GREENHOUSE SEEDLING PRODUCTION RECOMMENDATIONS

Dewitt T. Gooden

Production of tobacco seedlings in a greenhouse differs greatly from field production. Management is critical since the large excess of seedlings common to conventional production will not be present using a greenhouse. Every effort should be made to obtain maximum seedling usability.

BEFORE THE SEASON

November through January is the time to get the greenhouse ready for the upcoming season. Water analysis should be done at this time. Water should be analyzed on a **yearly** basis. Sanitize trays if you have not already done so (please see the disease management section for procedures). Inspect the trays for damage and order replacement trays. You may also want to place your media and seed orders at this time. Inspect all greenhouse equipment and perform any needed maintenance. The float bed plastic should be replaced at this time. Fire ants and mice may become a problem as they eat and carry off seed. These pests should be eliminated prior to seeding. In general, get the greenhouse ready to be filled.

WATER QUALITY CORRECTION AND FERTILIZATION

Water quality (bicarbonate) correction should be performed before the trays are floated. Add the required amount of acid after the beds are filled. A flow meter, available at plumbing supply houses, is helpful in determining the amount of water in the bed. The amount of acid to add is calculated from a **recent** water analysis report. First, calculate the total carbonate (TC) concentration by adding the concentrations of HCO_3 and CO_3 from the report. Then multiply TC by 1.11 to get the fluid ounces of battery acid (9.19 N sulfuric acid) per 100 gallons of float water. **The amount of acid to use is now calculated at the Clemson laboratory and will be added to the water analysis report.** Use only virgin acid, as recycled acid may contain harmful concentrations of heavy metals. Add the acid several days before the trays are floated to allow time for the acid to react. The final water pH should be in the 6.0 to 6.5 range before fertilizer is added. Do not add more acid than called for by the formula or an excessively low pH will result. Consult your county agent for advice. It is not beneficial to preheat the float water.

GENERAL FERTILITY INFORMATION

All the fertilizer should be added through the waterbed with the float system. One-hundred (100) ppm N early in the season is adequate. After four weeks, add another 150 ppm N. The initial application has been reduced to lessen the possibility of salt injury. Research at VPI has indicated that plant quality is improved when initial fertility application is delayed until two-three days after seeding. Since the second application has been increased, the total rate is the same as in past years. This change is based on several years of research conducted at both Clemson University and at North Carolina State University.

Split applications of fertilizer are recommended to reduce soluble salt problems sometimes experienced during germination. The addition of fertilizer at four weeks after seeding should coincide with the first addition of water to the beds. In severe situations (TC greater than 5), acid

should be added along with the water. Adding water with the second fertilizer application should aid in mixing in the beds. It may be helpful to add the solution at several spots in the bed. Please refer to the following section for recommended fertilizer programs and rates.

Due to limitations in formulation of soluble fertilizers, no fertilizer can supply all nutrients needed for good seedling growth. Calcium, magnesium, and/or sulfur may not be supplied by a particular fertilizer. In order to supply a **complete fertility program**, gypsum (calcium sulfate) and epsom salts (magnesium sulfate) may be needed (see **Fertility Programs** section for use and rates). Sulfuric acid, if needed, will supply plant available sulfate. Acid should be used only for water quality correction, not solely as a fertilizer.

Over-fertilization with nitrogen and phosphorus may result in succulent plants which are more prone to disease. In addition, over-fertilized plants will have to be clipped more frequently. Each clipping carries with it the possibility of introducing disease. Do not exceed 10% phosphorus in the fertilizer. To avoid excessive algae growth, float trays as soon as possible after adding fertilizer. Recent research and a grower waste solution survey have indicated that previously used fertility programs (20-20-20, 20-10-20) contained too much phosphorus. Potential negative effects of high phosphorus include higher cost, the tendency to produce "leggy seedlings, and increased clipping demand, "tender" transplants, and greater waste nutrient disposal problems. Seedlings grown with the low phosphorus programs will appear to grow slower, but will be ready at the normal time. Since the phosphorus status of the plants may be low at transplanting, a high phosphorus starter fertilizer in the transplant water may be advisable.

Calcium deficiency has been observed in several greenhouses. Some varieties are quicker to exhibit deficiency symptoms, but all should respond to calcium fertilization. Use of calcium in a complete fertility program will prevent potential problems. Calcium fertilization is necessary when the calcium level of the water is less than 20 ppm. If calcium is not in the regular fertilizer, it can be supplied by the addition of gypsum to the water bed.

Boron deficiency can occur when fertilizer without boron is used with water low in boron. To prevent deficiency, a fertilizer containing boron as part of its micro nutrient package should be used when water analysis indicates less than 0.5 ppm boron. Since boron can be toxic and only very small amounts are needed for good growth, use of Sol-u-bor or Borax to supply boron is not recommended.

FERTILITY PROGRAMS

With the continual introduction of new fertilizers for greenhouse use, the grower has more fertility options than ever. Many are low phosphorus materials, which may aid in height and clipping management while reducing nutrient waste. Any of the materials listed below will grow good transplants.

Described below are several complete fertility programs based around several popular fertilizers. Gypsum and epsom salts, where needed, should only be applied before seeding. There is no need to reapply gypsum or epsom salts when adding water. In addition, gypsum is not soluble enough to be used with an injector and should be slurried and added directly to the water bed. See the table following the descriptions for rates.

20-10-20: This fertilizer was at one time the standard for seedling production, but recent research indicates that the phosphorus content is higher than needed. It has received continued use due to its compatibility with acid in an injector tank. It does not contain calcium, magnesium, or sulfur. To provide a complete nutritional package, gypsum and epsom salts are needed in all circumstances regardless of acid use.

20-5-20: This material is a low-phosphorus version of 20-10-20. It is compatible with acid in an injector tank, but also works well in waters where acid is not needed. It does not contain calcium, magnesium, or sulfur. To provide a complete nutritional package, gypsum and epsom salts are needed in all circumstances regardless of acid use.

16-5-16: This material is a low phosphorus version of 20-10-20 that also contains magnesium and sulfur. It does not contain calcium. It is compatible with acid in an injector tank, but also works well in waters where acid is not needed. To provide a complete nutritional package, gypsum is needed in all situations.

16-4-13: This fertilizer replaces 16-4-16. It is neutral rather than acid forming and will not depress water pH. It contains calcium and magnesium, but does not contain sulfur. Sulfur can be supplied by adding epsom salts if acid is not used for bicarbonate correction. It is **not** compatible with acid or epsom salts in an injector tank. Add these materials directly to the water bed.

15-5-15: The first low phosphorus fertilizer used for tobacco seedlings, this material has been reformulated to be potentially basic and will not depress water pH. It contains calcium and magnesium, but does not contain sulfur. Sulfur can be supplied by adding epsom salts if acid is not used for bicarbonate correction. It is **not** compatible with acid or epsom salts in an injector tank. Add these materials directly to the water bed.

The following table summarizes the fertility options. All but the 20-10-20 program are low phosphorus programs. Please note that mixing 15-5-15 or 16-4-13 with sulfuric acid and/or epsom salts in an injector tank will likely result in salting out of the mixture. This will not be a problem in the water bed. Initially, a small amount may salt out in the bed, but it will return to solution before the plant needs the nutrients.

To use a fertilizer injector, the rates in the table should be used per **1 gallon** of solution in the injector tank. The injector should then be set to 100:1, which will result in 1 gallon of concentrate being delivered into 100 gallons of bath water.

FLOAT FERTILITY PROGRAMS WITH RATES

FERTILIZER	SEEDING RATE (oz/100 gal)	4-WEEK RATE (oz/100 gal)	EPSOM SALT (oz/100 gal)	GYPSUM (oz/100 gal)
20-10-20	6.5	10.0	3	5
20-5-20	6.5	10.0	3	5
16-5-16	8.3	12.5	0	5
16-4-13	8.3	12.5	3 if no acid	0
15-5-15	8.8	13.2	3 if no acid	0

Note: The rates in this table are different from a few years ago. The seeding rate has been reduced, and the 4-week rate has been increased. The total fertilizer applied is the same. These fertility recommendations will now appear on the Clemson water analysis report.

TRAY FILLING AND SEEDING

Tray filling is a critical part of production. Packing the media too tightly may result in plant roots not penetrating the media (spiral roots), while packing too loosely may result in cells which do not wick properly (dry cells). One of the several brands of media intended for tobacco transplant production should be used. Most batches of media require water to be added for proper packing. The amount of water needed varies greatly. It is best to practice wetting a bag or two of the media and filling a few trays a week or two before you plan to seed. Float the trays and observe if any dry cells are present. Adjust the water or packing as needed. A filler box greatly improves packing uniformity as compared to hand filling. The media needs to be checked for clods and sticks that may interfere with filling. Sticks can also lodge in cells, causing dry cells.

Greenhouses in South Carolina should not be seeded before February 1. Traditionally, greenhouses have been seeded earlier. It is now known that good plants can be produced in less time than originally thought. Delaying seeding will also result in energy savings, and should reduce the number of clippings needed. The February 1 seeding date will provide good transplants in late March to early April.

Proper seeding is the first step toward obtaining maximum seedling usability. Either tube or vacuum seeders can be used. Both types need frequent checking to be sure they are delivering one seed per cell. Use only fresh, high quality seed intended for direct seed greenhouse use. Seed intended for precision seeding field beds or custom-coated bare seed may not be suitable for use in the greenhouse. Often these seeds are of lower germination and vigor than greenhouse seed. While this poses no problem in field beds, it can result in lowered usability in the greenhouse. Do not use primed seed saved from years before. Priming damages the long-term storage ability of tobacco seed. Low germination and seedling vigor can result from using old primed seed.

Care must be taken as the trays are floated to avoid rough handling, which may dislodge seeds, resulting in double and missing plants. There is no need to water over the top in the float system. A properly packed tray will provide sufficient moisture for germination. For proper germination, the greenhouse **floor** temperature should be held at 68 to 70 degrees F until germination is complete.

Recent records indicate 68 degrees F at night and 86 degrees F in the day as ideal for germination of most varieties. Thermometers should be located on the floor, not at eye level. There can be a great difference between the floor temperature and the temperature at 5 feet (see engineering section for details of temperature control systems). After germination, the temperature can be reduced to 50 degrees. If cold injury symptoms appear (it looks the same as in the plantbed), increase temperature slightly and/or readjust the horizontal air flow fans to prevent cold spots. Usually, cold injury causes no permanent damage. Some varieties are more sensitive to cold injury and may require slightly higher night temperatures.

VENTILATION

Ventilation is critical in the greenhouse to control humidity and temperature. Side curtains should be lowered in stages throughout the morning. Several visits to the greenhouse should be made each day. To control humidity, it is often necessary to over-ventilate the greenhouse early in the day. Care should be taken not to overly chill the seedlings when trying to control humidity. Dripping from excess humidity can upset young seedlings and may increase disease potential.

Extreme care must be taken to keep the greenhouse temperature below 90 degrees, above which heat injury is likely. Greenhouse temperature can increase **very rapidly** on sunny days anytime during the production period. There is no substitute for frequent visits to the facility. Be sure to stress the importance of ventilation to workers with responsibility in the greenhouse.

CLIPPING

Clipping should be used to increase seedling uniformity and maximize the number of usable seedlings per tray. It should be used to hold seedlings only in emergency situations where field conditions do not allow transplanting. By paying attention to fertilization and seeding date, clipping can be minimized. Due to increased plant density and potential for producing "leggy" seedlings, management of clipping becomes more critical as the number of cells per tray increases.

Mower maintenance is an integral part of successful clipping. The blade must be kept sharp. Keeping the mower underside clean and slick will reduce the amount of clipped matter that falls back on the plants. Since clipping is an excellent way to spread disease, good mower sanitation is vital (see disease section). **RAISED MOWERS CAN BE VERY DANGEROUS. EXERCISE EXTREME CAUTION!**

Begin clipping early to establish uniformity. Clip lightly at first to minimize plant shock and to reduce problems with clippings falling back onto the plants. Do not clip closer than 1\2 inch above the bud. Clip as needed to maintain uniformity and prevent excessive stem length. Five to ten clippings should suffice. In 2007, a survey indicated that most growers clip an average of 7 times. If more clippings are required, seeding date and/or the fertility program should be modified for the next year. The reduced phosphorus programs given in the fertility table should minimize the need for
clipping. Virginia research suggests the following clipping programs: Begin clipping when plants are 2 - 2.5 inches tall (to bud). Set the mower 1 - 1.5 inches above the bud. Clip on 3 day intervals for first 3 clippings and 5 days thereafter.

KEY POINTS FOR SUCCESS IN A GREENHOUSE

1. Have water analysis done on a yearly basis. Water composition can change from year to year. Correct water quality problems as needed. Do **not** use untreated surface water.

2. Make sure the greenhouse and equipment are ready for the season. Mice and fire ants should be eliminated prior to seeding.

3. Do not over-fertilize. Consider using one of the new low phosphorus fertility programs outlined previously.

4. Do not seed before February 1. Earlier than needed seeding wastes fuel and increases the demand for clipping.

5. Pay attention to seeding and germination. Good germination has a large impact on final seedling yield. The ideal temperature during germination is 68 degrees F at night and 86 degrees F during the day.

6. Keep a close eye on temperature. Greenhouse temperature can rise high enough to kill young seedlings very quickly on sunny days. Measure temperature at the plant level.

7. Begin clipping early to establish uniformity. The first clipping should just cut the largest plants. The amount of leaf removed at each clipping should increase as the season progresses.

8. Be alert for symptoms of disease. Remove diseased plants early. Keep your mower sanitized.

CROP ROTATION IS AN EFFECTIVE AND EFFICIENT METHOD TO IMPROVE TOBACCO PRODUCTION EFFICIENCY.

Tobacco production is most successful when grown in combination with other crops. Pests, especially diseases, are easily managed when a good cropping sequence is followed. Soil structure is improved with rotation, thus allowing better root development, greater water infiltration, and reduced soil erosion. Tobacco will respond to all aspects of the rotational crop, and in some cases, this may create additional management needs, such as excess nitrogen or nematodes from a legume crop in the rotation. Grain crops, like small grain or corn, are good rotational crops for tobacco. County Agents estimate that practically all tobacco received rotation in 2007 (43% follow soybeans while 41% follow corn and 14% follow cotton). Crop rotation is the backbone of a good disease management program! See disease section.

CULTIVATION AND WEED MANAGEMENT

Cultivation is essential to aerate crusted soil, build the row ridge, reduce drowning, and aid in weed control. Hard soil around newly set transplants must be shattered, as this soil remains cold, and roots cannot penetrate to pick up nutrients. Cultivate early and deep enough to shatter the crust, as later cultivation may injure roots.

Herbicides are used on nearly all of the tobacco acreage to control weeds and grasses. Most farmers use herbicides and cultivation to control weeds. Unnecessary cultivations increase production cost, spread mosaic virus, and may cut roots, thus contributing to soilborne diseases such as bacterial wilt and black shank.

WEED PROBLEMS AND HERBICIDE USE

Chris Main & Dewitt Gooden

South Carolina tobacco producers face tough challenges in weed management. Annual grasses, pigweeds, sicklepod, yellow nutsedge and morningglory complex, common cocklebur, and eclipta are the most common and troublesome weeds in South Carolina tobacco fields. Weeds compete with tobacco for water, nutrients and sunlight. While low levels of weed infestations may not reduce tobacco yield, late season weeds can interfere with harvest and reduce leaf quality. A successful weed management plan will use multiple production methods to keep these weed populations low.

While options for weed management in tobacco production are limited, adequate weed control can be obtained with proper herbicide selection and application. Tillage and seedbed preparation should eliminate all emerged weeds prior to planting. The transplant bed should be smooth and level at the time of preplant incorporated (PPI) herbicide application to insure even application across the field. This will allow for uniform incorporation of PPI herbicides with tillage. Activating rainfall or irrigation is needed for optimum preemergence herbicide activity and weed control. Timely shallow cultivation (no deeper than two inches) when weeds appear after crop establishment will provide season long weed control. Deep cultivation only brings more weed seeds to the surface prolonging weed interference. Use of specific herbicides depends on the weed spectrum of your field, economic considerations and your application system. Consider your situation and tailor a weed control program to your needs. The following sections will guide you in the decision making process. Always read and follow label directions, as labels frequently change.

A 2007 survey indicated that 57% of the acreage was treated with Prowl, 32% with Command and 55% with Spartan. The following were results of several on farm tests using Spartan herbicide for weed control.

ON FARM TOBACCO HERBICIDE TEST
AVERAGE OF 9 LOCATIONS 2000-2002

Treatment	Type Treatment	Rate / A	Yield (lb/A)	QI
Check	-	-	2845a	70a
Prowl	PPI*	1.8 pts	2819a	70a
Spartan	PPI	8 oz	2951a	71a
Spartan	PPI	12 oz	2912a	70a
Spartan + Prowl	PPI	8 oz + 1.8 pts	2925a	70a

* Herbicides were sprayed on a knocked down bed and then incorporated with a power tiller followed by a bed shaper.

* Tests were conducted by Dewitt Gooden and David Morrison.

Spartan is considered an excellent tobacco herbicide, especially for nutsedge and morningglory control. There is concern about potential injury from Spartan use. In these studies, Spartan had no effect on yield or quality at the recommended rate of 8 oz. In two of the seven locations, there was some early season problems with stunting and leaf fleck when the 12 oz rate was used. At one location, a slight yield depression (not significant) at the 12 oz rate was seen. The two locations were sandy soils. Research has shown that injury is more likely to occur on sandy soils when rainfall occurs soon after planting. In most cases, the plants soon outgrow the injury symptoms, and yield and quality are not affected.

The following points offer insurance for good weed control with lowest injury potential from Spartan herbicide:

- Use the lowest labeled rate of Spartan for soil type and weed species.
- Take special precautions for uniform distribution during bedding and transplanting.
- Pre-emergence (Pre-T) applications are considered safer than incorporated treatments (PPI). Care must be taken to ensure herbicide is not displaced when transplanting. Pre-emergence applications need rainfall or cultivation for activation.

Regardless of equipment used when applying herbicide or any pesticide to a pre-existing bed, careful attention must be paid to applications techniques. The bed should be knocked down to near final shape prior to pesticide application and incorporation.

Herbicides for Weed Management in Tobacco [1]

PrePlant Incorporated (PPI) and Preemergence (PRE) Herbicides for Weed Management in Tobacco.

	Rate/Acre Broadcast		
Herbicide	**Formulation**	**Active Ingredient**	**Remarks/Precautions**
Command 4EC (Clomazone) ***Apply PPI*** Command 3ME ***Apply PRE***	1.5-2.0 pt. 2.0-2.67 pt.	0.75-1.0 lb. 0.75-1.0 lb.	**Apply Command 3ME to the soil surface prior shallow tillage (no deeper than 2 inches) or immediately after transplanting. Excellent control of prickly sida and annual grasses. Good control of ragweed.** See label for other restrictions and drift control measures. **Command may persist and cause injury to small grain cover crops.** 3 ME May be applied up to 7 days after transplanting. **REI = 12 hr**
Devrinol 2E (Napropamide) ***Apply PPI*** Devrinol 50DF ***After Transplanting***	2.0 qt. 2.0 lb.	1.0 lb. 1.0 lb.	Apply preplant incorporated by shallow disking or overtop transplants (50DF formulation) immediately after transplanting. Do not apply Devrinol 2EC over-the-top of transplants. If rainfall is not received within 24 hours of a post-transplant application, irrigation or tillage is necessary for activation. Controls pigweed, ragweed and several other broadleaf weeds. Will not control morningglories. Some growers have had good success with Devrinol tank mixed with Prowl or Tillam. **REI = 12 hr**
Prowl H_2O 3.8EC (Pendimethalin) Prowl 3.3EC ***Apply PPI***	1.57-2.10 pt. 1.8-2.4 pt.	0.75-1.0 lb.	Apply on soil surface and incorporate with a disk set to cut 3-4" deep. Disk twice for thorough mixing. Use the higher rate of chemical in each rate range where weed pressure is heavy. Controls most **annual grasses and pigweeds**. **REI = 24 hr**
Spartan 4F (Sulfentrazone) ***Apply PPI or PRE***	8.0 oz.	0.25 lb.	Apply Spartan 4F to the soil surface following land preparation prior to transplanting. Use a well calibrated sprayer with good agitation. Avoid excessive overlap of spray swaths. Spartan may be mechanically incorporated, **but no deeper than 2 inches.** Excellent control of morningglory, pigweed, lambsquarters and yellow nutsedge. Good annual grass suppression. For improved grass control, use with Command 4EC or Prowl. **REI = 12 hr**

(Continued on next page)

PPI and PRE Herbicides Continued

Herbicide	Rate/Acre Broadcast Formulation	Active Ingredient	Remarks/Precautions
Tillam 6EC (Pebulate) ***Apply PPI***	2.67 qt.	6.0 lb.	Apply and **incorporate immediately** with a disk set to cut 4-6" deep. Drag or cultipack to help seal chemical in soil. Provides good control of most grasses and **nutsedge**. Tillam is not persistent in the soil and weeds germinating late in the season may not be controlled. **REI = 12 hr**

Postemergence (POST) Herbicides for Weed Management in Tobacco.

Herbicide	Rate/Acre Broadcast Formulation	Active Ingredient	Remarks/Precautions
Poast 1.5E (Sethoxydim)	1.5 pt.	0.28 lb.	Apply to control annual grasses, johnsongrass and bermudagrass. Always add crop oil concentrate at 2 pts. per acre. For rhizome johnsongrass, apply 1.5 pt. A second application of 1 pt./A may be needed for johnsongrass regrowth up to 12" tall. For bermudagrass, apply 1.5 pt./A before stolons reach 6" long. A second application of 1 pt./A may be needed for control of re-growth. **REI = 12 hr**

Layby Herbicides for Weed Management in Tobacco.

Herbicide	Rate/Acre Broadcast Formulation	Active Ingredient	Remarks/Precautions
Devrinol 50DF (Napropamide)	2.0 lb.	1.0 lb.	Controls annual grasses and some broadleaf weeds. Make application following last cultivation. Direct spray into row middles using drop nozzles. **Will not control emerged weeds. REI = 12 hr**
Prowl H_2O 3.8EC (Pendimethalin) Prowl 3.3 EC	1.0-1.57 pt. 1.2-1.8 pt.	0.5-0.75 lb.	Apply on soil surface and incorporate with a disk set to cut 3-4" deep. Disk twice for thorough mixing. Use the higher rate of chemical in each rate range where weed pressure is heavy. Controls most **annual grasses and pigweeds**. **REI = 24 hr**

[1] The use of trade names in this publication is intended for the purpose of clarity and information. Inclusion of a trade name does not imply approval to the exclusion of other products, which may be of similar composition. Clemson University does not guarantee or warranty the products named.

Crop Replant and Rotation Restrictions for Tobacco Herbicides[2].

	Corn	Cotton	Grain Sorghum	Peanuts	Soybeans	Sunflower	Tobacco	Wheat
Command	9 M	None	9 M	9 M	None	12 M	None	12 M
Devrinol	12 M	12 M	12 M	12 M	12 M	12 M	12 M	6 M
Prowl H_2O	Spring	None	None	None	None	None	None	None
Spartan	10 M	18 M	10 M	None	None	None	None	4 M
Tillam	No information available.							
Poast	120 D	None	120 D	None	None	120 D	None	120 D

[2] M = months, D = days.

Weed Response[3] to Herbicides for Tobacco Weed Management.

	PPI or PRE					POST	LAYBY	
	Command	Devrinol	Prowl H_2O	Spartan	Tillam	Poast	Devrinol	Prowl H_2O
Cocklebur	5	3	2	7	2	0	2	2
Florida pusley	---	9	9	---	8	0	8	9
lambsquarters, common	8	8	8	8	8	0	8	8
Morningglory	4	3	4	9	2	0	4	3
Pigweed	4	8	8	7	8	0	8	8
prickly sida	9	6	2	8	2	0	7	6
Ragweed	6	6	3	3	2	0	7	6
Sicklepod	2	3	2	1	2	0	2	2
Smartweed	7	3	2	8	2	0	2	2
Crabgrass	9	9	9	7	9	8	9	9
Crowfootgrass	9	9	9	7	9	8	9	9
johnsongrass, seedling	7	7	8	6	8	8	7	8
Texas panicum	8	---	8	6	5	8	---	8
Nutsedge	3	3	2	9	8	0	3	2

[3]***KEY TO RESPONSE RATINGS: 0****=No control;* ***10****=100% control;* ***----****=Data not available. Ratings are based on application of labeled rates of each herbicide, applied at the optimum timing for each weed.*