The Float System for Producing Tobacco Transplants

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The 1990s were a decade of transition in tobacco transplant production. Grower use of the float system in Tennessee increased from less than 1 percent in 1990 to about 80 percent in 1999.

The high level of grower adoption of the float system is due to its advantages over the conventional plant bed. The primary benefits of the float system are:

- the task of pulling plants is eliminated,
- the risk of plant bed failure from dry weather is eliminated,
- plant bed weed-control measures are eliminated,
- survival and early-season growth of transplanted float plants are generally improved compared to conventional plants,
- storage of unused plants is a simple matter of re-floating the trays,
- daily transplanting rate can be increased because the time pulling plants is eliminated and float plants can be transplanted anytime of the day, and
- the primary labor requirements (pulling plants in the plant bed system, and seedling transfer or seeding in the float system) are shifted from the busy transplant season to a generally less busy period several weeks earlier

A disadvantage of the float system is the increased incidence of early-season ground suckers. In most cases, however, these suckers do not develop enough to be a serious problem. In a few cases, float plants have been observed to be more susceptible to early-season, temporary injury from soil-applied pesticides, probably due to the extensive and immediately-functioning root system of the float plant. High initial cost of greenhouses may be considered a disadvantage. The need for increased management of seedling diseases is also a disadvantage of the float system.

Growers have several options for using the float system:

1) plug-and-transfer,
2) direct seeding in greenhouse,
3) direct seeding in outdoor bed,
4) purchase of pre-finished plants, and
5) purchase of finished or field-ready transplants.

Plug-and-transfer involves purchasing seedlings in mini-trays (the seedlings will be 3-4 weeks old and about 1-1½ inches tall) and transferring the seedlings, or plugs as they are often called, to the float trays. Plants are usually ready to transplant about 3-4 weeks later. Plug and transfer was the way most growers in Tennessee got started in the float system, but this method has declined in popularity as growers generally prefer direct seeding and sentiment for local production of transplants strengthens.

Pre-finished plants are direct seeded in float trays, are approximately plug size when purchased and are floated for 3-4 weeks in outdoor beds or greenhouses until ready to transplant. Pre-finished plants should be managed in the same way as plug-and-transfer plants (excluding the transfer of plugs, of course).

General Float System Topics

Trays

A University of Tennessee study found no significant differences in transplant survival or percent usable plants among plants from trays with 200, 242, 253, 288, 338 and 392 cells. However, the higher cell-number trays (those above 288) will produce a smaller-sized plant that must be clipped more often to produce a comparable-sized plant. The 242-, 253- and 288-cell trays are the most popular trays with Tennessee producers. With proper management, the 338- and 392-cell trays can also provide acceptable transplants. However, disease control may require more attention in trays with greater density of plants and restricted air circulation. Growers who still use plug-and-transfer prefer the 200-cell tray.

Table 5.a-1. Cell volume and number of cells per square foot for different float trays.

No. Cells per Tray	*Cell Volume (cubic centimeters)*	*Cells per Sq. Ft.*
200	27.0	80
242	23.5	97
253	16.5	101
288	17.0	115
338	11.2	135
392	13.6	157

The number of trays needed depends upon the number of plants set per acre, the number of cells per tray and the estimated percent usable plants produced per tray. The percent usable plants will depend upon which float system option is used and how closely the plants are managed. With plug-and-transfer, 90-95 percent usable plants is reasonable. With direct seeding, a figure of 75-85 percent is more typical.

Table 5.a-2. Number of plants per tray and number of trays needed for 7500 plants.

	80% Usable Plants		*90% Usable Plants*	
No. Cells per Tray	***No. Plants per Tray***	***No. Trays for 7500 Plants***	***No. Plants per Tray***	***No. Trays for 7500 Plants***
200	160	50	180	42
242	194	42	218	35
253	202	40	228	33
288	230	35	259	29
338	270	30	-	-
392	314	26	-	-

Potting Mix (Media)

Potting mixes formulated for tobacco float systems generally are "peat-lite" mixes, meaning that they contain an equal or near-equal amount of two primary ingredients – peat moss and vermiculite. These mixes usually also contain small amounts of other materials, such as limestone, gypsum, trace amounts of nutrients and a wetting agent. Mixes with coconut hull fiber, called "coir," have also been formulated for tobacco float systems and seem to work fine. Some growers (primarily with plug-and-transfer) use a fertilized potting mix containing a slow-release fertilizer. Due to the difficulty of obtaining uniform and predictable amounts of fertilizer with this fertilization method, most growers use an unfertilized potting mix and do their own fertilizing.

Filling Trays

The objective in filling trays is to create a uniform, very lightly compressed column of mix from the bottom to the top of each cell. Adjust mechanized tray filling units to fill the cells completely but not to pack the mix into the cells. If manually filling the trays, pile the mix onto the tray, smooth the mix to tray-top level, gently drop the tray to settle the mix uniformly within the cells, then top off the tray with mix to completely fill the cells to tray top. The number of trays filled per cubic foot of potting mix (a bag typically contains 3 or 4 cubic feet) will depend on the physical characteristics of the mix. As a general guide, each cubic foot of mix should fill at least 4½ to 5½ trays.

Dry cells. Dry cells result in stand reduction and are caused by a gap in the column of mix or by an excessively fine, packed mix, both of which interfere with the wicking of water up through the mix. A seed that remains dry generally will not germinate. A few dry cells are to be expected. However, more than just a few dry cells per tray is a signal that something needs to be corrected. New trays sometimes have slick walls, causing the mix to slide out of the trays, resulting in dry cells or insufficient mix in the cells. This can be prevented by wetting the new trays immediately before filling. With old or new trays, using a slightly pre-moistened mix, or adding about ½ gallon of water per cubic foot of dry mix, can also help minimize dry cells. Don't overdo the water – wet mix often results in excessively packed trays, which can result in poor growth (and spiral rooting in direct seeding). A few producers fill the trays with dry mix and float these trays overnight before seeding. This allows dry cells to be identified and corrected (by pushing the mix toward the bottom of the cell) before seeding.

Dibbling. The mix needs to be "dibbled" prior to seeding (this obviously applies primarily to direct seeding – dibbling can be done with plug-and-transfer but is not necessary). Dibbling slightly compresses the mix, centers the seed in the cell and helps create a favorable environment for germination. Commercial dibble boards and rolling dibblers are commonly used. The dibble is created by a pyramid or round-shaped projection on the board or roller. The pyramid shape is generally preferred. Homemade dibblers will also work well if precisely built, using electrical wire connectors, wooden pegs or other dibbling device. Dibble depths of about 3/4 inch generally reduce spiral rooting compared to more shallow dibble depths. With these dibble depths, it is important that the dibble be wider at the top of the cell than at the bottom, to keep the mix from collapsing on the seed.

Fertilization

The fertilization program for float systems should maintain a 75-125 parts per million (ppm) nitrogen level. University of Tennessee studies have shown that 6-7 ounces of 20-10-20 water-soluble fertilizer (with micronutrients) per hundred gallons of water applied at seeding produced excellent transplants. An additional application of fertilizer may be needed later (to maintain the recommended concentration of fertilizer) when and if additional water is added. The rate of 6-7 ounces of 20-10-20 fertilizer corresponds to approximately 100 ppm nitrogen. Weigh the fertilizer, if necessary, to be sure of an accurate amount. Be sure to calculate the correct number of gallons of water in the bed (see section below on "determining gallons of water"). Some growers wait 7-10 days after seeding before fertilizing, hoping this will result in more uniformly-sized seedlings and reduced risk of soluble salts problems. Research has not confirmed this. However, delayed fertilization may reduce algae (although algae generally does not cause problems). Fertilization at seeding or later is a matter of personal preference. The at-seeding time is usually more convenient. Float system fertilizers should not contain urea (or certainly no more than a low percentage urea) as the nitrogen source. Instead, the nitrogen should be in the nitrate form and ammoniacal form. At least 50 percent of the nitrogen should be nitrate nitrogen, and the nitrogen content should be at least twice as high as the phosphorous content. Also, the fertilizer should contain micronutrients (boron deficiencies have been observed in a few cases when a fertilizer without micronutrients was used.) Fertilizers that meet these requirements typically include analyses such as 20-10-20, 20-9-20, 15-5-15, 16-4-16, etc. Before buying, always read the label on the fertilizer bag, especially to check the nitrogen sources, micronutrients and electrical conductivity (see the ***Electrical Conductivity Meters*** section in this chapter).

Determining gallons of water in a float bed. There are several ways to determine the number of gallons of water in a float bed. Measuring the number of gallons delivered by the spigot in one minute, and then tracking the time required to fill the float bed is one method. An estimate can be obtained by using the following formula:

number of trays x water depth in inches x 1.64

Another formula commonly used to calculate the number of gallons of water in a float bed is:

length of bed (ft) x width of bed (ft) x average water depth (ft) x 7.5 = number of gallons

For example, a bed 30 feet long, 14 feet wide, with an average water depth of 5 inches (or 0.42 feet), would contain 1,323 gallons (30 x 14 x 0.42 x 7.5). This amount is equivalent to 13.23 units of 100 gallons (1,323 divided by 100), which can be rounded to 13.2 hundreds of gallons for calculation purposes. To calculate a fertilizer concentration of 100 ppm Nitrogen (N) (6.7 ounces per 100 gallons), multiply 13.2 times 6.7, which amounts to 88 ounces of fertilizer. This amount, 88 ounces, divided by 16 ounces per pound, equals 5.5 pounds.

Table 5.a-3. Examples of fertilization rates for selected bed sizes and water volumes.

Gallons of water in selected bed sizes for indicated water depths.			
	Average water depth (inches)		
Bed size	***4***	***5***	***6***
6' x 18'	269	337	404
12' x 24'	717	898	1077
14' x 30'	1046	1310	1571

Amount (ounces) of typical 20-10-20 fertilizer required to obtain selected nitrogen levels in indicated gallons of water.		
Gallons	***75 ppm Nitrogen***	***100 ppm Nitrogen***
269	13 oz.	18 oz.
337	17	23
404	20	27
717	36	48
898	45	60
1046	52	70
1077	54	72
1310	66	88
1571	79	105
To convert to pounds, divide ounces by 16.		

Electrical Conductivity Meters. The fertilizer concentration in the float water should be monitored frequently by use of an inexpensive electrical conductivity meter such as the DiST 4 (by Hanna), Sharp EC (by Milwaukee Instruments) or some other similar meter. To use this meter, you must know the electrical conductivity for the fertilizer you used and the meter reading for unfertilized water (from the same water source used in the float bed). The meter reading for the unfertilized water is subtracted from the meter reading for the fertilized water. The resulting difference in meter readings is then used to estimate fertilizer concentration, using a conversion table or chart for the type of fertilizer used (see your Extension Agent for assistance). Finally, the meter must be periodically calibrated (using a calibration solution or known concentration solution) to maintain reliable readings. Calibrations should be performed at least one or two times per season (and more frequently if a meter is acting erratically). The batteries will need replacing occasionally (at least annually). Meters that stop working or begin to give erratic readings usually need batteries. Replacement batteries can be purchased from the same source as the meter. However, these meters usually accept commonly available batteries such as Duracell DA 675, Everready AC 675 E or other comparable batteries.

The following tables give electrical conductivity (EC) readings for several fertilizers:

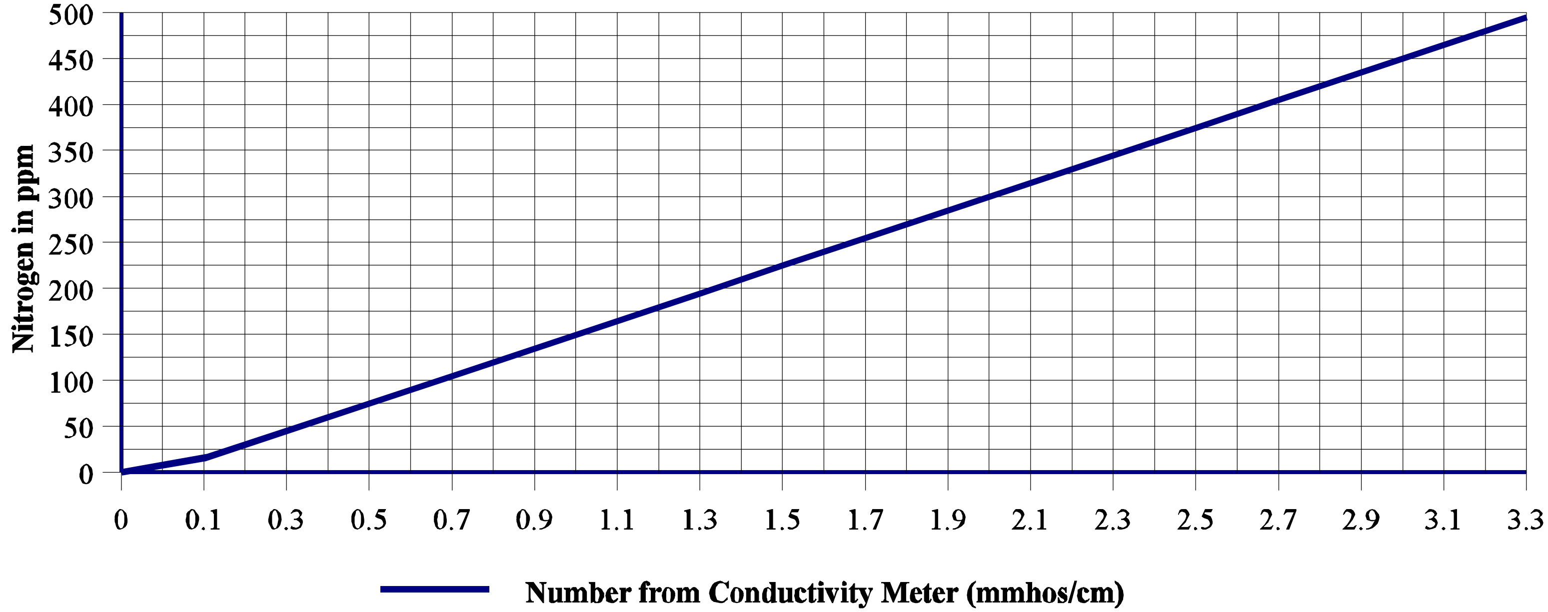
Table 5.a-4. Electrical conductivity information for selected water-soluble fertilizers.

Fertilizer	***50 ppm N***			***100 ppm N***			***150 ppm N***		
	EC[1]	***DiST 4[2] (mmhos/cm)***	***oz/100 gal***	***EC[1]***	***DiST 4[2] (mmhos/cm)***	***oz/100 gal***	***EC[1]***	***DiST 4[2] (mmhos/cm)***	***oz/100 gal***
Peters Peat-Lite 20-10-20	0.33	0.33	3.3	0.66	0.66	6.7	1.00	1.00	10.0
Carolina Choice 20-10-20	0.30	0.30	3.3	0.57	0.57	6.7	0.84	0.84	10.0
Speedling 20-10-20	0.33	0.33	3.3	0.65	0.65	6.7	0.98	0.98	10.0
Miller 20-10-20	0.30	0.30	3.3	0.57	0.57	6.7	0.84	0.84	10.0
JCC 20-10-20	0.33	0.33	3.3	0.66	0.66	6.7	1.00	1.00	10.0
Champion Bulldog 20-10-20	0.31	0.31	3.3	0.63	0.63	6.7	0.93	0.93	10.0
Prosol 20-10-20	0.33	0.33	3.3	0.65	0.65	6.7	0.98	0.98	10.0
Peters Agrosol 20-9-20	0.33	0.33	3.3	0.66	0.66	6.7	1.00	1.00	10.0
Peters Agrosol 15-4-15	0.39	0.39	4.5	0.78	0.78	9.0	1.17	1.17	13.5
Miller Supreme 16-4-16	0.43	0.43	4.2	0.84	0.84	8.3	1.23	1.23	12.5
Peters 20-20-20	0.20	0.20	3.3	0.40	0.40	6.7	0.60	0.60	10.0
Prosol 20-20-20	0.20	0.20	3.3	0.40	0.40	6.7	0.60	0.60	10.0
Miller 20-20-20	0.26	0.26	3.3	0.51	0.51	6.7	0.74	0.74	10.0
Champion Bulldog 20-20-20	0.19	0.19	3.3	0.39	0.39	6.7	0.62	0.62	10.0

[1] EC (Electrical Conductivity) is expressed as millimhos/cm.

[2] Difference in meter reading of fertilized water minus unfertilized water. Note: Most conductivity meters read in mmhos/cm, including the new DiST 4 meter and the Milwaukee Instruments Sharp EC meter. However, the "old" DiST 4 meters read in a different unit (100µS/cm). The numbers listed in this table under the Dist 4 column are for the new DiST 4 meter and must be multiplied by 10 (decimal moved one place to the right) if using the old DiST 4 meters. Be sure you know the units your meter is reading.

Table 5.a-5. Conductivity Chart for Typical 20-10-20.



Subtract water source meter reading from fertilized water reading. Find this number on the bottom line & follow the vertical line upward until it reaches the diagonal line. The reading to the left should be the approximate ppm N.

Clipping

Clipping is an important management tool to hold back plant growth, improve ventilation and sunlight penetration into the canopy, make plants easier to handle during transplanting and achieve uniformity when seedlings are not uniformly sized.

Clipping with direct-seeding systems should be started when the plants are small (approximately 2-2½ inches tall) and should not remove very much of the leaf tissue at any one clipping. Heavy clippings close to the bud can severely stunt and yellow the plants. A few light clippings are preferred over one heavy clipping. Two or three clippings may be sufficient in many cases. Try to remove no more than about ½-¾ inch of leaf at a time. Set the clipping height 1-1½ inches above the buds of the tallest plants.

Greenhouses (as well as direct-seeded outdoor beds) should be equipped with a clipping boom and lawnmower attachment so the trays do not have to be handled during clipping. Plants can also be clipped using a lawnmower unit mounted above a platform that holds the trays while they are rolled or pushed underneath the mower. This requires that the trays be removed from the water bed. Lawnmowers should be the high-vacuum type to minimize the amount of leaf residue that falls back on the trays. Clipping residues can increase the risk of diseases, such as damping off or bacterial soft rot.

Transplanting

When plants reach transplant size, they should be transplanted instead of held back and clipped numerous times. Holding transplantable-size plants increases the risk of disease development. Diseases are more likely to occur in plants that are ready or almost ready to transplant, since these plants have a dense canopy that restricts air movement. Float plants should therefore be transplanted as soon as possible once they reach transplant size. Be sure to set float plants sufficiently deep to thoroughly cover the root ball (for stem support and possible discouragement of ground suckers.)

Float plants can and should be transplanted at a smaller size than plant bed plants. Smaller plants usually handle more easily at transplanting. Furthermore, results from University of Tennessee studies have shown that small, rapidly-growing float plants not only survived transplanting as well as large, hardened-off plants, they actually grew and developed faster than larger, tough plants. Float plants should be transplanted as soon as the roots fill the cell and the plant is big enough to be held by the fingers of a conventional transplanter. Of course, the calendar should say May and not April! An ideal, ready-to-transplant float plant will have an intact root ball (but is not root-bound), a stem diameter that is pen/pencil size and an average height from the top of the root ball to the base of the bud of about 2½-3 inches.

Disinfecting Old Trays

Keep soil away from the float bed and trays. Many tobacco diseases are soil-borne. So, don't walk in the water bed, don't lay the trays on the ground, and so forth. Wash all trays as soon as possible after using them. Be sure to wash and sterilize or disinfect the float trays each year. Trays can be dipped in a mixture of bleach and water (1 part bleach to 9 parts water) or in a commercial disinfectant (Prevent®, Green Shield®, etc.) Since a gas material does a superior job of disinfecting styrofoam trays compared to a liquid material, and since chlorine or bleach products can cause plant injury, methyl bromide is the preferred means of disinfecting float trays. The trays should be washed but dry when treated with methyl bromide. The methyl bromide applicator should be placed on top of the stack of trays, since methyl bromide is heavier than air. Stack trays in a criss-cross manner, cover securely with plastic, seal with duct tape and treat with methyl bromide at the rate of 3 lbs per 1,000 cubic feet. For example, a stack 10 feet long, 10 feet wide and 5 feet high would require 1½ lbs of methyl bromide (use one 1½ lb or two 1 lb cans.) Methyl bromide is extremely dangerous and must always be used with caution and according to label directions.

Store the trays during the off-season in a place where rodents cannot damage them. The storage site should also be out of the sunlight and away from sparks or fire hazard. Greenhouses (especially walkways and bed frames) should be disinfected with a bleach/water mix or with a commercial greenhouse disinfectant (Prevent®, Green Shield®, others.)

Direct Seeding in Greenhouses

Direct seeding is the most popular version of the float system in Tennessee. Direct seeding involves growing the plants from seed to transplant size in the float trays. Seedlings are germinated in the same tray from which they will be transplanted, thereby eliminating the task of seedling transfer from a starter tray to the float tray. This reduces the labor requirement, since seeding a tray is faster than transferring plugs into a tray. However, the management requirement is increased because care must be taken to provide a favorable environment for seedling germination and early seedling growth.

This favorable germination environment is crucial, because there is only one seed per cell in each tray. A 10 percent difference in germination, say 90 versus 80 percent, will make a tremendous difference in the number of plants supplied. Optimizing the number of plants produced per square foot of greenhouse space will maximize the return on expensive greenhouse investments. In addition to a high percent germination, it is desirable for germination to occur soon after seeding and be completed within a few days. This will make the plants easier to manage for uniformity and readiness for transplanting.

Optimum germination of coated tobacco seed is most likely to occur when the average air temperature at tray level is within about 65-75 degrees F. Germination will occur at lower temperatures, but will take longer and may result in less uniform plants. This optimum temperature range should be maintained during the germination period, which will generally be the first 7-10 days after seeding. Direct seeding should therefore be done in a structure equipped with a heating and cooling system since outside temperatures in March-April-May are highly variable. These structures may be greenhouses or properly equipped outdoor float beds. Once germination is completed, heater thermostats can be cut back to about 60 degrees F. **Note**: Excessive heat is actually more detrimental to germination than cold. Cold temperatures delay germination; hot temperatures can kill the germinating seedlings. High temperatures in the greenhouse should be kept below 90 degrees F for maximum germination.

Greenhouse Requirements. In addition to having a vented heat system, the greenhouse must also be properly ventilated for cooling and humidity control. Ventilation is best achieved with large exhaust fan-louver systems. Some greenhouses are equipped with side curtains to further assist with ventilation. Side curtains, which roll down along the outside wall, can be operated manually or automatically by thermostat. Automatic controls are recommended for growers who will not be at the greenhouse to open or close the curtains on short notice when the weather changes. Side curtains also permit easy access to the trays from the outside (for transport to the field, for example). However, the ventilation system should be able to supply one air change per minute for the entire greenhouse. Air change capacities of less than one per minute will be unable to adequately cool the greenhouse. Maximum temperature in the greenhouse should not exceed about 90 degrees F.

Air circulation fans (small fans hung from the greenhouse bows) are also an important component of the greenhouse setup. These fans improve the uniformity of air temperatures throughout the greenhouse and help keep the plants dry. The fans are positioned to move air along the length of the greenhouse, with fans on the two sides moving air in opposite directions to maintain air movement in something of a circular pattern. This is called horizontal air flow. An alternative way to provide air circulation is with a polytube, a large plastic tube with holes that runs the top length of the greenhouse. A fan moves air through the tube and out into the greenhouse. With either system, the fans should be operated continuously.

The direct-seed greenhouse should have a double-layer plastic cover, with an inflation fan to keep a thin layer of air between the two layers. Ideally, the outside layer should be resistant to ultraviolet light degradation, and the inside layer should be made of a material that blocks infrared light. The double-layer covering will reduce heating and cooling costs, and minimize condensation inside the greenhouse. Excessive condensation not only raises the relative humidity (which promotes disease development) but can drip onto the trays and interfere with germination or early seedling growth. Damp or wet plants are much more at risk for disease development than plants that remain dry. Humidity control is therefore crucial in the prevention of diseases in float systems. This is especially critical during the night hours when humidity is higher. Circulation fans should always be running. Exhaust fans operating on a temperature thermostat may not cut on during the night. A timer control may be required to cut fans on several times during the night for maximum control of humidity. Maintaining a nighttime minimum temperature no lower than about 60 degrees F can also help minimize humidity.

Refer to **Chapter 5.c**, **Greenhouse Heating and Ventilation**, for details about tobacco greenhouse construction and setup.

Seeding. Seeders are necessary to rapidly place one seed in each tray cell. Coated or pelleted seed must be used to have tobacco seed large enough to be handled individually. Many growers who direct seed buy a commercially-available seeder. Commercial seeders are usually vacuum operated and range in cost from a few hundred to several thousand dollars.

Some growers build their own seeder or buy a "homemade" seeder (such as the "Poor-Boy Seeder"). Homemade seeders generally consist of two templates (plexiglass or aluminum) with holes offset for seed loading into the top template, after which the templates are aligned so the seeds fall into the tray below. The top template should be approximately 1/16-inch thick with holes about 3/32-inch diameter. The bottom template should be about 1/4-inch thick with holes 1/8-1/4 inch diameter. The two templates should be clamped or taped together, while the 3/32-inch holes are drilled (using a drill press). The holes in the bottom template can then be re-drilled with the larger bit. Always keep the templates in the same position they were in when drilled. Otherwise, the holes may not line up perfectly. Refer to The University of Tennessee Research Report 94-04, "**Instructions for Building Poor Boy Tobacco Seeders**," for details or find it on the web at http://web.utk.edu/~taescomm/tes/poorboy.html.

Some growers lightly mist overtop the trays after seeding to reduce the time to dissolve the clay seed coat and/or to maintain moisture around the seed. Misting must be gentle to avoid covering the seed with potting mix. Covered seed generally germinate poorly. Research at North Carolina State University has shown that misting did not increase the number of usable transplants and did not reduce the time required to grow the transplants. Misting after seeding is considered an option but not a necessity. However, misting sometimes reduces the incidence of spiral rooting.

Spiral Rooting. The initial root developed by a germinating coated seed sometimes grows aerially on top of the potting mix instead of down into it. This is called spiral rooting. Spiral-rooted plants generally will not develop into usable transplants.

Spiral rooting was a major problem in 1999. Numerous factors seem to influence the spiral rooting process. Spiral rooting was initially thought to be caused exclusively by restricted aeration to the emerging root, and therefore factors such as excessively packed trays or mix with too much wetting agent were considered primary causes. However, experiences in 1999 showed that the causes of spiral rooting are not simple to determine.

Spiral rooting has most often been observed in Tennessee under conditions of unseasonably hot, sunny weather during germination. One theory is that this environment promotes the drying and hardening of the seed coat, which somehow triggers spiral rooting. The wicking properties of the potting mix and the characteristics of the seed coat that affect wetting/drying/hardening would therefore be key factors in spiral rooting.

Research is being continued by several universities and seed companies to improve the understanding and management of spiral rooting. We currently do not have the complete answers we need. However, based on current understandings, the following is a recommended strategy to minimize the likelihood of major problems with spiral rooting.

1. Use a "peat-lite" potting mix (one whose main components are peat moss and vermiculite in approximately equal amounts). The new coconut hull fiber (coir) mixes seem to work fine also.
2. Do not overpack the trays with mix.
3. Do not wet the mix before filling the trays.
4. Prevent temperature in greenhouses or outdoor beds from exceeding 90 degrees F.
5. Pay attention to dibbling – a "deep" (about 3/4 inch) dibble that is pyramid or non-round shaped is preferred.
6. The following practices are generally helpful:
    a. Mist **gently** overtop trays after seeding, especially during hot sunny weather, or daily for about a week after seeding. The goal is to keep the seed coat moist during the germination period. Misting in the early to mid afternoon is probably the best time. During unseasonably hot, sunny weather, misting two times a day may be needed (early and late afternoon). Mist gently to keep from moving or displacing the seed. Days 3-7 after seeding may be the most critical.
    b. Placing a seed bed cover over the trays during germination has not significantly reduced spiral rooting in most tests conducted to this point. A light sprinkling with potting mix may be helpful, but applying enough yet not too much is tricky. The seed should not be completely covered.
7. Contact your local Extension Agent to see if these recommendations have been changed.

Production Time. On average, plants should be ready to transplant about 6½-8 weeks after seeding. Weather conditions, such as the relative amount of sunshine and cloudiness, day length, temperatures, etc., can affect this time period. Plants seeded in early March should be ready to transplant in about eight weeks. Plants seeded in early April may be ready to transplant in about 6½-7 weeks, due to longer days and warmer temperatures.

Water Analysis. When direct seeding, the water to be used in the float system should be analyzed prior to the production season. This analysis can alert growers to possible problems, such as high soluble salts, excessive alkalinity (a measure of bicarbonates and carbonates), pH concerns or special nutrient requirements (such as boron, calcium, etc.). Test kits (forms, instructions and plastic sample bottle) are available from several commercial laboratories and/or float system suppliers. The sample is sent to a lab for analysis. The cost generally ranges from about $15 to $30 per sample.

Tobacco plants generally tolerate a wide range of water quality. The following are current general guidelines for desirable ranges for several aspects of float system water quality. Water quality is more of an issue for direct seeding than for plug-and-transfer or pre-finished systems.

Table 5.a-6. Desirable ranges for selected water-quality factors.

Factor	*Range*	*Units*
pH	**6.0-7.5**	**-**
Alkalinity (carbonates)	**0-100**	**ppm**
Soluble Salts (conductivity)	**0-0.75**	**mmhos/cm**
Calcium	**40-100**	**ppm**
Magnesium	**15-50**	**ppm**

The primary water quality factor that can cause plant growth problems is alkalinity. Alkalinity in this case does not refer directly to high pH, but rather to the capacity of the water to neutralize acids and therefore resist a lowering of the water pH when an acid is added. Bicarbonates and carbonates are usually the major contributors of alkalinity in float water. Alkalinity has not proven to be a widespread problem in float production in Tennessee, perhaps because much of our water contains lots of calcium, which acts as a protection against alkalinity. (In Tennessee, the alkalinity-causing carbonates generally come from calcium carbonate instead of sodium carbonate, and the calcium usually offsets the negative effects of the carbonates.) Nevertheless, the potential for alkalinity problems always exists when alkalinity levels are quite high or calcium is low, and alkalinity levels should be checked annually in all direct seed operations.

Excessive alkalinity can be neutralized several ways. In cases where alkalinity is only slightly excessive (in the 100-200 ppm range), use of an acidifying fertilizer (such as most 20-10-20's, Peters Excel 15-5-15, Peters Agrosol 20-9-20 or comparable acidifying materials as indicated on the label) should correct the problem. In cases where the alkalinity exceeds 200 ppm and the calcium level in the water is less than 60 ppm, the excess alkalinity can be neutralized by adding battery acid to the water. Battery acid strength is indicated by a chemical term called “normality.” Typical battery acid is 9.19 normal (or 35 percent) sulfuric acid. The formula for determining how much battery acid is needed to reduce the alkalinity to an acceptable 100 ppm level is as follows:

[(ppm alkalinity - 100) x 2.56] ÷ normality of acid = ounces of acid per 1,000 gallons water

For example, if the float water analysis indicated an alkalinity level of 300 ppm, then 300-100 = 200 ppm alkalinity must be neutralized. Then, 200 x 2.56 = 512, which divided by 9.19 normality, indicates 56 ounces of (virgin) battery acid to be added per 1,000 gallons of water. The acid must be added to the water (never water to the acid) in small amounts in a 5-gallon plastic bucket, for example, then added to the float water. Wear safety goggles, rubber gloves and a chemical-resistant apron when handling acids. Never work alone. Battery acid is very dangerous!

Soluble Salts. Very young tobacco seedlings are extremely sensitive to soluble salts (or fertilizer salts) for a period of about 3-4 weeks. Older, larger seedlings are more tolerant of soluble salts. Seedlings that are injured from soluble salts are generally yellow and stunted, have restricted root systems and often have leaf margins that roll or curl upwards. Soluble salts injury is a relatively common problem in float systems, and can be caused by one or more of several factors.

First, conditions that cause excessive wicking and evaporation of water from the trays can result in accumulation of soluble salts in the top half-inch or so of potting mix. To minimize these conditions, keep the high temperatures below 90 degrees F and position exhaust and circulation fans so they are not moving excessive air directly across the trays. Ventilation is necessary to keep the temperature below 90 degrees F, but the major movement of air should be above tray level. Second, be sure to use a non-urea fertilizer and don’t exceed the recommended concentration of 75-125 ppm

N. Urea-containing fertilizers sometimes cause an accumulation of ammonia and/or nitrite. The ammonia can be toxic to plants and nitrite adds to soluble salts accumulation. And although many cases of soluble salts injury are not due to over fertilization, over fertilization clearly increases the risk of soluble salts problems.

Third, the potting mix itself has occasionally been found to contain excessive quantities of fertilizer. Even unfertilized mixes contain some fertilizer, and occasionally the amount is excessive, especially when in combination with a regular fertilizer program. The potting mix can be checked for soluble salts by a soil test lab or by using the conductivity meter (DiST 4 or similar meter) as described below. Fourth, delaying the application of fertilizer for about 3-7 days or more after seeding sometimes helps, but is still no guarantee that soluble salts will not be a problem. Growers equipped to apply fertilizer to beds after seeding should consider this practice.

The DiST 4 (or similar meter) can be used not only to monitor fertilizer concentration in the float water, but also to conduct a quick test for soluble salts. This quick test can be used to help diagnose soluble salts injury or to check the soluble salts content of potting mix prior to its use. Make a slurry comprised of one part potting mix and two parts water. If diagnosing soluble salts injury, collect potting mix only from the top half-inch of the cells, and use the float bed water to make the slurry. Stir the water and potting mix, let stand for about a minute, and then take a meter reading of the slurry. As a general guide, if the reading is more than about 1.0 or 1.5 mmhos/cm, a soluble salts problem is likely. For comparison, repeat this quick test using potting mix from cells with healthy plants. If there is a soluble salts problem, this reading should be lower than the reading from the problem cells.

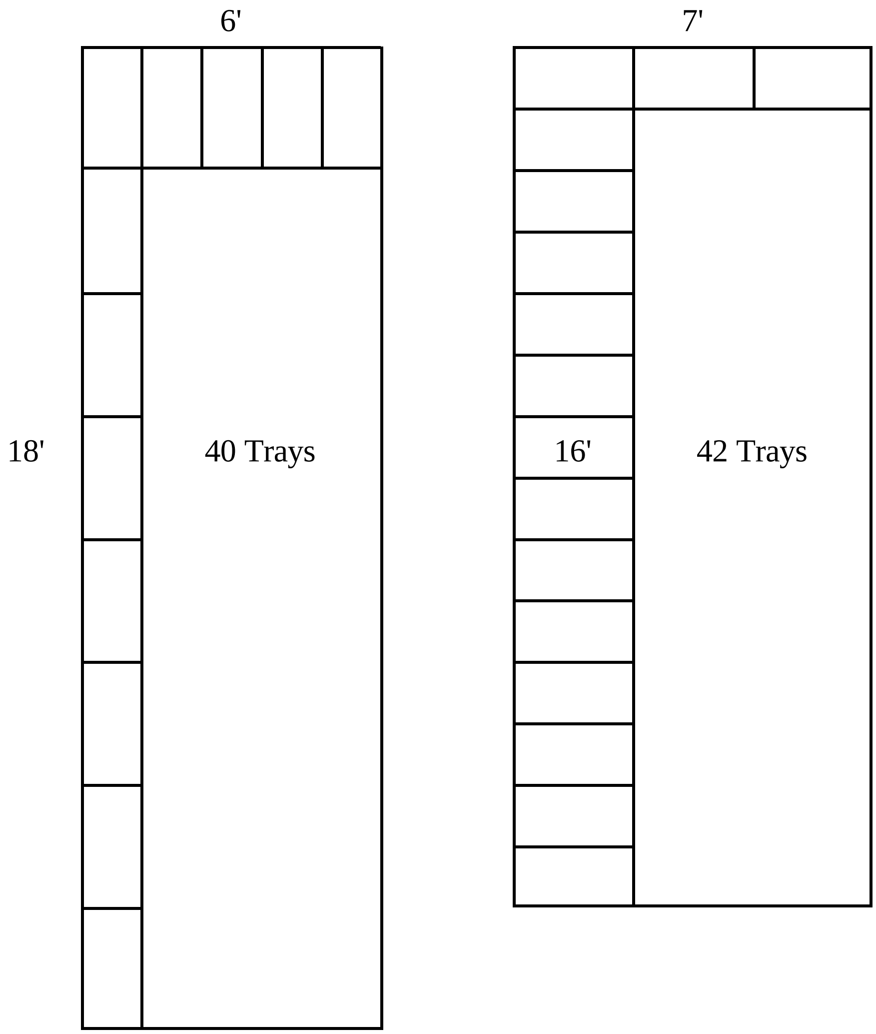
Once tobacco seedlings are injured by soluble salts, the only way to correct the problem is to dilute the concentration of soluble salts in the top half-inch of potting mix. This requires overhead watering – generally one or two times a day for about three or four days, or until the seedlings begin to green up and grow. Don’t water late in the day – plants that stay wet during the night are at increased risk of disease.

Outdoor Float Beds

Constructing the Float Bed. Outdoor float beds are required for direct seeding in outdoor beds, for finishing beds in certain greenhouse operations and for plug-and-transfer operations. Float beds are made with a treated lumber frame (usually 2" x 6" or 2" x 8" stock) and black plastic lining. The bed site must be leveled and smoothed. A grossly unlevel bed can be overflowing on one end and dry on the other. A grossly unsmooth bed may accumulate excessive amounts of fertilizer in the holes or pockets. Don't level by eyesight – use a level or transit. Remove all rocks, glass, wire or other objects that could puncture the plastic lining. Some growers use sand, limestone or similar material to make a soft foundation for the lining. This is not necessary if the soil is properly prepared. Straw or sawdust underlinings may invite varmints that could puncture the plastic. However, insulation board placed under the plastic serves as a liner cushion and minimizes heat loss to the ground.

Secure the outside edges of the frame with stakes or stobs. These will keep the frame from bowing outward when water is added. Placing soil around the outer perimeter of the frame is an alternative way to secure and reinforce the frame.

Build the frame to hold the specific number of trays needed. Plan the bed size (using **inside** width and length dimensions for the frame) based on an area 14 inches wide and 27 inches long for each tray. For example, a bed with inside dimensions of 6 x 18 feet will hold 40 trays. The 6-foot width will hold five trays arranged side by side; the 18-foot length holds 8 trays end to end. A 7 x 16 foot bed will hold 3 trays width-wise arranged end to end and 14 trays lengthwise arranged side by side, for a total of 42 trays. In greenhouses, several smaller beds are preferred over one large water bed.



Use a plastic lining that is 6-mil in thickness, or else double a 4-mil plastic. The previous year's lining can be saved and used for additional padding underneath the new lining each year. A leaking lining is a management headache, since water must be added frequently to a bed with a punctured lining. Most outdoor float beds should contain sufficient water to grow plug plants to transplant size without needing added water. However, some float beds may require additional water after about four weeks. Maintain at least 2-3 inches of water; 4-6 inches is preferable. When filling the float bed with water, always use well or utility water. Water from a pond or stream may contain pythium, black shank or other disease organisms.

Water Bed Heaters. In outdoor float beds, water bed heaters are placed underneath the plastic lining to heat the water and thereby facilitate plant growth and root development and help provide frost protection. The benefits from water bed heaters will vary, depending upon weather conditions. Since springtime temperatures fluctuate greatly during most any 3-5 week period, use of water bed heaters is recommended. A rule of thumb is to use one water bed heater for each 40 trays or for approximately every 100 square feet of float bed.

Bed Covering. The outdoor float bed should be covered with plant bed cover. The float bed cover should be raised slightly above the plants, supported by PVC bows, metal bows, wire or other material. A height of about 1½-2 feet above the plants works well. This distance is high enough to keep the cover off the plants, yet low enough to permit temperatures to build up under the cover during the day and help keep the night temperature elevated somewhat. Bows for cover support can be placed over rods or smaller pipe driven into the ground beside the frame, or can be attached to the bed frame with brackets on the outside of the frame or through drilled holes in the top edge of the frame. Spunbonded polypropylene covers (e.g. Typar, Reemay, Continental or similar cover) are preferred over spunbonded polyester-type covers (e.g. regular Reemay types), since they are heavier and provide more protection. The section on direct seeding in outdoor float beds contains more information about covers for float beds.

Frost Protection. Frost protection is an important consideration with the outdoor float bed. Floating plants in outdoor beds extremely early in the season when the risk of frost remains rather high is not recommended. Plug-and-transfer plants floated in late March are much more likely to encounter frost conditions than plants floated in April. Plants are normally ready to transplant about 4 weeks (sometimes 3 weeks) after floating, so there is no reason to float plants in March.

Frost protection is provided by using three practices in combination: 1) place black plastic over the existing cover on cold nights (low temperature below 40 degrees F) [note: never use plastic alone to cover water beds for frost protection, for plastic alone seems to increase the risk of frost damage] 2) the water bed heater(s) mentioned previously, and 3) empty float trays (one tray positioned upside down near each end and one in the middle of the bed) to allow heat from the heated water to rise above the trays and be captured by the black plastic cover. The water bed heaters and empty trays will already be in place, while the black plastic lining will be used only as needed on cold nights.

Direct Seeding in Outdoor Float Beds. Direct seeding in outdoor float beds has generally required more management, but less capital, than direct seeding in a greenhouse. The primary management requirements in outdoor direct seeding are temperature management (to keep high temperatures below 90 degrees F and low temperatures above 55 degrees F) and protection against rainfall drip through the cover during the germination and early growth period. This requires someone to be available during the day in case adjustments in cover/ventilation, etc., are required on quick notice.

Research and observations from the 1990's demonstrated that covering with clear plastic to retain heat and prevent rain drip can result in temperatures exceeding 110 degrees F which can destroy seed germination or severely stunt plants. Covering with black plastic was a better alternative to protect the plants from cold and rain drip but was more management intensive because of the need to cover at night or when rain was approaching and removing during the day to allow the plants to receive light.

Current studies in Tennessee and Kentucky are focusing on the development of a system of direct seeding outdoors that significantly reduces the need for frequent availability of management. This system uses a white plastic shade cover that prevents excessively high temperatures and also eliminates rain drip. This system also uses a removable cover frame and a clipping boom mechanism modified from a commercial greenhouse system. Contact your County Extension Office or find plans on the web at http://www.utextension.utk.edu/tobaccoinfo/ for detailed drawings and pictures of the clipping system.

Research from the 2000 season evaluated various white plastic shade coverings ranging from 30-55 percent shading all in 6-mil thickness and compared them to the more traditional type canvas covers Typar and Continental. High temperature reached 107 and 106 degrees F each, respectively, under the Typar and Continental covers. Considerable water damage occurred to the tray cells along the edges of the bed covered with the Typar. The majority of water damage under the Continental cover occurred to trays in the center of the bed when the canvas sagged between bows funneling water to the trays below. The 30 percent shade factor white plastic allowed the temperature to rise to 106 degrees F which can adversely affect seed germination and retard plant growth while the 55 percent shade factor white plastic provided too much shading which slowed plant growth and produced very tender and spindly plants. All the white plastic shade covers prevented drip damage from water entering the beds as a result of rainfall.

Research conducted again in the spring of 2001 by the Universities of Tennessee and Kentucky evaluated a 50 percent shade factor white plastic in 5 ml. thickness and the spunbonded polypropylene covers Typar and Continental. High temperatures under the Typar and Continental covers again reached 107 and 106 degrees F, respectively. The same patterns of water damage from drip as seen in the 2000 tests were observed again in 2001 for the Typar and Continental covers. The high temperature under the 50 percent shade white plastic reached 101 degrees F (higher than desired, but the reading was not sustained over long enough time to cause damage) and there was no water damage to the cells beneath it. No supplemental heat source (mat-type water bed heaters) was used in the 2001 research. If growers are willing to postpone seeding until late March to early April, supplemental heat is less critical to consistently produce transplants in outdoor beds.

All of the covers were placed over the beds at seeding. The beds were 12' x 24', hold 105 trays, were deep dibbled to ½ - ¾” and seeded with primed seed. The beds were completely enclosed until daytime temperature reached 70 degrees F at which time the beds were ventilated by raising the sides and ends of the covers six inches. The covers were removed at the first clipping and remained off if temperatures permitted.

Summary -

Direct Seeding in Outdoor Beds

- Seed trays from the third week of March up to the second week of April
- Select a media which will allow for the deep dibble
- Deep dibble trays ½ - ¾”
- Cover with white plastic 50 percent shade factor in 5-mil thickness (**CAUTION: Other shade factors and thicknesses give unreliable results based on 2000 year research**.)
- Ventilate the beds when air temperatures outside the beds reach or exceed 70 degrees F by ventilating all 4 sides of the beds by at least 6"
- Monitor the plants for any signs of diseases or insect damage
- Remove the white plastic 50 percent shade 5-mil thickness at the first clipping and leave it off weather permitting.

Based on research results at this time, 50 percent shade white plastic in 5 mil thickness appears to be a good alternative cover for the production of transplants in Tennessee. This cover research will be repeated for the 2002 season.