AGRONOMIC INFORMATION

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VARIETY SELECTION

Variety selection is an important decision for profitable production of flue-cured tobacco. Producing the highest possible yield of high quality, marketable tobacco is essential to profitability. However, many factors play a role in a grower obtaining the full potential of a variety. Foremost among these is a knowledge of the field history of each farm and selecting a variety or multiple varieties having the necessary disease resistance characteristics. When plant losses occur, it is important to confirm the actual cause in order to properly address the problem in later seasons. Additionally, the ease of curing and characteristics of the cured leaf are important considerations. Varieties differ in cured leaf color and other physical characteristics desired by purchasers (color, body, proportion of tip leaves, etc.), but these factors are also influenced by growing conditions and curing practices as well. In most cases, growers will need to choose more than one variety to grow to maximize their yield and address the requirements of individual field histories. Growers should carefully consider any dramatic change in varieties grown without first trying a new variety on a limited basis on their farm to get an idea on how the variety will perform under their management practices.

Tobacco breeders continue to make progress in developing new varieties with improved resistance to the diseases that can cause yield loss in flue-cured tobacco. Detailed information on the disease resistance of flue-cured tobacco varieties is presented in the disease section of this production 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. The past three years have seen an increased incidence of Fusarium wilt (soil-borne fungus) in Virginia, and we have little varietal resistance among our current varieties to address this disease. If past performance of a disease resistant variety has been less than anticipated, growers are encouraged to contact their local agriculture extension agent to investigate possible explanations and evaluate options. Proper identification of disease losses is essential to making the proper variety decision for the following season.

Our official flue-cured tobacco variety conducted annually includes nearly three dozen commercially available varieties and usually an additional 15 to 20 entries comprised of experimental lines or prospective varieties. Virginia growers may collectivity grow as many as 20 varieties; but more than threequarters of the total acreage is made-up of only 3 or 4 varieties each year (NC 196, K 326, and CC 143 in recent years). Other popular varieties would include PVH 1920, PVH 2254, PVH 2310, CC 37, GL 365, GL 26H, and NC 1226. NC 960 was commercially released for the 2024 season and was widely grown on a significant number of acres with very good results.

Results from the 2024 Flue-Cured Tobacco Official Variety Trial conducted at the Southern Piedmont Center near Blackstone, Virginia are shown in Table 1. Data are shown for yield, grade index, and relative yield. Grade index is a numerical measure of tobacco quality that allows for comparisons between varieties. Relative yield is calculated based on the overall average yield of all varieties in the test. A relative yield of 100 indicates a yield approximate to the overall average of the test while values of 104 or 96 indicate that the yield of a particular variety was 4 percent above or below the test average, respectively. The variety tests at Blackstone in 2024 produced typical yield results and the overall quality was reasonable as tobacco from all varieties was cured collectively as one. The crop experienced varied growing conditions over the season. Following excessive rainfall in May, dry conditions existed throughout the month of June and into early July. Storms brought rain in the latter portion of July and dry conditions returned again in late August into September. Fortunately, the crop did not experience any significant plant lodging that occurred elsewhere. The test site is free of soil-borne diseases and nematodes and a preventative fungicide was applied in the transplant setter water; thus, the data reflect the yield potential of the varieties in the absence of any disease losses. One preventative foliar fungicide spray was applied and the tobacco had minimal leaf spot disease incidence.

Relative yield data from the Flue-Cured Official Variety Trial for the past three seasons are presented in Table 2. The small number in parenthesis indicates the ranking of a specific variety among all the varieties for each season. The test conducted at the Southern Piedmont Center is generally indicative of the yield potential of the different varieties grown under an irrigated, disease-free situation. A variety with a relative yield consistently above 100 should be considered as having an above average yield potential.

Our one new variety for release in 2025 is NC 987. This new hybrid was developed by Dr. Ramsey Lewis in the tobacco breeding program at North Carolina State University. NC 987 has consistently exhibited yields above the test average in our OVT trials with good, cured leaf quality. The variety is considered to have moderate resistance to black shank but minimal bacterial wilt resistance.

NC 960 was released commercially for the 2024 season as a high yielding variety having a superior level of black shank resistance. One important note on NC 960 is the late flowering nature of the variety and the potential to produce more than optimal leaf number before flowering. Growers of NC

960 need to be mindful of this and top when desired number of leaves is produced. Doing so will improve the standability of the variety in the event of severe wind. Growers are encouraged to consider new varieties that may address needs (disease resistance, cured leaf characteristics, and yield) in their production. However, any new variety should initially be tried on a limited acreage to evaluate the variety under their specific conditions and management.

All varieties made available for sale to growers have been approved by the Minimum Standards Program conducted by the Regional Flue-Cured Tobacco Variety Evaluation Committee. This program is conducted to ensure that new varieties meet necessary chemical and physical characteristics as well as the smoking properties of the cured leaf. Growers are encouraged to visit varieties trials conducted each year both at the Southern Piedmont Center and on-farm with cooperating growers to view potential new varieties for their farm. Limited data are available regarding agronomic traits, disease resistance, handling, and curing traits under a wide range of geographic conditions. Such information continues to be collected once a variety is made commercially available.

Table 1. Agronomic results from the 2024 Official Variety Trial conducted at Southern Piedmont Center - Blackstone, VA. New varieties are in bold.

Variety	Yield (lbs./ac)	Relative Yield	Grade Index
NC 960	3800	112	81.0
PVH 2254	3753	111	77.3
NC 196	3723	110	85.0
PVH 1920	3664	108	86.3
CC 143	3657	108	80.0
K 326	3656	108	84.7
NC 71	3613	107	75.0
NC 291	3572	106	78.7
PVH 2343	3526	104	80.3
NC 987	**3503**	**104**	**78.7**
CC 145	3463	103	72.0
CC 1063	3452	102	78.3
CC 13	3450	102	79.7
PVH 1600	3408	101	80.3
CC 35	3401	101	64.0
GL 365	3400	101	79.0
GL 386	3388	100	76.0
GL 26H	3379	100	72.7
CC 37	3370	100	70.3
CC 27	3328	99	76.3
NC 1226	3326	98	65.3
NC 72	3290	97	71.7
PVH 2310	3265	97	83.7
NC 299	3228	96	81.0
NC 925	3222	95	71.0
GF 318	3210	95	81.3
CC 67	3178	94	77.3
GL 395	3174	94	71.3
K 730	3118	92	69.0
K 346	3034	90	81.7
CC 700	3017	89	78.0
PVH 1940	2968	88	73.3
NC 606	2944	87	85.3
Test Average	**3378**		**77.1**

Table 2. Relative yields for Flue-Cured Tobacco Official Variety Trials conducted at the Southern Piedmont Center near Blackstone, Virginia for 2022 - 2024.

	Relative Yield and Ranking within Year						3-yr Avg
Variety	2024		2023		2022		Rel. Yield
NC 960	112	*1*	113	*3*	106	*6*	110
PVH 2254	111	*2*	107	*5*	104	*7*	108
NC 196	110	*3*	97	*23*	108	*4*	105
PVH 1920	108	*4*	103	*12*	98	*24*	103
CC 143	108	*4*	102	*15*	99	*16*	103
K 326	108	*4*	107	*5*	112	*1*	109
NC 71	107	*7*	114	*1*	107	*5*	109
NC 291	106	*8*	102	*15*	102	*10*	103
PVH 2343	104	*9*	104	*10*	100	*15*	103
NC 987	104	*9*	114	*1*	101	*10*	106
CC 145	103	*11*	90	*31*	103	*8*	99
CC 1063	102	*12*	99	*21*	98	*23*	100
CC 13	102	*12*	91	*30*	100	*15*	98
PVH 1600	101	*14*	100	*20*	100	*15*	100
CC 35	101	*14*	102	*15*	101	*14*	101
GL 365	101	*14*	105	*8*	112	*1*	106
GL 386	100	*17*	105	*8*	99	*16*	102
GL 26H	100	*17*	104	*10*	110	*3*	105
CC 37	100	*17*	103	*12*	102	*10*	102
CC 27	99	*20*	101	*19*	100	*15*	100
NC 1226	98	*21*	102	*15*	102	*10*	101
NC 72	97	*22*	106	*7*	100	*15*	101
PVH 2310	97	*22*	93	*27*	90	*33*	93
NC 299	96	*24*	109	*4*	94	*29*	99
NC 925	95	*25*	98	*22*			98

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Table 2 continued. Relative yields for Flue-Cured Tobacco Official Variety Trials conducted at the Southern Piedmont Center near Blackstone, Virginia for 2022 - 2024.

	Relative Yield and Ranking within Year						3-yr Avg
Variety	2024		2023		2022		Rel. Yield
GF 318	95	*25*	103	*12*	103	*8*	100
CC 67	94	*27*	95	*26*	94	*29*	94
GL395	94	*27*	93	*27*	100	*15*	96
K 730	92	*29*	96	*25*	97	*25*	95
K 346	90	*30*	85	*32*	84	*34*	86
CC 700	89	*31*	97	*23*	96	*26*	94
PVH 1940	88	*32*	80	*33*			
NC 606	87	*33*	92	*29*	96	*26*	92

GREENHOUSE TRANSPLANT PRODUCTION

The goal of greenhouse tobacco transplant production should be to produce as high a yield of useable transplants as possible. Management practices necessary for successful greenhouse management are outlined later in this chapter. However, over time, some of these practices need to be re-emphasized. These include: (1) conducting a greenhouse water analysis and following the recommendations, (2) select fertilizer to use in the greenhouse based on the water analysis, (3) place closer attention on knowing the actual bay water volumes to more accurately add fertilizer, and (4) add fertilizer in a time manner and monitor bay water volume, and (5) monitor fertilizer concentrations in bays and ensure uniform distribution with bays. Greenhouses should be checked regularly to monitor seedling stand and growth. If potential issues appear, seek assistance as soon as possible to minimize potential plant losses.

Plastic Greenhouse Float Trays

The expanded polystyrene (EPS) float tray has been the foundation of the greenhouse float system that we currently use for tobacco. However, the continued use of EPS trays is a concern to the tobacco industry since EPS is not readily recycled, relatively difficult to dispose of in an environmentally sound manner and represents a potential source of NTRM in cured tobacco. A more practical concern for growers is the cost and effectiveness of EPS tray sanitation. As EPS trays age they become more porous and greater root penetration of the cells occurs. Such adds to the difficulty of removing contamination from the tray and reduces the effectiveness of tray sanitation.

A hard plastic float tray was introduced commercially to the tobacco industry in 2015 and enhancements made the following year to reduce the tray weight. A plastic tray addresses the environmental concerns of EPS trays and provides the grower with a tray that is easier to effectively sanitize and a tray with a substantially longer useful lifespan. The tray is compatible with most existing tray filling and seedling lines. Floatation of the trays comes from air trapped in multiple compartments on the underside of the trays. The trays have a lower floating depth resulting in increased media saturation, though seedling emergence is similar to that with EPS trays.

Greater attention to detail is warranted when clipping. Reel mowers need to be properly adjusted, and blades sharpened to ensure a clean clipping of the plant foliage and avoid grabbing of the seedlings. Clipping height of both reel and rotary mowers should be adjusted to avoid pushing seedlings over with clipping. Excess space in float bays that allow movement of the trays when clipping is detrimental as well.

A trial was conducted in 2017 comparing EPS and the Trilogy plastic trays for initial plant stand (14 days after seeding) and usable transplants. Trays were evaluated with two soilless mixes, Beltwide and Carolina Choice. Additionally, trays were seeded with NC 938 to allow for comparison with two difference seed sources (Cross Creek and Rickard). Overall results showed a similar plant stand between the two trays and only a small difference in the percent usable transplants (89.6 and 87.5 % for EPS and plastic trays, respectively). Looking at the data for the tray types according to mix brand or seed sources illustrates the interaction of multiple factors on overall tray performance.

Table 3. Comparison of plant stand and usable transplants in EPS and Trilogy plastic float trays with two soilless mixes and seed sources.

Tray type	Plant Stand (14-days)	Usable transplants	Seedling mortality	Small seedlings
	-------------------- (%) --------------------			
Beltwide mix and Cross Creek Seed				
EPS	94.6	88.6	2.8	3.2
Plastic	92.6	87.8	2.0	3.2
Beltwide mix and Rickard Seed				
EPS	94.6	91.8	2.0	0.6
Plastic	92.6	84.4	4.8	3.4
Carolina Choice mix and Cross Creek Seed				
EPS	91.0	87.2	1.0	2.8
Plastic	89.6	84.8	1.4	3.4
Carolina Choice mix and Rickard Seed				
EPS	95.2	90.8	2.0	2.8
Plastic	96.6	93.0	1.4	2.2
Rickard Seed averaged over overall mixes				
EPS	92.8	87.9	1.9	3.0
Plastic	91.1	86.3	1.7	3.3
Cross Creek Seed averaged over overall mixes				
EPS	94.8	91.3	2.0	1.7
Plastic	94.6	88.7	3.1	2.8
Beltwide mix averaged over seed sources				
EPS	94.5	90.2	2.4	1.9
Plastic	92.6	86.1	3.4	3.3
Carolina Choice mix averaged over seed sources				
EPS	93.1	89.3	1.5	2.8
Plastic	93.1	88.9	1.4	2.8
Averaged over both mix and seed source				
EPS	93.8	89.6	2.0	2.4
Plastic	92.9	87.5	2.4	3.1

Tobacco growers have become accustomed to greenhouse management and the incidence of significant production problems that result in plant losses is unusual. Common production concerns include soilless mix issues, spiral root seedlings, fertilizer salts injury, algae growth, and various pest occurrence. Greenhouse management practices described in this guide are intended to provide the basics for successful greenhouse production.

The occurrence of spiral root seedlings is always a concern but has generally declined in recent years as seed coatings have evolved to better match the requirements of the tobacco seed and the wetting properties of our commonly used greenhouses mixes. A spiral root seedling may occur when the emerging root tip is damaged and does not function properly to establish a young seedling. The single most important factor that a grower can do to reduce spiral roots is to avoid over packing of the soilless mix into trays. Such over packing will result in excessively wet media in the trays, and this can often impact seedling emergence. In general, spiral root seedlings will be reduced when using an automatic tray filling line with a rolling dibbler. The goal is to fill trays as uniformly as possible. However, under the best of circumstances spiral root seedlings may occur due to seed related factors. Results of a greenhouse test conducted in 2010 to compare the performance of three commercial seed lots of the one variety are shown in Table 4. All trays were filled and seeded in a similar manner. Spiral root seedling incidence ranged from 3 to 17% and closely matched observations of the same seed lots in grower greenhouses. The impact of the spiral roots was apparent in the percentage of usable transplants as well as small seedling and observed seedling mortality.

Table 4. Seed performance trial results of three commercial seed lots of one variety. Test was conducted at the Southern Piedmont Center in Spring 2010, Blak stone, Va. Data shown are averages of six replications.

Seed lot	14 dy seedling emergence	Spiral root seedlings	Usable transplants	Small seedling	Seedling mortality
	------------------------------		(%)		------------------------------
A	93.1	17.1 a	75.9 b	13.5 a	4.9 a
B	93.1	3.3 b	84.9 a	6.8 b	1.4 b
C	91.0	10.3 a	79.0 ab	12.4 a	2.9 a

Results of this trial reinforce the observation that seed pellet factors still play a role in the incidence of spiral root seedlings. Previous research has shown that an average of one-third of these will survive to produce usable transplants, one-third will survive but are too small to transplant, and one-third will not survive.

The commonly used commercial soilless media used for tobacco transplant production are generally similar in their physical and chemical properties. When a problem does occur, it is not usually a common occurrence but limited to individual greenhouses or just a few. This would indicate that something unusual has occurred with a relatively limited quantity of media. Such could occur during manufacture, transport, at the dealer, or on the farm. Although not common, problems can occur with excessively wet or dry mix, sticks or other debris impacting tray filling, and inadequate wetting chemical agents. Growers should always keep lot numbers from their greenhouse media in case a problem does occur. The use of old media should be avoided since the chemical wetting agent degrades over time and this can impact the amount and uniformity of media wetting in the trays (wicking). Media should be stored so to avoid excessively high temperatures and drying. Whenever possible, bags should be kept wrapped in plastic until seeding time to preserve proper condition. Water should not be added to bags of mix unless expressly directed by the manufacturer.

Algae growth on the media surface is a common occurrence and excessive growth that covers the seed can be a concern. Other than tray sanitation, there is actually very little growers can do to prevent algae growth and algae seldom has any significant impact on seedling growth. The best strategy is to provide conditions as favorable as possible for seed germination and early seedling growth. The intention is to allow for seedlings to grow as rapidly as possible and eventually shade out any algae growth.

Research Trial to Evaluate Timing of Initial Fertilization

Fertilizer salts injury can be a significant source of seedling mortality thus impacting the yield of useable transplants from a tobacco greenhouse. Mortality may occur when salt levels in the growing medium around a young seedling increase to a point where roots are burned and no longer able to provide adequate water uptake to the developing seedling. Float tobacco seedlings are most susceptible to injury during the third week after seeding and are seldom affected once roots have grown into the float bay water. Float production is more susceptible to accumulation of fertilizer salts than an overhead water system since water is continuing moving upward through the media and evaporating from the surface of the tray. The result is the accumulation of salts near the surface where the seedlings are emerging and developing. This accumulation is a natural occurrence in the float system and our goal as greenhouse managers is to maintain this below damaging levels. Factors that can lead to fertilizer salts injury include:

- A water source with high soluble salts – may require a delay in fertilizer addition or a reduced initial amount of fertilizer.
- Improper bay fertilization –such as too much fertilizer, or too early, or uneven distribution within the bays will increase fertilizer salts accumulation.
- Delayed or uneven seedling emergence – thus younger seedlings are exposed to increased salts level. Prolonged cloudy weather following seeding can delay germination or poor seed performance and subject seedlings to increased salt levels. Salts injury can

frequently be observed in trays along the side curtains where germination can be somewhat delayed due to cooler nighttime temperatures.

- Excessive air movement over the trays will contribute to increased water loss and salts accumulation. This can be especially apparent where horizontal airflow fans (HAF) or heater fans are blowing directly onto trays.

A study of the timing of fertilizer addition was conducted at the Virginia Tech Southern Piedmont Center in 2021. The study compared the addition of fertilizer at 1, 6, 11, and 16 days after seeding. The fertilizer used was a 16-5-16 and the initial fertilizer addition was 150 ppm N. Two different varieties were seeded with the intent to having differing seed performance and corresponding different levels of fertilizer salts injury. However, seed of both varieties exhibited excellent seedling emergence (early and uniform) and thus the data were combined as one. Data collected included: bay water Ec levels, media Ec levels, seedling emergence, seedling mortality, and final usable transplant counts. Electrical conductivity (Ec) is a measure of the soluble salts or fertilizer salts. The bay water Ec values of each treatment are shown in Figure 1a. The unfertilized Ec value of the bay water was less than 0.25 mS and the addition of the fertilizer is evident as an increase by more than 1.5 mS for each treatment following fertilizer addition to the bay water. The Ec of the soilless mix with the trays is the measure of the fertilizer salts exposure to the seedlings and this is shown in Figure 1b. The unfertilized Ec level was approximately 1.75 mS and the resulting impact of fertilizer addition can be seed for each treatment. Generally, an Ec value from a direct media extract of 3.0 to 3.5 mS at 14 days after seeding is a sign of potential fertilizer salts injury. The 1 DAS treatment exceeded 4.0 mS while the 6 and 11 DAS treatment peaked at 3.5 mS closer to 21 days after seeding.

The corresponding impact of fertilizer salts on the seedlings is shown in Table 5. Seedling stand or emergence at 14 days after seeding was quite high for these seed and was not impacted by fertilizer addition. However, the percent usable transplants were significantly reduced by early fertilizer addition at 1 DAS. Usable transplants were reduced to 86.4% by the earliest fertilizer addition, followed by 6 DAS at 91.9%. The loss of usable transplants occurred through early seedling mortality or seedlings too small to be transplanted. The number of dead seedlings corresponded to fertilizer timing, with 7.6% mortality with fertilizer added at 1 DAS.

Table 5. Results of greenhouse fertilization timing study conducted at the Southern Piedmont Center, 2021. Data shown are averages of 8 replications.

Timing of initial fertilization	14-day stand	Usable transplants	Seedling mortality	Small seedlings
	-------------------- (%)	----------------------		
1 DAS	96.5 a	86.4 a	7.6 a	2.5 b
6 DAS	65.4 a	91.9 b	2.1 b	1.4 ab
11 DAS	95.7 a	94.3 b	0.5 b	1.0 a
16 DAS	95.4 a	93.1 b	0.3 b	2.0 ab

Value within a column followed by the same letter are not significantly different

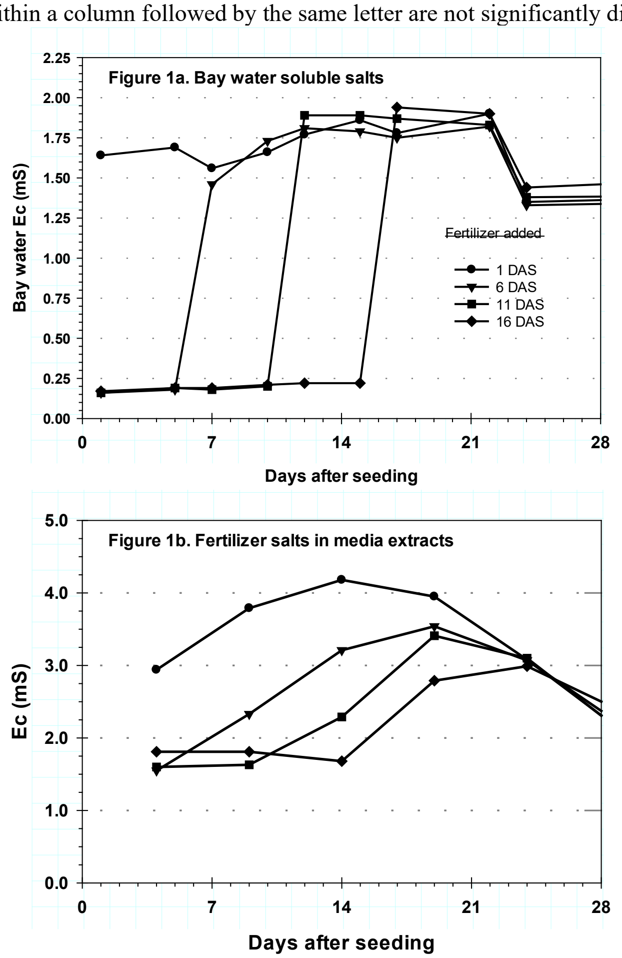

Figure 1. Bay water soluble salts (Fig. 1a) and fertilizer salts measured in media extracts (Fig. 1b) resulting from the addition of fertilizer to bays at 1, 6, 11, and 16 days after seeding (DAS). Test conducted at the Southern Piedmont Center, 2021.

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 the 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 in late afternoon are particularly 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 optimum germination is obtained, the minimum temperature should be maintained at 70 to 72°F. Extended periods of cooler temperatures will delay germination and may decrease the uniformity in seedling emergence. Varieties differ somewhat in their temperature requirements. Providing some fluctuation in day to night temperatures is beneficial for some varieties and is seldom detrimental with others.

   After germination, the minimum temperature may be initially reduced to 60-65°F and later to 55°F. Preventing high temperatures is perhaps of even greater importance. Young seedlings are particularly sensitive, and the temperature should not be allowed to reach 95°F during the 2- to 4-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 100°F. 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.

   Avoid seeding too early to reduce the cost of greenhouse heating. High quality transplants can be grown in seven week s in most situations;

though, some growers have found eight week s 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 for only a 40^{o}F night time temperature and keeping the greenhouse cool during the day (open) 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 representation 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 over packing of 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 are generally 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 trays wick properly, watering over the top should not be necessary to assist with seed germination. However, if trays are watered, only a fine mist should be used to prevent packing and waterlogging of 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. Also important to

proper fertilization is an accurate estimation of fertilizer solution concentration. 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 a bay, the fertilizer analysis, and the desired nutrient level of the float bay. Additional information on fertilization is presented on page 19.

6. <u>Water Quality</u>
   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 having water analyzed it is important to have the results interpreted for plant production properties rather than as drinking water.

7. <u>Clipping</u>
   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.

   <u>Suggested Clipping Program</u>

   - Begin clipping when plants are 2 to 2.5 inches tall (bud height)
   - Set mower blade at 1 to 1.5 inches above bud
   - Clip on a 3-day interval between the first 3 clipping dates and every 5 days thereafter

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

The above description of greenhouse tobacco transplant production is greatly abbreviated. Additional information is available from your local Extension agent and is detailed in a "Float Greenhouse Tobacco Transplant Production Guide", VCE Publication No. 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. Add 150 ppm N 3 to 5 days after seeding
2. Maintain water level at 75% of the original depth for the first 3 week s
3. Refill bays to original depth and add 100 ppm N at 4 week s after seeding in preparation for initial clipping

Though seedling injury or mortality is not necessarily common, the most likely timing for the occurrence is during the third week after seedling before root grow into the water. A potential cause can be avoided by not allowing the bay water levels to fall below 75% of the original depth during the first 3 week s after seeding thus not allowing the fertilizer to become concentrated.

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 insure 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 walk way 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 1 to 3 days after seeding with adequate mixing in the bay water. The injector would be used to add <u>125 ppm N</u> with each later addition of water to the bay. An alternative would be to fill bays to an 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.

<u>Calculation of Water Volume and Fertilizer Concentration</u>

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:

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

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

<u>Organic Greenhouse Transplant Fertilization</u>

Organic greenhouse fertilization is substantially more difficult than with a conventional greenhouse since organic fertilizers are not highly water soluble and the nitrogen is not readily available to the plants. Seabird guano (typically 12-10-2) is the most commonly used product and is predominately urea and contains very little plant available nitrate-N. Therefore, the N must be converted from urea to ammonium and then nitrate through natural processes that occur with variable rates in the anaerobic conditions present in greenhouse float bays. Seabird guano pellets are especially slow to dissolve so the process can be hastened by grinding the pellets to a powder and by soaking pellets in buckets of water to make a tea than can be periodically poured off into the float bay. To overcome the detrimental effects of anaerobic conditions in float bays, research has been conducted to evaluate the aeration of bays to added oxygen to the water. Results have shown benefits of doing so by a practical means of effectively aerating large bays has not be determined.

Research conducted at North Carolina State University has provided two suggested organic greenhouse fertilization programs.

Program 1:

- 13.9 oz per 100 gal.seabird guano (12-11-2)
- 3.0 oz per 100 gal potassium sulfate (0-0-52)

Program 2:

- 4.9 oz per 100 gal.seabird guano (12-11-2)
- 6.8 oz per 100 gal sodium nitrate (16-0-0)
- 3.0 oz per 100 galpotassium sulfate (0-0-52)

The fertilizer should be added to the bays in spilt applications approximately 1 and 3 week s after seeding. Seabird guano is relatively high in phosphorus and can result in relatively spindly seedlings. Program 2 addresses this by supplying the majority of the nitrogen from sodium nitrate which is readily available to the plants and does not contain any phosphorus.

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 Center. 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% compared to 6% where fertilizer was added three days after seeding. Delaying fertilizer addition until after seeding and floating of the trays resulted in 5 to 15% 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.

FERTILIZATION

The basic principles of flue-cured tobacco fertilization have been established by decades of research, but the subject has received much greater attention in recent years due to dramatic increases in the cost of fertilizer. Such increases in cost have provided growers with greater reason to examine their overall soil fertility program and how they fertilizer their tobacco. Any soil fertility program should begin with soil testing. Lime should be applied according to soil test recommendations. The amounts of phosphorus (P_2O_5) and potash (K_2O) fertilizer should follow soil test levels.

A cost effective tobacco fertilization program begins with the selection of the complete grade fertilizer product based on soil P levels. Phosphorus contributes greatly the cost of fertilizer, and therefore; the lowest P grade fertilizer product to meet the soil test recommendation should be the most economical. Fields with a history of tobacco will usually tests at a medium plus (M+) to high level for soil P due to past applications of high P fertilizer products. Over application of P will not improve crop performance, but will continue to build-up high soil P levels and potentially contribute to environmental contamination through soil runoff into watersheds. Historically, the tobacco grade fertilizer with the lowest P level has been a 6-6-18 product.

The choice of a sidedress fertilizer product should be based on whether additional potash is needed above that supplied in the complete fertilizer application. Historically this was a choice primarily between 16-0-0 nitrate of soda and 15-0-14 soda potash. However, the availability of both of these products has been sporadic in recent years but alternative products have been introduced. Below is a list of tobacco sidedress products expected to be available next season.

Common Tobacco Sidedress Fertilizer Products

	Percent (%) nitrate-N
15.5-0-0 (calcium nitrate)	100
15-0-2 (predominately nitrate of soda)	100
13-0-14 (blended product)	~25
12-0-46 (predominately potassium nitrate)	100
Liquid products	
CN-9 (liquid calcium nitrate)	100
UAN-30 (liquid urea ammonium nitrate solution)	25

The above materials were evaluated in 2017 in a sidedress fertilizer trial at the Southern Piedmont Center. The potash recommendation for test site was 120 lbs per ac and this was supplied with an application of 700 lbs per ac of 6-6-18 at bedding. Sidedress products were applied at rates necessary to provide 40 lbs per ac of N and therefore sidedress potash rates ranged from 0 to 153 lbs per ac depending on the sidedress product. No significant differences were observed for either yield or cured leaf quality.

Sidedress products with all nitrate N would be expected to result in quick er uptake and response in the crop. Application of liquid sidedress products such as CN-9 and UAN are convenient in application and save time in handling materials although specialized equipment is necessary. To reduce potential loss of N through volatilization, shallow incorporation of UAN is suggested. Sidedress products should be applied by the third week after transplanting to ensure for adequate uptake by the plants and proper crop maturation.

Tobacco Fertilizers

Historically, complete tobacco fertilizers (NPK) have been formulated to supply at least 50% of the total N as nitrate-N. Doing so ensures a more precise availability of the nitrogen to the plant, regardless of soil and environmental conditions. However, due to the cost and availability of basic fertilizer ingredients, tobacco fertilizers containing only 25% nitrate-N have been marketed in recent years. Research in Virginia with tobacco fertilizers with 50, 25, and 0% nitrate-N has not shown the reduced nitrate-N content to have a significant impact on either yield or quality of the cured tobacco. If the lower nitrate-N content is a concern, growers still have the option of using an all nitrate-N sidedress product to minimize the total amount of ammonium-N applied to the crop. Ammonium-N is naturally converted to nitrate-N for uptake by the plant. Therefore, application of a 25% nitrate-N fertilizer should not be excessively delayed beyond transplanting.

Tobacco fertilizers have traditionally been ammoniated products where the basic ingredients are melted and mixed to produce individual fertilizer granules that are as uniform in their content as possible. Another cost saving measure has been the use of blended tobacco grade fertilizer products. Blending produces a product that is as uniform a mixture of different fertilizer sources as possible. The quality of any blended fertilizer is dependent on the capacity of the fertilizer blender to provide a uniform product.

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 sidedresser provides the nutrients to the cop when they are needed and the grower has greater control over the availability.

A third traditional property of tobacco grade fertilizers is a limitation on chlorine or muriatic sources (potassium chloride). Chlorine is a factor that impacts the chemical quality of the tobacco by affecting the burn rate of tobacco as well as the curability of air-cured tobacco types. This remains an important issue to the industry and growers must not try to save on fertilizer expense by using fertilizer products containing excessive chlorine.

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 liming according to recommendations are critical to avoid either a low pH situation or an excessively high pH that results from over liming. Overliming can increase the possibility of certain disease problems (black shank and black root rot) and cause an imbalance of certain micronutrients; *though this should not be considered as a justification for not liming according to soil test recommendations*. The most common soil fertility problem associated with tobacco production in Virginia is low pH. As soil pH falls below 5.0, the availability of most soil nutrients may become limiting and elements such as manganese and aluminum can become toxic to tobacco. Furthermore, the efficiency of applied fertilizers is reduced by low soil pH as shown below. Fertilizer efficiency is considered to be optimum at a pH of 7.0; though this pH is not considered optimal for tobacco. The desired pH range for flue-cured tobacco is 5.7 to 6.2.

	Fertilizer Efficiency		
Soil pH	**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

Tobacco plant development, and more importantly leaf ripening, are directly affected by the availability of soil nitrogen. The cropping history and rotations of most typical tobacco fields precludes little carryover of nitrogen to be available to tobacco. As a result, the N requirement for flue-cured tobacco is supplied primarily through chemical fertilizers. Control of the amount and timing of N directly impacts the ripening and the curability of flue-cured tobacco. Inadequate N results in both low yield and quality as the plant does not develop and mature properly. However, the application of too much N is more likely to occur. Excessive N delays ripening and is associated with tobacco that is undesirable in color (K L, K F, GK , etc.), high in nicotine, and is of generally poor quality. Harvesting unripe tobacco affects curing costs by lengthening the yellowing time and thereby delays the turnaround time for curing barns. Excessive nitrogen may have secondary effects on the cost of production by increasing sucker growth as well as the susceptibility or severity of the crop to late season insect pests and disease outbreaks.

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 N availability are organic matter content, soil texture, 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 loams soils of average fertility, suggested nitrogen rates for different topsoil depth are as follows:

Topsoil depth (in.)	**Nitrogen rate (lbs/ac)**
0 to 12	50 to 60
12 to 18	60 to 70
18 to 24	70 to 80

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 6 (taken from N. C. Agric. Ext. Serv. Pub. AG-187) may be used as a general guide for making leaching adjustments.

Table 6. Nitrogen Adjustment for Excess Water[a]

Topsoil depth (to clay) (in.)	Estimate amount of water percolated through soil (in.)[b]	% of applied N to replace after transplanting ---------------week s---------------		
		1 to 3	4 to 5	6 to 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 lb. of N used as an adjustment for leaching, use about 1 lb. of potash (K $_2$0) 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 nutrients lost through leaching should be made as soon as possible after leaching rains occur. Waiting until deficiency symptoms develop in the crop before applying supplemental fertilizer will decrease the likelihood of a positive response to the fertilizer.

Phosphorus and Potassium

Phosphorus is probably the nutrient used more excessively 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 nutrient. Soil analyses of tobacco fields conducted by the Virginia Tech Soil Testing Laboratory indicated that approximately 97% 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 pounds of phosphorus (P_20_5) per acre are adequate to give maximum production and maintain the soil phosphorus levels. 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 impacts acceptable smoking characteristics of the tobacco. Soils vary in their supply of available potassium, depending upon the parent material, previous fertilization, and cropping history. Approximately 100-175 pounds of potash (K_20) per acre 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).

Soil Test Category	Pounds suggested per acre 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 P_20_5/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 (MgO) 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. Though not likely to occur, boron is the micronutrient most likely to be deficient for tobacco. Generally, 0.25 pound of elemental boron per acre (approximately 2.5 pounds of borax) is sufficient to correct or prevent such deficiencies.

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 the nutrient 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 4.5 to 5 lbs P_2O_5 per acre to be sufficient and not result in crop injury. The use of high P transplant starter fertilizer can be expected to provide more rapid and uniform early season growth. Such can be beneficial when cultivating and will most likely result in earlier, and 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 Trts. 3 - 6 (high P) resulted in more rapid early season growth than observed with the low P fertilizer (Trt. 2) or untreated plants (Trt. 1). As plants neared topping stage, difference es between the treatments tended to diminish. However, plants in Trts. 3 - 6 did come into top earlier than those in Trts. 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 7).

Table 7. 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 and PB = plant bed grown transplants

Fertilizer Calculations

(1) Calculating nutrient rates

A **6-6-18** fertilizer is **6%** N, **6%** P_2O_5, and **18%** K_2O (potash)

Example:

700 lbs/ac of 6-3-18 would supply:

42 lbs/ac N or 700 lbs/ac x 0.06 N

42 lbs/ac P_2O_5 or 700 lbs/ac x 0.03 P_2O_5

126 lbs/ac K_2O or 700 lbs/ac x 0.18 K_2O

(2) Calculating fertilizer rate to obtain a desired nutrient rate

Example:

30 lbs/ac N from 15.5-0-0 (calcium nitrate) would be supplied by:

194 lbs/ac or $\dfrac{30 \text{ lbs/ac N}}{0.155 \text{ N}}$

DE-LUGGING OF FLUE-CURED TOBACCO

The demand for high quality U.S. tobacco remains strong in the world market. However, this is tempered somewhat by changes in recent market seasons toward specific styles of cured leaf and weaker market demand for otherwise high quality tobacco grades deemed undesirable by some contract companies. Quality upper stalk tobacco that is not orange to mahogany can be significantly discounted by some buyers. Additionally, thin-bodied grades of tobacco (lugs and cutters) has become increasing difficult to mark et due the comparatively high price of this style of tobacco in the world market. Such tobacco is in an oversupply from numerous sources worldwide and the price of U.S. tobacco creates a severe competitive disadvantage. As a result, some contract purchasers of U.S. tobacco have either limited purchases of thin-bodied tobacco or substantially discounted the prices for such tobacco.

The practice of removing of lower leaves and discarding is described as "de-lugging" and has been discussed within the industry from time to time given the supply and demand for lug and even cutter grades of tobacco in the world market. Research evaluating de-lugging management practices has been conducted in multiple countries as the oversupply of thin-bodied tobacco is not limited to the U.S. De-lugging studies have been conducted in Virginia the past two seasons. Factors studied included: (1) the number and timing of lower leaf removal, (2) topping higher to compensate for removal of lower leaves, and (3) the addition of extra nitrogen to replace that lost in the early removal of leaves from the plant. A description of four de-lugging studies conducted at the Virginia Tech Southern Piedmont Center in 2017 are described below.

Field Research Tests

1. Timing and number of removed for de-lugging
   - Timing of leaf removal: layby, topping, and time of normal first harvest
   - Number of leaves removed at de-lugging: 4, 6 and 8 leaves

2. De-lugging leaf number and topping height
   - Number of leaves removed at de-lugging: 4, 6 and 8 leaves
   - Topping height: normal (18-20 leaves), plus 2, and plus 4 leaves
   - All de-lugging occurred at topping time

3. De-lugging timing and added nitrogen sidedress
   - Timing of leaf removal: layby, topping, and time of normal first harvest
   - Extra N sidedress: 0, 5, and 10 lbs per ac
   - Number of leaves removed was 4.

4. Topping height and added nitrogen sidedress
   - Topping height: normal (18-20 leaves), plus 2, and plus 4 leaves
   - Extra N sidedress: 0, 5, and 10 lbs per ac
   - All de-lugging occurred at topping time
   - Number of leaves removed was 4.

All four tests were planted with NC 196. Standard fertilization for all of the above tests was 72 lbs per ac of N supplied from 700 lbs of 6-6-18 and 195 lbs of 15.5-0-0. Additional N treatments were supplied from 15-0-2.

Results of the limited research conducted shows clearly the yield loss expected with the de-lugging treatments. This yield loss can be reduced by de-lugging earlier (at layby compared to topping or later) before the plants directs additional resources to the leaves and giving the plant additional time to compensate for leaf removal. Removal of 4 leaves eliminated lug (X) grades in these studies while cutters (C) were eliminated by only 6 and 8-leaf removal. However, results for an individual grower will depend on harvest management practices such as the number of leaves in the first harvest and the total number of harvests. Although results are not conclusive, topping higher to make-up for de-lugging yield loss dues appear to be effective. However, it should be noted that topping higher will impact crop maturity and ripening and should be considered carefully on an individual farm basis. Perhaps the most prudent approach would be to evaluate this on your farm and to try topping two leaves higher initially. The additional of added nitrogen (5 or 10 lbs per ac) did not result in increased yield and is therefore not recommended.

De-lugging Study no. 1. Average yields (lbs per ac) of de-lugging treatments evaluating the timing and number of leaves removed. The percent reduction in yield compared the standard treatment is shown below each average yield in parentheses.

Yield of standard management treatment = 2829 lbs per ac

Timing of de-lugging treatment	Number of leaves removed with de-lugging		
	4	**6**	**8**
Layby	**2692** (4.8%)	**2326*** (17.8%)	**2255*** (20.3%)
Topping	**2598** (8.2%)	**2251*** (20.4%)	**1955*** (30.9%)
At first harvest	**2268*** (19.8%)	**2289*** (19.1%)	**2016*** (28.7%)

Yields highlighted with a '*' are significantly different from the standard treatment.

De-lugging Study no. 2. Average yields (lbs per ac) of de-lugging treatments evaluating the number of leaves removed and topping height. De-lugging of four leaves occurred at topping time. The percent reduction in yield compared the standard treatment is shown below each average yield in parentheses.

Yield of standard management treatment = 2761 lbs per ac

Added topping heights (leaves)	Number of leaves removed with de-lugging		
	4	**6**	**8**
normal	**2208*** (20.0%)	**2075*** (24.8%)	**1649*** (40.3%)
Plus 2	**2492** (9.7%)	**2163*** (21.7%)	**1887*** (31.7%)
Plus 4	**2591** (6.2%)	**2235** (19.1%)	**2311** (16.3%)

Yields highlighted with a '*' are significantly different from the standard treatment.

De-lugging Study no. 3. Average yields (lbs per ac) of de-lugging treatments evaluating the timing and extra N fertilization. The percent reduction in yield compared the standard treatment is shown below each average yield in parentheses.

Yield of standard management treatment = 2966 lbs per ac

Timing of de-lugging treatment	Added N sidedress (lbs per ac)		
	0	**5**	**10**
Layby	**2725** (8.1%)	**2675** (9.8%)	**2718** (8.4%)
Topping	**2471*** (16.7%)	**2409*** (18.8%)	**2657*** (10.4%)
At first harvest	**2351*** (20.7%)	**2393*** (19.3%)	**2303*** (22.4%)

Yields highlighted with a '*' are significantly different from the standard treatment.

De-lugging Study no. 4. Average yields (lbs per ac) of de-lugging treatments evaluating topping height and extra N fertilization. De-lugging of four leaves occurred at topping time. The percent reduction in yield compared the standard treatment is shown below each average yield in parentheses.

Yield of standard management treatment = 2784 lbs per ac

Added topping heights (leaves)	Added N sidedress (lbs per ac)		
	0	**5**	**10**
normal	**2482*** (10.8%)	**2271*** (18.4%)	**2475*** (11.1%)
Plus 2	**2682** (3.7%)	**2629** (5.6%)	**2722** (2.2%)
Plus 4	**2683** (3.6%)	**2791** (+0.3%)	**2769** (0.5%)

Yields highlighted with a '*' are significantly different from the standard treatment.

SUCKER CONTROL

Flue-cured 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 reaching the button stage. Allowing tobacco to remain untopped for up to three week s after reaching the button stage will reduce yields 20 to 25 lb per acre per day. Late topping increases the number of pretopping suckers that must be removed as well as 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.

MH Residues

Residues of MH have long been a concern for the tobacco industry and this factor is especially critical for tobacco sold for international markets. Virginia has historically had some of the lowest MH residues levels of any tobacco grown in the U.S. This has largely been due to the hand application of flumetralin products such as Drexalin Plus, Flupro, and Prime+. However, this is a more labor intensive procedure and worker safety is a significant concern. Growers need to be mindful of product signal words and the required personal protection equipment for each.

Residues of MH remain an industry concern and Virginia is generally among the lowest in MH. However, growers are evaluated individually in regard to MH residues and must follow recommended practices to decrease the likelihood of residues becoming an issue.

Guidelines to Minimize MH Residues

1. Observe the preharvest interval (PHI) of 7 days following MH application. Rainfall during the preharvest interval is helpful in reducing MH residues. Additional time beyond the PHI will further reduce the likelihood of excessive MH residues.
2. Make only 1 application of a labeled rate of MH. Do not make split applications of MH even at reduced rates since the second application will likely increase residues present in later harvests.
3. Consider the addition of flumetralin to a sequential sucker control program. These products may be tank mixed with MH, applied before the first harvest and delaying MH, or applied alone after MH (usually 3 to 4 week s later).

   The application MH after first harvest should not exceed 1 gal per ac. (1.5 lbs a.i.) and should be made as soon as possible after the harvest.
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 pre-topping suckers have grown too large (greater than 1 in. long). The first application of a C8 / C10 fatty alcohol mixture should be made at a 4% concentration (4 gal. to 96 gal. of water) and later applications should be made at 5% (5 gal. per 95 gal.).
5. The use of coarse spray tips (i.e. TG3-TG5-TG3) and low pressure for MH applications results in coarser droplets that result in less wetting of the underside of the leaves and thus not as exposed to rainfall and dews.
6. Make certain of the concentration of your MH product as formulations may contain either 1.5 or 2.25 lbs of MH per gal. The 1.5 lb per gal. formulation has traditionally been the product of choice in Virginia though either is acceptable if the correct application rate is used.
7. Don't add spray surfactants to MH applications. Product labels for MH do not state either their usefulness or necessity. Research has not shown their effectiveness in increasing rain fastness.

Research is ongoing at the Southern Piedmont Center toward management practices to reduce MH residues. Early results are encouraging but additional testing is necessary before changes can be made to current practices. One such test has been the comparison of MH applications made at 8 a.m., noon, and 4 p.m. Results from 2012-15 show consistently lower MH residues with the early morning application with no reduction in sucker control when applied in a sequential program with flumetralin.

MH Plant Factors Study

A multi-year study is underway at the Southern Piedmont Center to investigate various plant related factors that may impact MH residues in cured tobacco. One such factor is the time of day when MH is applied to a tobacco field. The physiological condition of plants changes throughout the day due to changes in moisture, temperature, and sunlight. These daily changes in plant stress levels impact how MH is absorbed into the plant to control suckers and how MH is metabolized within the plant and broken down.

The study compared MH applications made at 8 a.m., noon, and 4 p.m. Additionally, applications were made either before the first harvest, after the first harvests, or later after first harvest. The three applications were typically spaced 13 days apart over the past 4 years. A rate of 1.5 gal/ac (2.25 lbs a.i. per acre) was applied to all treatments in a sequential sucker control program with contact fatty alcohol and flumetralin.

Four-year averages of MH residues from tobacco in the fourth harvest are shown in Table 8. Additionally, the range in seasonal average MH residues that resulted from each treatment is shown below the 4-year average. Cured leaf MH residues were consistently lower with applications made before the first harvest with the overall average and the ranged in season averages below an 80 ppm tolerance. In contrast, applications made at noon and 4 p.m. after the first harvest were consistently above 80 ppm. Residues below 80 ppm occurred only in one year out of four.

Table 8. Cured leaf MH residues from the final harvest of tobacco treated with MH at three times of day. Applications were made on three dates relative to the first harvest. Data shown are averages of 4 years of tests from 2012-2015. Values in parentheses are the range of seasonal averages in MH residues.

Timing of MH application	Time of day for MH application		
	8 a.m.	Noon	4 p.m.
Before 1st harvest	**33** (19 - 53)	**53** (30 – 64)	**44** (22 – 78)
After 1st harvest	**49** (33 – 66)	**101** (70 – 154)	**105** (87 – 124)
Late after 1st harvest	**50** (31 – 70)	**101** (75 – 159)	**115** (68 – 159)

Test results show that an early morning application of MH is an effective means of reducing MH residues compared to applications made later in the day. No significant differences were observed in the level of sucker control obtained. Additionally, if MH residues in the tobacco of from the first harvest are not a concern, application before the harvest will effectively reduce MH in tobacco of later harvests. If MH is prohibited in the first harvest tobacco, then the rate of MH applied afterwards should be reduced (1 gal. rather than 1.5 gal./ac) to address MH residue concerns.

Suggestions for MH-Free Sucker Control

Dropline application of flumetralin has been long proven to be an effective alternative to the use of MH and specific details are described later as Program II. Worker safety and following label requirements with regard to PPE must be a consideration.

More recently, over-the-top spray applications of flumetralan have been successfully used in place of MH. Application of flumetralin should follow 2 or 3 applications of a fatty alcohol. Although labeled up to 1 gal. per ac, 2 to 3 qt/ac of flumetralin will be sufficient in most circumstances. If 3 qts are used, this should be spilt as two applications with 2 qts applied 1 week after the last contact and followed with 1 qt 3 to 4 week s later.

Flumetralin does not provide the true systemic activity of MH and therefore the spray material must contact a small sucker in every leaf axil. This may not be feasible with crooked or windblown stalks. Likewise, spray nozzles must be positioned properly over the plants for optimum control. This best achieved by spraying the same number of rows as the crop is transplanted.

Chemical Sucker Control Materials

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 K ill 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 concerned solution of contact material is required to obtain adequate sucker control. Use a 4% solution or 2 gal. in 48 gals of water.

   The strength of a contact fatty alcohol product is dependent 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 and 4% concentration of a C_{10} product would be comparable to 4 and 5% 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, only one application of up to the labeled rate of MH must be applied per season. Wait at least one week between MH application and harvest.

3. Products that have a local systemic mode of action stop cell division in a localized area and must wet the sucker buds in each leaf axial to be effective. The primary local systemic material flumetralin and is sold under the trade names of Prime+, Flupro, and Drexalin Plus. 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 K ill both primary and secondary suckers, contact solutions should not be applied at concentrations less than 4%. It may be necessary to increase the concentration to 5% when applications are made under cool overcast weather conditions.

Precautions with local systemics:

1. Rain occurring within 2 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 before application (greater than 1 in.).
5. Flumetralin residues may carryover in the soil to injure small grain 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 should be reapplied to maintain good sucker control.

EPA WORK ER 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).

Suggested Sucker Control Programs

Program I. Sequential Method

1. Apply contact sucker control chemical (4% concentration) before topping when approximately 50 to 60% of plants reach the button stage. A small percentage (5%) of plants should be chemically topped by this application.
2. A second contact application (5% concentration) should be made 3-5 days after the first. Fields having irregular growth will require a third application (5% concentration) 5-7 days later.
3. About 5 to 7 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 tankmix; or
   c) tankmix of MH with flumetralin
   d) flumetralin (up to 1 gal per acre but 2 to 3 qts is suggested)

4. Flumetralin may be substituted for the last contact application and delay an application of a reduced rate of MH until after the first harvest.
5. If control of late season sucker growth is necessary, one of the following alternatives may be applied 3-4 week s after MH application:

   a) Flumetralin
   b) 5% concentration of contact material

Program II. Individual Plant Method with a Flumetralin

Apply flumetralin with a dropline, back pack , 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).**

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 personal protection equipment (PPE) requirements for WPS is challenging for hand application of sucker control chemicals.

Chemical Sucker Control Test

A sucker control test was conducted at the Southern Piedmont Center in 2016 to compare treatments of reduced rates of MH and MH-free treatments. The treatment applications described in Table 9 were applied following two contact fatty alcohol applications at 4 and 5%. All applications were made with 3 nozzles per row (2 TG-3 and 1 TG-5). Pre-topping SPL16U13were removed but any suckers that escaped control from the chemical applications were allowed to grow until the end of the season. The level of sucker control is expressed as the percent sucker control compared to a topped-not-suckered treatment where no chemical sucker control was applied.

Reasonable sucker control was obtained from all treatments with the possible exception of no. 7 where only 2 qts/a of Flupro was applied. Among the MH-free treatments, 90% or better control occurred with the addition of a contact fatty alcohol (Off-Shoot T) to the first Flupro application. Butralin is an alternative dinitroaniline product that can be used to reduce the amount of flumetralin applied. Although trt. no. 4 with Butralin provided the highest level of sucker control among the MH-free treatments, the differences in sucker control with the comparative treatment (no. 3) with the addition of a 3 qt of Flumetralin is likely of little practical importance. Similarly, the addition of a 5% rate of the fatty alcohol to the Flupro application was not significant, but tended to improve sucker control. Whether this is a direct result of the contact fatty alcohol activity or improved wetting of the suckers that may occur with the addition of fatty alcohol to the DNA product needs to be further studied.

The systemic activity of MH is important is controlling suckers not controlled by contact fatty alcohols locally systemic DNAs. Improved sucker control was generally observed with the addition of MH to the sequential sucker control treatments in this test. However, results of this test show that reduced rates of MH can be used to obtain good sucker control. Reducing the MH application rate is one of the most effective means of reducing MH residues in cured tobacco. One gal of MH applied either before first harvest (trt. no. 9) or after first harvest (trt. no. 10) provided sucker control equivalent to 1.5 gal of MH (trt. no. 8). Furthermore, a 0.5 lb rate of MH provided similarly good sucker control with the addition of a third qt. of Flupro (trt. no. 11) though control was reduced where only 2 qt of Flupro were applied (trt. no. 12).

Table 9. Reduced MH and MH-Free Sucker Control Test Conducted at the Southern Piedmont Center, Blackstone, Va. 2016.

Trt. No.	Application no. before 1st Harvest	Application no. after 1st Harvest	Sucker Control (%)[1]
1	Topped-Not-Suckered	(used to calculate sucker control)	
MH-Free Treatments[/2]			
2	OST + Flupro 5% + 3 qt/ac	----	92.4 bc
3	OST + Flupro 5% + 2 qt/ac	Flupro 1 qt/ac	91.9 bc
4	OST + Flupro 5% + 2 qt/ac	Butralin 1 qt/ac	95.6 ab
5	Flupro 2 qt/ac	Flupro 1 qt/ac	88.9 c
6	Flupro 3 qt/ac	----	87.1 dc
7	Flupro 2 qt/ac	----	82.8 d
Treatments with MH[/3]			
8	RMH-30 + Flupro 1.5 gal + 2 qt/ac	----	100.0 a
9	RMH-30 + Flupro 1.0 gal + 2 qt/ac	----	98.4 a
10	Flupro 2 qt/ac	RMH-30 1.0 gal/ac	100.0 a
11	RMH-30 + Flupro 0.5 gal + 2 qt/ac	Flupro 1 qt/ac	97.0 ab
12	RMH-30 0.5 qt/ac	Flupro 2 qt/ac	89.7 c

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

[/2]Flupro is one of three flumetralin products labeled for tobacco, alternatives include Prime+ and Drexalin Plus. Use rates are the same for all three products.

[/3]Royal MH-30 was used for this test (1.5 lbs a.i. per gal.)

Suggestions for Application of Sucker Control Materials

<table>
<tr><th>Product Type</th><th>When to Apply</th><th>Application Rate</th></tr>
<tr><td>Contacts (fatty alcohols)</td><td>1. 1^{st} appl. at 50% elongated button
2. 2^{nd} appl. 3 to 5 days after 1^{st} appl.
3. Late season application 3 to 4 week s after MH, if needed</td><td>1^{st} application as a 4% solution or 2 gal in 48 gal of water
2^{nd} 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 1^{st} and 2^{nd} applications, respectively</td></tr>
<tr><td colspan="3">Application Procedure
<u>Power Spray</u>
20 psi using 3 solid cone nozzles per row (i.e. 1 TG-5 and 2 TG-3's)
Apply 50 gal of spray material per acre
<u>Hand Application</u>
20 psi max. and ½ to $^{2}/_{3}$ fl oz per plant</td></tr>
<tr><td>Local systemics (flumetralin)</td><td>1. Individual plants at elongated button stage (dropline or jug application)
2. 5 days after 1^{st} contact application
3. Late season application 3 to 4 week s after MH, if needed</td><td><u>Power Spray</u>
2 qt/a of flumetralin
Apply 50 gal of spray material per acre.

<u>Hand Application</u>
2% solution or 1 gal in 49 gal of water (2.5 fl oz of flumetralin per gal of water). Do not apply more than 30 gal of spray per acre</td></tr>
<tr><td colspan="3">Application Procedure
<u>Power Spray</u>
15 - 20 psi using 3 solid cone nozzles per row (i.e. 1 TG-5 and 2 TG-3's)
<u>Hand Application</u>
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</td></tr>
</table>

Suggestions for Application of Sucker Control Materials (Cont'd)

<table>
<tr><th>Product Type</th><th>When to Apply</th><th>Application Rate</th></tr>
<tr><td>Premix product of fatty alcohol and flumetralin (Plucker Plus)</td><td>1. Apply from elongated button to full flower, either before or after topping (apply within 24 hours of topping)
2. A second application can be made 5 to 7 days after the first
3. May be applied following an MH application</td><td><u>Power Spray</u>
Up to 4 qt/a with 2 to 4 qt/a in sequence with MH
Apply 50 gal of spray material per acre.
<u>Hand Application</u>
1 gal in 49 gal of water (2.5 fl oz of per gal of water).
Do not apply more than 30 gal of spray per acre</td></tr>
<tr><td colspan="3">Application Procedure
<u>Power Spray</u>
15 - 20 psi using 3 solid cone nozzles per row (i.e. 1 TG-5 and 2 TG-3's)
<u>Hand Application</u>
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</td></tr>
<tr><td>Systemics (MH)</td><td>When used as part of sequential control program - apply 1 week after 2nd contact application.</td><td>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.</td></tr>
<tr><td colspan="3">Application Procedure
Apply as a coarse spray using 3 solid cone nozzles (i.e. TG-5 and 2 TG-3's). Direct spray toward upper third of the plant.</td></tr>
<tr><td>Tank mix of MH with flumetralin</td><td>When used as part of sequential control program - apply 1 week after 2nd contact application.</td><td>2.25 to 3.0 lb MH with 2 qt/A of flumetralin
Apply 50 gal of spray material per acre.</td></tr>
<tr><td colspan="3">Application Procedure
Apply as coarse spray using 3 solid cone nozzles (i.e. TG-5 and 2 TG-3's) and 20-25 psi.</td></tr>
</table>

CHEMICAL COLORING AGENTS

Ethygen 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.

Ethygen is 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 e 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 per gal) was the original ethephon product labeled as a yellowing agent for tobacco and was followed by Prep, Boll Buster, and Marture XL (6 lbs per 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 per 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).