AGRONOMIC INFORMATION

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Variety Selection

Variety selection is an important decision for the profitable production of flue-cured tobacco. A high potential yield is probably more important than ever due to lower tobacco prices and reduced operating margins. However, ease of curing and specific characteristics of the cured leaf should also be considered. Varieties will differ in cured-leaf color and other physical characteristics desired by purchasers (proportion of tip leaves, etc.), but these factors are also influenced by growing and curing practices. Growers should carefully consider any dramatic changes in varieties grown without first trying the varieties first-hand. Likewise, the disease resistance of varieties varies greatly and is critical to profitable production. Growers should maintain detailed field histories with specific information on past varieties planted and the level of disease occurrence.

Tobacco breeders have made tremendous progress in recent years developing resistance to the major diseases of flue-cured tobacco. Detailed information on the disease resistance of flue-cured tobacco varieties is presented in the disease section of this guide. It is especially important that growers have a correct identification of any diseases that may be causing field losses. Black shank, Granville wilt, and *Pythium* stalk rot may be confused and the presence of nematodes can make these and other root diseases more severe than expected or symptoms may not appear as expected. To further complicate matters, there have been isolated cases of the less common root diseases that are not typically tested against our current varieties. If past performance of disease resistant varieties has been less than anticipated, growers are encouraged to contact their local agriculture Extension agent to investigate possible explanations and evaluate options.

No official figures are compiled for tobacco seed sales or varieties planted in Virginia. Growers have dozens of varieties available with a wide range in disease resistance properties, yield potential, leaf characteristics, and ease of handling and curing. Perhaps as much as 75 percent of the flue-cured acreage in Virginia in 2007 was planted in three varieties (K 326, NC 71, and NC 297). The long popular K 326 remains the most planted variety in Virginia due to its high yield, exceptional holding ability, and ease of curing. The variety was released in 1981 and still remains a good choice for growers with good rotations and field histories with no disease or nematode problems. Black shank is perhaps the most widespread disease problem in Virginia and growers have readily adopted varieties such as NC 71, and to a lesser extent, NC 291 and NC 72, to reduce losses due to this disease. Many of these same varieties possess resistance (Ph gene) to the tobacco cyst nematode and have provided dramatic reductions of nematode population levels. Granville wilt is a more localized disease that is primarily a problem in Mecklenburg and Brunswick Counties, and therefore, additional varieties are of interest in this area. K 149, and later, Speight 168, have historically been the variety grown for Granville wilt resistance. In recent years, newer varieties with greater resistance levels and yield potential are being grown, including NC 299, GL 350, and NC 810. Recent new releases from Speight Seed Farms show quite a lot of promise for Granville wilt. Finally, some growers desire resistance to the tobacco mosaic virus (TMV) and NC 297, CC 27, and RG H4 are TMV resistant varieties that have significantly better quality than earlier TMV resistant varieties.

Only one new variety will be released commercially for the 2008 season, following approval by the Regional Flue-cured Tobacco Minimum Standards Program the previous year.

CC 37 was developed by the tobacco breeding program at R.J. Reynolds Tobacco Company. The variety was developed with an emphasis on incorporating resistance to species of the root rot nematode other than the common root knot nematode to which most other commercial varieties are resistant. Only a very few growers in Virginia need to consider this resistance when making a choice on varieties to grow. The seed CC 37 is a hybrid so the parental cross is not public knowledge. Disease resistance can be considered similar to the previously released CC 27 with high race 0 black shank resistances and TMV resistance. In the limited testing conducted to date, CC 37 is considered to have a high level of resistance to Granville Wilt.

The results from the Official Variety Trial conducted at the Southern Piedmont Center in 2007 are shown in **Table 1. Relative yield** is calculated based on the overall average yield of all varieties in the test. A value of 100 indicates that the yield was the same as the test average. Values of 105 or 95 indicate that the yield of a particular variety was 5 percent above or below the test average, respectively. **Average price** was calculated based on a set of composite prices from multiple contract buyers. These prices tended to be lower than what you would expect when marketing the tobacco due to the difference in the appearance of the tobacco in small hands from the test compared to an 800 pound bales. The grade index is a better measure of the quality difference among varieties. When examing these data, one should remember that the data are from one year only. For more detailed information on varieties, refer to *Flue-cured Tobacco Variety Information for 2008*, Virginia Cooperative Extension publication 436-047 (Revised 2008). Additional information regarding disease resistance may be found in the disease control section of this guide.

Table 1. Agronomic results from the 2007 Official Variety Trial conducted at Southern Piedmont AREC - Blackstone.

New varieties for 2008 are bold.

Variety	Yield (lbs/A)	Relative Yield	Price ($/lb)	Grade Index	Value ($/A)
CC 27	3890	114	1.37	79.0	5372
PVH 1118	3768	110	1.34	77.0	5022
CC 37	**3756**	**110**	**1.30**	**73.3**	**4714**
NC 196	3726	109	1.38	77.3	5134
NC 102	3704	109	1.37	78.0	5076
NC 299	3695	108	1.41	80.7	5228
NC 72	3620	106	1.30	74.3	4694
RGH 51	3581	105	1.36	77.7	4851
NC 291	3580	105	1.35	77.0	4832
GL 350	3560	104	1.35	77.3	4814
NC 71	3558	104	1.30	74.7	4613
K 394	3492	102	1.13	66.0	3938
OX 414	3472	102	1.44	81.3	4991
Speight G-168	3460	101	1.31	75.7	4535
RG H4	3437	101	1.41	80.3	4868
K 326	3431	101	1.38	79.0	4724
Speight 234	3428	100	1.12	66.0	3842
Speight 227	3413	100	1.44	82.0	4917
Speight 220	3409	100	1.37	78.0	4663
NC 810	3389	99	1.32	76.0	4479
VA 119	3380	99	1.25	72.7	4220
RG 17	3377	99	1.32	75.3	4430
Speight H20	3372	99	1.36	77.7	4584
GL 939	3368	99	1.32	75.0	4430
CC 13	3352	98	1.34	76.7	4532
K 730	3335	98	1.42	80.3	4740
NC 55	3334	98	1.46	82.3	4872
VA 116	3328	98	1.38	79.3	4599
NC 297	3293	97	1.24	70.7	4088
K 399	3259	96	1.36	77.0	4434
NC 606	3247	95	1.37	77.7	4446
K 358	3236	95	1.27	72.7	4128
Speight 225	3235	95	1.39	79.0	4493
Speight 236	3202	94	1.39	79.7	4451
Coker 371Gold	3195	94	1.34	76.3	4276
Speight 210	3182	93	1.38	78.0	4387
K 346	3170	93	1.36	77.3	4326
Speight NF3	3141	92	1.40	79.3	4401
NC 471	3100	91	1.35	78.0	4183
K 149	3008	88	1.28	74.7	3878
Test Average	3412		1.34	76.8	4580

The test was grown at the Southern Piedmont Agricultural Research and Extension Center in Blackstone with no black shank or Granville wilt incidence. The tobacco cyst nematode was controlled with Temik 15G (20 lbs/A).

Table 2. Relative yields for Flue-cured Tobacco Official Variety Trials conducted at the Southern Piedmont AREC near Blackstone for 2006 and 2007.

Variety	2007 Relative Yield		2006 Relative Yield		2-yr Average Relative Yield
CC 27	114	(1)	113	(2)	113
PVH 1118	110	(2)	99	(25)	105
CC 37	**110**	**(2)**			
NC 196	109	(4)	110	(4)	110
NC 102	109	(4)	105	(9)	107
NC 299	108	(6)	106	(8)	107
NC 72	106	(7)	113	(2)	109
RG H51	105	(8)	103	(15)	104
NC 291	105	(8)	109	(7)	107
GL 350	104	(10)	101	(20)	103
NC 71	104	(10)	103	(15)	104
K 394	102	(12)	89	(38)	95
OX 414	102	(12)	105	(9)	104
Speight G-168	101	(14)	101	(20)	101
RG H4	101	(14)	100	(24)	101
K 326	101	(14)	110	(4)	105
Speight 234	100	(17)	103	(15)	102
Speight 227	100	(17)	99	(25)	99
Speight 220	100	(17)	98	(28)	99
NC 810	99	(20)	105	(9)	102
VA 119	99	(20)	101	(20)	100
RG 17	99	(20)	101	(20)	100
Speight H20	99	(20)	91	(37)	95
GL 939	99	(20)	95	(31)	97
CC 13	98	(25)	116	(1)	107
K 730	98	(25)	99	(25)	99
NC 55	98	(25)	105	(9)	102
VA 116	98	(25)	87	(40)	92
NC 297	97	(29)	110	(4)	103
K 399	96	(30)	95	(31)	95
NC 606	95	(31)	95	(31)	95
K 358	95	(31)	96	(30)	95
Speight 225	95	(31)	94	(35)	94
Speight 236	94	(34)	68	(41)	81
Coker 371 Gold	94	(34)	92	(36)	93
Speight 210	93	(36)	98	(28)	96
K 346	93	(36)	105	(9)	99
Speight NF3	92	(38)	95	(31)	94
NC 471	91	(39)	89	(38)	90
K 149	88	(40)	102	(18)	95

Relative yield data from the Flue-cured Official Variety Trial for the past two seasons are presented in Table 2. The small number in parenthesis indicates the ranking of a specific variety among all of the varieties for each season. The test conducted at the Southern Piedmont AREC should be indicative of the yield potential of the different varieties grown under a well-irrigated disease-free situation.

Greenhouse Transplant Production

Greenhouse culture has become the standard for transplant production with flue-cured tobacco producers in Virginia. Virtually all of Virginia's flue-cured tobacco acreage has been planted with greenhouse-grown transplants the past several years. The popularity of using greenhouse-grown transplants has created a new business opportunity for many growers, the custom growing of tobacco transplants. Today, a significant number of growers no longer grow their own transplants but purchase them from a transplant producer. When purchasing transplants, the best practice is to buy plants from a reputable grower in or near your local community. This is an important consideration if greenhouse pesticide applications are desired or if specific disease varieties are in your disease management program. If this is not an option, ask other growers about the reputations of prospective transplant producers outside your local area. Importing transplants from southern tobacco belts increases the likelihood of importing blue mold into Virginia and should be avoided.

The use of greenhouse-grown transplants has been advantageous for numerous reasons. Labor required for transplant production and for transplanting has been dramatically reduced compared to the use of bare-root transplants. Crop growth in the field tends to be much more uniform, resulting in easier cultivation and fewer trips through the field when topping. The results have been tobacco crops that grow-off and come into top more uniformly, and this will often carry over into the maturation and ripening of the leaves. Greenhouse management does require more time and different practices compared to traditional outdoor plant beds. Greenhouse sanitation and proper management are critical in avoiding disease problems as pesticide options are limited in the event of serious disease outbreaks. With the increased cost of LPG, growers selling transplants should carefully consider the actual cost of producing transplants. In addition to adding to the cost of heating the greenhouse, increased fuel prices will increase the cost of other items related to the greenhouse such as media, fertilizer, and trays.

Seed priming is an important tool of the seed industry to improve the seed performance of many vegetable and flower crops. The seed priming process is a laboratory procedure that begins the initial phase of the seed germination but suspends the process before actual emergence occurs. Seeds are then treated to allow for storage until germination is desired. The result of priming is seeds that typically will germinate at lower temperatures and will germinate quicker and more uniformly under less than ideal conditions. Seed priming often can be used to overcome seed dormancy that can occur naturally. This can be especially important with tobacco seed that is harvested in the fall immediately preceding use in the next greenhouse season. In order to obtain acceptable germination with recently harvested seed of tobacco hybrids or other varieties with poor germination characteristics, seed companies may find it necessary to prime the seed. However, seed purchasers need not make this decision since seed companies have the necessary laboratory test information to determine if seed priming is warranted. The primary disadvantage of seed priming is the reduced shelf life, and therefore, primed seed should not be held over from one season to the next.

Spiral roots continue to be a common occurrence in many tobacco greenhouses. A spiral-root seedling occurs when the growing point of the emerging root tip is damaged and the seedling fails to develop properly. The result is a root that does not penetrate into the surface of the growing medium. Often a secondary root will develop and grow normally allowing the seedling to become established and otherwise grow normally. The survival of spiral-root seedlings depends on their severity and specific growing conditions. Research studying the fate of spiral-root seedlings indicates that approximately one-third will develop to a usable transplant, one-third will result in swell, less than desired seedlings, and one-third will die to fertilizer salts injury.

The specific cause of spiral-root seedlings is not fully understood. Early research indicated that inadequate media aeration (too little air, too much moisture) played an important role in spiral-root seedling occurrence. This has largely been corrected by growers through better attention to tray filling and not overpacking media in the trays. Differences can occur among different brands of media. However, these differences are seldom consistent among greenhouses and are most likely how media tray-filling boxes handle different mixes. Once a grower gets accustomed to a particular mix, tray filling can be adjusted to minimize spiral roots.

Seed coating properties have a significant impact of seed performance and spiral-root seedling occurrence. The seed coating or pellet must wet uniformly and either melt away or split apart properly. Less vigorous seed will have a greater likelihood of having spiral-root seedlings and this is especially true when the pellet separates from the seed is less than desired. This situation is further complicated by the different wetting properties of the various brands of media and their impact on the breaking apart of the seed pellet.

Reducing Spiral-root Incidence. Growers can not alter the inherent properties of the seed and have little impact on media properties. Growers can give special attention to media handling and tray filling. Trays should be filled evenly, avoid overfilling or overpacking media in trays, and dibbled once with a dibbler that concentrates the force in the center of the cell. Research has demonstrated reduced spiral-root incidence with a pyramid dibbler compared to a spherical shape, though the difference is not great. Growers need to be mindful of the condition of their media at purchase and avoid media that is either excessively wet or dry. Media should be stored so to avoid excessively high temperatures and drying. Water should not be added to bags of mix unless expressly directed by the manufacturer.

Greenhouse Management Practices

The following is a brief description of the important management practices required for successful greenhouse production.

1. **Sanitation**

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

2. **Ventilation and Air Circulation**

   Ventilation is necessary to reduce to amount of moisture that naturally accumulates inside the greenhouse and to prevent the occurrence of enormously high temperatures. Brief openings of the side curtains early in the morning and late afternoon are particularity effective in removing moisture-laden air before condensation occurs. Air circulation within the greenhouse is beneficial to reduce temperature stratification, reduce condensation on the underside of the greenhouse cover, remove moisture from the plant canopy, and evenly distribute greenhouse gases. The use of horizontal airflow (HAF) or a polytube system is highly recommended to provide adequate air circulation.

3. **Temperature Control**

   The most demanding period for heating is during the seed germination period. Until maximum germination is obtained, the minimum temperature should be maintained at 70º to 72ºF. Extended periods of cooler temperatures will delay germination and may decrease the uniformity in the size of the seedlings. After germination, the minimum temperature may be initially reduced to 60º to 65ºF and later to 55ºF. Preventing high temperatures is perhaps of even greater importance. Young seedlings are particularly sensitive and the temperature should not be allowed to reach 95ºF during the two- to four-leaf stage. As seedlings grow, they are better able to withstand increasingly higher temperatures, although to reduce stress on the seedlings, the temperature should not be allowed to exceed 100ºF. High temperatures place greater stress on the tobacco seedlings due to increased water evaporation of and the resulting concentration of fertilizer salts on the surface of the growing medium.

   Recent research conducted by David Smith at NCSU has investigated how flue-cured tobacco varieties differ in their germination response to temperature. This research focused on NC 71, which has been characterized as being inconsistent in germination when examined across a large number of greenhouses. Results demonstrated that NC 71 is especially sensitive to temperature conditions. Although a fluctuation in day to night temperatures was beneficial, just moderately excessive daytime temperatures can induce seed dormancy, resulting in delayed germination. The best germination was obtained for NC 71 with a temperature regime of 68º and 85ºF. Although other varieties did better or were not adversely affected by high temperatures, 95º to 105ºF, better overall management of the greenhouse is obtained by preventing such high temperatures whenever possible.

   Avoid seeding too early to reduce the cost of greenhouse heating. High-quality transplants can be grown in seven weeks in most situations, though some growers have found eight weeks may be necessary with 338-cell trays. An added benefit of not seeding too early is that some pest problems may be avoided by minimizing the time that plants are in the greenhouse. Many growers seed their greenhouse when labor or seeding equipment is available. If this occurs during a period of very cold weather, one may decide to provide only minimal heat (prevent freezing) for a few days until better weather conditions occur and less heating will be necessary. Research conducted for three years in Virginia has provided excellent results with providing a nighttime temperature of just 40ºF and keeping the greenhouse cool (open) during the day for a period of three to five days. This allows for seed pellets to soften without beginning seed germination. Afterwards, normal heating can be started. This has been especially beneficial in reducing spiral-root seedlings.

Greenhouse temperatures should be measured at plant level in one or more locations that are representative of the entire greenhouse. The use of a recording thermometer to measure daily high and low temperatures is an excellent management practice. Thermostat settings for heating and cooling should be made of the basis of thermometers within the immediate environment of the plants.

4. Media and Tray Filling

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

5. Fertilization

Fertilizers used in float greenhouse transplant production are formulated to function with a soilless growing medium. Such fertilizers should contain at least 50 percent of their nitrogen as nitrate-N and should contain only a minimal amount of urea. In addition to using the correct fertilizer material, proper fertilization requires an accurate estimation of fertilizer solution concentration to ensure that seedlings are not injured by excessive fertilizer salts. The amount of fertilizer necessary for a float bay is determined by the volume of water in the bay, the fertilizer analysis, and the desired nutrient level of the float bay. Additional information on fertilization is presented on page 13.

6. Water Quality

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

7. Clipping

Clipping is an essential management practice for direct-seeded greenhouse tobacco production. Begin clipping when plants are at least 2 inches to the bud. If seedling growth is unusually uneven, earlier clipping will allow smaller plants to catch up. Research conducted in Virginia indicates that the timing of the first clipping, the severity of clipping, and the number of total clippings does not have a significant impact on the stem diameter of the transplants. However, the above factors were important in controlling the growth rate of the seedlings and the size of the field-ready transplant. Very early clipping (1.5 inches to bud or less) resulted in shorter than desired transplants.

Suggested Clipping Program

- Begin clipping when plants are 2 to 2.5 inches tall (bud height).
- Set mower blade at 1 to 1.5 inches above the bud.

- Clip on a three-day interval between the first three clipping dates and every five days thereafter.

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

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

Float Fertilization Programs

The suggested fertilization schedule for greenhouse tobacco transplant production has been changed for recent seasons. This is the result of research trials conducted the past year and extensive observation of grower greenhouses over the past several years. Such a change was warranted due to the relatively high fertilizer charge of the brands of greenhouse mixes that have gained in popularity in recent years. Furthermore, some of the newer, popular flue-cured tobacco varieties have a tendency for slow and uneven seedling emergence making them more subject to injury from fertilizer salts. The new suggested fertilizer program is intended to reduce the potential of excessive fertilizer salts build-up while not impacting early seedling growth.

Suggested Greenhouse Tobacco Fertilization Schedule

1. 150 ppm N added 1 to 5 days after seeding

followed by

2. 100 ppm N added 4 weeks after seeding

The total of both applications is the equivalent of 250 ppm N based on the original depth of water in the bay (usually 4 inches). For example: using a 16-5-16 fertilizer, a total of 20.8 oz per 100 gal. (250 ppm N) would be needed with 12.5 oz per 100 gal. (150 ppm N) for the first application and 8.3 oz per 100 gal. (100 ppm N) for the second. Under normal conditions, no additional fertilizer beyond the total of 250 ppm N should be necessary. However, if the greenhouse season is prolonged due to early seeding or late transplanting, a late-season addition of 75 to 100 ppm N may be needed to maintain adequate seedling nutrient levels.

The primary drawback of delaying fertilization until after the trays are floated is the difficulty in adequately mixing the fertilizer throughout the entire float bay. To ensure even mixing of fertilizer throughout the float bay: dissolve fertilizer in buckets of water, add fertilizer at several locations throughout the bay, and use pumps to circulate water and distribute the fertilizer throughout the bay. Handheld conductivity meters (e.g. DiST4 or TDR Tester 4) are excellent tools to verify that fertilizer is evenly mixed throughout the entire float bay and that the desired concentration is obtained. The nutrient solution should be checked in several locations along both the center walkway and side curtains.

Growers accustomed to using fertilizer injectors can continue to do so with the above fertilizer schedule. The most practical method would be to add fertilizer to the bay one to three days after seeding with adequate mixing in the bay water. The injector would be used to add **125 ppm N** with each later addition of water to the bay. An alternative would be to fill bays to initial depth of 2 in. and allow trays to wick. The following day, bays would be filled to a depth of 4 in. injecting a 300 ppm N fertilizer solution for a final concentration of 150 ppm in the bay. Later additions of water would contain a concentration of 125 ppm N through the injector.

Calculation of Water Volume and Fertilizer Concentration

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

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

Example: $$96\ \text{ft} \times 16\ \text{ft} \times \frac{4\ \text{in}}{12} \times 7.48 = 3829\ \text{gal}$$

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

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

Example: $$\frac{150\ \text{ppm N}}{16\%\ \text{N}} \times 1.33 = 12.5\ \text{oz per 100 gal}$$

Usable Greenhouse Transplant Yield Research

The impact of seed, media, and fertilization on the yield of usable transplants was investigated in research trials conducted on-farm and at the Southern Piedmont AREC. The timing of initial float bay fertilization

(150 ppm N) was found to have the greatest impact on usable transplants. Fertilization at seeding resulted in an average seedling mortality of 15 percent compared to 6 percent where fertilizer was added three days after seeding. Delaying fertilizer addition resulted in 5 percent to 15 percent more usable transplants, depending on the particular seed and media combination. The primary benefit of adding fertilizer after trays are initially floated is to minimize the accumulation of excessive fertilizer salts in the media. Seedling mortality observed during the third week after seeding is frequently a result of excessive fertilizer salts. Fertilization was not found to impact the occurrence of spiral-root seedlings. Seed, media, and the interaction of these two factors were related to the account of spiral-root seedlings.

An on-farm greenhouse trial conducted in 2002 investigated the impact of three production practices on usable transplant yield. These included the use of primed seed (NC 71), covering seed with AGRIMATE, and the timing of initial fertilization. Results are shown below:

Table 3. Usable transplant yield resulting from three different greenhouse production practices.

		Usable Transplants (%) Fertilization Timing[2]	
NC 71 seed	Seed covering[1]	at seeding	3 DAS
Primed	No	88.3	90.5
Primed	AGRIMATE	87.4	90.8
Non-primed	No	83.2	90.3
Non-primed	Yes	84.9	89.6

[1]AGRIMATE applied at 0.15 g per cell.

[2]Fertilization timing, 150 ppm N added at seeding or three days after seeding (3 DAS).

Both primed and nonprimed seed of NC 71 exhibited excellent seedling emergence with minimal spiral-root seedlings. As a result, neither priming nor covering seed with AGRIMATE had a significant impact on usable transplants. The single most important factor was delaying the addition of fertilizer from seeding to three days after seeding. Increases in usable transplants ranged from 2 percent to 7 percent by delaying fertilizer addition until three days after seeding.

Fertilization

The application of adequate amounts of the proper nutrients is necessary for profitable tobacco production. Either under- or over-fertilization may result in a crop of unsatisfactory quality and reduced value. Excessive use of fertilizer is an unnecessary production cost and may have adverse environmental impacts. Proper fertilization may be at more of a premium than in recent years as contract tobacco purchases place specific requirements on the quality of tobacco. Unripe tobacco will be severely discounted or perhaps refused. The principles of tobacco fertilization have been established by decades of research.

Soils differ in productive capacity and fertility level. Therefore, careful attention must be given to the physical and chemical characteristics of the soil in selecting the rate and grade of fertilizer to be used. Soil tests, a history of previous crop performance, and the amount and distribution of rainfall are helpful guides in estimating the fertilizer and lime requirements for specific fields.

Soil Testing

Only through soil sampling and soil testing can the pH and nutrient status of soils be determined and the most cost effective fertilization program followed. Fields used for tobacco production should be soil sampled every three years to monitor changes in soil pH. Soil testing and following liming recommendations are critical to avoid either a low pH situation or an excessive high pH that results from over liming. Over liming can increase the possibility of certain disease problems (black shank and black root rot) and cause an imbalance of certain micronutrients. However, the most common soil fertility problem associated with tobacco producers in Virginia is excessively acid soils or low pH. In extreme cases, certain elements such as aluminum and manganese become toxic to plants while other nutrients may be deficient. The desired pH range for flue-cured tobacco is 5.7 to 6.2.

Soil pH also has a big impact on the availability to the tobacco crop of nutrients applied with fertilizers. Fertilizer efficiency is considered to be optimum at a pH of 7.0 and decreases with increased soil acidity shown as following:

	Fertilizer Efficiency		
	Nitrogen	Phosphate	Potash
7.0	100%	100%	100%
6.0	89%	52%	100%
5.5	77%	48%	77%
5.0	53%	34%	52%
4.5	30%	23%	33%

Failure to maintain a soil pH within the desirable range of 5.7 to 6.2 results in reduced fertilizer efficiency and perhaps increased fertilizer costs due to the over application of fertilizer necessary to compensate for reduced nutrient availability.

Nitrogen

Flue-cured tobacco is very exacting in its nitrogen requirement. The regulation of the amount and timing of nitrogen availability is extremely important. Inadequate nitrogen results in low yield and quality of tobacco. Excess nitrogen delays maturity and is associated with tobacco that is undesirable in color (KL, KF, GK, etc.), high in nicotine, and is of generally poor quality. Excess nitrogen will also increase sucker growth which may lead to excessive use of maleic hydrazide (MH), and increase the severity of some diseases and insect problems.

Unfortunately, there is no reliable soil testing procedure for determining nitrogen needs as there is for phosphorus, potassium, and other nutrients. It is well recognized that soils differ in their ability to hold nitrogen. Some of the more important soil characteristics affecting this are organic matter content, texture of the surface, and depth to subsoil. Previous cropping history, seasonal rainfall, and variety must also be considered in determining nitrogen rates. Fields with deeper, sandy topsoils require more nitrogen than those with shallower, heavier textured topsoils. For sandy loam soils of average fertility, suggested nitrogen rates for different topsoil depths are as follows:

Topsoil depth (in.)	Nitrogen rate (lb/A)
0 to 12	50 to 60
12 to 18	60 to 70
18 to 24	70 to 80

At least 50 percent of the total nitrogen in the base fertilizers should be in the nitrate form. Evidence from numerous experiments has not shown any superiority of natural or synthetic organics over standard inorganic sources of nitrogen for the production of flue-cured tobacco.

Adjustment for Leaching

Leaching is the loss of certain nutrients as a result of excessive water moving (percolating) through the root zone. Many producers often confuse drowning and associated root damage with fertilizer leaching. Leaching is seldom a problem on heavier textured soils or on soils with a hardpan within 10 to 12 inches of the surface. It is not uncommon for nitrogen and potassium to move down to clay and then be absorbed later as root growth continues. Adjustment for leaching in this case usually results in over fertilization and a crop that is slow to mature and difficult to cure.

When leaching does occur, the reapplication of both nitrogen and potassium may be necessary. The quantity of nitrogen and potassium required will depend on the amount of water that percolates through the plow layer and the stage of plant growth at the time this occurs. Although research information on nutrient replacement from leaching is limited, the information in Table 4 (taken from North Carolina Cooperative Extension publication AG-187) may be used as a general guide for making leaching adjustments.

Table 4. Nitrogen Adjustment for Excess Water[a]

Topsoil depth (to clay) in inches	Est. inches of excess[b] water percolated through soil	% of applied N to replace after transplanting		
		weeks		
		1-3	4-5	6-7
Less than 10	1	0	0	0
	2	20	10	0
	3 or more	30	20	0
10 to 6	1	30	20	0
	2	45	30	10
	3 or more	60	40	15
17 or more	1	50	25	15
	2	75	35	20
	3 or more	100	45	25

[a]For each pound of N used as an adjustment for leaching, use about 1 pound of potash (K_20) where recommended potash levels as a base application have been used.

[b]Excess water is that quantity percolating through the soil after the water-holding capacity of the soil has been satisfied.

Applications of fertilizer to replace elements lost through leaching should be made as soon as possible after heavy, slow rains. Waiting until deficiency symptoms develop before applying supplemental fertilizer is not recommended.

Phosphorus and Potassium

Phosphorus is probably the nutrient most used to excess in tobacco fertilization in Virginia. Repeated applications of larger quantities of phosphorus than plants can absorb, and with essentially no loss from leaching, has resulted in a general buildup of this element. Soil analyses of tobacco fields conducted by the Virginia Tech Soil Testing Laboratory indicated that approximately 97 percent of the soils had a medium or higher phosphorus level. Extensive testing in Virginia and other states has shown that on soils with a medium or high phosphorus level, 40 lbs/A of phosphorus (P_20_5) are adequate to give maximum production and maintain the soil phosphorus level. Growth responses of tobacco to phosphorus application are observed more frequently early in the growing season than they are in final yield and quality.

Potassium requirements of tobacco are relatively high, and a high potassium content in flue-cured tobacco is needed for good smoking quality. Soils vary in their supply of available potassium, depending upon the parent material, previous fertilization, and cropping history. Approximately 100 to 175 lbs/A of potash (K_20) are adequate for most soil conditions. Potassium may be lost by leaching from the root zone in extremely sandy soils.

Due to the many factors necessary to consider when making fertilizer recommendations for a particular field, data in the following table can be used only as general recommendations for phosphorus (P_20_5) and potassium (K_20).

	Pounds suggested per acre	
Soil Test Category	**P_20_5**	**K_20**
L	230*	150-175
	60-100	
M	60-100	100-150
H	40	100
VH	40	100

*Basic application; to build up soil, phosphorus may be broadcast and plowed-in or disked-in before planting. The 230 lb P205/A can be obtained from 500 lb/A of 0-46-0.

Calcium and Magnesium

If the soil pH is maintained within the desirable range of 5.7 to 6.2 with dolomitic limestone, the available levels of calcium and magnesium will generally be sufficient to meet the needs of the crop. Otherwise, 40 to 50 lb/A of Ca and about 30 lb/A of available magnesium oxide (Mg0) are needed from the mixed fertilizer.

Micronutrients

The need for the application of micronutrients such as boron, copper, manganese, and zinc has not been demonstrated sufficiently with tobacco to warrant general applications. It is definitely known that if applied at excessive rates, these elements are toxic to tobacco. Boron is the micronutrient most likely to be deficient for tobacco. Generally 0.25 lb/A of elemental boron (approximately 2.5 pounds of borax) is sufficient to correct or prevent such deficiencies.

Selecting the Fertilizer Grade

The analysis of a fertilizer gives the percentage of nitrogen, phosphorus (P_20_5), and potassium (K_20) contained in the material. Complete fertilizer grade ratios ($N{:}P_20_5{:}K_20$) available for use on tobacco in Virginia are as follows: 1:3:3 (3:9:9); 1:2:3 (4:8:12, 5-10-15, 6-12-18, and 8-16-24); and 1:1:3 (6-6-18 and 8-8-24). The analysis determines the amount of nutrients supplied. For example, 6-12-18 supplies 6 pounds of nitrogen, 12 pounds of phosphorus (P_20_5) and 18 pounds of potassium (K_20) for each 100 pounds. The basic difference among the three available ratios is that they supply different amounts of phosphorus relative to nitrogen and potassium. Selection of the complete fertilizer grade should be based on the phosphorus (P) soil-test level. On soil testing high (H) to very high (VH), only a 1:1:3 fertilizer analysis should be used. A 1:2:3 analysis fertilizer should only be used for soils testing medium (M) or less for phosphorus. Very few fields used for tobacco production would have a low (L) phosphorus test level and thus warrant the use of 1:3:3 grade fertilizer.

The preplant fertilizer should supply approximately 40 lbs/A of N and 120 lbs/A of K_2O. Additional N and K_20 can be applied as a side application to obtain the total amount of nutrients desired. The soil test recommendation for potassium should be used as a guide in selecting the sidedress fertilizer. If no additional potash is recommended above that supplied in the complete fertilizer, a 1:0:0 analysis sidedress should be used to supply only nitrogen. Calcium nitrate (15.5-0-0) should be considered as an alternative to nitrate of soda. Calcium nitrate supplies 19 percent calcium. Liquid nitrogen solutions may also be used but equipment to apply liquid fertilizer is required and the materials should be incorporated to prevent loss to volatilization. If additional potash is necessary, then a 1:0:1 sidedress may be used to supply both nitrogen and potash. The primary N and potash products are 13-0-14 and 14-0-14. Fertilizer containing phosphorus should not be used as sidedresses since the late-applied phosphorus is not necessary for the crop and the cost of the fertilizer is more than a conventional sidedress products.

The practice of blending a complete fertilizer (NPK) with a sidedress fertilizer and working a single application is discouraged. Blending two dissimilar fertilizer products can result in a lack of uniformity. Furthermore, a single early application of fertilizer subjects all to potentially leaching rains and makes any necessary adjustment more difficult. Split application of a complete fertilizer and a sidedress provides the nutrients to the cop when they are needed and the grower has greater control over the availability.

Growers are strongly encouraged to soil test fields before tobacco is planted in the rotation, follow liming recommendations, and select a complete fertilizer grade based on phosphorus soil-test levels. Doing so will ensure optimum fertilizer efficiency, avoid unnecessary fertilizer expense, and reduce excessive phosphorus application that can have a negative environmental impact.

Sidedress Fertilizer Evaluation

Growers have lost two popular sidedress fertilizer products in recent years, mainly 16 N nitrate of soda and 15-0-14. Tests were conducted in 2006 to investigate available sidedresses. Data from the test conducted at the Southern Piedmont AREC are reported in Table 5.

The soil test for potash for the test site indicated that no additional potash was necessary with sidedress application. All sidedress treatments were applied at the rate to provide and additional 28 lbs/A of N. Final rates of potash varied according to the sidedress materials, as well as calcium and magnesium. K-Mag was applied at x lbs/A to supply 28 lbs/A of potash, comparable to treatment applied with the 14-0-14 treatment.

Table 5. Agronomic results of a sidedress fertilizer comparison conducted at the Southern Piedmont AREC in 2006.

Sidedresses	Yield (lbs/A)	Grade Index	Price ($/lb)
13-0-14	3892	87.3	1.47
14-0-14	3736	86.0	1.46
15-0-14	3614	85.0	1.43
15.5-0-0	3408	86.7	1.45
CN-9	3213	88.0	1.47
UAN-30	3872	85.3	1.44
CN-9 plus K-Mag	3459	87.0	1.47
UAN plus K-Mag	3552	88.0	1.48

Complete fertilizer was band after transplanting at a rate of 750 lbs/A to supply 45 lbs/A N and 135 lbs/A of potash.

Yield results were variable, possibly due to excessive rainfall that occurred and no significant differences were observed between the treatments. Average price and grade index were more consistent and do not show any practical difference among the treatments. Results of these show the sidedress treatments to be equal and the decision to choose between them should be based on cost, ease of application, and past experience.

Transplant Starter Solutions

The benefit of a high-phosphorus starter fertilizer in the transplant setter water results from the ready availability of P at the stage in crop development when P may be most limiting. Transplant starter fertilizers should contain a greater proportion of P_2O_5 than N and potash (i.e. 10-52-8, 9-45-16, 12-48-8, etc.) and research has shown a rate of 5 lbs/A ofP_2O_5 to be sufficient and not expected to result in crop injury. The use of high P transplant starter fertilizer can be expected to provide more rapid and more even early season growth that ultimately results in earlier more uniform topping. However, these effects do not persist through harvest and no yield response should be expected. The results of a comparison of transplant starter fertilizers are described in tables below. The test evaluated starter fertilizers using both plant-bed and greenhouse-grown transplants. Treatments tested included:

Trt. No.	Product	Analysis	Application rate
1	Untreated	--	--
2	Exceed	10-10-10	2 qts/A
3	Jump-Start	8-31-4	2 qts/A
4	Charge	8-32-5	2 qts/A
5	Pro-Sol	10-52-8	10 lbs/A
6	Miller	12-48-8	10 lbs/A

The products tested differ in analysis (N:P:K) and no attempt was made to apply similar nutrient levels with each product. Products were applied at suggested rates; and therefore, nutrient levels are not equal among the treatments.

Measurement of plants in the field indicated that Treatments 3 to 6 (high P) resulted in more rapid early-season growth than observed with the low P fertilizer (Treatment 2) or untreated plants (Treatment 1). As plants neared topping stage, differences between the treatments tended to diminish. However, plants in Treatments 3 to 6 did come into top earlier than those in Treatments 1 and 2. There was no apparent difference in the response of plant-bed and greenhouse-grown transplants to the fertilizers. Such early-season growth responses did not result in any significant difference in the yield of the treatments for both plant-bed and greenhouse transplants (see Table 6).

Table 6. Topping and yield data for six transplant water treatments applied to plant-bed and greenhouse-float transplants, Southern Piedmont AREC, 1993.

Starter fertilizer	Percent of plants topped by July 19		Yield (lbs/A)	
	GH	PB	GH	PB
Untreated	33	30	3456	3471
Exceed	23	30	3365	3400
Jump-Start	69	88	3094	3424
Charge	59	64	3440	3525
Pro-Sol	81	88	3122	3399
Miller	86	59	3169	3356

GH = greenhouse
PB = plant bed grown transplants

Crop Rotations and Cover Crops

Crop rotation is one of the most effective and inexpensive methods known to increase the efficiency of flue-cured tobacco production. Crop rotation improves soil structure and nutrient balance, increasing the efficiency with which tobacco plants can utilize fertilizer and soil water. Continuous tobacco culture, even in the best of fields, promotes soil erosion and loss of soil structure, which will eventually reduce the capacity of plants in such fields to obtain enough plant food and water for maximum production. In addition, crop rotation is an excellent practice for control of tobacco diseases, insects, and weeds. Not only does crop rotation reduce losses in yield and quality to these pests, but it also reduces the need for expensive pesticides, thus reducing production costs. Crop rotation can, therefore, increase net economic returns to producers by increasing the yield and quality from each field **and** by reducing the costs of producing flue-cured tobacco.

Special attention should be given to the crop immediately preceding tobacco in the rotation. For example, leguminous crops should not immediately precede flue-cured tobacco because the amount of nitrogen from the crop and the time of its availability varies widely and the following tobacco crop may be affected.

The conservation compliance provision of the Food Security Act of 1985 discourages production of crops in highly erodible fields where the land is not carefully protected from erosion. If crops are produced in such fields without an approved soil conservation system, producers may lose their eligibility for certain U.S. Department of Agriculture program benefits. Contact your local Natural Resources Conservation Service (NRCS) office for more information or for soil conservation planning assistance.

Some examples of rotation plans commonly used in the flue-cured tobacco producing area of Virginia include:

- **1-year rotation**
  tobacco followed by small-grain or ryegrass cover crop

- **2-year rotation**
  1st year - tobacco followed by small grain and fescue or ryegrass
  2nd year - grass

- **2-year rotation**
  1st year - tobacco followed by small grain

2nd year - small grain cut for silage and followed by grain sorghum followed by a winter cover crop

- **3-year rotation**

  1st year - tobacco followed by small grain and fescue

  2nd year - grass

  3rd year - grass.

Seed beds for cover crops should be medium smooth, but not level. Small grains, or a combination of small grains and a grass, should be seeded as soon as possible after the second disking of tobacco roots. Early seeding of the cover crop is important to allow the cover crop to grow as much as possible during the fall. The soil surface should allow a maximum number of tobacco roots to remain exposed, even after seeding the cover crop. Crops and seeding rates for common cover crops are: RYE or WHEAT - 1 to 1 1/2 bu/A; BARLEY - 2 to 3 bu/A; DOMESTIC RYEGRASS - 20 to 25 lb/A.; TALL FESCUE - 15 to 20 lb/A.; SORGHUM-SUDAN HYBRID - 25 to 30 lb/A; GRAIN SORGHUM - 5 to 7 lb/A. When seeding with small grains, the seeding rate for ryegrass and fescue should be reduced to 15 lb/A.

Cover crops should be plowed under while still young and succulent, generally from mid- to late-March. Temporary nitrogen deficiency, as well as other problems, may be encountered if cover crops are plowed under late in the spring after the plants within the cover crop have become tall and woody. If the sod of the cover crop is dense, it may be necessary to disk thoroughly in order to tear up the sod prior to plowing.

Sucker Control

Topping

Tobacco should be topped when 40 to 50 percent of the plants reach the elongated button stage of flowering. Remaining plants should be topped as early as practical after they reach the button stage. Allowing tobacco to remain untopped for up to three weeks after reaching the button stage will reduce yields 20 to 25 lbs/A per day. Late topping also increases the chance of plants blowing over in a windstorm.

The height at which to top the plants will depend primarily on seasonal conditions, variety, and, to some extent, on the fertility level of the soil. Optimum leaf number is generally in the range of 18 to 22 leaves per plant.

Chemical Sucker Control

Three types of chemicals are currently available for sucker control. Growers should have a basic understanding of how the various chemicals work in order to most effectively use them.

1. **Contacts** (fatty alcohols) quickly kill suckers by burning and must come in contact with the suckers to be effective. Suckers should begin to turn brown within an hour of contact application. A sufficiently concentrated solution of contact material is required to obtain adequate sucker control. Use a 4 percent solution or 2 gallons in 48 gallons of water.

   The strength of a contact fatty alcohol product depends on carbon chain length of the fatty alcohols. Products traditionally used in Virginia are a mixture of C_6, C_8, C_{10}, and C_{12} alcohols while products containing only C_{10} alcohols are available. To avoid possible injury, C_{10} products should be used at lower concentrations than mixed alcohol products (3 percent and 4 percent concentration of a C_{10} product would be comparable to 4 percent and 5 percent concentration of a mixed alcohol product, respectively).

2. **Systemic sucker control chemicals** or maleic hydrazide (MH) restrict sucker growth physiologically by stopping cell division. The only growth made after MH is applied is in the expansion of cells already present in the plant. To reduce MH residues on the cured tobacco, **no more than one application of the labeled rate of MH may be applied per season**. **Wait at least one week between MH application and harvest**.

3. Products that have a **local systemic** mode of action (Flupro and Prime+) stop cell division in a localized area and must wet the sucker buds in each leaf axial to be effective. The materials have no true contact activity and do not turn the sucker black. Affected suckers will have a yellow, deformed appearance.

Precautions with contacts:

1. Control is achieved when suckers are small (not over one inch long).

2. Never spray foam from tank; this will increase the likelihood of burning leaves.

3. Do not spray extremely succulent tobacco (tobacco with a light green to creamy white bud area). This indicates a fast rate of growth.

4. Rain within an hour after application of contacts may reduce their effectiveness.

5. In order to kill both primary and secondary suckers, contact solutions should not be applied at concentrations less than 4 percent. It may be necessary to increase the concentration to 5 percent when applications are made under cool overcast weather conditions.

Precautions with local systemics:

1. Rain occurring within two hours after spraying may reduce effectiveness.

2. Applications to leaning plants, wet plants, or wilted plants may reduce effectiveness.

3. Applications made before the elongated button stage of growth may result in chemical topping or distortion of leaves that were too immature at time of application.

4. Sucker buds must be directly contacted to obtain control. Control is reduced if suckers are allowed to grow too large (greater than 1 in.) before application.

5. Prime+ carryover residues may injure small grains and corn, and has been reported to stunt early-season growth of tobacco when used with dinitroaniline herbicides such as Prowl. Fall disking and deep tillage are suggested to mitigate this potential.

Precautions with systemics:

1. Do not apply during the hot part of the day when leaf stomata are closed.

2. Rain within six hours after application of MH may reduce control. Research has shown that if a significant rain occurs more than three hours after application, only a half rate of MH (0.75 gal/A) should be reapplied to maintain good sucker control.

EPA Worker Protection Standards

Read and follow all label directions regarding EPA Worker Protection Standards (WPS). Growers must follow requirements for personal protective equipment (PPE) and restricted-entry intervals (REI). Hand topping following an over-the-top contact application provides the best level of sucker control since the top serves to funnel the material down the stalk to contact each leaf axil. However, hand topping within the restricted-entry interval means that workers must wear all required PPE to comply with WPS. Likewise, hand application of sucker control chemicals and topping are impacted by the PPE requirements. Growers are also responsible for instructing early-entry workers on how to prevent, recognize, and give correct first aid for heat illness (too much heat stress).

MH Residues

Virginia's flue-cured tobacco has traditionally had some of the lowest MH residue levels in the United States and this has been a factor contributing to the traditional quality of the crop. Much of the low-residue nature of the crop has been a consequence of having a significant portion of the acreage treated by hand with Prime+ and similar products. In many cases, this tobacco is not treated with any MH or may be treated with a reduced rate of MH. For tobacco that is treated with MH in a more typical fashion (over-the-top sprays of two contact fatty alcohols followed by MH), there has generally not been a high proportion of samples with excessive residue levels. However, there is always the occurrence of some samples with excessive residues. There are several factors that impact MH residues: the rate, number, and timing of MH applications as well as weather and crop conditions. Leaf dealers and cigarette manufacturers remain concerned with MH residues and this is heightened with international markets. A contract marketing system lends itself to more rigorous sampling programs and traceability of the tobacco sold.

The high cost of labor and issues related to worker exposure to pesticides make the practice of hand application of sucker control problematic and growers should examine the practice given their specific circumstances. Unfortunately at the present time, the only alternative to hand application are the sequential sucker control programs with over-the-top foliar sprays of contact fatty alcohols followed by MH. However, growers must remain vigilant in minimizing MH residues in the cured tobacco.

Guidelines for Effective Sucker Control Practices to Minimize MH Residues

1. Make only one application of the labeled rate of MH-30 (2.25 lbs ai/A). Do not make split

applications of MH even at reduced rates since the second application will likely increase residues present in later harvests.

2. Observe the preharvest interval (seven days) following MH application.

3. Consider the addition of a dinitroaniline product such as Prime+ or Flupro to the typical sequential sucker control program. These products may be tank mixed with or substituted for the last contact fatty alcohol before MH, or tank mixed with MH, or applied alone after MH (usually three to four weeks later). The rate of either Prime+ or Flupro would be 1 to 2 qt/A. The 2-qt rate has been the most thoroughly tested and has been very effective will applied as describe above.

4. Maximize the effectiveness of contact fatty alcohols by limiting excessive growth prior to their application. It is important to make the first application before pretopping suckers have grown significantly (not more that 1 in. long). Large pretopping sucker may require hand clean-up. The first application of a C8 / C10 fatty alcohol mixture should be made at a 4 percent concentration (4 gallons fatty alcohol to 96 gallons of spray material water) and later applications should be made at 5 percent (5 gallons per 95 gallons).

5. The use of coarse spray tips (TG3-TG5-TG3) and low pressure for MH applications result in coarser droplets that result in less wetting of the underside of the leaves and thus MH is not as readily dissipated by rainfall and dews.

6. Don't add spray surfactants to MH applications. Product labels for MH do not state either their usefulness or necessity. The wide variety of surfactants available has not been sufficiently tested with MH to be able to predict the response in MH residue levels. A potentially positive response in rainfastness could be offset by excessive MH in the cured leaf.

Suggested Sucker Control Programs

Program I. Sequential Method

1. Apply contact sucker control chemical (4-percent concentration) before topping when approximately 50 percent to 60 percent of plants reach the button stage. A small percentage of plants should be chemically topped by this application.

2. A second contact application (5-percent concentration) should be made three to five days after the first. Fields having irregular growth may require an additional application (5-percent concentration) five to seven days later. Top remaining plants that were not topped originally.

3. About five to seven days after the last contact, apply one of the following alternatives:

   a) MH (**only one application per season**); or

   b) FST-7, Leven-38 or a contact and MH tank mix; or

   c) tank mix of MH with Flupro or Prime+

   d) apply Flupro or Prime+ (1 gal/A)

4. Prime+ may be substituted for the second contact application (or third, if field has irregular growth) and followed with a labeled rate of MH about 1 week later.

5. If control of late season sucker growth is necessary, one of the following alternatives may be applied three to four weeks after MH application:

   a) Flupro or Prime+; or

   b) 5-percent concentration of contact material

Program II. Individual Plant Method with a Dinitroaniline

Apply Flupro or Prime+ with a dropline, backpack, or jug when plants reach the elongated bud stage. Usually two or perhaps three trips are required to remove tops and treat all plants in a field. Individual plants should not be treated more than once. **Growers are reminded to comply with all label directions regarding worker protection standards (WPS).**

Sucker control in Virginia is highly dependent upon the hand application of local systemic chemicals such as Prime+ or Flupro. The reliance on the hand application of these chemicals to individual plants has been considered necessary due to the rolling landscape in Southside Virginia and the layout of fields to fit the landscape. Whether applied with jugs or with droplines, hand application of sucker control chemicals is problematic in regard to worker exposure to pesticides and issues related to worker protection standards (WPS). Complying with PPE requirements for WPS is challenging for the hand application of sucker control chemicals.

For the past several years, on-farm trials have been conducted to evaluate tractor-spray applications of sucker control and compare these to hand-applied treatments. These results have been reported annually in this production guide and have demonstrated the potential of over-the-top application for sucker control in Virginia. With proper planning and application technique, over-the-top sucker control programs can be used by the large majority of tobacco growers in Virginia, thus eliminating the necessity of hand application.

In order for over-the-top sucker control applications to be effective, the chemicals must be applied correctly. Contact fatty alcohols and local systemics must contact the growing sucker bud at every leaf position on the stalk. Therefore spray nozzles must be directly over the tobacco plants, making uniform row spacing throughout the entire field extremely important. Spray rows must be kept in good condition to allow for uniform travel speed and to minimize rough conditions that will cause excessive bouncing of the spray boom.

Historically, three hollow-cone nozzles arranged with a TG-5 in the center and a TG-3 on either side have been used for contact sucker control applications. With a spray pressure of 20 psi, a desired application rate of 50 gpa is obtained with a travel speed of approximately 3.8 mph. This speed is too fast for many field conditions in Virginia thus impacting the level of sucker control obtained. Using smaller spray tips, the desired application rate can be obtained at a reduced travel speed. Doing so will improve sucker control by allowing the spray operator to deliver the spray material to every plant and hopefully contacting every leaf axil. The following table gives the spray application rate (gpa) obtained from five different spray tip arrangements across a wide range in travel speeds. An application rate of 50 gal/A is optimal, higher rates will increase contact fatty alcohol usage and lower rates will reduce spray effectiveness (maintain at least 45 gal/A).

Sucker Control Spray Tip Options

Table. 7. Spray application rate with four different spray-tip arrangements over a range in travel speeds, calculated based on 48-in. row spacing and 20 psi spray pressure.

	Spray tip arrangement (3 tips per row)			
Speed (mph)	**TG-3 (2) TG-5**	**TG-3 (2) TG-4**	**TG-2 (2) TG-4**	**TG-2 (2) TG-3**
	gallons per acre			
2.0	93.4	84.8	68.7	60.0
2.2	84.9	77.1	62.4	54.6
2.4	77.9	70.6	57.2	**50.0**
2.6	71.9	65.2	**52.8**	46.2
2.8	66.7	60.5	**49.1**	42.9
3.0	62.3	56.5	45.8	40.0
3.2	58.4	**53.0**	42.9	37.5
3.4	55.0	**49.9**	40.4	35.3
3.6	**51.9**	47.1	38.2	33.3
3.8	**49.2**	44.6	36.1	31.6
4.0	46.7	42.4	34.3	30.0
4.2	44.5	40.4	32.7	28.6
4.4	42.5	38.5	31.2	27.3
4.6	40.6	36.9	29.9	26.1
4.8	38.9	35.3	28.6	25.0
5.0	37.4	33.9	27.5	24.0

Calibration of a sprayer using the 1/128th acre method is relatively easy. Using this method for a row spacing of 48 inches, the travel time with a tractor in the field is recorded for a distance of 85 feet. Collect water from the spray tips at operating pressure for the length of travel time (85 feet. The amount of water collected from all three nozzles of one row is equal to the spray application rate in gallons per acre (gal/A). The travel time for the 85-foot calibration distance increases from 16 seconds for 3.6 mph to 22 seconds for 2.6 mph. Detailed information on using the 1/128th acre method of calibration and determining travel speeds is available from your local Extension agent.

On-Farm Sucker Control Tests

Each year a number of sucker control tests are conducted on-farm across the flue-cured tobacco production area of Virginia. The objective of these on-farm tests is to demonstrate the feasibility of using tractor-mounted sprayers to apply sucker control chemicals, thus eliminating the expense of hand-application methods and reducing worker exposure to pesticides. These tests are conducted in typical grower fields and applications are made to three or four rows, depending on field arrangement. In 2004, all applications are made at a spray volume of 50 gal/A, using three nozzles per row of 2 TG-2 with a TG-4 in the center at a pressure of 20 psi. Tractor speed was approximately 2.8 mph. Sucker control is evaluated by counting the number and weight of suckers per 100 plants in each plot and determining the percentage of plants with no suckers (clean plants). Results of the tests illustrate the benefit of adding dinitroaniline such as FluPro in combination with MH. Sucker control was significantly improved with treatments 2 and 3 compared to 1. The dinitroaniline may also be substituted for the second contact application (treatments 4 and 5). A MH-free alternative was included as treatment 6 with the application of FluPro at the normal timing of MH application. Although the results in 2004 with treatment 6 were acceptable, results with such MH-free treatments are very dependent upon the season and the spray application conditions. Previous research has shown that FluPro and Prime+ are interchangeable as dinitroaniline products.

A test conducted in 2005 looked at the addition of Prime+ to malaic hydrazide or MH treatments and compared these to a dropline application of Prime+. Royal MH-30 was compared with FST-7 which is a mixture of MH contact fatty alcohol. All of the treatments except the Prime+ dropline application (treatment 7.) followed two applications of contact fatty alcohols of 4 percent and 5 percent. Results indicate that the addition of Prime+ (treatments 2, 3, and 5) improved sucker control compared to no Prime+ (treatments 1 and 4). The level of control obtained with the Prime+ dropline application (treatment 7) was not as good as it should have been due to a failure to ensure application to the uppermost leaf axils. Suckers that were not controlled by the chemical treatments were not cleaned-up but remained in the field until harvest completion.

Table 8. Average results of three on-farm sucker control tests conducted in Virginia in 2004.

	Sucker Control Treatment[2]			Sucker control at end of season[1]		
				Suckers per 100 plants		Clean plants
Trt no.	at topping	3 to 5 days later	1 week later	no.	wt. (lbs)	(%)
1	FA 4%	FA 5%	RMH-30 1.5 gal/A	90.7 b	33.8 a	52.0 b
2	FA 4%	FA 5%	RMH-30 1.5 gal and FluPro 2 qt/A	48.7 a	13.5 b	84.0 a
3	FA 4%	FA 5%	RMH-30 1.0 gal and FluPro 2 qt/A	47.3 a	14.2 a	85.3 a
4	FA 4%	FluPro 2 qt/A	RMH-30 1.0 gal	63.3 a	5.4 b	86.0 a
5	FA 4%	FluPro 2 qt/A	RMH-30 1.5 gal	52.0 a	21.6 ab	84.0 a
6	FA 4%	FA 5%	FluPro 3 qt/A	54.7 a	15.2 ab	82.0 a

[1]Means followed by the same letter are not significantly different.

[2]FA = contact fatty alcohol (Off-Shoot T was used in these particular tests both other products could be substituted with similar results)

Table 9. Results of chemical sucker control test conducted in Henry County in 2005.

Trt. No.	Systemic Sucker Control Application Following Contacts	Suckers per 100 plants	
		no.	wt. (lbs)
1	RMH-30 1.5 gal	39	7.0
2	MH-30 1.5 gal with Prime+ 2 qt 4 weeks later	4	0.3
3	RMH-30 1.5 & Prime+ 2 as a tank mix	4	1.5
4	FST-7 3 gal	50	11.9
5	FST-3 3 gal & Prime+ 2 qt tank mix	10	3.3
6	Hand application (droplines) Prime+ 2%	26	9.6

Results from a sucker control test conducted at the Southern Piedmont AREC in 2007 are presented in Table 10. This set of treatments is a part of a larger test conducted to evaluate reduced MH and MH-free treatments. Results are expressed in terms of percent sucker control which is calculated based on the weight of sucker compared to a treatment receiving no chemical sucker control (topped-not-suckered). All treatments were applied using two TG-3 tips and one TG-5 over the center of the row, except treatments 5 and 8. These treatments were applied with two TG-2 tips and a TG-6 to direct a greater proportion of the spray material directly over the plant stalk (60 percent compared to the typical 47 percent with the TG-3's and 5). Travel speed was reduced slightly to provide for the same application rate (50 gpa) with the two spray tip arrangements. The two treatments with 1.5 gallons of MH-30 (2.25 lbs ai/A) provided the poorest sucker control at approximately 30 percent. The tank mix of 1.5 gallons MH-30 and 2 qt/A of the dinitroaniline, Flupro, significantly improved sucker control to greater than 90 percent. Similar levels of control were obtained from treatments with reduced rates of MH in combination with Flupro (treatments 1 and 4). Omitting MH entirely and applying 2 qt/A of Flupro (treatments 5 and 6) did not provide satisfactory control when applied once, but when split in two applications of 1 qt each (treatment 2) did provide excellent control. The third and fourth spray applications in this test were separated by 18 days with the first harvest occurring during this time. No differences were observed among treatments comparing applications using TG-3s and a 5 with TG-2s and a 6. Results of the tests reinforce the fact that the tank mix of 1.5 gallons MH-30 with 2 quarts of a dinitroaniline is the standard for sequential sucker control. The results also show promise with regard to the possibility of reducing the rate of MH when used in conjunction with a dinitroaniline (treatments 1 and 4). These and similar reduced MH or MH-free treatments need to be evaluated further under a wider range of conditions to ensure their reliability. Reducing or eliminating the systemic control obtained from MH will require greater management to ensure satisfactory results from dinitroanilines. The proper application technique and timing will be critically important to minimize the growth of escape suckers that can occur.

Table 10. Reduced MH and MH free sucker control test conducted at the Southern Piedmont AREC, Blackstone, 2007.

Trt. No.	Application				Percent Sucker Control[1]
	1st	2nd	3rd	4th	
1	FA[2] 4%	FA 5%	Flupro1 qt	MH-30 & Flupro 3 qt and 1 qt	97.9 a
2	FA 4%	FA 5%	Flupro 1 qt	Flupro 1 qt	96.6 a
3	FA 4%	FA 5%	MH-30 & Flupro 1.5 gal and 2 qt		91.5 a
4	FA 4%	FA 5%	Flupro 2 qt	MH-30 1 gal	90.0 a
5	FA 4%	FA 5%	Flupro 2 qt	*(**2 TG-2 and 1 TG-6**)*	69.4 b
6	FA 4%	FA 5%	Flupro 2 qt		66.9 b
7	FA 4%	FA 5%	MH-30 1.5 gal	*(**2 TG-2 and 1 TG-6**)*	32.1 c
8	FA 4%	FA 5%	MH-30 1.5 gal		28.0 c

[1]Percent sucker control values followed by the same letter are not significantly different.

[2]FA= contact fatty alcohol (Sucker Plucker was used in this test but other products could be substituted with similar results).

Suggestions for application of sucker control materials

Product Type	When to Apply	Application Rate
Contacts (fatty alcohols)	1. 1st appl. at 50% elongated button 2. 2nd appl. 3 to 5 days after 1st appl. 3. Late season application 3 to 4 weeks after MH, if needed	1st application as a 4% solution or 2 gal in 48 gal of water 2nd application as a 5% solution or 2.5 gal in 47.5 gal of water C_{10} products are applied at 3 and 4% for the 1st and 2nd applications, respectively
Application Procedure **Power Spray** 20 psi using 3 solid cone nozzles per row (i.e. 1 TG-5 and 2 TG-3s) Apply 50 gal of spray material per acre **Hand Application** 20 psi max. and ½ to $^2/_3$ fl oz per plant		
Local systemics (Flupro and Prime+)	1. Individual plants at elongated button stage (dropline or jug application) 2. 5 days after 1st contact application 3. Late season application 3 to 4 weeks after MH ,if needed	**Power Spray** 2 qt/A of Flupro or Prime+ Apply 50 gal of spray material per acre. **Hand Application** 2% solution or 1 gal in 49 gal of water (2.5 fl oz of Flupro or Prime+ per gal of water). Do not apply more than 30 gal of spray per acre
Application Procedure **Power Spray** 15 - 20 psi using 3 solid cone nozzles per row (i.e. 1 TG-5 and 2 TG-3s) **Hand Application** Coarse spray (20 psi and TG-3 or 5 nozzle) or drench using jugs and apply ½ to $^2/_3$ fl oz per plant depending on height		
Systemics (MH)	When used as part of sequential control program - apply 1 week after 2nd contact application.	2.25 to 3.0 lb of MH (1.5 to 2 gal of 1.5 lb/gal product) (1 to 1.33 gal of 2.25 lb/gal product) Apply 40 to 50 gal of spray material per acre.
Application Procedure Apply as a coarse spray using 3 solid cone nozzles (i.e. TG-5 and 2 TG-3s) and 20 to 25 psi or as a fine spray using 3 hollow cone nozzles per row (i.e. 2 TX-26 and 2 TX-18) and 40 to 60 psi. Direct spray toward upper third of the plant.		
Tank mix of MH with Flupro or Prime+	When used as part of sequential control program - apply 1 week after 2nd contact application.	2.25 to 3.0 lb MH with 2 qt/A of Flupro or Prime+ Apply 50 gal of spray material per acre.
Application Procedure Apply as coarse spray using 3 solid cone nozzles (i.e. TG-5 and 2 TG-3's) and 20-25 psi.		

Chemical Coloring Agents

Ethy-gen, Livingston Tobacco Curing Gas, and ethephon are products reputed to aid in "coloring" tobacco and reduce the yellowing time during curing. Growers should not expect these products to solve problems such as ripening late maturing tobacco that is over-fertilized.

Ethy-gen and Livingston Tobacco Curing Gas are released in the barn during the yellowing stage of the cure. Ethephon is the only approved chemical to use for coloring tobacco in the field. The yellowing obtained from an ethephon application is influenced by weather conditions. Experience has shown that cool, cloudy conditions slow the yellowing rate and coloring may not be uniform. If a producer decides to use ethephon, a few representative test plants should be sprayed and observed for two to four days to determine if desired yellowing can be achieved. If the test plants fail to yellow as desired, further maturing may be needed before the crop should be sprayed. Only *physiologically mature* leaves remaining on the plant after the second or third priming should be treated. Ethrel (2 lbs/gal) was the original ethephon product labeled as a yellowing agent for tobacco and was followed by Prep and Marture XL (6 lbs/gal). Additional generic products have been labeled in recent years. **The use of other chemicals for this purpose is illegal and could result in severe penalty for the grower.**

Growers should follow manufacturer's suggestions on proper use of these materials.

Guidelines for the use of Ethephon (6 lbs/gal. products)*

Application method	Rate pts/A	Spray volume	Application directions
Directed spray	1 1/3	50 to 60 gal/A	Apply with drop nozzles to direct spray to leaves to be harvested. Use coarse spray tips at 35 to 40 psi.
Over-the-top	1 1/3 to 2 2/3	40 to 60 gal/A	Apply as a fine spray using three spray tips over each row to cover all leaves thoroughly. Use a spray pressure of 40 to 60 psi.

*Read and follow all label directions regarding use rates, application procedures, and worker protection standards (WPS). Growers must comply with label requirements regarding worker notification, restricted-entry interval (REI), and personal protective equipment (PPE)