bales or newer big bales.

Takedown and Bulking

Takedown and bulking are the processes of removing cured tobacco from the curing structure and consolidating onto a scaffold wagon or in a pile, or bulk, for access by workers or transport to the stripping location. Tobacco should be bulked on a clean dry surface such as wooden boards, a wagon bed, or similar materials. A plastic sheet can be used for a protective barrier on which to bulk the tobacco but be aware that a layer of moisture can condense against the plastic under certain temperature and moisture conditions. Check the tobacco against the plastic periodically to detect any moisture problems.

Tobacco must be in a pliable condition for handling and bulking, often referred to as being in "order" or "case," which results from exposure to a surrounding environment of 70 percent relative humidity or higher for several hours (4-12 depending on the temperature and dynamics of relative humidity). Tobacco should not be removed from the curing location until all the stems (midribs) of the leaves have dried to a firm condition (not "fat" or "mushy"). Producers typically await natural weather conditions of good humidity and temperature above 35 degrees for conditioning the tobacco for handling. In extreme dry periods, steamers or overhead misting systems (in dark fired barns) can be used in rather air tight barns for artificially conditioning tobacco for handling (see separate article in publications section of the BAE web site: www.bae.uky.edu/ext/tobacco).

Tobacco in equilibrium with air below approximately 60-65 percent relative humidity will be so dry that leaves will likely shatter when handled, thus losing quality and weight. Conversely, exposure to a continuous relative humidity of greater than 85 percent will cause the tobacco to become too moist and subject to deterioration and damage when bulked or baled. High moisture tobacco will "heat up" in the bulk after a day or so in warmer weather (above 50-55°F daily average) causing undesirable mold development, a bad smell, potential discoloration and, in a worst-case scenario, rot.

There are several different methods used for bulking tobacco. Tobacco harvested and cured using wooden sticks can be bulked with sticks still inserted or with sticks removed. Leaving the sticks inserted is often done early in the fall to provide better air and moisture diffusion from the bulk when the stalks are still "green" and moisture laden. "Stick bulking" also facilitates further handling convenience at the stripping location. Removing the sticks when bulking can be done when the stalks are dried enough (general brown color) that the moisture will not cause "heating" and other problems when the bulked stalks are tightly packed for several days of rather warm weather (above 45-50°F daily average) before stripping. If the stalks are still rather green and moist when bulked, then strip within two to three days or put wooden sticks between bunches of stalks to permit better ventilation and moisture diffusion for the extended period of bulking.

Bulking of notched plants from wire type curing structures should use the above stalk techniques according to whether the stalks are still green and moist or more dried and brown.

In any bulking method, put your hand deep into the bulk daily to determine that the tobacco is still cool and not beginning to heat up. If warmth is detected, then prepare to strip the bulk promptly, open up the bulk or move the tobacco around to air out.

The bulk of tobacco can be left uncovered in mild fall weather to allow moisture diffusion if dust or other contaminants are not prevalent. Later in the cooler and drier fall or winter weather, a tarp or plastic cover can be put loosely over the bulk to protect from excessive drying and prevent dust accumulation or other contamination.

Tobacco can also be taken down and put on scaffold wagons until stripping if wagons and storage space are available. In warmer fall weather, tobacco taken down onto scaffold wagons will be less likely to heat and does not have to be stripped as quickly as if it were bulked.

Stripping Burley

Stripping is the process of removing and grouping leaves by stalk position and physical characteristics to meet marketing requirements. A full-leafed mature burley plant can have 20-24 leaves. Over-mature harvest and/or loss of lower leaves during harvest may reduce the lower stalk position ("flyings") group. Often weather, soil and curing variations are such that only three distinct grades of leaf characteristics may exist on most plants. Several of the newer burley varieties maintain such sound lower leaves that a true flying may not be produced. Stripping of these plants into three grades might be done without significant loss in value if the marketing process permits. Past studies have shown that the labor cost to remove a fourth grade of limited quantity and value is not always economically feasible (Bridges, et. al. 2006).

However, with the advent of contracting in the year 2000, many companies suggest four grades but still get a high percentage of three-grade tobacco. Tobacco companies can utilize a small percentage of mixed stripped tobacco, but the handling characteristics of the four stalk positions differ substantially during processing. As the companies make their blends, they look for specific characteristics that differ from grade to grade.

A comparison of farmer produced burley tobacco reveals the different distribution of leaves between three-grade and four-grade tobacco. Tobacco stripped into three grades is typically grouped into flyings, lugs, and a leaf/tip grade. With three-grade tobacco, producers tend to strip too high on the first grade (lower stalk) and put too many leaves into the tip grade (top of stalk). Percentages for three grade tobacco in a past study were 25.6% for flyings, 54.9% for lugs, and 19.5% for the leaf/tip grade. Producers who strip their tobacco into four grades typically grouped it into the four appropriate grades (flyings, lugs, leaf and tips) that are true to previous Federal Grade Standards. Percentages for four grade tobacco in the study were 17.1% for flyings, 34.0% for lugs, 31.1% for leaf, and 17.8% tips. Assuming 20-24 leaves per plant, the breakdown for three grades would be 5-6 leaves stripped as flyings, 11-13 leaves as lugs and 4 leaves as leaf/tips. With four grades, one to two fewer leaves are stripped with the flyings. Approximately 7-8 leaves are stripped as lugs with 6-7 leaves stripped as leaf tobacco and 3-4 leaves as tips. The top grade represents a true tip in the four-grade tobacco, but could be graded as a leaf grade in three-grade tobacco. Three-grade tobacco generally will have a mixture of flyings and lugs in the first grade, a mixture of lugs and leaf in the second grade and may have a mixture of leaf and tips in the third grade. This may reduce market grades from 1's to 2's reducing the overall price paid for each grade. However, the difference between 1's and 2's is slight and may not be enough incentive to encourage four-grade stripping.

Some tobacco company contracts ask for a crop throw (percentage in each grade) that is different from how typical Kentucky tobacco farmers strip. One such crop throw would strip less tobacco into flyings with only 1-3 leaves in that grade, 4-6 leaves as lugs, half of the stalk, or 10-12 leaves, as leaf tobacco with the remaining 4-6 leaves as tips.

The predominant means of leaf removal is still by hand methods with the "relay" method generally being the best. The "relay" method uses workers along a 32-34 inch high bench or wagon bed with a source (pile) of cured plants at one end. The first worker pulls the "flyings" and lays the stalk on a next pile for the next worker to remove the next grade, and so on until all leaf grades have been removed. The stripped leaves are generally placed on the table or in a receptacle (tray, box, etc.) adjacent to the worker so another worker can conveniently gather the leaves for baling and do other support tasks. The receptacle can be a small device to hold a large handful of leaves for small bale (nominally 12" x 36" x 24") preparation. For handling into the new big bales (nominally 42" x 42" x 40"), larger plastic hampers, heavy duty cardboard boxes (up to 40 and 48 inches such as vegetable bins) or "burlap sheets" are being used to accumulate leaves of each grade prior to "big baling."

The accumulation of bare stalks at the end of stripping are periodically carried to a separate wagon, manure spreader, or similar vehicle for later transport to a field for spreading and disposal. Stalk choppers and conveyors for removing the stalks have been adapted by some producers. A prototype design is now under development.

Another manual method of hand stripping is for each worker to remove all grades from a plant, place the leaves in separate receptacles and the stalks in a "stalk rack." Other workers collect and carry the leaves and stalks to appropriate boxes, sheets, balers or wagons. This method makes the distribution of unstripped plants and collection of bare stalks more cumbersome as well as requiring efficient handling of the various grades of stripped leaves from each person.

With the introduction of non-oriented leaf packaging via the "big balers" (see later section on "baling"), innovative mechanical stripping aid devices are resurging across the burley growing regions. The advantage of these mechanical devices is that stalks are conveyed past the workers who then can use both hands (in most cases) for faster removal of leaves from the stalk. Such aids include devices like: the "stripping wheel" which conveys stalks upright in "cups" in a circle so workers can remove each grade; the single chain linear conveyor with cups attached for conveying upright stalks past the workers; the "dual chain" stick conveyor (dubbed by the originator as the "Stripping Line") which conveys sticks with plants still hanging on the sticks past workers who remove each grade and a horizontal mating-corrugated-belt-chain conveyor that grips the base of the plant for conveying upright plants past the workers. While accurate data on the performance of all these various innovations is not fully available yet, stripping wheel studies in the 1990s showed a 30–40 percent increase in stripping productivity for a 5-6 worker crew. Other devices have shown benefits to the farm managers and crews using them. These different devices have characteristics that dictate the minimum and maximum number of workers that can work efficiently with the device, some with 4-5 workers and others with 10-12 (see the BAE web site for videos and more information) The keys to increased productivity with these devices are that each worker must perform efficiently within the "team," the tasks are reasonably balanced or staged as to time required per worker-task, and the flow of tobacco and stalks in and out is smooth and efficient with minimum human handling distance.

One mechanical stripping machine has been demonstrated at recent field days, and another is known to be under development (see section Update on Burley Harvest and Stripping Mechanization).

Stripping Dark Tobacco

A fully mature dark tobacco plant will have 16–18 leaves. Dark tobacco (fire-cured and air-cured) has traditionally been sorted into 3 grades at stripping. These grades include lugs (3–6 leaves showing some ground injury from the lower portion of the stalk), seconds (4–6 leaves from the middle portion of the stalk), and leaf (4–6 leaves from the upper stalk). In addition, separate grades should be kept for "trash" and "green." The trash grade is leaves from the bottom of the stalk that show excessive ground injury and the green grade is leaves from anywhere on the plant that show an excessive green cast appearance or that have dark green areas from sunburn in the field. Many marketing contracts will only support lug, second, and leaf grades and will not support trash and green. Refer to marketing contracts for specific stripping and grading specifications.

Baling

The small conventional bale of oriented leaves with air cylinder compression in wooden-boxes (nominally 12” x 36” x 24”) has been the industry standard since the 1980s. A dark tobacco version with varying width boxes and a “pre-flake” box was developed in the early 1990s. During the 2005 season, a “big baler” system originally developed for use in flue cured tobacco was introduced by the buying industry to make 500-600 pound burley bales in a steel fabricated chamber (nominally 42” x 42” x 40”) using hydraulic cylinder compression (see BAE web site for an example operation). The use of the “big baler” was quickly adopted by several larger producers, some with cost sharing funds. Detailed labor studies are under way to evaluate potential labor savings of big bale packaging. Comprehensive data records kept by the U. K. Woodford County Research Farm Manager show a 26.6 percent increase in productivity per labor hour for bulking, stripping, and “big baling” 66,842 pounds into three grades in 2005 compared with similar production in 2004 and previous years of small bale packaging (see BAE web site for data).

The hydraulically operated big balers can be powered by a 230 volt electric motor or remote tractor hydraulic connections. The tractor power provides a lower cost baler and permits movement to various barns and stripping room locations where 230 volt power may not be available. The big balers have optional load cells and an electronic display to show the weight of leaves in the chamber thus permitting desired bale weights. Big balers can receive non-oriented (“tangled”) leaves, which presents new options and opportunities for mechanically removing and handling leaves from stalks when stripping as discussed above.

No studies have been reported yet as to whether any difference exists in the maximum or minimum moisture content of leaves that can be baled, thus similar management of leaf moisture for baling is important. The delivered big bales are tested by the same electronic equipment as small bale stacks for moisture content. The upper level of acceptable moisture content is specified by each buying company. Great compressive force of the hydraulic system (10,000–15,000 pounds at the press head) is required to apply compression over the large surface area of leaves. Over-compression of high-moisture leaves can lead to “caking” and “bruising” if the quantity placed in the chamber is not limited to specified weights, thus showing the benefit of the extra cost for the electronic scales.

The larger mass of leaves and longer moisture diffusion flow path of the big bale from the inside to the outside supports the theory that big bales will not equalize with the surrounding environment as quickly as small, oriented leaf bales, thus they cannot be expected to “dry out” or “cool down” as rapidly as similar high moisture content small bales. Big bales of 500–600 pound weight have essentially the same mass density as the small 80-90 pound bales, therefore they are not automatically more open to ventilation, moisture diffusion and/or migration. Further, the cardboard liner partially enclosing these bales may limit effective air ventilation from about 40 percent of the bale surface. Thus, the moisture content of leaves going into the big balers should be below the acceptable level of marketing for safe storage and subsequent marketing. Big bales that are rejected for too high moisture content are more difficult to “dry down.” The big bale cannot be as easily opened and flaked apart to facilitate drying even though some producers are finding it necessary to remove the wire ties and spread the tobacco out for drying and later re-baling.

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Update on Burley Harvest and Stripping Mechanization

George Duncan, John Wilhoit, and Larry Wells

The opportunity for burley producers to grow more tobacco after buyout legislation and the increasing shortages of labor for harvesting and stripping has prompted a resurgence of interest in burley mechanization options. Several commercial burley harvesters were demonstrated and a new experimental model was on display at Philip Morris USA-sponsored field days the past two seasons at the Roberts' farm near Pleasureville, Ky. Another experimental harvester was also demonstrated in Kentucky this past season. Several innovative stripping aids are also under development and emerging from stripping rooms around the burley belt. Ongoing work will certainly offer additional developments and innovations in the coming seasons. This article summarizes the status of equipment demonstrated or under development during recent years.

Automated Harvester

The former "Big Red" self-propelled, automated harvester developed during the last decade by University of Kentucky Agricultural Engineers is now being commercially manufactured as the "GCH Gold Standard" by GCH International[1] of Louisville. The machine is capable of harvesting up to five acres per "normal" day but could extend harvesting into the night time for additional production. Sturdy 8 x 14 ft. metal frames receive and support approximately 448 plants in the eight slotted rails of each frame. Approximately 15-16 frames are required per acre of harvested burley. Five empty frames are loaded onto the harvester at a time using an extended reach all-terrain forklift. A filled frame is set off the harvester on self-contained support legs. Later, the extended reach all-terrain forklift moves the filled frames to a sod area for covering with special poly tarps and curing. Two workers are required for the harvest, one to drive the harvester and the other to operate the forklift. Additional labor is required for moving and covering the frames. Two commercial prototypes harvested more than 80 acres each during 2007 at maximum rates of up to 0.5-0.75 ac/hr.

Plant-Notching Harvesters

A plant-notching harvester is being built by MarCo Manufacturing Co. LLC[1] of Bennettsville, SC. It is a tractor-mounted 3-point hitch machine powered by a PTO driven hydraulic system that cuts, notches and conveys the plants via the traditional "sticker chain" design onto a wagon pulled alongside the machine.

A French manufacturer has also developed a 3-point hitch plant-notching harvester that is powered by a PTO driven hydraulic system. This machine, called the "Kirpy" harvester[1], uses a small "log chain" type conveyor with small spike-laden metal plates that convey plants from a standing position to deposit them horizontally onto a flat bed wagon pulled alongside the harvester, as with the Marco harvester. A special requirement experienced by the trial users of the Kirpy harvester in the U.S. is that the tractor must have a very slow "creeper" ground drive (0.6–1.0 mph) while running the PTO near 540 rpm for proper hydraulic flow and pressure. The Kirpy machine was marketed by a U.S. distributor[1] in 2006. Current distributor status is unknown.

Both the MarCo and Kirpy harvesters can fill a farm wagon rather quickly with loosely stacked plants, usually in 400-500 feet of row length. Multiple tractor and wagon units (probably 3 or more) are needed to shuttle wagons from the harvester to the wire type field curing framework to get maximum productivity of the harvester of approximately 2.0–2.5 acres or more per normal day.

Walk-Behind Powered Cutter

Another machine demonstrated at the field days was a walk-behind powered cutter. This machine is also produced by a French manufacturer. The two-wheeled machine cuts and notches the plants and lays them on the ground for later pick up, either for hanging on wire-strung structures or for spearing onto on sticks. This harvesting aid may be a viable low cost mechanization option for smaller operations. Note, however, that since the only commercially available machine of this type is manufactured overseas, the shipping costs can nearly double the machine's price.

Burley Stalk-Spearing Machine

A self-propelled burley stalk-spearing machine developed and tested by University of Kentucky Agricultural Engineers a decade ago has received renewed interest because of labor availability concerns. This "Burley Spiker," which uses two workers (one to grasp plants cut by a saw blade and place them on a conveyor, and another to place filled sticks of tobacco on the ground), keeps the tobacco on the stick so it can be used with conventional stick and barn resources. It was used by one farmer in 2007 to harvest his six acre crop in Anderson County, Ky., and demonstrated at a field day there.

The "Spiker" and the walk-behind powered cutter are both harvesting machines that are more likely to benefit smaller producers because they do not necessarily reduce harvest labor requirements, but instead make the difficult job of harvesting tobacco less strenuous. Such an improvement in working conditions could be an important consideration related to the availability of labor for harvesting operations.

[1]More details on the equipment described and manufacturer's contact information can be obtained from the web site: www.bae.uky.edu/ext/tobacco.

Prototype Rail Harvester

A new machine for harvesting burley is under development by the University of Kentucky Biosystems and Agricultural Engineering Department. The new experimental system is similar in function to the automated harvester, but involves a tractor-drawn harvester that cuts, conveys, inverts and notches whole burley plants. Notched plants are inserted into slotted steel rails, 10 feet long, holding 40 plants each. Ten filled rails are unloaded on-the-go by the harvester onto the ground. A tractor-drawn retriever/transporter picks up the ten-rail "loads" and transports them to field curing structures. The rails are unloaded upon and supported by such structures with later covering for rain and wind protection. Preliminary estimates indicate an approximate harvesting capacity of 0.3 acres per hour for two workers.

High Tensile Wire Field Curing Structure

The MarCo and Kirpy machines require a high tensile wire field structure for hanging the plants for curing. Strong construction is essential, as several hurriedly built frameworks have partially failed after loading.

Several workers (possibly 8-10) are needed at the high tensile wire framework to unload the wagons quickly enough to keep up with the harvesting machines and maintain continuous harvesting operations. Thus, a total "crew" of 11-13 workers is needed to harvest 2.0 acres or more per day. An advantage of this method is that the workers are only handling one plant at a time rather than a heavy stick of 5 or 6 plants, and the plants are hung only at a single, low tier level. Thus, hanging operations are considerably less strenuous than with traditional stick hanging. All structures should have some form of plastic cover to protect the tobacco from rain and wind during the cure. The leaf breakage from piling the plants onto the wagon and removing them appears to be somewhat greater than normal manual harvest depending on the condition of the tobacco at harvest and worker care in removing tangled plants from the wagonload. Further studies are needed to determine the extent of leaf breakage and whether improvements can be made to reduce the breakage.

Mechanical Stripping Aids

An experimental, mechanical-leaf-removing stripping machine under development by Carolina Tobacco Services[1] was demonstrated at the tobacco field days. It uses "sticker" type chains that hold the plants hanging vertically downward, conveying them past angled wiper bars that strip off leaves as the plants move through a length of 14-16 ft. Different leaf grades fall into boxes below the plants along that length. Plants can be placed into the chains with either the tip or butt ends up. Leaf removal has been observed to be better with the tip end up, but the tip end is smaller and weaker, so the stalks are more prone to pulling out of the chains. Also, workers must remove 2-3 tip leaves prior to inserting the stalk tip in the chain teeth. Stalk release and removal still needs improvement. Another stripping machine concept is under development the University of Kentucky Biosystems and Agricultural Engineering Department.

Several innovative mechanical stripping aids are emerging from past research and current producers. Stalk choppers and conveyors for removing stalks from the stripping area are also under development.

The use of the stripping-wheel aid and several chain conveyor configurations are part of these mechanical stripping aids. These stripping aids enable the workers to remove leaves more rapidly with both hands while the plants are being conveyed past them. The opportunity for putting non-oriented leaf into the big bales has enabled these aids to become more efficient and productive. One or two workers pick up and insert plants into the conveyor devices, maybe removing the lower grade first, with the additional workers removing additional grades. Another worker removes, stacks, and/or carries the stalks to a wagon or truck bed for periodic disposal. Or, the stalks are directed into a stalk chopper mechanism that chops and conveys the particles into a hopper wagon or similar transport and self unloading vehicle for field distribution or other uses.

Some of these mechanical stripping aids are being built for commercial sale. Videos of operation and some sources of equipment are shown on the BAE tobacco web site. Data on performance and costs are being obtained and will be available later in 2007-2008. Check the BAE web site for periodic updates.

More details on the equipment described and manufacturer's contact information can be obtained from the web site: www.bae.uky.edu/ext/tobacco.