# Greenhouse Transplant Production

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Starting the growing season with an adequate supply of quality transplants is the first step to producing a high-yielding and high-quality crop. Greenhouse transplant production has become the primary method of transplant production. There are several advantages to producing transplants in the greenhouse in comparison to traditional plant beds. Three of the most often cited advantages of greenhouse transplant production include: reduced labor required for transplant production, greater control of environmental conditions, and increased uniformity of transplants resulting in a more even growing crop in the field. Greenhouse culture does require increased capital investment in transplant production compared to plant beds. Furthermore, the production of plants in a soilless growing medium using hydroponic (float) techniques requires attention to new aspects of plant production. Finally, greenhouse producers have limited pest control options available, while the potential for serious disease problems is greatly increased with greenhouse transplant production.

**Spiral Roots** can be a significant problem in some tobacco transplant greenhouses. A spiral-root seedling occurs when the root tip of the germinating seedling is damaged and grows aerially or on top of the media and not down into the media (Figure 2). Often the seedling develops a secondary root that grows into the media and the seedling will survive. However, in most cases the seedling's growth is delayed and usually it will not result in a useable transplant.

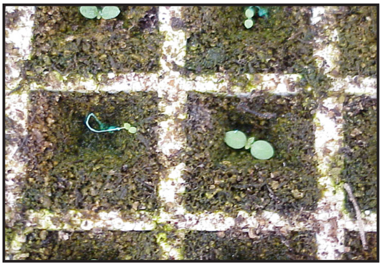


**Figure 2**. Example of spiral-root seedling and normal seedling

The specific cause of spiral-root seedlings is not fully understood. Early research indicated that inadequate media aeration (too little air, too much moisture) played an important role in spiral-root seedling occurrence. This has largely been remedied by growers through better attention to tray filling and not over packing the media in trays. Differences may occur between different brands of media, but these incidences usually result from quality control problems associated with specific batches of media rather than a consistent problem with a specific brand.

Recent research suggests a combination of factors is responsible for spiral-root seedlings. These factors include seed pellet, variety, soilless media, and environment. Research has shown that the seed pellet is an integral factor in the cause of spiral rooting. Tests have shown differences in the incidence of spiral root is dramatically decreased with the use of unpelleted seed. However, using unpelleted seed is not practical due to the fact that it's significantly slower and virtually impossible to determine if a seed is placed in each cell of the tray. Tests have also shown differences between seed companies' pelleting processes. Other factors such as growing media and environmental conditions seem to be important in how they interact with the seed pellet to allow the pellet to dissolve or breakdown. The basic properties of the seed that impact seed vigor play an important role and this is further impacted by the nature of the pellet and how well it separates with the emerging seedling on the media surface. This is a problem when the breakdown of the seed pellet is less than desired. This situation is further complicated by differing wetting properties of the various brands of media and their impact on breaking apart the seed pellet.

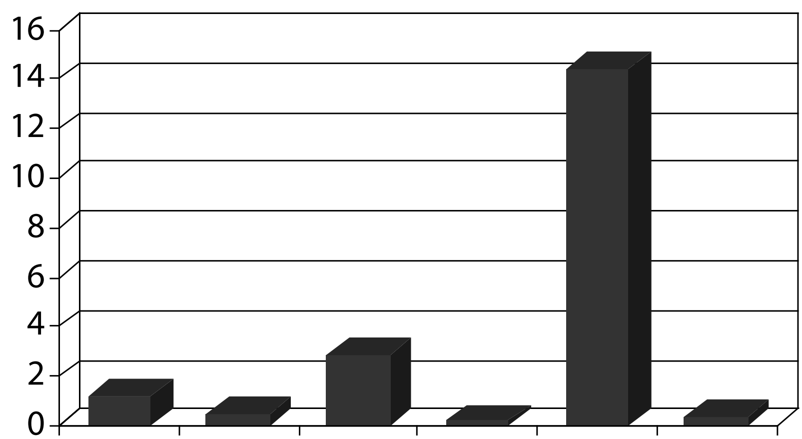
Consistent differences have shown up among burley varieties and the incidence of spiral rooting. For example KY14xL8 has proven to result in more spiral-root seedlings than most other varieties. As described above, many of the causes of spiral-root seedlings may be largely out of the hands of the growers. Growers cannot alter the properties of the seed and/or pellet. Growers should not try to alter the properties of a growing medium but rather avoid using a medium that is either too dry or too wet. Growers should be mindful of the environmental conditions of their greenhouse. A thermometer placed at tray level, and not the thermostat controls, should be used as an indicator of temperature. The optimum temperature is 70°F. Although it's not practical to expect this temperature to remain constant throughout the germination process the least amount of fluctuation should result in the fewest spiral-root seedlings and the most uniform stand of plants.

**Seed Covering to Reduce Spiral Roots.** Research has evaluated the practice of covering seeds to reduce or eliminate spiral-root seedlings. The purpose of covering the seed is to provide a more consistent environment around the seed pellet. Research conducted at Virginia Tech and North Carolina State University has shown that covering with growing medium and vermiculite is very effective in reducing the incidence of spiral rooting. However, even distribution of small amounts of these materials is difficult.

Uneven or excessive covering of the seed can result in decreased uniformity of seedling emergence and may result in a reduced plant stand. Ag-Gromate, a commercial product, has been tested as a seed covering material with results similar to that of covering with growing medium. One advantage of this new product is that it lends itself to automated application procedures. However, use rates are relatively low and excessive rates could be detrimental to plant stand. Thus, a calibrated applicator is necessary.

At the present time, covering tobacco seed is not recommended as a standard practice. However, growers who have significant problems with spiral-root seedlings may want to cover a few trays to evaluate this practice for their operation. Since covering seed could delay seedling emergence by one to three days, growers should delay fertilization one to three days after seeding to reduce the chance of salts injury. Additionally, growers should contact their local Extension agent for information on covering seed.

**Figure 3**: Effects of covering seeds from burley variety TN 90 with different materials and methods on the incidence of spiral-root seedlings



## GREENHOUSE MANAGEMENT PRACTICES

Greenhouse production of tobacco transplants involves a much greater level of supervision and management than is required with a plant bed. The following is a brief description of the important management practices required for successful production.

### 1. Sanitation

Sanitation is the primary means of pest control available to greenhouse tobacco producers. The four most important areas for sanitation include: the area in and around the greenhouse, people entering the greenhouse, float trays, and clipping equipment and the clipping operation. Specific information on sanitation is presented in the Disease Control section of this guide.

### 2. Ventilation and Air Circulation

Ventilation is necessary to remove moisture that naturally accumulates inside the greenhouse and to prevent high temperatures. Air circulation within the greenhouse is beneficial to reduce temperature stratification, reduce condensation on the greenhouse cover, remove moisture from the plant canopy (drier foliage), and evenly distribute greenhouse gases. The most common style of greenhouse used for tobacco transplant production utilizes side curtains that provide ventilation for cooling and allows fresh air exchange which is critical for reducing condensation within the greenhouse. The use of horizontal air flow (HAF) or a polytube system is highly recommended to provide increased air circulation.

### 3. Temperature Control

It is difficult to precisely control the temperatures in greenhouses used for tobacco transplant production. It's more difficult to keep temperatures cool than it is to keep it warm enough, especially on sunny days. The most demanding period for heating is during the germination of the seed. The ideal temperature for seed germination is 70°F. However, preliminary research shows you can reduce the temperature to 60°F at night and allow the temperature to increase to 80°F during the day and still reach 95 percent germination in 12 days. Extended periods of cooler temperatures will delay germination. After germination, the minimum temperature may be reduced to 55°F. Preventing high temperatures is equally as important as providing necessary heat for a greenhouse. Young seedlings are particularly sensitive to high temperatures, thus the temperature should be kept below 95°F during the two- to four-leaf stage. As seedlings grow, they are better able to withstand increasingly higher temperature; although, to reduce stress on the seedlings, the temperature should not be allowed to exceed 105°F. High temperatures place greater stress on the tobacco seedlings due to increased water usage and concentration of fertilizer salts within the growing medium.

Primed tobacco seed is specially processed seed that is "pregerminated" under controlled conditions and then pelleted. The use of primed seed will reduce the heating requirement and is recommended, especially in outdoor float beds. The germination rate of primed seed at 60°F will be similar to unprimed seed at 70°F. However, the final germination percentage will usually not differ between primed and unprimed seed of the same variety.

Greenhouse temperatures should be measured at plant level to more accurately measure conditions impacting the seedlings. The use of a recording thermometer to measure daily high and low temperatures is an excellent management practice.

## 4. Media and Tray Filling

Media and tray filling may be the source of the greatest number of problems for Virginia greenhouse tobacco producers in recent years. Dry cells and spiral roots are each related to media handling and the tray filling operation. Assuring that all cells within a tray are uniformly filled and that all trays are similar will improve the uniformity in seed germination and seedling growth. Cells must be completely filled for their entire depth to wick properly and prevent dry cells; but avoid over packing the cells to prevent the occurrence of spiral-root plants. Proper media moisture content is critical for adequate tray filling and the use of a premoistened medium is highly recommended. However, avoid excessively moist media since better plant stands are generally obtained with a medium having a dry consistency rather than a medium with more moisture and, therefore, a heavier consistency. Media should have only enough moisture to keep from falling through the trays before floating. If trays wick properly, watering over the top should not be necessary to assist with seed germination. However, if you water trays, use only a fine mist should be used to prevent packing and water logging of the media.

## 5. Fertilization

Fertilizers used in float greenhouse transplant production are formulated to function with a soilless growing medium. Such fertilizers should contain at least 50 percent of their nitrogen as nitrate and should contain minimal urea, which may injure young seedlings under certain conditions. In addition to using the correct fertilizer material, proper fertilization requires an accurate concentration of fertilizer solution to ensure that seedlings are not injured by excessive fertilizer salts. The amount of fertilizer necessary for a float bay is determined by the volume of water in the bay, the fertilizer analysis, and the desired nutrient level of the float bay. Additional information on fertilization is presented on pages 27 and 29.

**6. Water Quality**

Water quality is a critical factor to consider with greenhouse production. Although water sources across the flue-cured tobacco producing area of Virginia pose little difficulty for most growers, sporadic instances of water-quality problems have occurred for some growers. The only means of predicting such problems is through water testing and interpreting the results for plant production rather than as drinking water.

**7. Clipping**

Clipping is an essential management practice for direct-seeded greenhouse tobacco production. Begin clipping when plants are at least 2 inches to the bud. If seedling growth is unusually uneven, earlier clipping will allow the smaller plants to catch up. Research conducted in Virginia indicates that the timing of the first clipping, the severity of clipping, and the number of total clippings does not have a significant impact on the stem diameter of the transplants. However, the above factors were important in controlling the growth rate of the seedlings and the size of the field-ready transplant. Very early clipping (1.5 inches to bud or less) resulted in shorter than desired transplants. Growers should be able to produce good, uniform transplants by clipping three to five times. A higher number of clippings indicates the greenhouse was seeded too early. Seeding earlier than necessary will increase heating costs and the potential for disease problems.

## Suggested Clipping Program

- Begin clipping when plants are 2 to 2.5 inches tall (bud height)
- Set mower blade at 1 to 1.5 inches above bud
- Clip on a three-day interval between the first three clipping dates and every five days thereafter

*Plant clippings must be collected* to reduce the likelihood of disease development and spread throughout the entire greenhouse. *The mower used to clip plants should be thoroughly cleaned and sanitized with a 50-percent chlorine bleach solution following each use.*

The description of greenhouse tobacco transplant production is greatly abbreviated. Additional information is available from your local Extension agent and is detailed in the *Float Greenhouse Tobacco Transplant Production Guide,* Virginia Cooperative Extension publication 436-051.

## Float Fertilization Programs

Fertilization program suggested for float greenhouse tobacco production, depending on management level.

| | Program | |
|---|---|---|
| **Fertilizer Addition** | **I** | **II** |
| | --- ppm N --- | |
| at seeding | 0 | 75 |
| 3-5 days after seeding | 75 | |
| 4 weeks after seeding or at 1st clipping | 100 | 100 |

Under normal circumstances no additional fertilizer should be necessary beyond the total of 175 ppm N. However, if the greenhouse is seeded too early and the production season is extended or if transplanting is delayed, a late-season addition of fertilizer (50 to 75 ppm N) may be necessary to maintain adequate seedling nutrient levels.

**Program I** is the preferred fertilization schedule. This program delays fertilization until the trays have wicked. This helps to minimize fertilizer salts injury to young seedlings, increasing the total number of useable transplants. Research conducted at the Southern Piedmont AREC showed that delaying the addition of fertilizer by even one day resulted in lower conductivity of the media in the upper part of the cell as much as 21 days after seeding. Recently germinated seedlings need low levels of nutrients and most commercially available tobacco mixes will provide these nutrients. Nitrogen at 75 ppm is adequate for burley transplants for the first four weeks. Not allowing the fertilizer levels to become excessive will help reduce disease levels and the number of clippings necessary to produce a quality transplant.

**Program II** provides seedlings with 75 ppm N fertilizer level at seeding, making it easier to uniformly distribute the fertilizer across a bay. This program would primarily be used in outdoor float beds. Outdoor float beds result in less water evaporation thus decreasing the potential for salt injury due to over-fertilization. However, such injury observed in Virginia is generally the result of errors in fertilizer addition, poor media quality, or improper fertilizer materials.

Comparison trials with fertilizer rates ranging from 0 to 250 ppm N indicate that algae growth will occur at any level of fertilization (50 ppm N and greater). Withholding any fertilizer until one or two weeks after seeding will reduce algae growth at the expense of slower seedling growth.

**Program III** is to be used in greenhouses equipped with fertilizer injectors. Fertilizer injectors are used to add water containing a specified nutrient level to float bays. A concentrated fertilizer solution contained in a stock tank is diluted with the injector to obtain the desired nutrient level. The suggested fertilization program using an injector is to add 125 ppm N to the bays each time water is needed (including the original filling). Actual nutrient levels present in the float bays should be monitored to insure that adequate fertility is maintained. Research conducted on-farm in grower greenhouses in Virginia has shown that nutrients are taken up by the plants at a greater rate than water and fertility levels reached very low levels in some instances.

### Calculation of Water Volume and Fertilizer Concentration

1. The number of gallons of water in a float bay may be calculated by:

$$\text{length (ft)} \times \text{width (ft)} \times \frac{\text{depth (in)}}{12} \times 7.48\ \text{gal/ft}^3$$

**Example:** $16\ \text{ft} \times 5.5\ \text{ft} \times \frac{4\ \text{in}}{12} \times 7.48 = 217\ \text{gal}$

2. The amount of fertilizer required per 100 gal of water is calculated by:

$$\frac{\text{desired nutrient concentration (ppm)} \times 1.33}{\text{nutrient content of fertilizer (\%)}}$$

**Example:** $\frac{150\ \text{ppm}}{20\%\ \text{N}}\ \text{N} \times 1.33 = 10\ \text{oz per 100 gal}$

**Table 1**. Amount of selected fertilizer grades to produce fertilizer solutions with 50 to 200 ppm nitrogen.

| Fertilizer analysis | ounces of fertilizer per 100 gals of water at various nitrogen (N) concentrations (ppm) | | | | | |
|---|---|---|---|---|---|---|
| | **50** | **75** | **100** | **125** | **150** | **200** |
| 20-10-20 **or** 20-9-20 | 3.3 | 5.0 | 6.7 | 8.3 | 10.0 | 13.3 |
| 17-5-24 | 3.9 | 5.9 | 7.8 | 9.8 | 11.7 | 15.6 |
| 17-5-24 **and** 15-0-15[a] | 2.6 **and** 1.5 | 3.9 **and** 2.2 | 5.2 **and** 2.9 | 6.6 **and** 3.7 | 7.8 **and** 4.4 | 10.5 **and** 5.9 |
| 16-4-16 **or** 16-5-16 | 4.2 | 6.2 | 8.3 | 10.4 | 12.5 | 16.6 |
| 15-5 -15 **or** 15-4-15 | 4.3 | 6.7 | 8.9 | 11.1 | 13.3 | 17.7 |

[a]Fertilization program with 2 parts 17-5-24 and 1 part 15-0-15.

**Proper Tray Filling and Seeding** are essential to produce a high percentage of usable plants. The media used for float transplant production is a specially formulated material and cannot be satisfactory substituted with common potting media used with houseplants. Greenhouse tobacco mixes should be available from most farm supply dealers. When filling trays, media should have sufficient moisture to prevent it from falling out of the cells. Fresh media should not need any additional moisture. Tobacco mixes should not be carried over from one year to the next. The wetting agent degrades and thus, the cells don't wick.

When filling trays by hand, distribute the potting mix in a systematic manner to fill all cells with the same amount of mix. *Dry cells* occur when media does not fill the entire cell and thus fails to wick properly. Seed in dry cells do not germinate and thus a potential transplant is lost. A second problem related to tray filling is the occurrence of *spiral-root* plants. This condition occurs when the root of a germinating seed does not penetrate into the media. Such plants will eventually die and again a potential transplant is lost. The cause of *spiral-root* plants is not completely understood; however, it does appear to be related to inadequate media aeration (too little air/too much water). Media must not be packed too tightly into trays or excessively moistened. If float trays are watered over-the-top to help dissolve seed coatings, water should be applied as a fine mist. Large droplets can result in excessive packing and water logging of the media.

*Tray selection* will influence both the productivity and management of a greenhouse. Most trays used today are made of polystyrene and manufactures control the density of the tray by the amount of material put into the mold. Higher density trays seem to be more durable and have a longer useable life than low-density trays. However, higher density trays are also more expensive. Lower density trays may be useful for produces selling transplants and plan to purchase new trays annually to reduce disease pressure.

A relatively new tray on the market is the "glazed tray" made in a process where the manufacturer seals the inner surface of the cells. The tray is reduced in height by approximately 0.5 inch; however, the same amount of polystyrene is used so the tray is of higher density. This tray should be durable enough to be reused for several seasons, but it is more expensive.

An additional tray for 2008 season is a "shallow tray." This tray is the same length and width as a regular tray. However, the tray is only 1.5 inches deep compared to 2.5 inches deep for the normal tray. The only real advantage to the shallow tray is the need for less soilless media. Limited research shows little difference in seed germination and seedling growth. More research is needed to confirm that the number of useable transplants is not reduced by the minimal savings in soilless media cost.

Most of the Styrofoam float trays used for tobacco production are the same size but differ in the number of cells or plants per tray (see Table 2). The advantage of high cell-count trays is the increased productivity of a given size greenhouse. For example, 44 percent more transplants could be grown using 288 cell floats instead of 200 cell floats. However, the level of management is greater with the higher density float trays. Both root volume and stem diameter decrease with increasing cell number; therefore, greater clipping frequency will be required to ensure adequate stem size. In addition, the increased crowding of the seedlings necessitates more critical ventilation and moisture reduction within the greenhouse to prevent environmental conditions that favor the development of disease.

**Table 2**. Float trays commonly used for greenhouse tobacco production.

| Cells per tray | Vol. per cell (cc) | Plants per sq. ft. |
|---|---|---|
| 200 | 27.0 | 80 |
| 242 | 23.5 | 97 |
| 253 | 16.0 | 101 |
| 288 | 17.0 | 115 |
| 338 | 8.6-11.2 | 135 |
| 392 | 13.6 | 157 |

Research conducted in Virginia evaluated the impact of float cell number on transplant size and growth in the field. Stem diameter and plant size of 200 and 288 cell transplants were similar. Transplants from 338 cell trays, and to a greater extent 392s, were significantly smaller than those from 288 or fewer cell trays. However, there were no differences in plant stand, early-season growth, and yield of plants from any of the float trays tested.

The biggest difference between the float cell numbers is the cost per transplant. The larger transplants from a 200 cell float cost more to produce since fewer can be grown per square foot of greenhouse. For tobacco growers in Virginia, the 253 or 288 cell floats would be a good compromise between transplant size and transplant cost. This is especially important with outdoor float-bed growers who must balance the transplant number needed against the ability to adequately heat the float beds.

Attention to seeding the trays will result in a greater number of usable transplants. Tray cells not seeded or double seeded will reduce the number of transplants. Proper tray dibbling (creating shallow depressions in each cell) will provide better seed/media contact and position the seed in the center of the cells. The date that a greenhouse is seeded has a significant impact upon the management of the greenhouse. Seeding too early increases heating costs, lengthens the exposure of plants to possible pest problems, and requires excessive clipping. Sixty to 65 days is a conservative estimate of the time needed to allow for growing plants from seeding to transplanting time in a direct-seeded outdoor float bed.

## TOBACCO TRANSPLANT PRODUCTION IN OUTDOOR FLOAT BEDS

Outdoor float beds are a low-cost method of greenhouse tobacco transplant production for limited acreage. Seedlings in outdoor float beds may be started by two different methods. The first is direct seeding, as in a conventional transplant greenhouse. The alternative is to produce transplants using a seedling transfer production method.

*Transfer beds* are used only to grow plants off from a small seedling stage to transplant size. Seeds are not actually germinated in the outdoor transfer float bed. As a result, the heating requirement is greatly reduced since frost protection is the primary concern. The disadvantage of transfer beds is the increased labor necessary for hand transfer of the small seedlings to the float trays. The *plug-and-transfer* method was the original method of producing burley transplants using the float system. Commercially grown "miniplugs" or small seedlings are purchased in special trays and transferred by hand to conventional float trays. Seedlings are grown to transplant size in either an outdoor float bed or greenhouse. Although miniplugs represent an additional expense, they do reduce the risk and management associated with other float transplant production methods. In the *seed-and-transfer* method seedlings are started from conventional, uncoated seed and transferred to float trays in outdoor beds. Detailed directions for seed-and-transfer tobacco transplant production may be found later in this section of the production guide.

## FLOAT BED CONSTRUCTION

Outdoor float beds may be designed and constructed in many different ways. Individual growers should consider the materials available and the desired expense when considering how to construct float beds. Factors to consider include: 1) adequate strength of the top, 2) providing sufficient heating, and 3) ease of access for observation and management of seedlings. Outdoor float beds evaluated at the Southern Piedmont AREC in 1993 and 1994 utilized a narrow design with a separate frame for the top that can be completely removed from the bed. Such a design allowed for excellent access to the seedlings, complete ventilation of the float bed, and clipping of the seedlings with a tractor-mounted bush hog.

The size of the float bed(s) to be constructed will be determined by the required number of transplants, the ability to provide adequate heating, and the float tray cell size to be used. Float trays are approximately 13.5 inches wide and 26.5 inches long and vary in the number and size of cells in which the seedlings grow. Comparative information on the different float trays available is presented later in this section of the production guide.

The frame of the float bed should be sized to hold the desired number of trays and have approximately 2 inches of additional space along the length and width of the bed to allow easy removal of float trays. Larger amounts of exposed water will encourage excessive algae growth.

*One example of an outdoor float bed to grow transplants for the average-size burley tobacco producer would be a 40-tray float bay. Trays in the bay could be arranged 5 wide (side-to-side) and 8 trays long (end-to-end). The inside dimensions of the float bay frame (2 x 6 in lumber) would be as follows:*

*length = 8 trays x 26.5 in. + 2 in. = 17 ft. 10 in*

*width = 5 trays x 26.5 in. + 2 in. = 5 ft. 10 in.*

The number of transplants produced from this 40-tray float bed will be influenced by the float-tray cell number and the percentage of usable transplants produced from each (dependent on management).

| | Number of transplants from 40 trays with | |
|---|---|---|
| **Float tray cell number** | **75% usable** | **90% usable** |
| 200 | 6000 | 7200 |
| 253 | 7590 | 9108 |
| 288 | 8640 | 10,368 |
| 338 | 10,140 | 12,168 |
| 392 | 11,760 | 14,112 |

If an increased transplant number is needed, larger beds may be constructed. However, growers are reminded to consider the heating requirement, necessary structure strength of the top, and ease of management with larger float bed sizes.

The length of the bed can be made from one or more lengths of 2 x 6 treated lumber and joined securely. Short wooden stakes driven into the ground along the length of the bed will keep the frame from bowing under the weight of the water contained inside. The cover over the float bed may be constructed in one of many different ways. Factors to consider include:

- The top must have adequate strength to support any accumulation of rain or snow. Strength is dependent on construction materials used and spacing of the bows over the float bay.
- The height of the top over the trays should be sufficient to shed water. However, if too great, heating will be made more difficult.

- A top that can be easily removed and replaced will improve management. A completely removable top will allow for better observation of plants, ease of clipping, and allow for better ventilation.

The bed frame should be lined with a single layer of 6 mil black plastic to hold water in the float bay. The ground under the plastic should be smoothed and may be covered with a thin layer of sand or rock dust to reduce the likelihood of sharp objects puncturing the plastic liner. Any leaks that do occur should be repaired. Float beds should be located on a site receiving full sun and near electricity if necessary. The site should be leveled to provide uniform depth of water throughout the float bays. Sand or rock dust may be used for leveling and will reduce drainage problems and muddy areas around the bays.

## SUGGESTED SIZES OF OUTDOOR FLOAT BEDS

The following are suggested dimensions for the style of float beds evaluated at the Southwest Virginia and Southern Piedmont ARECs. These beds consisted of a 2 x 6 frame for the water bed and a 2 x 4 frame (turned up on the 2-inch side) around the water bed to attach cover support bows made from 0.75-inch flexible water pipe. The 2 x 4 cover frame can be completely removed from the float bed to provide ventilation and allow for clipping.

| | | | Inside Dimension | | | |
|---|---|---|---|---|---|---|
| Tray Number | | | 2 x 6 in. bed frame | | 2 x 4 in. frame for cover | |
| Width | Length | Total | $L_1$ | $W_1$ | $L_2$ | $W_2$ |
| 3 | 6 | 18 | 13′ 5″ | 3′ 7″ | 13′ 10″ | 4′ 6″ |
| 3 | 8 | 24 | 17′ 10″ | 3′ 7″ | 18′ 3″ | 4′ 6″ |
| 3 | 10 | 30 | 22′ 3″ | 3′ 7″ | 22′ 8″ | 4′ 6″ |
| 4 | 6 | 24 | 13′ 5″ | 4′ 8″ | 13′ 10″ | 5′ 1″ |
| 4 | 8 | 32 | 17′ 10″ | 4′ 8″ | 18′ 3″ | 5′ 1″ |
| 4 | 10 | 40 | 22′ 3″ | 4′ 8″ | 22′ 8″ | 5′ 1″ |
| 5 | 6 | 30 | 13′ 5″ | 5′ 10″ | 13′ 10″ | 6′ 3″ |
| 5 | 8 | 40 | 17′ 10″ | 5′ 10″ | 18′ 3″ | 6′ 3″ |
| 5 | 10 | 50 | 22′ 3″ | 5′ 10″ | 22′ 8″ | 6′ 3″ |
| 6[a] | 10 | 60 | 22′ 3″ | 6′ 11″ | 22′ 8″ | 7′ 4″ |
| 6[a] | 14 | 84 | 31′ 1″ | 6′ 11″ | 31′ 6″ | 7′ 4″ |
| 6[a] | 18 | 108 | 39′ 11″ | 6′ 11″ | 40′ 4″ | 7′ 4″ |
| 6[a] | 22 | 132 | 48′ 9″ | 6′ 11″ | 49′ 2″ | 7′ 4″ |

[a]The size of a removable top constructed with a 2 x 4 frame may be too large with float beds wider than 8 feet or longer than 15 or 20 feet.

Bows supporting the cover can be made from 0.5- or 0.75-inch plastic PVC pipe. Space bows 18 to 24 inches apart. The length of the bows should be 90 inches for a float bed 4 trays wide and approximately 104 inches for a bed 5 trays wide.

Constructing float beds wider than 6 trays or longer than 15 or 20 feet will make a removable top difficult to lift. In this case, other provisions must be made to provide adequate ventilation and access to the float trays.

## HEATING OF OUTDOOR FLOAT BEDS

Supplemental heat will be necessary for reliable production of transplants in outdoor float beds. Transfer beds may require limited heating for frost protection. Heat lamps strung above the plants for the length of the float bay (100 watts per 100 square feet) or water-bed heaters should provide adequate frost protection. Direct-seeded beds require more extensive heating to obtain satisfactory germination. The low-cost, temporary nature of outdoor float beds limits the available options for heating. Early research with outdoor float beds evaluated the use of ceramic heaters for direct-seeded outdoor float beds. However, the use of such heaters is discouraged due to the potential electrical hazard associated with outdoor float beds. The high electrical demand of ceramic heaters coupled with safety considerations limit their usefulness in heating outdoor float beds. Each ceramic heater requires a separate 20 amp circuit with a ground fault interrupt.

Water-bed heaters (heat mat placed under the bed liner) have successfully been used for heating direct-seeded float beds. One heater per 20 trays should be sufficient if other necessary procedures are followed. Thermostats should be set at 80°F. Empty trays (one per water bed heater) should be placed in the bed to allow heat to move from the water to the air above the trays.

*Heat loss, and therefore, the heating requirement can be significantly reduced by covering beds with solid plastic to reduce heat loss occurring at night by radiation. Such covers should be provided when low temperatures are predicted to fall to 35°F or below.*

**Growers must exercise extreme caution and follow all safety rules pertaining to electrical wiring and the use of electrical equipment in the outdoor environment and near water**.

## COVERS FOR OUTDOOR FLOAT BEDS

Clear, solid plastic should not be used as a cover material for outdoor float beds. High temperatures may buildup very rapidly under solid plastic and kill young seedlings. The typical outdoor float bed does not have sufficient ventilation to prevent the buildup of excessive heat. Fabric plant bed covers, such as Reemay and Typar, are better suited for float beds. Although not essential, two layers of Reemay or a heavier weight cotton cover may be used to further insulate the beds during cold weather, particularly during germination of the seed. Vispore, a plant-bed cover material made by Tredegar Industries, is a perforated plastic cover that has been evaluated on outdoor float beds at the Southwest Virginia and Southern Piedmont ARECs. The very small holes in this material are large enough to reduce the buildup of excessive heat, but are so small that rainfall cannot pass through the cover onto the plants. It is recommended that the heavier (2.5 mil) grade of this cover be used for float beds, and that the cover be turned with the rough side up to better shed water.

Resent research has shown the use of a 50 percent white shade plastic to be a very effective cover for outdoor float beds. Growers should be sure that the shade plastic is actually 50 percent. If the covering is higher percent shade, seedlings will become spindly for lack of sunlight; however, less shade would allow too much sunlight resulting in temperatures high enough to damage or kill seedlings.

An on-farm study showed fewer incidences of spiral-root seedlings when produced using the 50 percent shade plastic with the outdoor float bed than in a traditional greenhouse. This is thought to be a result of higher humidity in the float bed and less drying of the seed and pellet.