Management of Tobacco Float Systems

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The true value of a quality transplant lies in its potential to produce a high yielding plant at the end of the growing season. While good quality transplants can still result in low yields if fields are poorly managed, high yields are even more difficult to rescue from poor-quality transplants.

Many tobacco growers have the knowledge and skills necessary to grow good quality transplants, but some do not have the time to do the job well. For them, 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, but that does not mean that purchased plants are always better quality than those grown on farm. Transplant buyers should consider carefully the reputation of the transplant producer, ask questions about their management practices, request spray records for the purchased portion of the crop, and carefully inspect transplants upon delivery.

Transporting live plants over long distances increases the risk of spreading certain plant diseases more rapidly than would occur under natural conditions. Transplants may be infected with a disease even though they appear healthy at the time of delivery. If you choose to purchase transplants, working with a local producer is strongly recommended to minimize the risk of introducing diseases, such as blue mold or tomato spotted wilt virus, and to help stimulate the local farm economy.

For growers who choose to produce their own transplants there are three general systems to consider: plug and transfer in unheated outdoor float beds, direct seeding in unheated outdoor float beds, and 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 use more than one system; for example, seeding in a heated greenhouse and moving plants to an unheated bed after germination.

The US Tobacco Good Agricultural Practice (GAP) Program requires complete records for all transplants used, regardless of whether they were grown on your farm or purchased. Information to be recorded includes seed lot number, date sowed, and all chemical applications made during transplant production. If you purchase plants be sure to request this information from the transplant producer to include in your GAP records.

Tray Selection

Tray Types

Most trays used in tobacco float systems are made of expanded polystyrene (EPS), 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 by those who sell finished plants and have difficulty getting trays returned or are concerned about potential disease 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.

Trays made of a solid plastic material have been developed as an alternative to EPS trays. The plastic trays are designed to trap air beneath the tray so that it will float despite being much heavier than EPS trays. The expected advantages of the plastic tray are a longer useful life and potentially more effective clean-up and sanitation when compared to EPS trays. Potential disadvantages include the weight of the tray, plants falling out of the trays prematurely during transport and setting, and the initial investment cost of the trays. The trays that have been performance tested for the past two seasons match in size and cell number to the 288 cell EPS trays and can be used with most current seeding equipment. Plastic trays have only been available for a few years so the expected useful life of the tray or the impact on disease potential as the trays age have not yet been tested. Tests of new trays (both EPS and plastic) in the greenhouse show minimal difference in plant growth and usable transplant production (Table 2). No differences in field performance were observed for transplants grown in plastic float trays as compared to plants grown in EPS trays.

Tray Height and Cell Number

Trays may also differ in their height or depth measurements. 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 side-by-side comparisons, shallow trays had fewer dry cells, slightly lower germination, and slightly more spiral roots than regular trays (Table 3). There was no difference in the production of usable transplants. The field performance of plants produced in shallow trays has not been significantly different from plants grown in deeper trays. The advantages of the shallow trays include reduced amount of soilless media needed, reduced space for tray storage, and reduced volume of waste at the end of the tray's useful life.

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 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. Tray dimensions vary slightly from one manufacturer to another. Be sure that the tray you select matches the dibble board and seeder you will use.

Some float transplant producers try to maximize plant production per unit area as a means of lowering overhead production costs. Trays with a high cell number (338 and higher)

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

Table 2. Production of usable burley tobacco transplants in selected soilless media and tray combinations.

Brand of Media	Usable Plants (%)			
	EPS tray	Plastic tray 1	Plastic tray 2	Media Avg.
Carolina Choice	83.3	89.1	89.1	87.2
Promix TA	87.7	89.1	86.6	87.8
Southern States	84.8	90.5	91.7	89.0
Speedling Fortified	89.6	89.0	90.5	89.7
Sunshine Ag-Lite	87.3	88.5	91.6	89.1
Sunshine LT 5	83.8	86.0	89.7	86.5
The Gold	88.8	88.7	89.5	89.0
Workman's	83.1	88.0	89.4	86.8
Tray Avg.	86.1	88.6	89.8	

have been used successfully 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, growers are under less pressure to produce the maximum number of plants per square foot.

Tray Disposal

When trays have deteriorated to the point that they can no longer be reasonably cleaned and sanitized, they should be disposed of in a responsible manner. Burning trays is not recommended, as this can result in the production of noxious smoke. Disposing of used trays in an approved landfill is the best option if EPS trays are allowed.

Tray Sanitation and Care

A good sanitation program is critical for consistent success in the float system. For many of the diseases that are problems in float plants, sanitation is the first line of defense. Sanitizing trays is difficult because of the porous nature of polystyrene. As the trays age, they become even more porous. With each successive use, more roots grow into the tray, which allows pathogenic organisms to become embedded so deeply that they are difficult to reach with sanitizing agents.

Cleaning and Storage

Field soil is often infested with soil-inhabiting pathogens that cause diseases in the float system. After trays have been used to grow a crop of transplants and been taken to the field for transplanting, they may become contaminated if the trays came in contact with soil. Trays should be rinsed off immediately after transplanting to remove any media, plant debris, or field soil.

The surest way to reduce the risk of diseases carried over in trays is to purchase new trays each season. Previously used trays, which may be contaminated with pathogens, should be rinsed prior to fall storage and disinfected just before seeding in the spring. They should be stored indoors out of direct sunlight. Do not store trays for long periods of time in a greenhouse, where ultraviolet light and heat will cause deterioration and damage. Avoid storing sanitized trays in areas where trays may come into contact with soil or debris, or cover trays with plastic or a tarp. Take appropriate steps to protect trays from damage due to the nesting of small rodents and birds.

Tray Sanitization

EPS trays become more porous as they age, often leading to increased problems with disease carryover in older trays. Effective tray sanitation means the disinfecting agent must reach the resting states of pathogens in all the tiny cavities throughout the tray. Steam, chlorine bleach, and quaternary ammonium chloride salts are available disinfectants. None of these disinfectants can completely eliminate pathogens in contaminated trays, and each has positive and negative points, as discussed below.

Table 3. Greenhouse performance of float trays.

Tray type	Dry Cells (%)	Germination (%)	Spiral Root (%)	Usable Plants (%)
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.

Steam has been shown by university studies to be an effective way to reduce potential plant pathogens in used EPS trays. Steam sterilization of trays is especially recommended for commercial transplant producers. Steaming trays to a temperature of 160 to 175°F for at least 30 minutes has been demonstrated to successfully reduce disease problems in used trays. The key with all steam or high temperature treatments is to achieve and hold the desired temperature through the middle of the stack of trays for the duration of the treatment. EPS trays exposed to temperatures above 180°F may begin to soften and become deformed.

In actual practice, results with chlorine bleach have been varied, often due to poor technique. Research has shown little benefit of using more than 1 part bleach to 9 parts water (10% solution). Any commercially available household bleach can be used to make the sterilizing solution. Industrial-type bleaches cost more and don't add any additional benefit. Bleaches work best when the trays are first washed with soapy water, then dipped several times over a few seconds into clean 10% bleach solution, and covered with a tarp or plastic to keep them wet with the bleaching solution overnight. Because organic matter reduces the effectiveness of bleach over time, a fresh solution should be made up every two hours or whenever it becomes dirty, whichever comes first. After the overnight exposure period, the bleach solution should be washed from the trays with clean water or water plus a quaternary ammonium chloride salts product, followed by aeration to eliminate any residual chlorine. Without proper aeration and post-washes, salt residues can cause serious plant growth problems, especially with older trays that tend to soak up more materials. Worker safety issues are also an important consideration when working with bleach. Workers should be provided with appropriate personal protective equipment to minimize eye and skin contact with bleach. Bleaching of trays should be done in a well-ventilated area.

Quaternary ammonium chloride salts and other types of cleaners such as Greenshield, Physan-20, and CC-15 have been shown to be effective for cleaning and disinfecting hard surfaces in and around greenhouses. They are less effective in reducing pathogen levels in porous EPS float trays. In university tests, they have always provided some control as compared to using soap washes only, but they have typically been inferior to steam or bleach for sanitizing trays. These products do not damage trays like steam, are less corrosive to greenhouse surfaces than bleach, and are less irritating than bleach for workers. They are also less toxic to plants than bleach, so the greatest benefit for these products may be in the final tray rinse following bleach sanitation. These products can also be used on exposed surfaces in the greenhouse. Follow the product label for directions for proper dilution rates.

Water Quality

Untreated surface water may contain disease-causing organisms and should never be used for growing float plants. Treated water from most municipal and county water systems has been found to be suitable for use in the float system, although 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. 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 milli-siemens/centimeter (mS/cm) or alkalinity above 180 parts per million suggest the need for a complete water analysis. Water source analyses for plant growth are available from most labs that provide soil tests. In rare situations water quality problems may be severe enough to warrant switching to a different water source. For more information on water quality for float beds, see University of Kentucky Cooperative Extension publication AGR-164, *Water Quality Guidelines for Tobacco Float Systems.*

Media Selection,Tray Filling and Seeding

Media Types

The three basic components of soilless media used in the float system are peat moss, perlite, and vermiculite. Peat is the brown material that is used in all soilless media to improve 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 others (Table 2). 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.

Filling Trays

Careful attention to tray-filling procedures will minimize the occurrence of dry cells and spiral roots. In most cases, 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 up to the top of the cell, 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 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 sticks and clumps. If media is falling out the bottom of trays, you may need to add 1 or 2 quarts of water to each bag of media prior to tray filling. Wait 24 hours, if possible, to allow time for moisture to evenly adjust.

Each year, there are a few cases in which large groups of trays fail to wick-up water after a reasonable period of time. Many of these situations 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 leftover media should be avoided if possible; however if it is known that the media is old, try adding 2 or 3 quarts of water per bag at least a day before seeding. It is also a good idea to keep an intact empty bag or to record the lot numbers from the bags of media used, as this information can be very helpful in tracking down the source of problems. Before seeding the entire bed or greenhouse, it may also be a good idea to fill and float a few trays the day before seeding to evaluate how well media will wick.

Often wicking can be seen within 5 to 10 minutes of floating trays. It should never take longer than 1 to 2 hours after floating for wicking to occur. For mild wicking problems where dry cells are slightly above normal, misting trays over the top for 10 minutes or so per 1000 ft^2 of float bed (400 trays) using the fine mist setting on a nozzle attached to a garden hose can sometimes help improve wicking. Be sure to use the fine mist setting and not large droplets so seed are not dislodged from cells. Placing objects such as boards on trays in order to push the tray down further into the water can also help improve mild wicking problems. If dry cells are much over about 10%, these methods will provide little or no improvement. If fresh media is used, trays should wick well and none of these methods should be needed.

Seeding

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 so that the dibble mark is as close as possible to the center of each cell. The dibble should be a half- to three-fourths-inch 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 you have. There are slight differences in the dimensions of trays from different manufacturers. If the seeder is not matched to the tray, seeds might be placed near the edge of the cell and will be 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 the dibble or on the side of the dibble mark are more likely to experience problems with germination or spiral root.

Spiral Root and Germination Issues

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). Spiral root 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. The burley variety

Figure 1. Spiral root of a burley tobacco transplant.

KY 14 x L8 and the dark variety Narrowleaf Madole typically have a higher incidence of spiral root than other varieties, regardless of other factors.

The incidence of spiral root has decreased in recent years, due in part to changes made to the pellets by some tobacco seed companies. Nevertheless, spiral root can still be an occasional problem that results in a significant reduction in usable plants. To minimize spiral roots, 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.

If spiral root seedlings 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 in Virginia has suggested that in many cases all that is needed is slight jarring of 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, most likely due to the shaking of the tray while transporting.

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 can be 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. The use of 20-20-20 should be avoided due to the low nitrate content, high urea content, and comparative high phosphate content.

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, such as 20-10-20, 16-5-16, 15-5-15, 13-2-13, 16-4-16, etc. Some growers add Epsom salts ($MgSO_4$) to the float water; however, research has shown it to have little impact on the health and growth of transplants. Foliar application of any fertilizer to float plants is not recommended, as moderate to severe leaf burn can result.

Adding Fertilizer

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

Delaying the addition of fertilizer until a few days after seeding minimizes the risk of salt damage to young seedlings. When adding fertilizer or chemicals to an established float bed, the water should be circulated for 2 to 4 hours depending on the size of the bed to ensure even distribution. 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, then moved into the bed to provide circulation for mixing. Pumps and hoses should be sanitized with an approved greenhouse disinfectant to avoid spreading diseases between beds. The addition of fertilizer should not be delayed by more than 7 to 10 days after seeding, or a lag in plant growth may result.

Determining the Amount of Fertilizer Needed

Over-fertilization of float plants is a common mistake. The recommended level of fertilization is no more than 100 ppm nitrogen. This is equivalent to 4.2 pounds of 20-10-20 or 5.6 lb of 15-5-15/1,000 gallons 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 diseases such as target spot.

Monitor Fertility Levels

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 easily a current passes through a solution. The higher the salt content of the solution, the greater the current. Conductivity meters need to be calibrated periodically to ensure proper operation. Check the instructions that came with the meter or visit your county Extension office for help calibrating. Some of the newest meters require a specific solution that must be purchased from the manufacturer be used for calibration, so carefully read the instructions. To use the meter, measure the reading of your water source before fertilizing. Most water sources have a conductivity of between 0.1 and 0.5 mS/cm before fertilization. However, water with conductivity levels above 1.2 mS/cm may become too salty for optimum plant growth after fertilizer is added. Calculate the amount of fertilizer needed for the bed. Add the fertilizer to the bed and mix thoroughly before reading again. Readings can fluctuate for as much as 12 hours after adding fertilizer. The reading should go up by 0.5 to 0.9 mS/cm compared to the unfertilized water, depending on the type of fertilizer used. For the most commonly used 20-10-20 formulations, the reading increases by 0.3 mS/cm 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 with interpretation of conductivity readings. Some conductivity charts are listed in units of mmhos/cm which are the same as mS/cm.

Climate Control and Temperature Management

Tobacco seeds germinate best around 70 to 75°F. However, a slight fluctuation between nighttime and daytime temperatures may be beneficial for optimum plant growth. While cooler temperatures tend to slow germination and growth, higher temperatures are potentially more damaging to newly emerged seedlings. Temperatures that exceed 90°F may cause uneven germination and predispose plants to temperature stress. Young seedlings at the two- or three-leaf stage will often have scorched appearance on the leaf tips with a pale/translucent appearance to the body of the leaf after two or more hours of exposure to temperatures in excess of 100°F. A good rule is that if it's too hot to work in a greenhouse, it's too hot for the plants. Temperatures 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.

Temperature Stresses

Chill injury can result when plants that have been exposed to high temperatures are then exposed to cooler air. Chill injury can also result from significant but normal swings of 25 to 30 degrees between daytime and nighttime temperatures. Burley tobacco is much more susceptible to chill injury than dark tobacco. Symptoms of chill injury 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. Chill injury may be most apparent in trays located on the outside walls of greenhouses. If severe bud damage occurs, sucker bud initiation may occur as the bud can no longer 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 that may result in plants with multiple stalks that are difficult to harvest and produce poor quality tobacco. Maintaining an even temperature that doesn't fluctuate too drastically can help reduce chill injury and potential ground sucker problems.

Monitoring and Regulating Temperatures

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 CFMs, or cubic feet per minute. Typically a greenhouse used for tobacco float plant production should have enough fan capacity to exchange three-fourths to 1 times the volume of air in a greenhouse per minute. Two fans allow for the ventilation to be staged so that the first fan 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. They should have an opening 1.25 to 1.5 times the size of the fan. Motorized shutters are best and should be on a thermostat set at 2 to 3 degrees cooler than the fans, so that they open before the fans come on. Alternatively, fans may be set on an 8- to 10-second delay, which will accomplish the same thing. To reduce chill injury damage, locate fans and shutters at least 3 ft above the plants to minimize drafts and improve the mixing of cooler air with the warmer air inside the greenhouse. Baffles can be used inside to deflect cool, incoming air up and away from the plants.

Side curtains (walls) allow 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 warm, sunny day. If no one is available to make sure the 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. For the most control of the growing environment, both fans and curtains are recommended. A side curtain should, at its maximum, provide 1 ft of vertical opening per 10 ft of greenhouse width. A typical 36-ft-wide greenhouse may have a 3-ft side curtain that will drop 2 ft but may have 1 ft of plastic hanging down over the side, providing only 1 ft of effective ventilation. The best system would have a 5-ft side wall that could be opened to 3.5 to 4 ft to meet the required guideline for ventilation.

For more information, please see Kentucky Cooperative Extension publication 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. Water droplets can dislodge and fall to the trays, disturbing seeds and seedlings and knocking soil out of cells, which results in stand loss. High humidity also favors the development of disease problems, and can 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.

Sources of humidity in float systems. Excessive humidity is more common in greenhouses than in outdoor float beds, which tend to be well ventilated. 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 gas or propane. Non-vented heaters will generate more humidity than vented heaters, 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.

Regulating humidity. 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 or cracking a side curtain open pushes warm, humid air out of the greenhouse, replacing it with cooler, less humid air. The exchange of air can reduce condensation problems that tend to escalate as the inside air cools. This process will take only a few minutes of fan time to complete, but many producers are reluctant to use this method due to the cost of reheating the cooler air. The benefits often 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. Many tobacco greenhouses have enough on-going air leakage around doors, curtains etc. that this one air exchange is sufficient to control moisture problems.

In greenhouses that are sealed very tight, additional air exchanges during the night or at daybreak may be necessary to control moisture problems. Using fans for nighttime or early-morning ventilation is generally safer than lowering side curtains due to possible injury from the sudden influx of cool air, though cracking a side curtain on the leeward side of the greenhouse is also an option for air exchange. Once the humid air has been exchanged, the fans (or curtains) should be switched back to automatic for temperature control.

Protecting plants from condensation. Other methods may be used to protect plants from the direct 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 for the roof 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 plants from dripping. With this method three common problems occur: (1) the plants get too hot, (2) plants 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 (about dime size) to protect the cell from damage. There are also some commercial materials available that can be sprayed on interior surfaces of greenhouses to reduce surface tension in order to help water roll off the sides rather than drip.

Circulation Fans

Circulation fans are primarily designed to circulate air and prevent formation of hot and cold zones that could cause condensation and influence plant growth. Circulation fans should be located approximately 40 to 50 ft. apart, one-fourth of the house width from each side wall, and about halfway between plant level and the highest point of the roof. Ideally circulation fans on each side of a greenhouse should point in opposite directions to create a good circulation pattern and should be set to turn off when the ventilation fans are on. Circulation fans should not be pointed down at a sharp angle or they can increase evaporation on the tray surface and potentially increase salt accumulation at the soil surface, affecting germination and plant growth. An elliptical pattern of abnormal growth or injury across several trays and in front of a fan is generally an indication that a circulation fan is positioned at too steep an angle.

Circulation fans are also important in maintaining optimum temperatures at plant level. Since warm air rises, circulation fans help to direct warm air down toward the plants. A greenhouse without circulation fans or with circulation fans turned off may have temperatures 15 to 18 degrees lower at the plant level than just 4 ft. above the plant level.

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 significantly, nor does it contribute to early blooming or ground sucker formation.

Procedures for Proper Clipping

When clipping is done properly, it actually aids in disease control by opening up the plant canopy to allow for greater light penetration and improved air circulation around the plants. Clipping equipment must be sanitized to avoid spreading diseases. 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. Disinfection between individual beds and greenhouses will reduce the potential for spreading disease.

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 mower 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 of certain diseases. A dull blade may tear the leaf, which may not heal properly as a result. 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 at least 100 yards from the transplant production facility to minimize the spread of diseases such as *Sclerotinia* collar rot. Gasoline-powered reel-type mowers have been used successfully for clipping plants. This type of mower tends to make a clean cut, producing large pieces of intact leaf and depositing them in a catcher with little or no grinding. Rotary mowers, however, may be easier to adjust and maintain. An improperly maintained or adjusted mower may result in improper clipping that could injure plants, reduce vigor, and promote disease development.

Timing and Frequency of Clipping

The first clipping is usually the most beneficial, and direct-seeded float plants should be clipped for the first time when the plant buds are approximately 1.5 to 2 inches above the tray surface. The cut should be made approximately 1 to 1.5 inches above the bud and ideally should remove no more than a 0.5 to 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 before clipping. After the first clipping, plants should be clipped every five to seven days, depending on growth rate. Clipping frequency should be timed to remove no more than a half inch to 1 inch of leaf material at a time. Clipping too much leaf material in one pass increases the amount of debris deposited on leaves and may enhance disease development. Two passes may be necessary in cases of rank growth between clippings. Four to six clippings may be necessary to achieve the best plant quality. Seldom are more than six clippings necessary unless field planting is delayed due to weather. However, plants produced in trays with smaller cells (338) may require more frequent clipping. Plants that need to be held for some length of time before transplanting can be clipped additional times 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. Plugged plants should be clipped for the first time approximately one to two weeks after plugging (as soon as the roots have established). The same guidelines that apply to clipping direct-seeded plants apply to plugs. Plugged plants should only require two or three clippings unless setting is delayed.

Pest Control in Tobacco Float Beds

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

Pesticides are useful tools for managing certain pest problems on tobacco seedlings. Many of the pesticides that are labeled for tobacco in the field, however, can't be used in float beds. Check labels carefully to make sure that the products you intend to use are cleared for tobacco and are approved for use in greenhouses and outdoor float beds.

Several products containing the active ingredient acephate are labeled for use in float systems. Orthene 97 is labeled to use in tobacco greenhouses at a rate of ¾ Tablespoon in 3 gallons of water to cover 1000 square feet of bed surface area. Float water from treated beds should be disposed of on tobacco fields either as spray water or transplant barrel water. Generic products containing acephate may also be labeled for this use but with different use rates, consult and follow the label directions for all products used. The use of some Bt products such as Dipel may also be allowed for caterpillar control in greenhouses at rates of ½ to 2 teaspoons per gallon.

Management of Insect Pests

A variety of insects and other organisms that live in water or moist organic matter can cause problems or damage seedlings in the float system. Algae on the media surface and organisms that can grow in float water provide food for fungus gnats, shore flies, bloodworms, mosquito larvae, and waterfleas. Pillbugs, and even some scavenger beetles, can burrow into media, while slugs, cutworms, thrips, and aphids can feed on developing plants. Insect pests can uproot or eat and destroy many seedlings in a short period of time. In most cases, it is easier to prevent infestations that to control them once they have started. Regular inspection is necessary to catch developing problems before serious damage occurs.

Cultural Controls are Essential

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

- Keep doors, screens, and ventilators in good repair.
- Use clean or sterile media.
- Maintain a clean, closely mowed area around the greenhouse or float beds to eliminate shelter for insect pests.
- Eliminate pools of standing water on floors, and open water in float beds. Algal and moss growth in these areas can be sources of fungus gnat, shore fly, and mosquito problems.
- Remove all plants and any plant debris; thoroughly clean the greenhouse after each production cycle.
- If possible, keep the greenhouse open during the winter to eliminate tender insects like aphids, gnats, and whiteflies.
- Avoid overwatering and promote good ventilation to minimize wet areas conducive to fly breeding.

Bloodworms, Flies, Gnats, Mosquitoes, and Waterfleas

Bloodworms. Bloodworms are the small, red wriggling worms that live in float water green with algal growth. The red color comes from oxygen-carrying hemoglobin that allows it 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 bottom of float trays, but they do not feed on them. These insects are similar to mosquitoes, but the adults (gnats) do not feed on blood or plants.

Shore flies. Shore flies also are small gnats with short antennae; heavy, darker bodies; and a pair of smoky wings with several distinct clear spots. They rest on plant foliage or most any surface around the float beds. The shore fly's life cycle is similar to that of the fungus gnat. The maggot-like yellow to brown larva is up to one-fourth-inch long and does not have a distinct head. Both the larva and adult feed mostly on algae, but occasionally a larva will bore directly into the base of a small plant. These plants will break easily at the soil surface. The adults do not feed on plants, but may spread soil pathogens that stick to their body as they crawl over media and move from tray to tray.

Fungus gnats. Occasionally, fungus gnat larvae can be serious pests. The legless white larvae with distinct black heads are scavengers that live and feed in decaying organic matter. Occasionally, they will chew on root hairs, enter the roots, or even attack the stem or crown of the plant. Damaged or infested plants grow poorly and may die.

The adults are small (one-eighth inch) black flies with long legs and antennae, tiny heads, and one pair of clear wings. Females lay tiny ribbons of yellowish-white eggs in the growing media that hatch in about four 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 three to four weeks.

Mosquitoes. Standing water in empty float beds can be a breeding site for large numbers of mosquitoes. In addition to being a painful nuisance, some of these mosquitoes can carry West Nile virus or types of encephalitis. If float water stands for more than a week after trays have been removed, mosquito dunks or granules containing Bt-i (*Bacillus thuringiensis israelensis*) should be added according to label directions. Mosquito dunks are not labeled for use while plants are on the water.

Waterfleas. Waterfleas are very small crustaceans that swim through the water with jerky movements. They are common in many temporary water puddles during the summer and can accidentally end up in float water. They feed on a wide range of small organisms that live in the water, especially algae. They are harmless, but massive numbers may cause concern.

Reducing Fly/Gnat Problems. Eliminate wet areas and standing puddles and provide good drainage in and around greenhouses or float beds. Have a minimum amount of exposed water surface. Using empty trays to fill the bed so open water is not available will reduce egg laying by mosquitoes and gnats.

Regularly clip grass along bed margins so these areas can dry quickly. Avoid letting clippings get into float water. They can provide food for gnats, etc.

Excessively wet media in trays attracts 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 fungus gnats or shore flies. 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 both species. However, they do not reach 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 destroy small plants as they begin to grow. Slugs can enter from overgrown areas around the bed or may come from under plastic bed liners, stacked boards, etc. They feed at night or during overcast days and hide in cool, moist places when the sun is out. Their rasping mouthpart scrapes away at leaves and tender stems, producing holes or scars on the leaf surface. Slugs often leave behind silvery slime trails.

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. Slug baits containing iron phosphate or metaldehyde can be distributed along these areas, too. It is best to manage slugs before they get to the trays. Insecticides are not effective against slugs.

Cutworms

The variegated cutworm causes serious problems in some greenhouse or float systems almost every year. The adult (a moth) flies in mid-March and lays clusters of about 60 eggs on the stems or leaves of low-growing plants. The smooth, pale gray to light brown larva has a row of pale spots down the center of its back. This cutworm feeds for three to four weeks and is about 1.6 inches long when full grown. Since their eggs are laid in clusters, entire trays of plants can be destroyed 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 that point. 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 two 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. Excess outside lighting will attract moths to an area. Checking trays along bed margins regularly for feeding damage to leaves 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 live in decaying organic matter. They occasionally feed lightly on young plants, but the damage is minor. They do churn up and burrow into plant media, uprooting and killing small seedlings. Once they're in trays, it is difficult to control them. Their armored bodies protect 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, and other items resting on damp ground. They will also congregate in grassy or overgrown areas.

Reducing pillbug problems. Cleanup 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. Ventilation to reduce excess humidity also helps to lower problems with pillbugs and slugs.

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.

Green Peach Aphids

Green peach aphids can begin to build up when covers are removed or sides are opened to let plants begin to harden off before transplanting. Infestations start as winged aphids that 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 seven to 10 days after plants are uncovered and continue to check a few trays each week until transplant time. Look on the underside of leaves for colonies.

Acephate (Orthene, etc.) can be used for aphid control in greenhouses and outdoor float systems if transplant is greater than five days away. Catch infestations before they become too large to control effectively and direct sprays to the underside of the leaves. In situations where aphid infestations develop within five days of transplant and tray drench applications of imidacloprid are planned, this treatment can be applied and will control aphids prior to transplant. Imidacloprid should not be applied to plants in the greenhouse more than five days before transplant.

Thrips

Thrips are slender, tiny (0.04 inch), 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.

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.

Use screens on ventilators, inspect new material entering the greenhouse, and control weeds in the greenhouse to prevent and manage thrips.

Management of Diseases

General Information

The float system offers a number of advantages for growing tobacco transplants, but also creates ideal conditions for some important diseases. High moisture levels and high plant populations favor infection of roots and leaves by a number of plant pathogens. Prevention is the most important part of disease management in tobacco float beds.

The major diseases encountered in production of transplants in the float system are *Pythium* root rot, *Rhizoctonia* stem rot and target spot, Sclerotinia collar rot, and black leg or bacterial soft rot. Less common are anthracnose, damping-off (*Pythium* and *Rhizoctonia*), Botrytis gray mold, angular leaf spot, and virus diseases (such as tobacco mosaic). The following is a summary of recommended practices for the control of diseases commonly encountered in the float system. Lists of recommended fungicides (Table 4) and relative effectiveness of cultural and chemical practices against common diseases (Table 5) have been included.

Develop an Integrated Plan to Manage Diseases

Disease-free transplants pay dividends over the course of the growing season because they are more vigorous and less prone

Table 4. Guide to chemicals available for control of tobacco diseases 2015—transplant production.

Product(s) and (FRAC Code)	Product Rate Per Application[a]	Product Rate Per Season	Target Diseases	Label Notes
Agricultural Streptomycin (25) (Agri-Mycin 17, Firewall, Harbour)	100-200 ppm (1-2 tsp/gal H_2O)	no limit	angular leaf spot wildfire blue mold	Apply in 3-5 gal/1,000 sq ft. Begin when plants are dime-sized or larger.
Aliette WDG (P7)	0.5 lb/50 gal H_2O	1.2 lb per 1,000 sq ft	blue mold	Apply 3 gal of solution per 1,000 sq ft on small plants; increase to a maximum of 12 gal as plants grow.
Mancozeb (M3) (Manzate ProStick [CT, SC,OH, KY,NC,TN] or Penncozeb [VA])	0.5 lb/100 gal H_2O	no limit	blue mold anthracnose damping-off	Apply 3-12 gal/1,000 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			
Quadris (11)	0.14 fl oz (4 ml)/ 1,000 sq ft	0.14 fl oz (4 ml)/ 1,000 sq ft	target spot	Only one application prior to transplanting.
Terramaster 4EC (14)	Preventive: 0.7-1.0 fl oz/100 gal H_2O Curative: 1.0-1.4 fl oz/100 gal H_2O	3.8 fl oz	damping-off (*Pythium* spp.) root rot (*Pythium* spp.)	For prevention, apply to float-bed water at 2-3 weeks after seeding. Additional applications can be made at 3-week intervalsThe curative rates can begin no sooner than 3 weeks after seeding. Apply no later than 5 days before transplanting.
Oxidate 2.0	Preventative 6 to 24 oz/1000 gal H_2O	no limit	Pythium	Approved for use in organic production, Should be used preventatively.

[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 5. Relative effectiveness of recommended practices for tobacco transplant production as part of an integrated disease management plan.

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, low blade speed, and remove no more than ½" of foliar tissue at a time, all under conditions that promote rapid drying of foliage.

to attack by pathogens in the field. Use a 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.

Exclude Pathogens from Transplant Facilities

To avoid the introduction of plant pathogens into the float system, consider the following:

- Use well or city water to fill float beds. Surface waters (ponds, creeks, rivers) may harbor pathogens, such as *Pythium*.
- Keep soil and surface water out of float bays. Soil and surface water are key sources of *Pythium*, *Rhizoctonia*, and other plant pathogens. Cover dirt walkways with landscape cloth, gravel, or concrete. Keep trays out of contact with soil when removing them from float beds.
- Use new plastic liners for float beds each year, and avoid introducing natural soil into the bed by removing shoes before walking on new liners.
- Control weeds in and around greenhouses and outdoor float beds. Weeds interfere with ventilation and also harbor pathogens and insects.
- If using plugs, grow your own or purchase from a local supplier. Don't buy plugs or plants from sources in the Deep South to avoid the possible introduction of the blue mold pathogen.
- Don't grow vegetables or ornamentals in the same facilities where tobacco seedlings are being produced. Vegetables and ornamentals may harbor pathogens that can infect tobacco.

Make Sanitation a Routine Practice

Good sanitary practices during transplant production reduce the chances of introducing pathogens or carrying them over between growing seasons. Recommended sanitary practices include:

- Sanitize old trays or use new trays for each crop of transplants. Discard trays that are more than 3 to 4 years old, as these trays become porous and nearly impossible to sanitize thoroughly. A simple way to label trays by the year purchased is to spray paint a line down the stack of new trays; use a different color each year. See "Tray Sanitation and Care" in this article for details.
- Thoroughly clean plant residue from mower blades and other equipment, then sanitize with a solution of 1 part bleach to 9 parts water. Bleach solutions may be inactivated by excess plant material.
- Remove diseased plants before clipping to avoid spread to healthy seedlings.
- Promptly dispose of diseased or unused plants. Discard these plants at least 100 yards downwind from the transplant facility to minimize movement of pathogens from cull piles back into the float system.
- Clip properly to avoid buildup of leaf matter in trays, and remove excess material that collects in trays. Diseases such as black leg and collar rot often begin on debris and then spread to healthy seedlings.
- Wash hands and sanitize shoes before entering the transplant facility or handling plants.
- Avoid the use of tobacco products when working with tobacco seedlings.

Create an Unfavorable Environment for Plant Pathogens

Management of temperature and humidity are critical factors in the management of float bed diseases. Long periods of leaf wetness favor many pathogens, so keeping foliage as dry as possible should be a major goal. Take steps to manage soil moisture. Although transplants are floating on water continuously during the production cycle, plugs in properly filled trays are not waterlogged. Waterlogging of cells can lead to the development of disease problems, particularly as temperatures rise. The environment in float systems can be made less favorable for disease by employing the following guidelines:

- Maintain good air movement around plants through the use of side vents and fans.
- After the first clipping, keep water levels high enough for float trays to clear the side boards of the bays, allowing for better air movement.
- Avoid overhead irrigation and minimize potential for water splash between trays. Condensation that forms on cool nights can drip onto plants, wetting foliage and spreading pathogens.
- Avoid temperature extremes. Cool temperatures favor diseases like collar rot, while warmer temperatures favor target spot and black leg (bacterial soft rot).
- Don't over-pack trays with media, and dispose of trays more than 3 to 4 years old. Over-packed trays tend to waterlog easily, as do older trays, and disease risk increases in these cases.

Optimize Production Conditions

Improper fertilization or clipping can increase the likelihood of disease, particularly for pathogens that are common in the environment, such as *Pythium* or black leg bacteria. The following practices can help keep slow the spread of plant diseases.

- Keep nitrogen levels in float beds between 75 and 125 ppm. Seedlings are more susceptible to target spot when nitrogen drops below 50 ppm, and problems with black leg (bacterial soft rot) are most common when nitrogen levels exceed 150 ppm for extended periods. Excess nitrogen also promotes rapid growth that takes longer to dry and is more susceptible to disease. Over-fertilized plants also need to be clipped more frequently, increasing the risk of certain diseases.
- Clip properly (see "Clipping" in this article) to reduce the volume of clippings. Make sure the mower's blade is sharp to promote rapid healing of wounds. Clip plants when leaves are dry to reduce the risk of spreading disease.

Apply Fungicides Wisely

A small number of fungicides are labeled for use on tobacco in the float system. These products are aimed at *Pythium* root rot, blue mold, anthracnose, damping-off, and target spot. The remaining diseases can be managed only by cultural practices.

Fungicides need to be applied in a timely manner to get the best disease control in the float system. Products labeled for use in the float system and their rates are listed in Table 4. Do not use products that are not labeled for tobacco, or those that prohibit use in greenhouses. Guidelines for using fungicides against important diseases are listed below.

Pythium Root Rot

- Preventive applications of Terramaster EC generally give better control of disease than curative applications and tend to cause less injury to seedlings.
- For disease prevention, apply Terramaster EC (1 fl oz/100 gal of float water) when tobacco roots first emerge from the bottoms of trays (approximately two to three weeks after seeding, or longer depending on water temperature).
- Single preventive applications of Terramaster are usually adequate if new or properly sanitized trays are used. Where disease risk is higher, supplemental applications can be made up to five days before transplanting. The interval between applications is three weeks, and use no more than 3.8 fl oz/100 gal of float water per crop of transplants.
- Curative treatments can be made by treating float water with Terramaster EC at 1 to 1.4 fl oz/100 gal, beginning at the first appearance of symptoms. Do not make a curative treatment earlier than three weeks after seeding.
- Curative treatments do not eradicate *Pythium* from the float system, and retreatment is occasionally required. Follow-up treatments can be made as described for the preventive schedule. Seasonal limits and timing between treatment and transplanting are the same as for the preventive schedule.
- Always mix Terramaster EC thoroughly in float water to avoid plant injury and to achieve the best control of *Pythium* root rot.

Plant injury is a concern with Terramaster EC, but serious problems can be avoided by careful mixing and timely application. Terramaster EC will burn the roots of tobacco seedlings, but plants quickly recover. Stress from root burn is minimized if Terramaster EC is applied when roots first enter the float water and is greatest when 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 EC early.

- Oxidate 2.0 is an organic approved option labeled for use in tobacco float beds for management of multiple diseases including *Pythium*.
- According to label directions Oxidate 2.0 should be used preventatively at a rate of 6 to 24 oz/1000 gal of water.
- Float water must be treated on a regular basis with Oxidate 2.0 to maintain a residual 100 ppm concentration.
- Preliminary studies indicated reasonable control of *Pythium* with new trays in float water inoculated at a single time with *Pythium*
- The long term efficacy of Oxidate 2.0 in a float system with old trays and continued disease pressure has not been adequately studied.

Target Spot, Rhizoctonia Damping Off, and Blue Mold

- Check float beds regularly for problems, and treat when symptoms of disease are first observed if a routine fungicide program is not in place.
- Fungicides containing mancozeb (Manzate Pro-Stick in CT, PA, SC, NC, OH, TN and KY; Penncozeb in CT, VA) can be used for prevention of target spot. Routine application is recommended for facilities with a history of target spot. Regular applications of mancozeb also offer protection against blue mold. Apply in enough water to achieve coverage of leaves and

stems. Avoid treating plants smaller than the size of a dime due to risk of plant injury.
- Quadris Flowable fungicide is labeled for use on tobacco transplants, but only for the control of target spot. This fungicide can be used only once before transplanting, and growers must have a copy of the Special Local Need label (labeled in MD, SC, KY, NC, IN, GA, VA, PA and TN) in their possession at the time of treatment. Apply at a rate of 4 ml/1000 sq. ft (just under 1 tsp), using 5 gal/1000 sq. ft to achieve good coverage. For best results, make this application after the first or second clipping, or when symptoms are first observed. If needed, mancozeb can be used prior to and after treatment with Quadris. The application of Quadris in the greenhouse counts against the total number of applications allowed for the crop once in the field.
- If blue mold threatens or is found in your area, treat with mancozeb or Aliette WDG. Consult your local Cooperative Extension agent or news outlets to learn about the current status of blue mold.

Special Considerations for Outside Direct-Seeded Float Beds

Production of tobacco transplants in outside direct-seeded beds is inherently more risky than greenhouse production. 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-by-6's or 2-by-8's is sufficient to construct a float bed. Most float trays are slightly smaller than 14 by 27 inches. Float tray dimensions can be used to calculate the dimensions needed for the float bed, but allow for a very small amount of extra space in case trays are slightly larger than expected. Cover any extra space that must be left, as open water will only lead to increased algae growth and potential insect problems.

Six-millimeter plastic is more forgiving and preferred over thinner plastic. The plastic should be draped over the frame and pushed into corners before 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 to 4 ft 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 plants 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 inside the beds can fall below outside temperatures 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 for seeding 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 covered the cell. However, failure to remove the plastic when the sun comes out can damage seeds and kill plants very quickly. A clear cover heats up inside quickly, and a black plastic cover left on for an extended period of time during rainy weather can cause plants to stretch due to lack of light. Once plants stretch, they will not recover. 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 is usually sufficient), wind is less of a problem.