TRANSPLANT PRODUCTION IN THE FLOAT SYSTEM

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

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

Transplant production costs per acre increase when the percentage of usable transplants decreases. Therefore, management practices that improve stands and promote uniform growth decrease production costs. Nearly all management practices affect usability, but these are some of the most important:

1. Consider the materials.
   • Analyze the water source and manage alkalinity.
   • Select a uniform, high-quality growing medium with a low and well-mixed nutrient charge.
   • Consider tray design.
   • Use seeds with high germination rates and acceptable pelleting materials.

2. Promote uniform emergence.
   • Sow seeds during sunny periods.
   • Fill trays uniformly.
   • Place seeds uniformly (in the center of the dibble).
   • Provide a warm temperature (68 to 70°F at night).
   • Reduce spiral rooting.
   • Control ants and mice.

3. Promote uniform growth.
   • Monitor fertilizer salts in the medium and leach with water from overhead when necessary.
   • Continue to analyze water and manage alkalinity when necessary.
   • Clip properly.
   • Manage insects and diseases.

   • Provide proper ventilation and airflow to prevent heat injury.
   • Avoid early seeding, high nitrogen rates, and hot daytime temperatures that promote stem rot diseases.
   • Fumigate trays with methyl bromide or purchase new trays.
Consider the Materials

Analyze the Water Source and Manage Alkalinity

Water quality management is an important part of successful transplant production. Bicarbonate levels (alkalinity) are high in water from many areas, particularly in eastern counties, counties, primarily in Eastern North Carolina. Excessive boron levels have occasionally been found in water samples from the east, and boron deficiencies have been observed on seedlings in float systems from the piedmont. Sodium is occasionally high, which can cause salt problems for overhead-irrigated systems, although recent research has shown tobacco seedlings in float systems to be very tolerant to sodium. Surface water should be avoided because of potential disease problems.

The three most important water quality parameters for most growers are: pH, soluble salts (conductivity), and alkalinity or total carbonates. A low pH (5.0 to 6.0) indicates an acidic condition and a fertilizer that will raise the pH should be used. A higher pH (greater than 7.5) will generally indicate high alkalinity levels (high carbonates). Acidifying fertilizers that lower the pH and neutralize alkalinity should be used. Remedies for high alkalinity will depend on the severity. Alkalinity levels of 100-200 ppm would correspond to total carbonate levels of 2-4 meq and would not be expected to cause substantial growth problems. Corrective action in this case would only involve the use of an acidifying fertilizer such as the Peters Excel 15-5-15. Alkalinity levels of 200+ and carbonate levels of 4+ call for corrective action such as the addition of calculated amounts of acid.

Analysis: The University of Georgia Agricultural Services Laboratories provides water analysis for pH and Basic Cations (P, K, Ca, Mg, Mn, Fe, Al, B, Cu, Zn, Na, Cr, Cd, Ni, and Mo) at a cost of $10.00 per sample (Soil, Plant and Water Laboratory, 2400 College Station Road, Athens, GA 30602, Phone: (706) 542-5350. Analysis for Alkalinity (the total bicarbonate content) of the water is performed for $12.00 per sample (Feed and Environmental Water Laboratory, 2300 College Station Road, Athens, GA 30602, Phone: (706) 542-7690. Results for alkalinity are reported in parts per million (ppm).

A 16-ounce sample should be collected from each potential water source and for each analysis requested. A clean, nonreturnable drink bottle with a screw-on cap is an excellent sample bottle. Rinse the bottle (but do not use soap) several times before collecting the sample, and allow the water to run several minutes before collecting the sample. Fill the bottle completely so that no air remains. Forms and assistance are available from county Extension offices. Sample reports should be requested to be sent to the local County Extension Agent and to the Extension Agronomist - Tobacco. Recommendations related to the nutritional suitability of the water for transplant production will be discussed and forwarded by the local agent.

Wells are the most desirable water sources. Municipal sources that have been treated and filtered also are satisfactory. Pond or river water usually is suitable nutritionally. However, black shank has been observed on seedlings in float-systems filled with pond water in Kentucky. The potential for water contamination with soil-borne pathogens also exists for tobacco in North Carolina. Herbicides that injure tobacco also could be carried in soil runoff into ponds. Therefore, most (if not all), surface water sources should be avoided.

Select a High-Quality Growing Medium

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

**Consider Tray Design**

Researchers continue to investigate tray design in relationship to production costs and disease management. A significant factor affecting tray cost to the grower is the cost of fuel. High natural gas prices have increased the cost of manufacturing, while high fuel prices have increased the cost of transportation and delivery.

Tray costs have always been an issue outside the United States because of shipping costs. Polystyrene trays are light, but they are bulky, which makes them expensive to ship. The high cost of growing medium is also a factor overseas. One way to reduce production and shipping costs is to decrease the depth of the tray, which allows more trays to be placed in a shipping container or on a truck. Shallower trays have the additional advantage of requiring less growing medium to fill the cell, which decreases the cost to a grower. Less on-farm storage space is required for shallow trays than for traditional-depth trays.

Recently a glazed tray was introduced that has hardened sidewalls within the cell, which are formed by superheating during the manufacturing process. The idea is that the hardened sidewalls will resist root penetration and be easier to sanitize. However, the tray depth is slightly shallower than a traditional 288-cell tray. This difference in depth results in slightly smaller cells (15 cubic centimeters versus 17 to 17.5 cubic centimeters), which partially offsets the cost of glazing and decreases growing medium requirements by 12 percent. Observations suggest that fewer roots penetrate the tray, but research has not been conducted to determine if disease incidence is different with plants produced in glazed trays versus those produced in traditional trays.

Studies conducted in 2004 and 2005 measured the effects of cell density and volume on transplant production (Tables 4-1 and 4-2). Researchers compared four trays differing in cell density and volume filled with three different growing media. They compared the following trays:

1. A glazed 288-cell tray with a cell volume of 15 cubic centimeters and cell density of 122.5 cells per square foot in 2004 and a traditional 288-cell tray with a cell volume of 18 cubic centimeters and cell density of 122.5 cells per square foot in 2005.
2. A shallow, glazed 288-cell tray with a cell volume of 8.6 cubic centimeters and cell density of 122.5 cells per square foot.
3. A traditional 200-cell tray with a cell volume of 27 cubic centimeters and cell density of 85 cells per square foot.
4. A shallow 200-cell tray with a cell volume of 8.6 cubic centimeters and a cell density of 85 cells per square foot.

Results indicate that 200-cell trays produced larger plants than 288-cell trays. However, there were no differences in plant size due to tray depth. Thus, in a float system, cell density is more important than cell depth (root volume) in affecting plant size. These results indicate that shallow trays can be used without reducing transplant quality. There were minor differences in usability among media in 2005. However, there were no interactions between media and tray type in 2004 or 2005. Thus, all of these media would be suitable for shallow trays.
Table 4-1. Effect of Cell Volume and Density on Transplant Production in the Float System, 2004

<table>
<thead>
<tr>
<th>Treatment</th>
<th>ISM (%)</th>
<th>Spiral Root (%)</th>
<th>Total Plants (%)</th>
<th>Usable Plants (%)</th>
<th>Stem Length (cm)</th>
<th>Stem Diameter (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trays</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Glazed 288 Traditional (15 cc per cell)</td>
<td>95</td>
<td>3</td>
<td>94</td>
<td>88</td>
<td>6.4</td>
<td>3.0</td>
</tr>
<tr>
<td>Glazed 288 Shallow (8.6 cc per cell)</td>
<td>96</td>
<td>4</td>
<td>92</td>
<td>84</td>
<td>6.3</td>
<td>3.0</td>
</tr>
<tr>
<td>200 Traditional (27 cc per cell)</td>
<td>96</td>
<td>3</td>
<td>95</td>
<td>90</td>
<td>7.0</td>
<td>3.6</td>
</tr>
<tr>
<td>200 Shallow (8.6 cc per cell)</td>
<td>95</td>
<td>3</td>
<td>94</td>
<td>87</td>
<td>7.0</td>
<td>3.8</td>
</tr>
<tr>
<td><strong>LSD (0.05)</strong></td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>4</td>
<td>0.3</td>
<td>0.3</td>
</tr>
</tbody>
</table>

Growing Medium

| Carolina Gold | 95 | 3 | 94 | 87 | 6.6 | 3.3 |
| Carolina Choice | 96 | 4 | 94 | 88 | 6.5 | 3.4 |
| All Peat, Aggregate Free - Experimental | 96 | 4 | 93 | 86 | 6.8 | 3.3 |
| **LSD (0.05)** | NS | NS | NS | NS | NS | NS |

1
ISM = Modified Index of Synchrony which is a measure of the germination that occurred over a 48-hour period.
NS = Not statistically significant. similar. Treatments should be considered similar.

Table 4-2. Effect of Cell Volume and Density on Transplant Production in the Float System, 2005

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Emergence (%)</th>
<th>Total Plants (%)</th>
<th>Usable Plants (%)</th>
<th>Stem Length (cm)</th>
<th>Stem Diameter (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trays</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Glazed 288 Traditional (15 cc per cell)</td>
<td>94</td>
<td>90</td>
<td>79</td>
<td>4.9</td>
<td>2.5</td>
</tr>
<tr>
<td>Glazed 288 Shallow (8.6 cc per cell)</td>
<td>96</td>
<td>91</td>
<td>81</td>
<td>5.9</td>
<td>2.4</td>
</tr>
<tr>
<td>200 Traditional (27 cc per cell)</td>
<td>94</td>
<td>91</td>
<td>84</td>
<td>6.2</td>
<td>2.9</td>
</tr>
<tr>
<td>200 Shallow (8.6 cc per cell)</td>
<td>94</td>
<td>92</td>
<td>84</td>
<td>6.1</td>
<td>2.9</td>
</tr>
<tr>
<td><strong>LSD (0.05)</strong></td>
<td>2</td>
<td>NS</td>
<td>NS</td>
<td>0.4</td>
<td>0.3</td>
</tr>
</tbody>
</table>

Growing Medium

| Carolina Gold | 93 | 87 | 78 | 5.7 | 2.6 |
| Carolina Choice | 95 | 93 | 84 | 5.8 | 2.6 |
| All Peat, Aggregate Free - Experimental | 95 | 93 | 84 | 5.9 | 2.7 |
| **LSD (0.05)** | 2 | 5 | 4 | NS | NS |

NS = Not statistically significant. similar. Treatments should be considered similar.
Promote Uniform Emergence

Uniform emergence and growth are necessary to produce a high percentage of usable transplants. Research conducted in 1999 and 2000 showed that even a three-day delay in emergence in 25 percent of the seedlings could reduce usability (Table 4-3). The researchers seeded random cells within a tray 3, 5, 7, or 12 days after seeding the rest of the tray. In general, the delayed treatments produced fewer usable seedlings than the initial seeding. These results show the importance of uniform emergence and that clipping will not correct the uneven growth from delayed emergence.

Table 4-3. Effect of Staggered Seedling Emergence on Transplant Production, 1999-2000

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Total Stand at Day 50</th>
<th>Usable Transplants at Day 50</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1999 Experiment</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Check (100% seeded day 1)</td>
<td>89 a</td>
<td>76 a</td>
</tr>
<tr>
<td>75% seeded day 1, 25% seeded day 5</td>
<td>89 a</td>
<td>59 b</td>
</tr>
<tr>
<td>75% seeded day 1, 25% seeded day 7</td>
<td>90 a</td>
<td>66 ab</td>
</tr>
<tr>
<td>75% seeded day 1, 25% seeded day 12</td>
<td>80 b</td>
<td>65 ab</td>
</tr>
<tr>
<td><strong>2000 Experiment</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Check (100% seeded day 1)</td>
<td>95 a</td>
<td>91 a</td>
</tr>
<tr>
<td>75% seeded day 1, 25% seeded day 3</td>
<td>96 a</td>
<td>85 b</td>
</tr>
<tr>
<td>75% seeded day 1, 25% seeded day 5</td>
<td>97 a</td>
<td>78 c</td>
</tr>
</tbody>
</table>

Note: For each experiment, averages followed by the same letter in a column are not statistically different and should be considered similar.

Fill and Seed Trays Uniformly

Begin seeding 50 to 55 days before the anticipated transplanting date using only high-quality, pelleted seeds. Make sure that one seed is placed in each cell. Misting trays from overtop after floating has not been shown to speed seedling emergence. However, the use of a premoistened medium decreases the amount of medium that falls through the holes in the bottom of the tray and increases the speed of emergence as compared to a dry medium. Overly wet media do not flow from the hopper box as uniformly as dry media. Be sure the trays are filled uniformly.

Wet new trays before filling them, and screen the planting medium if it contains sticks and clods. Use a moist medium, and pack the medium all the way to the bottom of the cell. Research indicates that taking these precautions will help to prevent dry cells within a tray. Dry cells create a common problem in float systems, particularly with new trays, because they float higher than old trays and because it is difficult to keep the medium from falling through the hole in the bottom of the tray.

Manage Spiral Rooting

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

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

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

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

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

**Provide a Warm Temperature**

The ideal germination temperature for tobacco seeds is approximately 68°F at night and 86°F during the day. Fuel use
decreases 15 percent for every 5-degree reduction in temperature. Therefore, after maximum seedling emergence is
obtained, nighttime temperatures should be reduced to a range of 55 to 60°F to conserve fuel usage. Daytime
temperatures of 80 to 85°F are adequate for normal growth. Heat injury (browning of leaves or seedling death) has been
observed when air temperatures inside the structure exceed 110°F.

Different varieties respond in various ways to germination temperature, and it is very common to see differences in
germination rate among varieties in the same greenhouse. The response of four popular varieties to temperature
during germination is shown in Figures 4-1 through 4-8. In all varieties the germination was earlier at 68°F night
and 86°F day than at 68°F night and 95°F day. However, the delay in germination from high temperatures differed
greatly among varieties and, in some cases, between seed lots within a variety. These data show that higher than
ideal temperatures, even as low as a 95°F day, can delay emergence, reduce uniformity of emergence, and
sometimes even decrease total emergence. For a variety such as K 326, the delay in emergence at high temperatures
is relatively small (Figures 4-1 and 4-2). However, for NC 71 (Figures 4-3 and 4-4) and NC 297 (Figures 4-7 and 4-
8), the delay in germination is significant. It is important to remember that these studies were conducted in an
incubator. Response to high temperature stress in a greenhouse will be greater because delayed germination makes
the plants more susceptible to salt injury and disease.

While research has shown 68°F night and 86°F day to be the most favorable temperatures for germination in all
tested varieties, it is very common to observe a range of germination times among varieties. Studies conducted with
seed from the 2003 Official Variety Test found that most varieties reached maximum germination in 7 to 8 days
when exposed to ideal temperatures of 68°F night and 86°F day. However, the range among varieties was from 6 to
13 days. The germination of most varieties was delayed by 1 day when the daytime temperature was increased from
86°F to 95°F. However, the germination of NC 71 was delayed by 2 days (from 9 days to 11 days).

Promote Uniform Growth

Monitor and Manage Fertilizer Salts in the Growing Medium

Fertilizer salts injury is the most common nutritional problem in float systems. Fertilizers supply nutrients in the
form of salts. When fertilizer is added to the waterbed, these salts dissolve in the water. Then the nutrients move
into the growing medium as water is absorbed from the waterbed.

High temperatures, low humidity, and excessive air movement promote water evaporation from the surface of the
growing medium, which results in the accumulation of fertilizer salts in the medium in the top of the cell. Salts can
reach levels high enough to injure seedlings, even when recommended fertilization programs are followed (Figure
4-11). Fertilizer salts levels in the upper ½-inch are directly related to the total amount of fertilizer applied (in the
waterbed and in the medium). Therefore, it is better to use a medium with no fertilizer (or with only a minimal
amount) than to use a highly charged medium.

![Graph showing conductivity of a soilless medium at two fertilization levels and at three depths in the cell](image)

**Figure 4-11. Conductivity of a soilless medium at two fertilization levels and at three depths in the cell**

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

Salts should be monitored in the growing medium every 24 to 48 hours from seedling emergence until the plant
roots grow into the waterbed. Collect a sample of the medium from the upper ½-inch of the cell from several trays,
then add twice as much distilled water as growing medium on a volume basis (a 2:1 water-to-growing-medium
dilution). Shake or stir the sample and wait 2 to 3 minutes before measuring the conductivity. Normal levels range
from 500 to 1,000 microseimens (0.5 to 1 millimhos). Readings of 1,000 to 1,500 microseimens (1 to 1.5
millimhos) are moderately high, and readings above 1,500 microseimens are very high. Apply water from overhead to leach and dilute salts when: (1) conductivity readings are above 1,000 microseimens and plants are pale or stop growing; or (2) conductivity readings are 1,500 microseimens or above.

Fertilize Properly

Growers with fertilizer injection systems have been successful in using a constant application rate of 125 parts per million (ppm) nitrogen from 20-10-20, 16-4-16, 16-5-16, 15-5-15, or similar ratio fertilizers. For noninjected systems, fertilizer can be added to the water in two steps. Research has shown that excellent transplants can be obtained from an initial application of fertilizer to supply 100 to 150 ppm nitrogen within seven days after seeding plus a second application to supply 100 ppm nitrogen four weeks later. Use a complete fertilizer (with 2-1-2, 3-1-3, or 4-1-4 ratios) for the first application. The same fertilizer or ammonium nitrate can be used for the second application. Higher application rates cause tender, succulent seedlings that are more susceptible to diseases. Also, high application rates promote fertilizer salts injury to seedlings as noted above. If high fertilizer salts levels are detected during the first four weeks after seeding (>1,000 microseimens in the medium from the upper ½-inch of the cell), apply water uniformly from over-top to reduce fertilizer salts levels.

Monitoring waterbed fertility levels. Pocket-sized conductivity meters can be used to monitor fertility levels in waterbeds. Most fertilizer labels contain a chart that provides the expected conductivity level for the initial fertilizer concentration, usually expressed as nitrogen concentration in ppm. Conductivity is useful in measuring the accuracy of fertilizer injectors and how well the fertilizer is mixed throughout the waterbed. Conductivity measurements can also provide a rough estimate of the general fertility status in a waterbed throughout the growing season. It is important to understand that while the chart lists nitrogen concentration, the meter is measuring total conductivity from all salts (nutrients). Therefore, as the season progresses and plants adsorb nutrients from the waterbed at different rates (and water levels fluctuate), the relationship between conductivity and nitrogen concentration becomes less dependable (Figure 4-12). Therefore, collecting a water sample for analysis by the NCDA&CS (or another laboratory) is the only way to get an accurate measure of the concentrations of all nutrients in the waterbed.

Nitrogen form. Fertilizers commonly provide nitrogen from various combinations of nitrate, ammonium, and urea sources. Tobacco seedlings can use nitrogen in the nitrate and ammonium forms, but urea must be converted to ammonium before the nitrogen can be used by the plant.

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

<table>
<thead>
<tr>
<th>Urea Concentration</th>
<th>Stem Length</th>
<th>Fresh Weight</th>
<th>Dry Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>% of total N</td>
<td>cm</td>
<td>gm/20 seedlings</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>5.4a</td>
<td>77a</td>
<td>5.3a</td>
</tr>
<tr>
<td>52</td>
<td>3.8b</td>
<td>54b</td>
<td>4.0b</td>
</tr>
<tr>
<td>77</td>
<td>4.4b</td>
<td>43c</td>
<td>2.9c</td>
</tr>
</tbody>
</table>

Note: Averages followed by the same letter in a column are not statistically different and should be considered similar.

Phosphorus. Research at Clemson University has shown the need to limit phosphorus concentrations to 35 to 50
ppm in the waterbed. Applying excess phosphorus causes spindly transplants and leaves more phosphorus in the
waterbed for disposal after transplant production. Therefore, 20-10-20 and 20-9-20 are better choices than 20-20-20
fertilizer. Other fertilizers, such as 15-5-15, and 16-5-16, are also good choices because very little phosphorus is
left in the float water after the transplants are taken to the field. However, over-application of acidic fertilizers in
low-alkalinity water can reduce the solution pH to less than 4.0, which damages roots (if plant roots grow into the
waterbed).

Fertilizer effects on waterbed pH. The pH of well water in North Carolina ranges from 4.5 to 8.5. Some fertilizers,
such as 15-5-15 and 21-5-20, are acidic and were designed for use in high pH (high bicarbonate) water. However,
in water sources without bicarbonates or with a low pH, acidic fertilizers can reduce the pH to levels low enough to
damage roots.

Studies conducted in 1997 in water with a low pH (4.8) showed that applying 15-5-15 at seeding reduced water pH.
This should be expected, because this fertilizer was developed for alkaline waters. The water pH in these studies
rose above 4.0 in two weeks and over 5.0 at four weeks. Root damage was not observed. The second application at
four weeks again reduced the pH, but not enough to affect roots. In another study conducted in 1998, waterbed pH
was reduced below 4.0 at seeding and again with the second application at four weeks. Root growth was reduced
with 15-5-15 (at the high rate) compared to 20-10-20. These data indicate that the use of acidic fertilizers in low pH
water can reduce the water pH below 4.0 and result in temporary root damage, particularly when applied at higher
than recommended rates. The drop in water pH is temporary, and root growth recovers when the pH rises to 4.0 or
higher. Effects on stem length and plant weight were not observed.

Sulfur. A sulfur deficiency is occasionally observed in float systems when the medium was not supplemented with
magnesium sulfate (epsom salts) or calcium sulfate (gypsum) and sulfur was not provided by the fertilization
program. The major media marketed for tobacco should contain sulfur. Also, some fertilizers such as 16-5-16
contain sulfur. If the sulfur content in a medium is questionable, the fertilizer used does not contain sulfur, or a
sulfur deficiency is observed, add Epsom salts to the waterbed at a rate of 4 ounces per 100 gallons of water.

Boron. A boron deficiency causes bud distortion and death and has been observed in several float systems. In most
cases, the water and the fertilizer did not contain any boron. The best solution to this situation is to choose a
fertilizer such as a 20-10-20 with a guaranteed micronutrient charge if the water analysis indicates no boron. If a
fertilizer with boron is unavailable, adding no more than 0.25 ounce of Borax per 100 gallons of float water should prevent a deficiency.

Organic fertilization. In recent years, some growers have contracted to grow tobacco organically. Thus far, it has been acceptable to produce transplants with the water-soluble fertilizers typically used in float systems. However, growers may be required to use organic fertilizers during transplant production for USDA organic certification in the future. Studies were conducted in 2002 and 2003 to compare seedling production when using bat manure (8-4-1) and Peruvian seabird guano (13-8-2) to seedling production when using the standard water-soluble fertilizer 16-5-16 (Table 4-4).

<table>
<thead>
<tr>
<th>Fertilizer</th>
<th>Stem Length-(cm/Plant)-</th>
<th>Usable Transplants-(%)-</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2002</td>
<td>2003</td>
</tr>
<tr>
<td>16-5-16</td>
<td>8.7</td>
<td>5</td>
</tr>
<tr>
<td>Bat Manure (8-4-1)</td>
<td>2.6</td>
<td>1</td>
</tr>
<tr>
<td>Peruvian Seabird Guano (13-8-2)</td>
<td>6.8</td>
<td>3</td>
</tr>
<tr>
<td>Bat Manure (8-4-1) at a 3X rate</td>
<td>----</td>
<td>3</td>
</tr>
</tbody>
</table>

Results show that seabird guano is a better choice than bat manure when both are applied at the normal rate. Only 33 percent of the nitrogen in bat manure is in a plant-available form, which resulted in small, nitrogen-deficient seedlings when used at the normal rate in 2002 and 2003. In 2003, tripling the bat manure rate to compensate for reduced availability resulted in seedlings comparable to the seabird guano. However, a $3\times$ rate of bat guano is very expensive.

In 2003, both organic products produced smaller seedlings and a lower percentage of usable seedlings than 16-5-16. In 2002, the seabird guano and 16-5-16 produced similar percentages of usable transplants. Based on these results, the Peruvian seabird guano seems to be a better choice than bat manure for organic seedling production. Growers using seabird guano should monitor alkalinity levels in the waterbed closely and correct when necessary.
Calculation of Water Volume

The number of gallons of water in a float bed may be calculated by:

\[
\text{length (ft.)} \times \text{width (ft.)} \times \text{depth (in.)} \times 7.48 \text{ gal./cu. ft.} \\
\]

Example: \(50 \text{ ft.} \times 16 \text{ ft.} \times 4 \text{ in.} \times 7.48 = 1994 \text{ gal.}\)

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

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

Where:

- \(\text{Fertilizer added per 100 gallons}\) = amount of fertilizer to add to each 100 gallons of water in the waterbed;
- \(\text{Concentration}\) = desired concentration in parts per million;
- \(\%\) = concentration of the nutrient in the fertilizer.

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

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

Clip Properly

Proper clipping is an important practice that can increase the number of usable transplants and improve transplant hardness, stem-length uniformity, and stem diameter. A properly clipped plant is essential for carousel transplanters because uniform stem lengths are needed to transplant seedlings at the proper depth, and excessive foliage disturbs the timing mechanism. Clipping can also be used to delay transplanting when field conditions are unfavorable. Research has shown that maximum usability is obtained with 3 to 5 clippings. However, many growers clip 15 to 20 times. Too many clippings indicate that the greenhouse was seeded too early. Early seeding increases heating costs as well as the potential for collar rot. Another problem is improper clipping (clipping too early and too close to the bud), which reduces stem length, increases stem rots, and slows plant growth in the field.

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

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

Current recommendations are to begin clipping at three- to five-day intervals when total plant height is 2 to 2.5 inches above the tray and to set the blade height at 1 to 1.5 inches above the bud. This procedure provides the best balance of uniformity, stem length, and disease management.
Figure 4-1. Effect of temperature on the germination of K 326 (2003)

Figure 4-2. Effect of temperature on the germination of K 326 (2004)

Figure 4-3. Effect of temperature on the germination of NC 71 (2003)
Figure 4-4. Effect of temperature on the germination of NC 71 (2004)

Figure 4-5. Effect of temperature on the germination of K 346 (2003)

Figure 4-6. Effect of temperature on the germination of K 346 (2004)
Figure 4-7. Effect of temperature on the germination of Speight 168 (2003)

Figure 4-8. Effect of temperature on the germination of Speight 168 (2004)

Figure 4-9. Effect of temperature on the germination of NC 297 (2003)
Figure 4-10. Effect of temperature on the germination of NC 297 (2004)

GREENHOUSE DISEASE CONTROL

Table 4a. Greenhouse Disease Control.

<table>
<thead>
<tr>
<th>DISEASE</th>
<th>CHEMICAL AND FORMULATION</th>
<th>RATE</th>
<th>REMARKS AND PRECAUTIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rhizoctonia,</td>
<td>Methyl Bromide 98%</td>
<td>3 lbs / 1000</td>
<td>Stack polystyrene trays loosely with sticks separating trays after each ten trays in the stack to improve movement of the gas into the trays. Release gas into and maintain a closed environment (plastic tarp or other container) for at least 72 hours when air temperature is at least 50°F. Greenhouses should not be used as fumigation chambers as they cannot be properly sealed. Trays should be ventilated prior to filling with media. Proper precautions should be taken to avoid worker injury from remaining gas when the cover is opened.</td>
</tr>
<tr>
<td>Sclerotinia and Pythium</td>
<td>Steam 160°F - 175°F for 30 minutes</td>
<td>Excessive heat for an extended period of time can cause trays to be brittle and warp resulting in problems during mechanical seeding.</td>
<td></td>
</tr>
</tbody>
</table>
### Table 4b. Greenhouse Disease Control.

<table>
<thead>
<tr>
<th>DISEASE</th>
<th>CHEMICAL AND FORMULATION</th>
<th>RATE PER 1000 SQ. FT.</th>
<th>REMARKS AND PRECAUTIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blue Mold, Rhizoctonia (Damping Off &amp; Target Spot)</td>
<td>mancozeb (Dithane DF, Penncozeb 75 DF)</td>
<td>0.5 lb (One level teaspoon per gallon)</td>
<td>Use 0.5 lb per 100 gallons of water. Spray to run-off (3 gallons per 1000 sq.ft.) every 5-7 days when plants reach dime size (0.5 - 1 inch tall). Gradually increase the spray volume to 6 to 12 gallons per 1000 sq.ft. as plants enlarge until transplanting to the field.</td>
</tr>
<tr>
<td>Target Spot</td>
<td>Azoxystrobin (Quadris F)</td>
<td>0.14 oz in 5 gallons of water per 1000 sq.ft.</td>
<td>This application allowed by GA 24c labeling. Make only one application prior to transplanting. Additional field applications may be made according to the Quadris federal label.</td>
</tr>
</tbody>
</table>

### Table 4c. Greenhouse Disease Control.

<table>
<thead>
<tr>
<th>DISEASE</th>
<th>CHEMICAL AND FORMULATION</th>
<th>RATE PER 100 GALLONS</th>
<th>REMARKS AND PRECAUTIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pythium Root Rot</td>
<td>Etridiazole (Terramaster 35 WP)</td>
<td>2 oz.</td>
<td>Mix Terramaster per 100 gallons of water 2-3 weeks after seeding and again up to 8 weeks after seeding as needed. Mix Terramaster with water in a bucket and add to float water while providing thorough mixing. A sequential application may be made three weeks after the initial application as needed.</td>
</tr>
<tr>
<td></td>
<td>(Terramaster 4 EC)</td>
<td>1 fl. oz.</td>
<td></td>
</tr>
</tbody>
</table>

If Pythium shows up a second treatment can be made up until 8 weeks after seeding.

The plant producer assumes all responsibility for any stunting or plant injury that may occur.
Growing tobacco transplants in greenhouses has increased tremendously in Georgia over the last several years. So far insects have not caused serious problems in greenhouses, but several insects have the potential to become economic pests. Most problems have been caused by field crickets, vegetable weevils, aphids, cutworms, ants and slugs. Since a limited number of insecticides is labeled for use in greenhouses, managing insect pests requires routine inspection of greenhouses for potential problems. The following practices are recommended.

### Table 3. Greenhouse Insect Control

<table>
<thead>
<tr>
<th>INSEC T</th>
<th>CHEMICAL AND FORMULATION</th>
<th>RATE PER 1000 SQ. FT.</th>
<th>REMARKS AND PRECAUTIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aphids,</td>
<td>acephate (Orthene 75S)</td>
<td>1 tbsp in 3 gals water</td>
<td>Apply to foliage as a spray.</td>
</tr>
<tr>
<td>Cutworm</td>
<td>(Acephate 75SP)</td>
<td>1 tbsp in 3 gals water</td>
<td>Do not apply through an irrigation system. Over application can cause plant injury.</td>
</tr>
<tr>
<td>ms or</td>
<td>(Orthene 97PE)</td>
<td>0.75 tbsp in 3 gals water</td>
<td></td>
</tr>
<tr>
<td>Flea Beetles</td>
<td>imidacloprid (Admire 2F or other generic formulations) (Admire PRO 4.6 SC)</td>
<td>1.0-1.4 oz. per 1000 plants</td>
<td></td>
</tr>
<tr>
<td></td>
<td>thiamethoxam (Platinum 2SC) (T-MOXX)</td>
<td>0.5-1.2 oz. per 1000 plants</td>
<td></td>
</tr>
<tr>
<td></td>
<td>imidacloprid (Admire 2F or other generic formulations) (Admire PRO 4.6 SC)</td>
<td>0.8-1.3 oz. per 1000 plants</td>
<td></td>
</tr>
<tr>
<td>Mole Crickets</td>
<td>imidacloprid (Admire 2F or other generic formulations) (Admire PRO 4.6 SC)</td>
<td>1.4-2.8 oz. per 1000 plants</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.6-1.2 oz. per 1000 plants</td>
<td></td>
</tr>
</tbody>
</table>
### Chemical Control

An insecticide must be specifically labeled for use on tobacco in a greenhouse before it can be used legally. Orthene and Admire should be applied as a spray over the top of tobacco seedlings and not in the float water. Metaldehyde (Deadline Bullets) is labeled for slugs and snails in the greenhouse. It should be applied to walkways and margins and not directly to seedlings in the float beds.

### Cultural Controls

Areas around the greenhouse should be kept free of weeds, trash, leaves, plastic, lumber and other items that offer protected sites for insects. The greenhouse should also be kept free of trash, supplies, and other unnecessary equipment that offer protected sites for insects. Vegetable weevils, slugs, crickets, grasshoppers and cutworms often move into greenhouses from sheltered areas outside the greenhouse. Aphids can migrate into greenhouses from weeds adjacent to the greenhouse and establish new colonies on tobacco seedlings. If greenhouses are used for production of ornamentals or vegetables in the off season, allow a fallow period between crops to reduce the chances of pests such as aphids or white flies being carried over to the tobacco seedlings. Keeping the greenhouse open during the winter may help reduce pests that might overwinter inside. Trays and other materials that might offer protection to pests from the cold should not be left inside the greenhouse. Closing the greenhouse during the summer and bringing the temperature up to 140°F for several days should reduce insect numbers.
The application of fertilizers in the transplant water has been discouraged because of the lack of crop response and the potential for crop injury from fertilizer salts. However, early-season growth of greenhouse transplants is occasionally slower than that from plant-bed plants. This slower growth has resulted in renewed interest in transplant water fertilizers.

Numerous on-farm tests have been conducted with several fertilizer treatments in all the flue-cured tobacco producing states. The following summary statements can be made concerning the results of the 4-year study:

- High-phosphorus transplant water treatments often stimulated early-season growth.

- Growth differences among treatments usually disappeared by flowering and there were usually no differences observed in time of flowering.

- Yield and quality were not affected by transplant water treatments at any location.

- Float water is nutritionally acceptable for use as transplant water. However, typical nutrient levels are not sufficient to affect early-season growth.

- Similar field responses to transplant water treatments were observed for plantbed and greenhouse transplants.

Based on these studies it is likely that some fertilizers, particularly those high in phosphorus, will enhance early-season growth. However, it is doubtful that these fertilizers will promote earlier harvest. It is also unlikely that yield or quality will be enhanced.

It is important to remember that there is a level of risk associated with any product, particularly a fertilizer, added to the transplant water. These studies dealt with a relatively small number of fertilizers that were applied with high rates of transplant water (about 300 gallons per acre).

Fertilizer salt injury to tobacco roots is possible

(1) when transplant water fertilizers are not applied according to label directions;
(2) when low (less than 200 gallons per acre) rates of transplant water are used;
(3) when the soil is dry;
(4) when the regular fertilizer was applied broadcast or in the row ridge before transplanting; or
(5) with transplant water fertilizers that have not been tested on tobacco.

Also, adding field-type fertilizers such as 16-0-0 and 30% nitrogen solution to transplant water usually injures or kills transplants.
DETERMINING PLANT NUMBER PER ACRE

Each year growers have questions relating to determining plant numbers per acre. The table below may be useful in planning for planting density. In recent years growers have tended to increase the plant population per acre in an attempt to compensate for losses to tomato spotted wilt virus. While this may be helpful when losses are single plants, this approach may not be as helpful when losses are more than one plant consecutively. While yields may be increased by increasing plant populations under certain conditions the percent yield increase is not comparable to the percent increase in plant population. Overplanting results in the need for greater numbers of transplants and the handling of greater numbers of leaves. While this factor may not be as important today with mechanical harvesting as in previous years when harvest was all a result of hand labor there is a cost for handling a greater number of lighter leaves per box or barn. Previous work indicates best overall performance is a result of combinations of row width, in-row spacing and topping height which yields approximately 120,000 leaves per acre.

<table>
<thead>
<tr>
<th>Drill Distance (feet)</th>
<th>Row Width (feet/inches)</th>
<th>3.00</th>
<th>3.17</th>
<th>3.33</th>
<th>3.50</th>
<th>3.67</th>
<th>3.83</th>
<th>4.00</th>
<th>4.17</th>
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<tbody>
<tr>
<td></td>
<td>36</td>
<td>10890</td>
<td>10317</td>
<td>9801</td>
<td>9334</td>
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<td>8523</td>
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</table>

Number of Plants Per Acre Needed at Various Row Widths and Drill Distances