4. PRODUCING HEALTHY TRANSPLANTS IN A FLOAT SYSTEM

Loren R. Fisher
Extension Tobacco Specialist and Professor—Department of Crop and Soil Sciences
Matthew C. Vann
Assistant Professor and Tobacco Extension Specialist—Department of Crop and Soil Sciences

Profitability remains a concern to many growers as a result of rapidly increasing production costs. The first step in minimizing heating-fuel costs is to avoid seeding too early. Most growers have learned that it only takes 60 days to produce a transplant, and that seeding before the second week in February increases fuel usage and the cost of transplant production.

Nearly all of the costs in transplant production are on a whole-greenhouse basis. Thus, the best way to decrease the cost on a per-transplant basis is to increase usability. Therefore, management practices that improve stands and promote uniform growth decrease production costs. Nearly all management practices affect usability, but these are some of the most important:

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

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

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

4. **Prevent stand loss.**
   - Provide proper ventilation and airflow to prevent heat injury.
   - Avoid early seeding, high nitrogen rates, and hot daytime temperatures that promote stem rot diseases.
   - Fumigate trays with methyl bromide or purchase new trays.

CONSIDER THE MATERIALS

Analyze the Water Source and Manage Alkalinity

Water quality management is an important part of successful transplant production. Bicarbonate levels (alkalinity) are high in water from many areas, particularly in eastern counties, and boron is absent from the water in many counties in the piedmont. Have a water sample analyzed from each potential water source before beginning transplant production.

The North Carolina Department of Agriculture and Consumer Services (NCDA&CS) analyzes water at a nominal cost. Growers receive a detailed report about the nutritional suitability of each water sample for transplant production.

Collect a twenty-ounce sample from each potential water source. A clean, nonreturnable drink bottle with a screw-on cap makes an excellent sample bottle. Rinse the bottle (but do not use soap) several times and allow the water to run several minutes before collecting the sample. Forms and assistance are available from county Cooperative Extension centers.

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

Select a High-Quality Growing Medium

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

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.

A few years ago, 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.

Research has 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 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 two-hundred-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 and that all media evaluated would be suitable for shallow trays.

Table 4-1. Effect of cell volume and density on transplant production in the float system, 2004

Treatment	ISM[1] (%)	Spiral Root (%)	Total Plants (%)	Usable Plants (%)	Stem Length (cm)	Stem Diameter (mm)
Trays						
Glazed 288 traditional (15 cc per cell)	95	3	94	88	6.4	3.0
Glazed 288 shallow (8.6 cc per cell)	96	4	92	84	6.3	3.0
200 traditional (27 cc per cell)	96	3	95	90	7.0	3.6
200 shallow (8.6 cc/cell)	95	3	94	87	7.0	3.8
LSD (0.05)	NS	NS	NS	4	0.3	0.3
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 uniformity of germination. It is calculated as the percentage of the total germination that occurred over a 48-hour period.
NS = Not statistically significant. Treatments should be considered similar.

Table 4-2. Effect of cell volume and density on transplant production in the float system, 2005

Treatment	Emergence (%)	Total Plants (%)	Usable Plants (%)	Stem Length (cm)	Stem Diameter (mm)
Trays					
288 traditional (17.5 cc per cell)	94	90	79	4.9	2.5
Glazed 288 shallow (8.6 cc per cell)	96	91	81	5.9	2.4
200 traditional (27 cc per cell)	94	91	84	6.2	2.9
200 shallow (8.6 cc/cell)	94	92	84	6.1	2.9
LSD (0.05)	2	NS	NS	0.4	0.3
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. Treatments should be considered similar.

PROMOTE UNIFORM EMERGENCE

Uniform emergence and growth are necessary to produce a high percentage of usable transplants. Research has shown that even a three-day delay in emergence in 25 percent of the seedlings could reduce usability (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 seeding emergence on transplant production, 1999–2000

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

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.

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 five-degree reduction in temperature.

Therefore, after maximum seedling emergence is obtained, nighttime temperatures should be reduced to a range of 55°F to 60°F to conserve fuel usage. Daytime temperatures of 80°F to 85°F are adequate for normal growth. Heat injury (browning of leaves or seedling death) has been observed when air temperatures inside the structure exceed 110°F.

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 three popular varieties to temperature during germination is shown in Figures 4-1 through 4-6. 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. However, for NC 71 and NC 297, 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 seven to eight 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 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 4-7). Fertilizer salts levels in the upper half inch are directly related to the total amount of fertilizer applied (in the waterbed and in the medium). Therefore, it is better to use a medium with no fertilizer (or with only a minimal amount) than to use a highly charged medium.
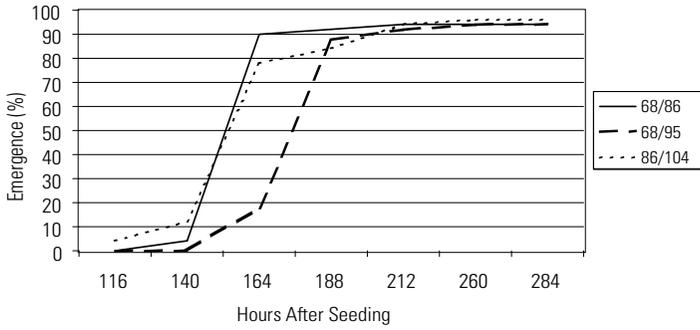
Figure 4-1. Effect of temperature on the germination of K 326 (2003)
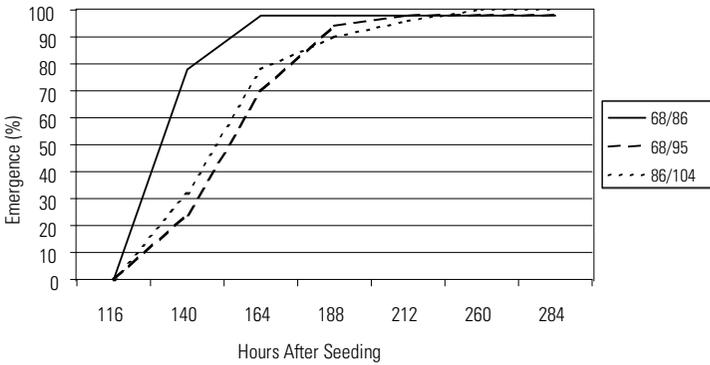

Figure 4-2. Effect of temperature on the germination of K 326 (2004)
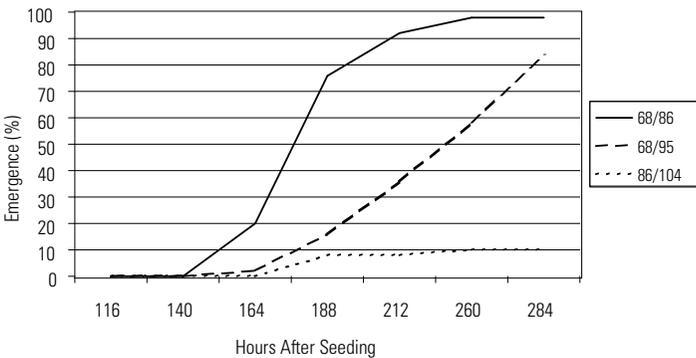

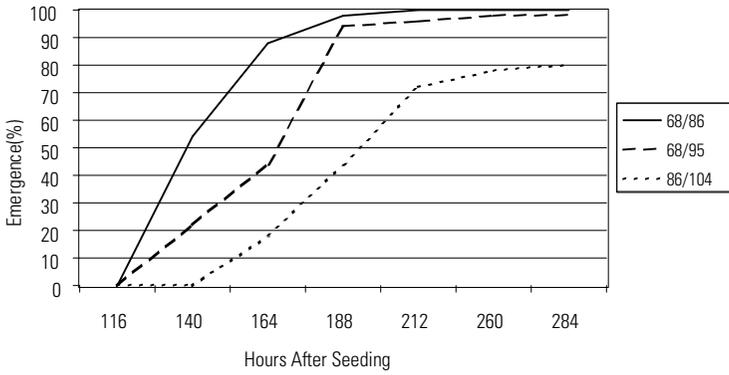**Figure 4-3. Effect of temperature on the germination of NC 71 (2003)**

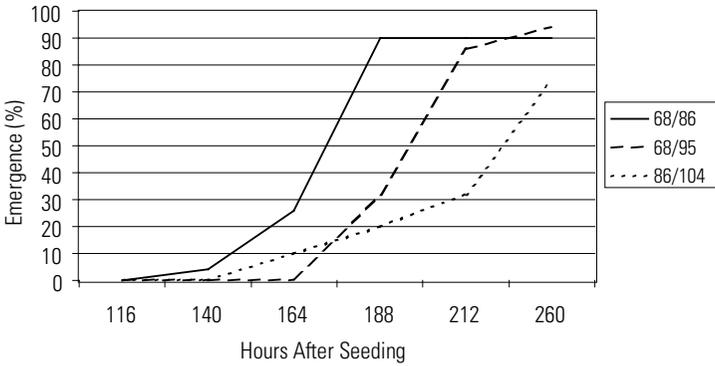*Figure 4-4. Effect of temperature on the germination of NC 71 (2004)*

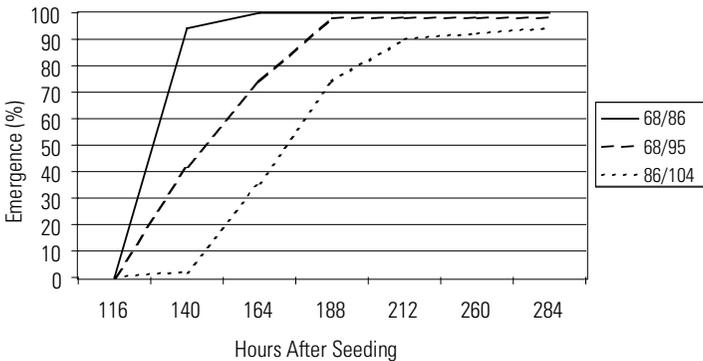*Figure 4-5. Effect of temperature on the germination of NC 297 (2003)*

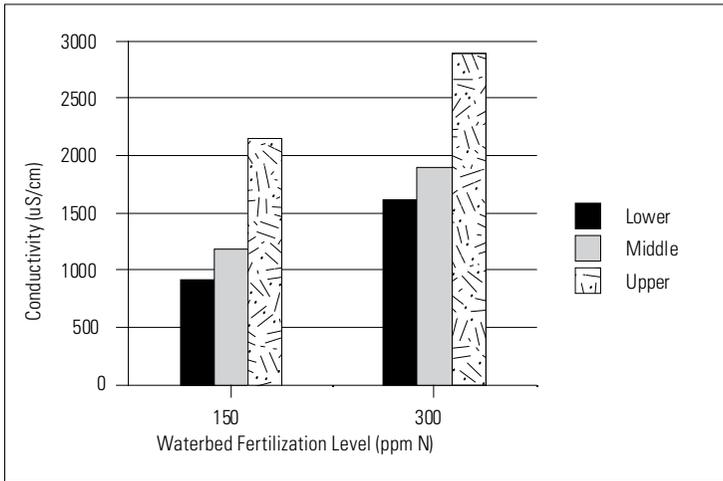*Figure 4-6. Effect of temperature on the germination of NC 297 (2004)*

Figure 4-7. 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 half 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 two to three minutes before measuring the conductivity. Normal levels range from 500 to 1,000 microseimens (0.5 to 1 millimhos). Readings of 1,000 to 1,500 microseimens (1 to 1.5 millimhos) are moderately high, and readings above 1,500 microseimens are very high. Apply water from overhead to leach and dilute salts when: (1) conductivity readings are above 1,000 microseimens and plants are pale or stop growing; or (2) conductivity readings are 1,500 microseimens or above.

Fertilize Properly
Growers with fertilizer injection systems have been successful in using a constant application rate of 125 parts per million (ppm) nitrogen from 20-10-20, 16-5-16, 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 or 3-1-3 ratio) for the first application. The same fertilizer or ammonium nitrate can be used for the second application. Higher application rates cause tender, succulent seedlings that are more susceptible to diseases. Also, high application rates promote fertilizer salts injury to seedlings as noted above. If high

fertilizer salts levels are detected during the first four weeks after seeding (>1,000 microseimens in the medium from the upper half inch of the cell), apply water uniformly from overtop to reduce fertilizer salts levels.

Monitoring waterbed fertility levels. Pocket-sized conductivity meters can be used to monitor fertility levels in waterbeds. Most fertilizer labels contain a chart that provides the expected conductivity level for the initial fertilizer concentration, usually expressed as nitrogen concentration in ppm. Conductivity is useful in measuring the accuracy 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 4-8). 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.
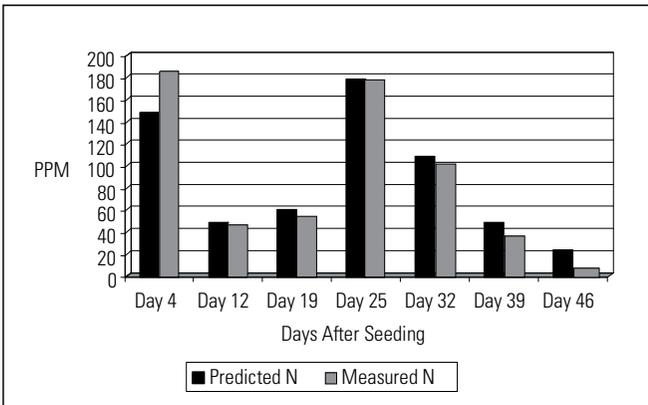

Figure 4-8. A comparison of predicted (based on conductivity) and measured nitrogen concentrations in a float bed, 2002

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

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

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

Phosphorus. Research at Clemson University has shown the need to limit phosphorus concentrations to 35 to 50 ppm in the waterbed. Applying excess phosphorus causes spindly transplants and leaves more phosphorus in the waterbed for disposal after transplant production. Therefore, 20-10-20 and 20-9-20 are better choices than 20-20-20 fertilizer. Other fertilizers, such as 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.

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 four ounces per one hundred 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. Studies were conducted to compare seedling production when using bat manure (8-4-1) and Peruvian seabird guano (13-8-2) to seedling production when using the standard water-soluble fertilizer 16-5-16 (Table 4-4).

Table 4-4. Effect of fertilizer on stem length and transplant usability, 2002 and 2003

Fertilizer	Stem Length (cm/plant)		Usable Transplants (%)	
	2002	2003	2002	2003
16-5-16	8.7	5	73	88
Bat manure (8-4-1)	2.6	1	0	0
Peruvian seabird guano (13-8-2)	6.8	3	77	72
Bat manure (8-4-1) at a 3× rate	—	3	—	84

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

Both organic products produced smaller seedlings and a lower percentage of usable seedlings than 16-5-16 in one study, but in another study 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.

Various formulations and brands of seabird guano exist; however, those most commonly used by tobacco producers are high in organic nitrogen and phosphorus and low in potassium (e.g., Sunleaves 12-11-2). Many producers have expressed concern with the use of fertilizer sources high in organic nitrogen due to the negative effects the source can have on seedling development, specifically as urea is released from the nutrient source. In addition, as producers add seabird guano to the float water at rates designed to supply sufficient nitrogen (typically 125-150 ppm N), they often over-supply phosphorus (by as much as 3x) and under-supplying potassium (by as much as -6x). Furthermore, tobacco float beds fertilized with seabird guano often contain extremely high concentrations of bicarbonate (HCO_3^-) which can increase water pH, limit nutrient availability, and reduce seedling growth/vigor.

In order to improve nutrient recommendations for organic tobacco seedling producers, research was conducted to evaluate three organic nitrogen (N) programs that might serve to address the following:

1. Provide sufficient N for seedling growth
2. Limit phosphorus exposure
3. Reduce bicarbonate concentrations (prevent high float water pH)

The three organic N programs evaluated were 100 percent seabird guano (Sunleaves 12-11-2), 100 percent sodium nitrate (SQM Allganic 16-0-0), and a combination of guano and sodium nitrate. Sodium nitrate is mined material from South America that is Organic Materials Review Institute (OMRI)-listed and contains 100 percent nitrate-N. Treatments were supplemented with OMRI-listed water soluble 0-0-52 (potassium sulfate, SQM Allganic). Each fertility program was designed to provide 125 ppm N, 0-115 ppm P, and 125 ppm K. Three additional treatments of each organic N program that included gypsum (calcium sulfate) were also evaluated. Each treatment was compared to a conventional water soluble fertilizer source (SQM 16-5-16). A complete list of treatments and the nutrients supplied by each fertilizer program can be found in Table 4-5.

Table 4-5. Fertilizer programs and the corresponding nitrogen, phosphorus, potassium, and calcium concentrations

Fertilizer Program[a]	N	P	K	Ca	Quantity[b] (oz/100 gal water)
		ppm			
SG + PS	125	115	20(SG) + 105(PS)	0	13.9 (SG) + 2.7 (PS)
SG + PS + Gyp	125	115	20(SG) + 105(PS)	50	13.9 (SG) + 2.7 (PS)
SN + PS	125	0	125 (PS)	0	10.4 (SN) + 3.2 (PS)
SN + PS + Gyp	125	0	125 (PS)	50	10.4 (SN) + 3.2 (PS)
SG + SN + PS	44(SG) + 81(SN)	40	7(SG) + 118 (PS)	0	4.9 (SG) + 6.8 (SN) + 3.0 (PS)
SG + SN + PS + Gyp	44(SG) + 81(SN)	40	7(SG) + 118 (PS)	50	4.9 (SG) + 6.8 (SN) + 3.0 (PS)
16-5-16	125	40	125	0	10.4 (16-5-16)

[a] SG, Seabird Guano; PS, potassium sulfate; SN, sodium nitrate; Gyp, gypsum.

[b] Figures in column represent fertilizer sources presented in the "Fertilizer Program" column. Gypsum not included in figure estimates, but was supplied at 2.90 oz/100 gal to obtain 50 ppm Ca in designated treatments.

Treatments containing sodium nitrate as the sole source of nitrogen failed to produce usable seedlings due to the absence of phosphorus in the selected fertilizer program (Table 4-6) and the low phosphorus (<1.0 ppm) content of the soilless media and source water. Seedling growth and development was acceptable in treatments composed of guano only or guano + sodium nitrate, and was similar to that of 16-5-16 (Table 4-6). In addition, it does not appear that calcium was a limiting production factor; therefore, gypsum was not required for plants to reach optimal transplanting size. Although, it is probable that calcium demand could vary from season to season, based upon growing conditions. Should calcium deficiency develop, producers are encouraged to utilize OMRI-listed sources of gypsum for correction. The use of lime is discouraged, as it may increase the solution pH to a level that the availability of other nutrients in limited—in much the same way as bicarbonate.

Ammonium-N float water concentration was greatest in guano treatments 25 days after seeding (DAS), but declined rapidly over the following 20 to 30 days. The decline in ammonium concentration was complemented by an increase in nitrate-N concentration during the same period, indicating that ammonium was converting into nitrate. Bicarbonate concentration was greatest in guano only (≥12.0 meq/L) and guano + sodium nitrate (≥3.0 meq/L) treatments 25 DAS but was <1.0 meq/L in sodium nitrate–only treatments, further implicating guano as a source of bicarbonate in organic float systems. The established bicarbonate limit is 2.0 meq/L (or 100 ppm), beyond which acidification is recommended. Despite the high bicarbonate concentrations documented in guano-only treatments, seedling growth was not impacted. Ultimately, guano and guano + sodium nitrate based fertility programs produced seedlings comparable to 16-5-16 and appear to be suitable for the production of organic tobacco seedlings. These fertility programs should be managed to include additional nutrients, such as phosphorus, in order to provide a complete nutrition program. Furthermore, bicarbonates should be monitored and corrected accordingly.

Table 4-6. Transplant usability and physical measurements as influenced by organic fertility program[1]

Fertilizer Program[2]	Total Plants	Usable Plants	Stem Diameter (mm/plant)	Stem Height (cm/plant)
	%			
Guano	90 a	78 c	2.76 b	5.62 b
Guano + Gyp	91 a	79 bc	2.84 b	6.08 ab
Sodium Nitrate	--[3]	--	--	--
Sodium Nitrate + Gyp	--	--	--	--
Guano + Sodium Nitrate	91 a	85 ab	3.48 a	6.27 ab
Guano + Sodium Nitrate + Gyp	93 a	86 a	3.43 a	6.47 ab
16-5-16	88 a	79 bc	3.30 a	6.62 a

[1] Treatment means followed by the same letter within the same column are not significantly different.
[2] Guano, Sunleaves (12-11-2) Peruvian Seabird Guano; Sodium Nitrate, Allganic 16-0-0; Gyp, gypsum (Calcium Sulfate). All treatments were supplied with Allganic 0-0-52 to ensure 125 ppm K.
[3] Treatment did not produce usable transplants; therefore, data are excluded from the analysis.

Additional points for consideration:

- Producers might consider processing (grinding) guano prior to application. Smaller guano particles will have more surface area and will be more water soluble, both of which should increase nitrogen release into solution. In addition, soaking and agitating guano in warm water at least 24 hours before application will also promote solubility.

- When blending organic nitrogen sources, target 40 ppm phosphorus (P) from guano (example: 4.85 oz. 12-11-2/100 gallons float water). This will ensure sufficient P for the season when added to the float water in two applications. The remaining nitrogen needed for seedling growth can be sourced from sodium nitrate. Examples of this blend can be found in Table 4-6.

- Consult with your local Cooperative Extension agent if you suspect a deficiency (such as calcium or boron). Organically approved secondary and micronutrient sources are available; however, deficiencies should be confirmed prior to application.

- Consult with your organic certifier and contract holder prior to the use of ANY fertilizer source.

- Water circulation is critical for organic nutrient sources, as some (guano) are not easily dissolved or distributed in solution. Submersible pumps will help circulate water/nutrients and can add oxygen to the float water. The addition of oxygen is recommended, as it will help promote nitrification, reduce bicarbonate concentration, and increase oxygen concentration in the float water.

- 2.90 oz gypsum/100 gallon of float water will add roughly 50 ppm calcium and 40 ppm sulfur.

- Float water samples should be collected and analyzed at frequent intervals (weekly).

- Split-apply organic fertilizer to float beds. The first application should take place 7-10 days after seeding, and the second about two to three weeks later. This will reduce seedling exposure to soluble salts, bicarbonate, urea, and nitrite (NO_2^-).

- Bicarbonate (HCO_3^-) concentration can reach such a level that seedling growth may be negatively affected. One OMRI-approved vinegar source (Green Gobbler) has proven successful in preliminary screening at NC State. Green Gobbler is 30 percent acetic acid, which is much higher in concentration than food-grade vinegar sources, which are typically approximately 5 percent acetic acid. Producers should exercise caution (wear gloves and eye protection) when applying acidifying materials to float water.

- If greenhouse source water is high in bicarbonate, then treatment before seeding is recommended, just as it is in conventional production. For information pertaining to application rates of organic acidifiers, please contact your local Extension agent.

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

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

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

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

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

Clip Properly
Proper clipping is an important practice that can increase the number of usable transplants and improve transplant hardiness, 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 three to five clippings. However, many growers clip 15 to 20 times. Too many clippings indicate that the greenhouse was seeded too early. Early seeding increases heating costs as well as the potential for collar rot. Another problem is improper clipping (clipping too early and too close to the bud), which reduces stem length, increases stem rots, and slows plant growth in the field.

Research conducted by Walter Gutierrez of NC 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 to 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 two to 2.5 inches above the tray and to set the blade height at one to 1.5 inches above the bud. This procedure provides the best balance of uniformity, stem length, and disease management.