ABSTRACT

Edwards, Patrick Boddie. The Effect of Management Practices on Grade Distribution in Flue-Cured Tobacco. (Under the direction of W. David Smith.)

Two studies were conducted in 2002, 2003, and 2004. The first study was conducted at eleven locations and evaluated the effect of certain management practices on tip grade production in flue-cured tobacco. Treatments included six varieties, a normal nitrogen rate or normal plus 22 kg/ha of nitrogen, a normal or high topping height, and four versus five harvests. Four harvests involved keeping the last ten to twelve leaves together while five harvests split the ten to twelve leaves into two groups. The nitrogen rate treatment was only used in 2002 and was replaced with the topping height variable in 2003 and 2004. The variety NC 606 was added only in 2004. The second study was conducted at one location in 2003 and one in 2004 and investigated the effect of lower-leaf removal on the yield, quality, and grade distribution of flue-cured tobacco. Six treatments were included in the test in which the two controls involved no lower-leaf removal but were harvested three or four times. The other four treatments included a combination of removing the bottom four or eight leaves and harvesting the remainder of the leaves either two or three times.

In the tip grade production study, the most consistent factor affecting tip grades was cured-leaf color. Harvesting five times consistently produced more tip grades than harvesting four times in all three years of research. In 2002, a higher nitrogen rate reduced tip grades when it contributed to unripe tobacco. In 2003 and 2004, older varieties such as Speight G 28 and McNair 944 produced more tip-graded tobacco than the newer varieties K 326 and NC 71. High topping resulted in more tip grades in two of three locations in 2003

and one of four locations in 2004.

In all three years of the study, an immature and/or unripe grade of tobacco was less likely to receive a tip grade regardless of treatment applied. Riper grades that were more likely to receive a tip grade included F, FR, K, and N1BO which are based on the USDA grading system. Cultivars K 326 and NC 71 produced higher yield and values per hectare than Speight G 28 and McNair 944 at nearly all test locations. Also, Speight G 28 and McNair 944 tended to receive lower average prices per kilogram than K 326 and NC 71. In general, varieties McNair 944 and Speight G 28 and the management practice of five harvests resulted in the highest proportion of tip graded tobacco because the treatment resulted in ripe grades that were dark in color such as FR and K. Although Speight G 28 and McNair 944 received a higher percentage of tip grades, these varieties are not a good varietal choice for production due to low yields and disease resistance.

For the lower-leaf removal research conducted in 2003 and 2004, the most significant decreases in yield and value per hectare occurred when eight leaves were removed, regardless of the harvest method. Removing four leaves had a minimal impact on yield and value. No significant differences were observed in grade distribution in either year of lower-leaf removal research.

THE EFFECT OF MANAGEMENT PRACTICES ON GRADE DISTRIBUTION IN FLUE-CURED TOBACCO

By

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Biography

Patrick Boddie Edwards, son of Wayne and Gaye Edwards, was born in Rocky Mount, NC on September 24, 1979. He was raised ten miles from Whitakers, NC where he enjoyed working on the farm and rabbit hunting. After graduating from Enfield Academy in 1998, Patrick enrolled at North Carolina State University. He graduated in December of 2002 with a Bachelor's degree in Agronomy and a minor in Agricultural Business Management. In January of 2003, Patrick was admitted to graduate school at North Carolina State University where he has pursued a Master of Science degree under the direction of Dr. W. David Smith and Dr. Loren R. Fisher. Upon completion of his Master of Science studies, Patrick will return home to help manage the family farm with his father and brother, Wayne and Robert.

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INTRODUCTION

The traditional American blend cigarette is a carefully formulated combination of flue-cured, burley, and oriental tobaccos. To achieve a successful tobacco blend, the final product must provide consistent consumer satisfaction at a competitive price (15). Consumer satisfaction is dependant upon the flavor and aroma provided by the cigarette. Generally, flavor refers to taste of the smoked tobacco while aroma refers to the distinctive, pleasing smell derived from either leaf tobacco or smoke (26). Due to high reducing sugar levels that are fixed during the curing process, flue-cured tobacco contributes a sweeter taste than the other tobacco types. Burley tobacco is associated with a more basic smoke with a winey or nutty taste and an ammonia-like aroma. Oriental tobaccos offer more aromatic properties (35).

Cigarette blends consist of different tobacco types as well as stalk positions within types. Cigarette manufacturers classify tobaccos into three industry-grading groups: flavor, modifier, and filler grades. Flavor grades impart a specific flavor contribution to the smoke with a desired degree of irritation. Modifier grades are not a positive flavor contributor on their own, but when combined with other types, they impart a pleasant taste and aroma with the desired degree of irritation. Filler grades help to fill the cigarette tube without having an adverse effect on taste or chemistry (15).

Flavor contribution is the most important aspect in blending and has a direct relationship to stalk position (15). Leaf separation by stalk position (from lower leaves to upper leaves) can be classified into primings, lugs, cutters, smoking leaf, leaf, and tips (28). The primings and lugs offer the least flavor contribution. These stalk positions are beneficial as filler because they do not contribute off-taste characteristics. The cutter stalk position is generally used as a modifier, although a ripe cutter grade can impart some flavor contribution (15). The highest flavor and aroma contributions are made by the upper-stalk leaves, which include smoking-leaf, leaf, and tips (8). Smoking-leaf and leaf grades are based on the USDA classification system and are often used by purchasers to classify tobacco. Tip grades are not based on the USDA system but are used by purchasers to describe ripe to overripe leaves from the uppermost stalk position.

Although all upper-stalk leaf positions are beneficial contributors to a blend, tips have specific characteristics that differentiate them from the leaf and smoking-leaf stalk positions. Tips are the top four to six leaves located on a tobacco plant. The physical, chemical, flavor, and aroma that tips contribute to the blend make them highly desirable to the cigarette manufacturer (28). Therefore, tips receive the highest price in the market. In recent years, growers have harvested the smoking-leaf, leaf, and tips together, which decreases the likelihood of the tobacco receiving a tip grade and also impedes the blending process. Better separation of upper-stalk leaves would likely result in a higher percentage of tip grades (28). Although separation of upper-stalk tobacco may increase the percentage of tip grades, the physical and chemical properties of tobacco can be influenced by a number of factors including genetics, fertilization, environment, weather, harvesting, and curing procedures. A change in any of these factors can markedly alter the chemical composition of the leaf and thus affect smoking quality (30, 31).

Relationship Between Stalk Position and Leaf Chemistry

The chemical constituents of flue-cured tobacco consist primarily of organic substances such as organic acids, alkaloids and other nitrogenous constituents, organic bases, carbohydrates, resins, and essential oils (8). Organic substances are contained in every leaf, but their concentrations differ among leaves from different stalk positions (25). Since the quantity of each constituent as well as the balance between constituents affects the quality of the tobacco and smoke, chemical analysis and blending by stalk position are important in predicting smoke characteristics, primarily total alkaloids, nitrogen, and reducing sugars (8, 14). Stalk position chemical differences are shown in Table 1. Rogers and Mitchem (25) reported that when leaves produced on a plant are harvested at a comparable degree of maturity, the levels of total nitrogen, alpha-amino nitrogen, nicotine and water-soluble acids increased in leaves from successively higher stalk positions; the reducing sugars would decrease, the hydrogen ion concentration would increase.

Table 1. Chemical analysis by stalk position of a typical flue-cured tobacco plant harvested seven times (three leaves per harvest)

Primings	Total Nitrogen	Alpha-Amino Nitrogen	Nicotine	Reducing Sugars
	--	---------------------%---------------------	--	
7 (top)	2.31	0.260	3.89	9.8
6	2.21	0.168	3.35	15.5
5	1.78	0.102	2.47	20.3
4	1.55	0.084	1.82	22.7
3	1.48	0.092	1.53	20.6
2	1.69	0.134	1.40	16.3
1 (bottom)	1.77	0.184	1.28	10.6

Rogers and Mitchem, 1976

Total nitrogen is higher in upper than lower leaves because as the bottom leaves undergo senescence, nitrogen is transported upward in the plant. This is important when considering that excessively high amounts of total nitrogen can increase the strength of smoke (25). Alkaloids (principally nicotine) are very important because they affect taste and provide the physiological stimulus that makes the consumption of tobacco products pleasurable. Total alkaloid concentrations are lowest in leaves from the lower stalk position and increase in leaves from ascending stalk positions (6). Reducing sugars are known to 'balance' the smoke flavor, primarily by modifying the sensory impact of nicotine and other tobacco alkaloids (20). The highest concentration of sugars is typically found in leaves from middle stalk positions (25).

Acids, lipids, polyphenols, and volatile oils are other important chemical constituents that have differing concentrations by stalk position and can affect smoke delivery, strength, and flavor (12, 36). Table 2 shows the differing concentrations of some constituents for lug (X), cutter (C), and leaf (B) stalk positions.

Table 2. Concentration of other compounds associated with the flue-cured leaf

	Stalk Position		
Constituents	**X (Bottom)**	**C (Middle)**	**B (Top)**
	mg/g		
Lipids	12	34	30
Nonvolatile Acids	133	80	45
Polyphenols	17	24	30
Volatile oils	0.25	5	10

Weeks, W.W.[1]

When considering tobacco acids, nonvolatile acids are important because they impair burning and interfere with smoke delivery. These compounds are found in higher quantities in leaves from the bottom of the plant than from upper leaves[1]. Data from Chu *et al.* (7) showed that total fatty acid concentration was highest at stalk position two, next highest was

[1] Weeks, W.W. unpublished data.

stalk position three, stalk positions four through eight contained the next highest concentrations that were equal, and stalk position one had the lowest concentration. Fatty acids can be divided into high and low molecular weight compounds. High molecular weight fatty acids are poor contributors to smoke flavor and the highest concentrations are associated with immature upper-stalk tobacco, while low molecular weight fatty acids are positive contributors to tobacco flavor. In relation to leaf surface lipids and their contribution to aroma and taste, studies conducted by Kawashima and Gamou (18) showed that washing out the leaf surface lipid from tobacco resulted in a reduction of smoking aroma and taste, increasing bitterness and astringency. Lipid fractions are higher in the upper stalk positions. Volatile oils are also found in higher concentrations from upper-stalk leaves and contribute to a desirable aroma. Polyphenols can contribute to a smokey-like aroma, but are generally not contributors to tobacco flavor and aroma (35). Polyphenol concentrations generally increase from bottom to upper stalk positions (10).

Relationship Between Stalk Position and Leaf Physical Properties

As with leaf chemistry, cured leaf yield also is influenced by stalk position. Generally, relative yield is lowest in the bottom stalk positions and increases with higher stalk positions. In 1972, Brown and Terrill (5) determined the relative yield by stalk position and yield was calculated for a twenty-leaf plant. From the lowest stalk position to the highest, in four leaf increments, relative yield was 12.6%, 20.2%, 25.1%, 23.2%, and 18.2%. Research conducted by White and Matzinger (38) showed similar results in that relative yield generally increased with higher stalk positions.

Due to the low relative yields and less desirable chemical qualities in leaves from the lower stalk positions, a number of lower-leaf removal studies have been conducted. In the 1970’s, lower leaf positions were in less demand resulting in research on the removal of the bottom four leaves and higher topping to provide the addition of four upper-stalk leaves on nonflowering (mammoth) varieties (8). Research conducted by Court and Hendel (11) showed that lower-leaf removal had a negative impact on yield when addition of upper-stalk leaves was not imposed while differences in total alkaloids and reducing sugars were not significant. Thus, the addition of upper-stalk leaves when removing lower leaves may be necessary to achieve desirable yields. Black (4) also studied the removal of lower leaves and addition of upper-stalk leaves with mammoth (photoperiod-sensitive) cultivars and concluded that the addition of six upper-stalk leaves tended to overcompensate for the weight of the four leaves discarded from the bottom of the plant. Thus, based on these studies the removal of less desirable lower-stalk leaves without the addition of upper-stalk leaves will result in decreased yield.

Factors Affecting Leaf Size

Leaf size (area and shape) is important to cigarette manufacturers because it affects lamina to stem ratio. A high ratio of lamina to stem is desirable in manufacturing cigarettes. Leaf size can be influenced by a number of factors including genetics, environment, and management. Genetic control of leaf quality is well recognized (27). With the breeding of different varieties, tobacco leaves inherit characteristics such as shape, thickness and size, leaf asymmetry, and formation of a leaf tip (21). Research has shown that the ratio of leaf length to width can be attributed to varietal differences (29). Povilaitis (23) researched leaf characteristics among eight varieties and concluded that differences for shape of the leaf were significant for top and middle stalk positions.

Environmental factors such as soil, water, temperature, and day length have a profound affect on the characteristics of tobacco leaves (37). Well-drained soils, such as sandy or sandy loam soils, should be used for tobacco production. These soils are best to support the very active root system of tobacco, which is required to support the development of an enormous leaf area within a short period of time (32). Water throughout the growing season must be adequate to allow for maximum leaf expansion. Temperature can also play an important role in leaf size. Tso (32) concluded that moderately high temperatures in association with the length of growth period and sunlight are essential for dry-matter production and accumulation. Also, minimum temperatures of 18° to 22°C and maximum temperatures of 28° to 32°C are considered ideal for the critical leaf growth and expansion stage five to eight weeks after transplanting. Research conducted by Raper *et al.* (24) showed that as the temperature decreased from 30ºC daytime/26ºC nighttime to 18ºC daytime/14ºC nighttime the leaf area decreased and specific leaf weight increased. Since most *Nicotiana* species are day-neutral in respect to floral initiation, day length can play a significant role in leaf size. Short days, in combination with cold temperature, have been associated with premature early flowering of many *Nicotiana* species (32). Early floral initiation could decrease the amount of time the leaf has to expand during the major growth phase five to eight weeks after transplanting.

A number of experiments have examined the effects of management practices on physical growth of tobacco. Timely removal of the terminal flower (topping) and sucker control of tobacco are production practices that eliminate growth of reproductive structures and axillary shoots and allow the plant to partition nutrients and water to harvested leaves. Therefore, these practices increase the specific leaf weight, especially those from upper stalk positions (8). Controlling leaf number by topping height can greatly influence leaf size. Research has shown that as the leaf number per acre increases, the average leaf size decreases and with each increase of topping height, the area of the top leaf decreases (13, 19). Topping low, 14 to 16 leaves, produces an increase in lamina weight thus increasing average leaf thickness (13, 39). Whether topping low or high, this cultural practice can have a profound effect on leaf size, primarily in the upper-stalk region.

Nutrient supply can also play a key role in leaf size. When considering all the essential elements, nitrogen has the most pronounced effect on the development of a flue-cured tobacco plant. Research conducted by Peterson (22) showed that increased nitrogen rates increased the leaf area and the ratio of width to length of individual leaves; while dry weight per unit area (thickness) of the leaf was reduced. An increase in the supply of nitrogen from deficient to excessive has been shown to increase leaf size, decrease body (thickness), and inadequate amounts have tended to produce a lower-quality leaf (8).

Nitrogen rate in combination with other cultural practices has been shown to alter leaf size. Nitrogen rate and topping height have been studied together and results show that alterations of both factors can produce profound effects on leaf size and yield. Wolf and Gross (39) stated that an increase in the height of topping decreased the leaf thickness. Therefore, when plants are topped high, additional nitrogen may be needed to achieve desirable leaf size. Collins *et al.* (9) showed that at a higher topping height, yield was higher for the recommended rate of nitrogen plus 22 kg/ha than where the recommended rate was applied. Thus, the increase in leaf number due to a higher topping height resulted in a higher nitrogen rate needed to achieve the desired leaf size for a good yield. Higher than recommended rates of nitrogen should be avoided where tobacco is topped relatively low (9).

Harvesting by stalk position is a basic practice that has a significant influence on quality because it separates leaves into similar chemical and leaf size characteristics. The number of harvests can influence yield and possibly market price. Generally, leaf size is a good predictor of yield; the larger the leaf area and thickness, the higher the weight per unit leaf area. Research conducted by Collins and Hawks (8) showed a five percent yield reduction with three primings compared to the five to seven primings. Gwynn (16) showed that harvesting the total plant at one time resulted in lower total yield than three multiple harvests. Brown and Terrill (5) compared a normal harvest method to a once-over harvest and reported that tobacco from the normal harvest method had a greater yield, value, and price than that harvested by the once-over method. The once-over method resulted in over-mature bottom and immature top leaves. In contrast, Johnson (17) found that tobacco harvested in two or three equal primings produced yields similar to that harvested in six primings, but average market price was generally reduced with the two or three harvest method as compared to that from six primings. Overall, gross income is greatest with multiple harvests due to yield and/or price increase.

Leaf Demand

Due to increasing focus on meeting consumer preference, high-quality leaf is desired by the tobacco industry. A high-quality leaf that is key to blending for the desired taste generally comes from the upper-stalk regions of the plant. Other than a good filling value, which is the amount of tobacco occupying a given space, leaves from lower stalk positions contribute very little to a blended product. The primings and lugs offer the least flavor contribution and have the lowest nicotine content (15). Lower leaf regions of the plant are associated with low demand leaf and the price per pound illustrates their importance compared to other leaves from different stalk positions. The priming (P) stalk position brings the lowest price in the market. In 2004, a leading manufacturer paid $0.81 less per kilogram for a first quality priming than it did for a first quality tip (3). Along with the lowest prices, lower-leaf stalk positions contribute the least to overall yield. The priming stalk position is the lowest stalk position on the plant and research conducted by Brown and Terrill (5) showed that the bottom four leaves contributed to only 12.6% of the overall yield. Considering yield and price, the lower stalk positions have the lowest gross income of any stalk position on the tobacco plant.

USDA Grading System

To ensure that smoke delivery by a particular blend is consistent, much of a blender's skills are directed towards minimizing the effects of smoke variability by selectively using specific grades and sources of leaf demanded by the changing market situation (33, 34). The quantity, desirability, and use of different leaf influence the value of each lot of tobacco and is distinguished apart by USDA Standard grades. The USDA grading system was created to aid growers and manufactures by determining the quality of cured tobacco by visual inspection (8).

Inspection of tobacco according to U.S. Standard grades began in the United States in 1929. The U.S. Standard grades of tobacco consist of class, type, group, quality, and color

(1). The following is a description of the categories (1).

Class: A major division of tobacco based on characteristics caused by varieties, soils, or climatic conditions, and the method of cultivation, and curing as well as principal usage.

Type: A division of a class of tobacco having certain common characteristics and closely related grades. Tobacco which has the same characteristics and corresponding qualities, colors, and lengths is classified as one type.

Group: A division of a type covering closely related grades based on certain characteristics which are related to stalk position, body, or the general quality of the tobacco.

Quality: A division of a group or the second factor of a grade based on the relative degree of one or more elements of quality.

Color: The third factor of a grade based on the relative hues, saturations or chromas, and color values common to the type.

Within a group, the tobacco is classified basically into stalk positions. The stalk positions characterized in the USDA Standard grading system, from the bottom of the plant to the top, include primings (P), lugs (X), cutters (C), smoking leaf (H), and leaf (B) (1, 8). These stalk positions are an important indicator of certain chemical properties (32) and can be distinguished apart by the leaf’s texture, body, and color.

Color (1, 8) is an indication of ripeness and is described as lemon (L), whitish-lemon (LL), orange (F), orange-red (FR), red (R), green (G), greenish (V), variegated ripe (K), variegated unripe (KF, KR, KL, KM, KG, KD, KV, KS), oxidized (NO), and scorched (KK).

The most desirable colors are F, FR, and K because they are mature and ripe. L and LL result from low nitrogen. Colors V, G, KF, and KS are a result from harvesting unripe tobacco.

A quality factor of 1 to 5, 1 representing the highest quality decreasing to 5 representing the lowest quality, is also determined and is composed of ten elements: maturity, leaf structure, body, oil, color intensity, width, length, uniformity, injury tolerance, and waste tolerance. Examples of grades that could be given to a particular lot of tobacco would be B3F or B5F. B3F indicates that the tobacco has leaf (B) stalk position characteristics, is 3rd quality, and has an orange (F) color. B5F has the same stalk position and color characteristics as the B3F grade, but it has a lower quality indicated by the number 5. These descriptions help in determining the leaf quality and usability for certain cigarette blends.

Cigarette manufacturers and leaf dealers have different preferences for the styles of tobacco needed to meet customer needs (28) and will therefore purchase different quantities of leaf grades to blend for a specific taste. The price paid to growers for leaf position and quality varies between companies depending on what is desired for that companies specific cigarette blend. When comparing 2004 grade price sheets for Phillip Morris USA and Brown and Williamson tobacco companies, differences in price for certain stalk positions and quality is small, but evident. Phillip Morris's market price for a fourth quality lug (X4) was $3.41 per kilogram while Brown and Williamson paid $3.45. When considering fourth quality leaf tobacco (B4), Phillip Morris paid $4.03 per kilogram while Brown and Williamson paid $4.00. The biggest difference in company leaf quality preference can be seen in the tip grade. The USDA grading system does not designate a tip grade for flue-cured tobacco, but tips are the uppermost four to six leaves in the leaf position at the top of the tobacco plant. Leaves from the tip stalk position contribute greatly to the final taste of a cigarette blend. Phillip Morris's market price for the highest quality tip (T1) was $4.51 per kilogram, while Brown and Williamson paid $4.36 (2, 3). Although leaf styles and preferences differ between cigarette manufacturers and leaf dealers, the USDA Standard grading system is the foundation for determining leaf quality and usability.

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Effect of Variety, Nitrogen Rate, Topping Height, and Harvest Method on the Production of Tip Grades in Flue-Cured Tobacco

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ABSTRACT

Research was conducted at eleven locations in 2002, 2003, and 2004 to evaluate the effect of certain management practices on tip grade production in flue-cured tobacco. Treatments included six varieties, a normal nitrogen rate or normal plus 22 kg/ha of nitrogen, a normal or high topping height, and four versus five harvests. Four harvests involved keeping the top ten to twelve leaves together while five harvests split the top ten to twelve leaves into two groups. The nitrogen rate treatment was only used in 2002 and was replaced with the topping height variable in 2003 and 2004. The variety NC 606 was added only in 2004.

In 2002, the most consistent factor affecting tip grades was cured-leaf color. Harvesting five times, versus four, increased the percentage of tobacco that received a tip grade. The higher nitrogen rate reduced tip grades when it contributed to unripe tobacco. In 2003, harvesting five times consistently produced more tip grades than harvesting four times. Also, high topping resulted in more tip grades than topping normal in two of three locations. Older varieties such as Speight G 28 and McNair 944 produced more tip grades than the newer varieties K 326 and NC 71. In 2004, five harvests again significantly increased tip grade production. Speight G 28 and McNair 944 produced more tip-graded tobacco than K 326 and NC 71. High topping resulted in significantly more tip grades in one of the four locations in 2004.

In 2002, Speight G 28 and McNair 944 produced more K (variegated) colored leaf than K 326 and NC 71 at the Central Crops Research Station (CCRS). At Duplin County, more F (orange) style leaf was present in four harvests, but higher percentages of a riper

grade FR (orangish-red) was a result of harvesting five times. In 2003, McNair 944 produced more K colors than all other varieties at the Border Belt Tobacco Research Station (BBTRS). In 2004, Speight G 28 and McNair 944 tended to produce riper grades such as K and N1BO (overripe) than K 326 and NC 71. At Edgecombe County in 2004, four harvests resulted in more F grades than five harvests.

Cultivars K 326 and NC 71 produced higher yield and values per hectare than Speight G 28 and McNair 944 at nearly all test locations. Also, Speight G 28 and McNair 944 tended to receive lower average prices per kilogram than K 326 and NC 71. No significant trends were observed with grade index.

In all three years of the study, an immature and/or unripe grade of tobacco was less likely to receive a tip grade regardless of treatment applied. These grades include G GK, V, KL, KF, and KM. Riper grades that were more likely to receive a tip grade included F, FR, K, and N1BO. In general, varieties McNair 944 and Speight G 28 and the management practice of five harvests resulted in the highest proportion of tip graded tobacco because the treatment resulted in dark ripe grades such as FR and K.. Although Speight G 28 and McNair 944 received a higher percentage of tip grades, these varieties are not a good varietal choice for production due to low yields and disease resistance.

ADDITIONAL KEY WORDS

Tobacco, tips, variety, nitrogen rate, topping height, harvest

INTRODUCTION

The traditional American blended cigarette is a carefully formulated combination of flue-cured, burley, and oriental tobaccos. To achieve a successful tobacco blend, the final product must provide consistent consumer satisfaction at a competitive price (6). Consumer satisfaction is dependant upon the flavor and aroma provided by the cigarette. Generally, flavor refers to taste of the smoked tobacco while aroma refers to the distinctive, pleasing smell derived from either leaf tobacco or smoke (11).

Flavor contribution is the most important aspect in blending and has a direct relationship to stalk position and ripeness (6). The highest flavor and aroma contributions are made by the upper-stalk leaves, which include smoking-leaf, leaf, and tips, making them the most beneficial contributor to a blended cigarette (4). Smoking-leaf and leaf grades are based on the USDA classification system and are often used by purchasers to classify tobacco. Tip grades are not found in the USDA grading system but are used to describe ripe to overripe leaves from the uppermost stalk position. When considering ripeness, ripe to overripe styles of tobacco contribute a more desired flavor than less ripe grades. Color grades from the USDA classification system which indicate ripe to overripe styles of tobacco include orange (F), orangish-red (FR), red (R), variegated (K), and even some nondescript (NO) styles. Generally, these color grades represent the styles of tobacco that manufacturers desire for flavor contribution in a blended cigarette.

Although all upper-stalk leaf positions are beneficial contributors to a blend, tips have specific characteristics that differentiate them from the leaf and smoking-leaf stalk positions. Tips are the top four to six leaves located on a tobacco plant. The flavor and aroma that tips contribute to the blend make them highly desirable to the cigarette manufacturer (14). Although separation of upper-stalk tobacco may increase the percentage of tip grades, the physical and chemical properties of tobacco can be influenced by a number of factors including genetics and general production practices such as topping height, fertilization, and harvesting (16, 17).

Genetic control of leaf quality is well recognized and with the breeding of different varieties, tobacco leaves inherit characteristics such as shape, thickness and size, leaf asymmetry, and formation of a leaf tip (8, 12). Leaf size (area and shape) is important to manufacturers because it affects lamina to stem ratio in which a high ratio is desired. Research conducted has shown that the ratio of leaf length to width can be attributed to varietal differences (10, 15).

Timely topping and sucker control of tobacco are production practices that increase the specific leaf weight, especially those from upper stalk positions (4). Controlling leaf number by topping height can greatly influence leaf size. Research has shown that as the leaf number per acre increases, the average leaf size decreases and with each increase of topping height, the area of the top leaf decreases (5, 7). Topping low, 14 to 16 leaves, produces an increase in lamina weight thus increasing average leaf thickness (5, 18). Whether topping low or high, this cultural practice can have a profound effect on leaf size, primarily in the upper stalk region.

Research conducted by Peterson (9) showed that an increased nitrogen rate increased leaf area and the ratio of width to length of individual leaves; while dry weight per unit area (thickness) of the leaf was reduced. Also, alterations of nitrogen rate and topping height can produce profound effects on leaf size and yield. Wolf and Gross (18) stated than an increase in the height of topping decreased leaf thickness. Therefore, when plants are topped high, additional nitrogen may be needed to achieve a desirable leaf size.

Harvesting by stalk position is a basic practice that has a significant influence on quality because it separates leaves into similar chemical and leaf size characteristics. The number of harvests can influence yield and possibly market price. Research conducted by Collins and Hawks (4) showed a five percent yield reduction with three harvests compared to five to seven harvests. Research conducted by Brown and Terrill (3) also helps support previous results that a decrease in harvest number decreases yield and also decreases gross income.

Due to the high flavor and aroma contributions made by the tips, manufacturers will pay the most for this stalk position. Other than a good filling value, leaves from lower stalk positions contribute very little to a blended product. In 2004, a leading manufacturer paid $0.81 more per kilogram for a first quality tip than it did for a first quality priming (1). This was an 18% increase in payment between the two first quality stalk positions. With an increasing need to maximize gross income to the producer, there is a need to identify production practices that increase the percentage of tobacco receiving a tip grade. Therefore, the objective of this study was to determine the effect of variety, nitrogen rate, topping height, and harvest method on the production of tobacco receiving a tip grade.

METHODS AND MATERIALS

Eleven field experiments were conducted in 2002, 2003, and 2004 at seven locations across North Carolina. In 2002, field experiments were conducted at the Central Crops Research Station (CCRS), and on-farm locations in Forsyth, Duplin, and Rockingham counties. In 2003, field experiments were conducted at the Central Crops Research Station, the Border Belt Tobacco Research Station (BBTRS), and an on-farm location in Rockingham County. In 2004, field experiments were conducted at the Upper Coastal Plain Research Station (UCPRS), the Border Belt Tobacco Research Station, and on-farm locations in Rockingham and Edgecombe Counties.

Treatments were arranged in a factorial combination of variety, nitrogen rate, topping height, and harvest method (Tables 1-5). Varieties were selected due to their potential to affect tip production and difference between on-farm and research station test locations. NC 71, Speight 168, and K 326 were developed in the last 20 years, are relatively high yielding, and accounted for 59% of planted acres in North Carolina in 2003 (13). McNair 944 and Speight G 28 are older varieties and are no longer planted in the USA due to low yields and disease resistance. However, McNair 944 and Speight G 28 are relatively early maturing and produce smaller upper leaves than later releases such as NC 71, Speight 168, and K 326.

In 2002, two nitrogen rates were imposed on each variety, a recommended N rate and a recommended plus 22 kg/ha of N. A harvest variable was also added which involved harvesting the last 10-12 leaves together (four harvests) or dividing them into two separate harvests (five harvests). The fourth and fifth harvest were, however, conducted on the same day.

In 2003 and 2004, the nitrogen variable was replaced with a normal or high topping heights. Normal topping was from 18-20 leaves. High topping consisted of 22-24 leaves. The harvest variable was utilized in the same manner as 2002.

Treatments were arranged in a factorial treatment design with four replications except in Rockingham County in 2004 which consisted of only three replications due to field size. Research station test plots consisted of two rows, 12.2 meters long and on-farm test plots were four rows, 15.2 meters long. Plant spacing was 0.56 meters by 1.22 meters. Agronomic production methods recommended by the North Carolina Cooperative Extension Service (13) and normal production practices for each location were followed. At research station test locations the middle two rows were harvested from each plot, leaving a guard row on each side. All four plot rows were harvested at on-farm test locations. Plots were harvested four or five times by stalk position, depending on the treatment, and were cured in rack type bulk curing systems. After curing, the leaves were weighed by stalk position, assigned an Official U.S. Government grade, and yield and grade index (2) were calculated.

Samples were collected from each treatment and evaluated by industry representatives. Percentage of companies that assigned a tip grade was calculated after the company representatives made their analysis. For example, if one company out of five gave a sample of tobacco a tip grade then 20% represented the percentage of companies that assigned a tip grade. A subsample was collected from research station test locations and tested for percent reducing sugars and total alkaloids.

RESULTS

Tip Grades

2002

Harvesting tobacco five times increased the percentage of tip grades when compared to four harvests at all locations (Tables 6-9). A nitrogen rate by harvest interaction was observed in Forsyth County. The normal+22 kg/ha nitrogen rate harvested four times produced the lowest percentage of tip grades (Table 6).

2003

At the two research station test locations, Speight G 28 produced a higher percentage of tip grades than K 326 and NC 71. At the BBTRS, McNair 944 produced a higher percentage of tip grades than K 326 and NC 71 (Table 10). All three test locations in 2003 resulted in a higher percentage of tip grades when harvested five times versus four times (Tables 10, 11). In Rockingham County, high topping produced a higher percentage of tip grades than normal topping (Table 11).

2004

No significant differences due to variety were seen at either on-farm location (Tables 12, 13). At both research stations, McNair 944 and Speight G 28 produced a higher percentage of tip grades than that produced from NC 71 and K 326 (Table 10). All four test locations in 2004 showed that five harvests had a higher percentage of tip grades than four harvests and at the UCPRS high topping had a higher percentage than normal (Tables 10, 12, and 13). A variety by harvest interaction was observed at the UCPRS. McNair 944 harvested four times produced a higher percentage of tip grades than harvesting K 326 or NC 71 five times. Also, McNair 944 harvested five times had a higher percentage of tip grades than harvesting Speight G 28 four times (Table 10).

Cured-Leaf Color

2002

At the CCRS, the only significant differences due to treatment were in K (variegated) graded tobacco. McNair 944 and Speight G 28 produced more K colored leaf than K 326 and NC 71 (Table 14). In Duplin County, more F (orange) style leaf was present in four harvests, but more FR (orangish-red) style leaf was a result of harvesting five times. Three way interactions were also observed in Duplin County. Increasing the nitrogen rate, when harvesting the tobacco five times decreased FR colored leaf with Speight 168 but FR colors increased with K 326. When K 326 was harvested four times and the nitrogen rate was increased, more K colors were observed. But when K 326 was harvested five times and the nitrogen rate was increased, the K colors decreased (Table 15). No differences in cured-leaf color were observed at Forsyth and Rockingham Counties (Tables 16, 17).

2003

At the BBTRS, McNair 944 produced more K colors than all other varieties (Table 18). A three-way interaction was also observed at this location. Harvesting McNair 944 four times at a normal topping height produced more K colored leaf than all others except harvesting McNair 944 five times at a high topping height. When tobacco was topped at a normal height, an increase in harvest number increased F colored leaf. However, when plants were topped high, F colors decreased with the increase in harvest number. No significances in color were observed at the CCRS or Rockingham County (Tables 19, 20).

2004

In Edgecombe County more F colors resulted from harvesting four times as compared to five harvests (Table 21). In Rockingham County, K 326 and NC 606 had more FR colors than Speight 168 and NC 71 (Table 22). K colors were higher in NC 71 than K 326 and NC 606. When topping height was normal, increasing harvest number increased FR colors but FR style leaf decreased when topping height was high and harvest number was increased. At the UCPRS, more KF (variegated orange) colors were present in five harvests versus four harvests. McNair 944 had a significantly lower amount of F colors, but more N1BO (overripe, oxidized) style leaf than all the other varieties tested. A variety by harvest interaction was also observed at the UCPRS. Harvesting Speight G 28 five times resulted in a higher amount of K colored leaf than NC 71 harvested five times or K 326 harvested four times (Table 23). No significances in cured-leaf color were observed at the BBTRS in 2004 (Table 24).

<u>Yield</u>

2002

At the CCRS, NC 71 and K 326 yielded higher than McNair 944 and Speight G 28 (Table 7). A nitrogen rate by harvest interaction was observed in Duplin County. Yield from the normal+22 kg/ha of nitrogen harvested four times treatment was higher than from the normal rate harvested four times and a normal+22 kg/ha rate harvested five times treatments (Table 8). In Forsyth County a three-way interaction was observed. K 326 with a normal nitrogen rate harvested five times and NC 71 with a normal+22 kg/ha rate harvested five times yielded higher than K 326 with normal+22 kg/ha nitrogen rate harvested five times and K 326 with a normal rate harvested four times (Table 6). At Rockingham County, NC 71 yielded higher than Speight 168 (Table 9).

2003

At the CCRS and BBTRS, NC 71 yielded higher than all other varieties planted. K 326 yielded higher than Speight G 28 at both locations and higher than McNair 944 at the BBTRS location (Table 25). Also at the BBTRS, McNair 944 yielded higher than Speight G 28. Other significant main effects were observed at this location in which the high topping treatment yielded higher than the normal topping treatment and the harvesting five times treatment yielded higher than the four harvest treatment. For Rockingham County, NC 71 yielded higher than Speight 168 (Table 11). Also, the high topping treatment yielded higher than normal topping.

2004

The yield from K 326 was higher than that for Speight 168 and NC 606 while NC 71 was higher yielding than Speight 168 in Edgecombe County (Table 12). In Rockingham County, both K 326 and NC 71 were higher yielding than Speight 168 and NC 606 (Table 13). At the UCPRS and the BBTRS, K 326 and NC 71 yielded more than McNair 944 and Speight G 28 (Table 25). At the BBTRS Speight G 28 yielded higher than McNair 944 and in two out of the four locations high topping yielded higher than normal (Tables 12, 13, and 25).

<u>Grade Index</u>

2002

Differences in grade index due to treatment were observed only at the CCRS. The normal nitrogen rate resulted in leaf with a higher grade index than the normal+22 kg/ha rate (Table 7).

2003

At the CCRS location, leaf from NC 71 had a higher grade index than all other varieties (Table 26). Speight G 28 produced the lowest grade index at both research station test locations. A topping height by harvest interaction was observed in 2003 in which topping high and harvesting five times resulted in leaf with a lower grade index than topping high and harvesting four times as with as topping normal and harvesting five times. In Rockingham County, the grade index from high topping and harvesting five times was lower than that from all other Speight 168 treatments (Table 11). The grade index from K 326 was higher than NC 71 when the tobacco was topped high and harvested four times. The grade index from NC 71 was higher than Speight 168 when topped high and harvested five times.

2004

There were no differences among treatments in grade index at the Edgecombe County location (Table 12). In Rockingham County, the grade indices for K 326 and NC 606 were higher than that from NC 71 and Speight 168 (Table 13). A variety by harvest interaction was also observed at this location in which the grade index was higher from Speight 168 harvested five times versus four. At the UCPRS, the grade index from Speight G 28 was higher than McNair 944 and NC 71 while K 326 was higher than McNair 944. At the

BBTRS, K 326 had a higher grade index than all other varieties at this location (Table 26).

Price and Value

2002

The only significant difference in price per kilogram observed was at the CCRS in which a normal nitrogen rate resulted in a higher price than a normal+22 kg/ha rate (Table 7). Differences in value per hectare were observed at the CCRS location where NC 71 and K 326 resulted in a higher value per hectare than McNair 944 and Speight G 28. At Rockingham County, NC 71 had a higher value per hectare than Speight 168 (Table 9).

2003

At the BBTRS and CCRS, tobacco leaf from Speight G 28 received the lowest price and at the CCRS, NC 71 had the highest price compared to all other varieties (Table 27). NC 71 provided the highest value and Speight G 28 produced the lowest at both research stations (Table 28). No significant differences were observed in price or value at the Rockingham County test site (Table 11).

2004

Price differences among treatments were not measured at the Edgecombe County test (Table 12). In Rockingham County, leaf from K 326 and NC 71 received a higher average price than NC 606. A variety by harvest interaction was observed in which K 326 and NC 71, harvested four or five times, and harvesting Speight 168 five times resulted in higher prices than harvesting Speight 168 four times. Harvesting leaf from NC 606 four times rather than five resulted in higher prices (Table 13). At the UCPRS, leaf from McNair 944 received lower prices than all the other varieties. At the BBTRS, leaf from K 326 received higher prices than both McNair 944 and Speight G 28 while NC 71 was higher than McNair 944 (Table 27).

Results from the two on-farm test locations in 2004, showed that K 326 resulted in a higher value per hectare than that for Speight 168 and NC 606 (Tables 12, 13). NC 71 produced a higher value than Speight 168 and NC 606 at the Rockingham County location (Table 13). At both research stations, K 326 and NC 71 resulted in higher values than McNair 944 and Speight G 28. At the BBTRS location, high topping resulted in a higher value per hectare than normal topping (Table 28).

Leaf Chemistry (Total Alkaloids and Reducing Sugars)

2002

At the CCRS location, total alkaloids were highest in leaf from McNair 944, next highest in NC 71, and lowest in Speight G 28 and K 326. The normal+22 kg/ha nitrogen rate treatment resulted in a higher total alkaloid concentration than the normal nitrogen rate. McNair 944 produced the highest percentage reducing sugars with NC 71 and Speight G 28 being the next highest. The normal nitrogen rate treatment resulted in a higher percentage of reducing sugars than a normal+22 kg/ha rate (Table 29).

2003

McNair 944 was higher in total alkaloid concentration than all other varieties planted. At both research stations, leaf from NC 71 was higher than Speight G 28 and K 326. At the CCRS, leaf from Speight G 28 had lower percent reducing sugars than NC 71, K 326, and McNair 944. At the BBTRS, leaf from K 326 contained higher total alkaloids than Speight G 28 and NC 71. Normal topping resulted in higher total alkaloid concentrations than high topping (Table 30).

2004

At the UCPRS, leaf from McNair 944 and NC 71 was higher in total alkaloids than that from K 326 and Speight G 28. Higher concentrations of total alkaloids were also observed in normal topping than high topping at both research stations. Speight G 28 tended to be lower in reducing sugar concentration for both research stations. At UCPRS, Speight G 28 was significantly lower in reducing sugar concentration than the other varieties. Also, Speight G 28 and NC 71 were significantly lower in reducing sugar concentrations than McNair 944 at the BBTRS (Table 31).

DISCUSSION

Tip Grades and Cured-Leaf Color

Cured-leaf color, an indicator of ripeness, was the most consistent and important leaf factor affecting the percentage of tobacco receiving a tip grade. Riper grades that were more likely to receive a tip grade included FR, K, and N1BO (Table 32). These color grades received a higher percentage of tip grades than other color grades. Less ripe color grades such as G, GK, V, KL, KF, and KM received lower percentages of tip grades.

In all three years of evaluation, the most consistent production practice affecting the percentage of leaf that received a tip grade was harvesting five times. Harvesting five times, instead of harvesting four times, increased the percentage of tobacco receiving a tip grade at all eleven test locations. The five harvest method separated leaves into more distinct color and leaf size characteristics. The visible cured-leaf color difference between the top four leaves and the four to five leaves below them could be clearly seen at most locations. Color shifts between the two harvest methods were clearly evident at Duplin County in 2002. When comparing four versus five harvests, more F colors were present in the four-harvest method and FR colors were more prevalent in the five-harvest method (Table 15). FR colors received tip grades more often than F colors (Table 32). In 2004, the test in Edgecombe County received fewer F colors when harvesting five times. This resulted in a shift to a higher percentage of K colors which resulted in a higher percentage of tip grades than F colors (Tables 21, 32).

Nitrogen rate only affected tip grades when it contributed to unripe tobacco. For example, in Forsyth County the four harvest method decreased the percentage of tip grades and along with the higher nitrogen rate, contributed to the production of unripe leaf which is less likely to receive a tip grade (Table 6).

Significances in the percentage of tip grades received due to topping height were observed at Rockingham County in 2003 and at the UCPRS in 2004. Although no color trends were observed at the UCPRS, the Rockingham County test showed that with two out of the three varieties tested (K 326 and NC 71), an increase from normal to high topping shifted some of the KF and F grades to a K grade, which is a riper style of leaf more likely to be graded as a tip (Tables 20, 23). Wolf and Gross (18) stated that with an increase in topping height, additional nitrogen might be needed to achieve a desirable leaf size. Possibly at the Rockingham test, the desired leaf size was already achieved and an increase in topping height helped dilute the nitrogen to increase ripeness. At the BBTRS in 2003, high topping with four harvests and normal topping with five harvests had higher percentages of F grades than high topping with five harvests and normal topping with four harvests (Table 18). Normal topping and harvesting four times had more K grades, a riper grade than F, than high topping harvested four times. Topping high and harvesting five times versus normal topping harvested five times showed shifts into KF, a less ripe grade than F, and K grades. Thus, indicating that factors other than color are involved in receiving a tip grade, such as leaf size.

Varietal differences in percentage of tip grades were observed at research stations in all three years of evaluation. At all locations, Speight G 28 produced a higher percentage of tip grades than that produced from K 326 and NC 71. McNair 944 also produced a higher percentage of tip grades than that from K 326 and NC 71 at all locations except at the CCRS in 2003 (Table 10). The variety by harvest interaction observed at the UCPRS in 2004 can be simplified and explained by using the main interactions of McNair 944, Speight G 28, and five harvests receiving the highest percentages of tip grades (Table 23).

Older varieties (McNair 944 and Speight G 28) produced higher percentages of tip grades than NC 71 and K 326 primarily due to the trend difference in color. K, FR, and N1BO grades are riper styles of leaf and received the higher percentages of tip grades when averaging across all test locations. In 2004 at the UCPRS, McNair 944 had more K style leaf, the highest N1BO grades, and received the least F grades. Speight G 28 received mainly K and F grades. K 326 and NC 71 were primarily graded into KF and F colors, which are less ripe than FR and K colors (Table 23). K 326 and NC 71 received a majority of the KF grades at the UCPRS and CCRS in 2002 and Speight G 28 and McNair 944 received more K grades (Table 14). At the BBTRS in 2003, McNair 944 displayed again the production of a riper style of leaf by receiving more K grades while the other varieties received mainly F grades. Even though a three-way interaction was observed also at this location and lack of consistency across locations does not show a general trend, McNair 944 was the leading variety in receiving K grades in this interaction (Table 18).

The varieties evaluated at the test locations show an apparent difference in percentage of tip grades. However, the research data could possibly be offset since the maturity rates of varieties differ between older varieties such as Speight G 28 and McNair 944 and newer varieties, K 326 and NC 71. Test plots were all harvested at the same time, without regard for the differing maturity rate of varieties. Allowing the newer, slower maturing varieties of K 326 and NC 71 more time in the field to increase to a desired ripeness could possibly decrease difference in percentage of tip grades.

Although the older varieties Speight G 28 and McNair 944 produced a higher percentage of tip grades than K 326 and NC 71, the yield for varieties K 326 and NC 71 are much higher which compensates greatly for the decreased percentage of higher-priced tip grades. With an increasing focus on reducing grower cost per kilogram, planting these older varieties would not be economical and other production practices should be implemented first to increase the percentage of tip grades. Harvesting five times to ensure good separation of stalk position and sometimes high topping can help increase the percentage of tip grades. Although these factors have been related to color, color alone does not influence tip grades. Many instances in this research only a certain percentage of a color grade received a tip grade, indicating that other factors are involved producing a leaf that has tip grade characteristics. These factors could possibly be related to leaf characteristics such as size and thickness. However, color plays an important role in the grade process and other leaf characteristics should be studied to gather a more precise understanding on how to produce a leaf that will receive a tip grade.

Yield, Grade Index, Value, Price, Alkaloids, and Sugars

Yield differences among newer varieties proved to be similar to yields recorded from the tobacco official variety testing program published in Flue-Cured Tobacco Information (13). K 326 and NC 71 tended to yield higher than other varieties in the experiment. The older varieties, McNair 944 and Speight G 28, yielded lower than the newer-bred varieties, as would be expected with the emphasis on breeding higher yielding, disease resistant varieties in breeding programs today. Similar to research conducted by Kittrell *et al.* (7), high topping increased yield when compared to normal by increasing leaf number per acre. Yield interactions that occurred at two of the eleven locations were not enough to consider any significant trends for explanation.

Although significance in grade index was observed, the only trends were McNair 944 and Speight G 28 being lower than the other varieties at some locations. Lower quality in combination with low yields from the higher priced upper stalk positions resulted in lower average prices and values for McNair 944 and Speight G 28. With the high yielding capacity of K 326 and NC 71, these varieties produced the highest values.

Not only do varieties differ physically as previous research has shown (8, 15), but this research shows that chemical attributes may differ among varieties. McNair 944 tended to have the highest total alkaloid and reducing sugar concentrations. Speight G 28 and K 326 tended to have the lowest total alkaloid and reducing sugar concentrations.

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Table 1. Treatments imposed at the Central Crops Research Station, 2002

Treatment	Variety	Nitrogen Rate	Harvest
1	NC 71	Normal N	4 Harvests
2	NC 71	Normal N	5 Harvests
3	NC 71	Normal + 22 kg/ha	4 Harvests
4	NC 71	Normal + 22 kg/ha	5 Harvests
5	Speight G 28	Normal N	4 Harvests
6	Speight G 28	Normal N	5 Harvests
7	Speight G 28	Normal + 22 kg/ha	4 Harvests
8	Speight G 28	Normal + 22 kg/ha	5 Harvests
9	McNair 944	Normal N	4 Harvests
10	McNair 944	Normal N	5 Harvests
11	McNair 944	Normal + 22 kg/ha	4 Harvests
12	McNair 944	Normal + 22 kg/ha	5 Harvests
13	K 326	Normal N	4 Harvests
14	K 326	Normal N	5 Harvests
15	K 326	Normal + 22 kg/ha	4 Harvests
16	K 326	Normal + 22 kg/ha	5 Harvests

Table 2. Treatments imposed at Duplin, Forsyth, and Rockingham Counties, 2002

Treatment	Variety	Nitrogen Rate	Harvest
1	Speight 168	Normal N	4 Harvests
2	Speight 168	Normal N	5 Harvests
3	Speight 168	Normal + 22 kg/ha	4 Harvests
4	Speight 168	Normal + 22 kg/ha	5 Harvests
5	NC 71	Normal N	4 Harvests
6	NC 71	Normal N	5 Harvests
7	NC 71	Normal + 22 kg/ha	4 Harvests
8	NC 71	Normal + 22 kg/ha	5 Harvests
9	K 326	Normal N	4 Harvests
10	K 326	Normal N	5 Harvests
11	K 326	Normal + 22 kg/ha	4 Harvests
12	K 326	Normal + 22 kg/ha	5 Harvests

Table 3. Treatments imposed at Rockingham County, 2003 and 2004

Treatment	Variety	Topping Height	Harvest
1	Speight 168	Normal	4 Harvests
2	Speight 168	Normal	5 Harvests
3	Speight 168	High	4 Harvests
4	Speight 168	High	5 Harvests
5	NC 71	Normal	4 Harvests
6	NC 71	Normal	5 Harvests
7	NC 71	High	4 Harvests
8	NC 71	High	5 Harvests
9	K 326	Normal	4 Harvests
10	K 326	Normal	5 Harvests
11	K 326	High	4 Harvests
12	K 326	High	5 Harvests
13[a]	NC 606	Normal	4 Harvests
14[a]	NC 606	Normal	5 Harvests
15[a]	NC 606	High	4 Harvests
16[a]	NC 606	High	5 Harvests

[a] Treatments including variety NC 606 were only imposed in 2004.

Table 4. Treatments imposed at the Border Belt Tobacco Research Station, Central Crops Research Station, and Upper Coastal Plain Research Station, 2003 and 2004

Treatment	Variety	Topping Height	Harvest
1	NC 71	Normal	4 Harvests
2	NC 71	Normal	5 Harvests
3	NC 71	High	4 Harvests
4	NC 71	High	5 Harvests
5	Speight G 28	Normal	4 Harvests
6	Speight G 28	Normal	5 Harvests
7	Speight G 28	High	4 Harvests
8	Speight G 28	High	5 Harvests
9	McNair 944	Normal	4 Harvests
10	McNair 944	Normal	5 Harvests
11	McNair 944	High	4 Harvests
12	McNair 944	High	5 Harvests
13	K 326	Normal	4 Harvests
14	K 326	Normal	5 Harvests
15	K 326	High	4 Harvests
16	K 326	High	5 Harvests

Table 5. Treatment imposed at Edgecombe County, 2004

Treatment	Variety	Harvest
1	Speight 168	4 Harvests
2	Speight 168	5 Harvests
3	NC 71	4 Harvests
4	NC 71	5 Harvests
5	K 326	4 Harvests
6	K 326	5 Harvests
7	NC 606	4 Harvests
8	NC 606	5 Harvests

Table 6. Effect of treatment on agronomic performance at Forsyth County, 2002

Treatments			**Yield** (Primings 4 and 5)	**Grade Index**[a] (Primings 4 and 5)	**Price** (Primings 4 and 5)	**Value** (Primings 4 and 5)	**Tips**[b]
Variety	N-Rate	Harvest	kg/ha	1-100	$/kg	$/ha	%
Speight 168	Normal N	4 Harvests	1,145	71	4.10	4,737	64
Speight 168	Normal N	5 Harvests	1,111	72	4.14	4,599	47
Speight 168	Normal+22	4 Harvests	1,094	86	4.24	4,636	11
Speight 168	Normal+22	5 Harvests	1,234	70	4.15	5,120	57
NC 71	Normal N	4 Harvests	1,097	84	4.23	4,641	36
NC 71	Normal N	5 Harvests	1,147	82	4.21	4,831	32
NC 71	Normal+22	4 Harvests	1,218	71	4.13	5,028	39
NC 71	Normal+22	5 Harvests	1,291	73	4.11	5,305	47
K 326	Normal N	4 Harvests	984	64	4.05	3,988	25
K 326	Normal N	5 Harvests	1,298	79	4.17	5,426	54
K 326	Normal+22	4 Harvests	1,202	63	4.09	4,912	25
K 326	Normal+22	5 Harvests	973	84	4.22	4,102	50
Main Effect Means							
Harvest							
4 Harvests							34
5 Harvests							48
N-Rate ∗ Harvest							
Normal ∗ 4 Harvests							42
Normal+22 ∗ 4 Harvests							25
Normal ∗ 5 Harvests							44
Normal+22 ∗ 5 Harvests							51
LSD (P=.05)							
Variety			NS	NS	NS	NS	NS
N-Rate			NS	NS	NS	NS	NS
Harvest			NS	NS	NS	NS	10
Var ∗ N			NS	NS	NS	NS	NS
Var ∗ Harv			NS	NS	NS	NS	NS
N ∗ Harv			NS	NS	NS	NS	15
Var ∗ N ∗ Harv			298	NS	NS	NS	NS

[a] Based on U.S. Government grades; 1-100 scale, with 100 being the best.

[b] Percentage of companies that assigned a tip grade.

Table 7. Effect of treatment on agronomic performance at the Central Crops Research Station, 2002

Treatments			Yield	Grade Index[a]	Price	Value	Tips[b]
Variety	N-Rate	Harvest	kg/ha	1-100	$/kg	$/ha	%
NC 71	Normal N	4 Harvests	4,510	48	3.38	15,157	4
NC 71	Normal N	5 Harvests	4,552	56	3.63	16,561	32
NC 71	Normal+22	4 Harvests	4,606	51	3.50	16,113	0
NC 71	Normal+22	5 Harvests	4,696	45	3.42	16,136	29
Speight G 28	Normal N	4 Harvests	3,906	54	3.64	14,230	7
Speight G 28	Normal N	5 Harvests	3,839	55	3.59	13,754	43
Speight G 28	Normal+22	4 Harvests	3,897	55	3.57	13,936	14
Speight G 28	Normal+22	5 Harvests	3,645	45	3.34	12,224	25
McNair 944	Normal N	4 Harvests	3,686	54	3.54	13,054	11
McNair 944	Normal N	5 Harvests	3,866	53	3.59	13,892	32
McNair 944	Normal+22	4 Harvests	3,713	53	3.53	13,057	11
McNair 944	Normal+22	5 Harvests	4,179	45	3.42	14,312	22
K 326	Normal N	4 Harvests	4,382	53	3.46	15,130	4
K 326	Normal N	5 Harvests	4,394	57	3.64	15,995	36
K 326	Normal+22	4 Harvests	4,745	45	3.31	15,674	0
K 326	Normal+22	5 Harvests	4,602	49	3.40	15,609	18
Main Effect Means							
Variety							
NC 71			4,591			15,991	
Speight G 28			3,822			13,536	
McNair 944			3,861			13,579	
K 326			4,530			15,602	
N-Rate							
Normal				54	3.56		
Normal+22				48	3.44		
Harvest							
4 Harvests							6
5 Harvests							30
LSD (P=.05)							
Variety			218	NS	NS	937	NS
N-Rate			NS	5	0.10	NS	NS
Harvest			NS	NS	NS	NS	9
Var ∗ N			NS	NS	NS	NS	NS
Var ∗ Harv			NS	NS	NS	NS	NS
N ∗ Harv			NS	NS	NS	NS	NS
Var ∗ N ∗ Harv			NS	NS	NS	NS	NS

[a] Based on U.S. Government grades; 1-100 scale, with 100 being the best.

[b] Percentage of companies that assigned a tip grade.

Table 8. Effect of treatment on agronomic performance at Duplin County, 2002

Treatments			Yield	Grade Index[a]	Price	Value	Tips[b]
Variety	N-Rate	Harvest	kg/ha	1-100	$/kg	$/ha	%
Speight 168	Normal N	4 Harvests	3,851	76	3.95	15,211	58
Speight 168	Normal N	5 Harvests	4,068	81	4.02	16,326	84
Speight 168	Normal+22	4 Harvests	4,101	75	3.95	16,175	67
Speight 168	Normal+22	5 Harvests	3,897	66	3.72	14,502	75
NC 71	Normal N	4 Harvests	3,943	75	3.89	15,342	63
NC 71	Normal N	5 Harvests	4,028	78	3.99	16,062	79
NC 71	Normal+22	4 Harvests	4,424	76	3.97	17,581	67
NC 71	Normal+22	5 Harvests	4,147	79	4.04	16,736	71
K 326	Normal N	4 Harvests	4,087	83	4.04	16,511	63
K 326	Normal N	5 Harvests	4,073	82	3.98	16,407	71
K 326	Normal+22	4 Harvests	4,112	75	3.87	15,921	63
K 326	Normal+22	5 Harvests	4,004	82	4.02	16,094	75
Main Effect Means							
Harvest							
4 Harvests							63
5 Harvests							76
N-Rate ∗ Harvest							
Normal ∗ 4 Harvests			3,961				
Normal+22 ∗ 4 Harvests			4,212				
Normal ∗ 5 Harvests			4,056				
Normal+22 ∗ 5 Harvests			4,016				
LSD (P=.05)							
Variety			NS	NS	NS	NS	NS
N-Rate			NS	NS	NS	NS	NS
Harvest			NS	NS	NS	NS	7
Var ∗ N			NS	NS	NS	NS	NS
Var ∗ Harv			NS	NS	NS	NS	NS
N ∗ Harv			192	NS	NS	NS	NS
Var ∗ N ∗ Harv			NS	NS	NS	NS	NS

[a] Based on U.S. Government grades; 1-100 scale, with 100 being the best.
[b] Percentage of companies that assigned a tip grade.

Table 9. Effect of treatment on agronomic performance at Rockingham County, 2002

Treatments			**Yield** (Primings 4 and 5)	**Grade Index**[a] (Primings 4 and 5)	**Price** (Primings 4 and 5)	**Value** (Primings 4 and 5)	**Tips**[b]
Variety	N-Rate	Harvest	kg/ha	1-100	$/kg	$/ha	%
Speight 168	Normal N	4 Harvests	2,224	70	4.16	9,242	0
Speight 168	Normal N	5 Harvests	2,292	73	4.21	9,642	18
Speight 168	Normal+22	4 Harvests	2,335	79	4.23	9,874	11
Speight 168	Normal+22	5 Harvests	2,148	70	4.14	8,905	14
NC 71	Normal N	4 Harvests	2,536	63	4.11	10,381	4
NC 71	Normal N	5 Harvests	2,381	63	4.11	9,795	11
NC 71	Normal+22	4 Harvests	2,698	66	4.16	11,199	4
NC 71	Normal+22	5 Harvests	2,680	64	4.12	11,043	7
K 326	Normal N	4 Harvests	2,511	78	4.24	10,635	4
K 326	Normal N	5 Harvests	2,185	69	4.17	9,096	18
K 326	Normal+22	4 Harvests	2,270	71	4.18	9,484	0
K 326	Normal+22	5 Harvests	2,755	67	4.14	11,406	18
Main Effect Means							
Variety							
Speight 168			2,250			9,415	
NC 71			2,574			10,604	
K 326			2,430			10,155	
Harvest							
4 Harvests							4
5 Harvests							14
LSD (P=.05)							
Variety			229	NS	NS	930	NS
N-Rate			NS	NS	NS	NS	NS
Harvest			NS	NS	NS	NS	6
Var ∗ N			NS	NS	NS	NS	NS
Var ∗ Harv			NS	NS	NS	NS	NS
N ∗ Harv			NS	NS	NS	NS	NS
Var ∗ N ∗ Harv			NS	NS	NS	1,859	NS

[a] Based on U.S. Government grades; 1-100 scale, with 100 being the best.

[b] Percentage of companies that assigned a tip grade.

Table 10. Effect of treatment on the percentage of companies that assigned a tip grade at the Border Belt Tobacco Research Station, Central Crops Research Station, and Upper Coastal Plain Research Station, 2003 and 2004

			Location			
			2003		2004	
Treatments			**BBTRS[a]**	**CCRS[b]**	**BBTRS**	**UCPRS[c]**
Variety	Topping Height	Harvest	---------%	--------	--------	---------
NC 71	Normal	4 Harvests	5	5	25	21
NC 71	Normal	5 Harvests	50	30	11	53
NC 71	High	4 Harvests	15	0	0	19
NC 71	High	5 Harvests	35	45	46	85
Speight G 28	Normal	4 Harvests	15	15	40	79
Speight G 28	Normal	5 Harvests	70	40	66	90
Speight G 28	High	4 Harvests	20	20	74	79
Speight G 28	High	5 Harvests	65	45	79	95
McNair 944	Normal	4 Harvests	30	0	69	85
McNair 944	Normal	5 Harvests	60	40	85	100
McNair 944	High	4 Harvests	20	5	70	90
McNair 944	High	5 Harvests	60	35	68	95
K 326	Normal	4 Harvests	0	5	11	0
K 326	Normal	5 Harvests	50	35	39	10
K 326	High	4 Harvests	0	15	5	16
K 326	High	5 Harvests	35	40	43	43

Table 10. Continued

	Location			
	2003		2004	
	BBTRS	CCRS	BBTRS	UCPRS
	------------------%------------------			
Main Effect Means				
Variety				
NC 71	26	20	21	44
Speight G 28	43	30	65	86
McNair 944	43	20	73	93
K 326	21	24	24	17
Topping Height				
Normal				55
High				65
Harvest				
4 Harvests	13	8	37	49
5 Harvests	53	39	55	71
Variety ∗ Harvest				
NC 71 ∗ 4 Harvests				20
NC 71 ∗ 5 Harvests				69
Speight G 28 ∗ 4 Harvests				79
Speight G 28 ∗ 5 Harvests				93
McNair 944 ∗ 4 Harvests				88
McNair 944 ∗ 5 Harvests				98
K 326 ∗ 4 Harvests				8
K 326 ∗ 5 Harvests				26
LSD (P=.05)				
Variety	11	7	21	13
Topping Hght.	NS	NS	NS	9
Harvest	8	5	15	9
Var ∗ Top Hght	NS	NS	NS	NS
Var ∗ Harv	NS	NS	NS	19
Top Hght ∗ Harv	NS	NS	NS	NS
Var ∗ Top Hght ∗ Harv	NS	NS	NS	NS

[a] Border Belt Tobacco Research Station

[b] Central Crops Research Station

[c] Upper Coastal Plain Research Station

Table 11. Effect of treatment on agronomic performance at Rockingham County, 2003

Treatments			Yield	Grade Index[a]	Price	Value	Tips[b]
Variety	Topping Height	Harvest	kg/ha	1-100	$/kg	$/ha	%
Speight 168	Normal	4 Harvests	3,389	78	3.98	13,502	8
Speight 168	Normal	5 Harvests	3,485	74	3.81	13,247	41
Speight 168	High	4 Harvests	3,522	78	4.01	14,119	17
Speight 168	High	5 Harvests	3,707	64	3.85	14,287	66
NC 71	Normal	4 Harvests	3,598	77	3.98	14,280	0
NC 71	Normal	5 Harvests	3,522	71	3.91	13,776	25
NC 71	High	4 Harvests	3,897	69	3.70	14,478	17
NC 71	High	5 Harvests	3,839	76	3.99	15,318	50
K 326	Normal	4 Harvests	3,593	74	3.98	14,307	8
K 326	Normal	5 Harvests	3,705	80	3.99	14,777	33
K 326	High	4 Harvests	3,723	80	4.04	15,039	8
K 326	High	5 Harvests	3,722	72	3.72	13,904	58
Main Effect Means							
Variety							
Speight 168			3,526				
NC 71			3,714				
K 326			3,686				
Topping Height							
Normal			3,549				19
High			3,735				36
Harvest							
4 Harvests							10
5 Harvests							45
LSD (P=.05)							
Variety			161	NS	NS	NS	NS
Topping Hght.			132	NS	NS	NS	11
Harvest			NS	NS	NS	NS	11
Var * Top Hght			NS	NS	NS	NS	NS
Var * Harv			NS	NS	NS	NS	NS
Top Hght * Harv			NS	NS	NS	NS	NS
Var * Top Hght * Harv			NS	10	NS	NS	NS

[a] Based on U.S. Government grades; 1-100 scale, with 100 being the best.
[b] Percentage of companies that assigned a tip grade.

Table 12. Effect of treatment on agronomic performance at Edgecombe County, 2004

Treatments		Yield	Grade Index[a]	Price	Value	Tips[b]
Variety	Harvest	kg/ha	1-100	$/kg	$/ha	%
Speight 168	4 Harvests	3,110	88	4.03	12,525	0
Speight 168	5 Harvests	3,160	84	4.01	12,666	35
NC 71	4 Harvests	3,922	87	4.02	15,774	15
NC 71	5 Harvests	3,839	86	4.03	15,436	30
K 326	4 Harvests	3,858	88	4.05	15,641	0
K 326	5 Harvests	3,996	87	4.02	16,062	25
NC 606	4 Harvests	3,726	87	4.04	15,063	0
NC 606	5 Harvests	3,531	87	4.02	14,208	5
Main Effect Means						
Variety						
Speight 168		3,135			12,595	
NC 71		3,880			15,605	
K 326		3,927			15,851	
NC 606		3,628			14,636	
Harvests						
4 Harvests						4
5 Harvests						24
LSD (P=.05)						
Variety		258	NS	NS	1,057	NS
Harvest		NS	NS	NS	NS	16
Variety * Harvest		NS	NS	NS	NS	NS

[a] Based on U.S. Government grades; 1-100 scale, with 100 being the best.
[b] Percentage of companies that assigned a tip grade.

Table 13. Effect of treatment on agronomic performance at Rockingham County, 2004

Treatments			Yield	Grade Index[a]	Price	Value	Tips[b]
Variety	Topping Height	Harvest	kg/ha	1-100	$/kg	$/ha	%
Speight 168	Normal	4 Harvests	4,188	79	3.97	16,617	33
Speight 168	Normal	5 Harvests	4,100	83	3.99	16,338	73
Speight 168	High	4 Harvests	3,848	78	3.92	15,051	20
Speight 168	High	5 Harvests	4,359	82	4.00	17,433	60
NC 71	Normal	4 Harvests	4,496	78	3.97	17,893	13
NC 71	Normal	5 Harvests	4,392	83	4.00	17,534	73
NC 71	High	4 Harvests	4,667	82	4.02	18,738	7
NC 71	High	5 Harvests	4,834	81	4.00	19,358	73
K 326	Normal	4 Harvests	4,569	83	4.02	18,357	27
K 326	Normal	5 Harvests	4,506	85	4.01	18,056	67
K 326	High	4 Harvests	4,784	86	4.00	19,121	0
K 326	High	5 Harvests	4,650	81	3.99	18,560	73
NC 606	Normal	4 Harvests	3,996	83	4.00	15,970	27
NC 606	Normal	5 Harvests	4,301	81	3.92	16,874	33
NC 606	High	4 Harvests	4,202	85	3.97	16,662	33
NC 606	High	5 Harvests	4,361	82	3.95	17,213	67

Table 13. Continued

	Yield	Grade Index	Price	Value	Tips
	kg/ha	1-100	$/kg	$/ha	%
Main Effect Means					
Variety					
Speight 168	4,124	80	3.97	16,360	
NC 71	4,597	81	4.00	18,380	
K 326	4,627	84	4.00	18,524	
NC 606	4,215	83	3.96	16,680	
Topping Height					
Normal	4,318			17,205	
High	4,463			17,767	
Harvest					
4 Harvests					20
5 Harvests					65
Variety ∗ Harvest					
Speight 168 ∗ 4 Harvests		78	3.94		
Speight 168 ∗ 5 Harvests		83	3.99		
NC 71 ∗ 4 Harvests		80	4.00		
NC 71 ∗ 5 Harvests		82	4.00		
K 326 ∗ 4 Harvests		85	4.01		
K 326 ∗ 5 Harvests		83	4.00		
NC 606 ∗ 4 Harvests		84	3.98		
NC 606 ∗ 5 Harvests		82	3.93		
LSD (P=.05)					
Variety	148	2	0.04	652	NS
Topping Hght.	105	NS	NS	461	NS
Harvest	NS	NS	NS	NS	19
Var * Top Hght	NS	NS	NS	NS	NS
Var * Harv	NS	3	0.05	NS	NS
Top Hght * Harv	NS	NS	NS	NS	NS
Var * Top Hght * Harv	NS	NS	NS	NS	NS

[a] Based on U.S. Government grades; 1-100, with 100 being the best.

[b] Percentage of companies that assigned a tip grade.

Table 14. Effect of treatment on cured-leaf color at the Central Crops Research Station, 2002

Treatments			Color				
			KF	**F**	**FR**	**K**	**N1BO**
Variety	Topping Height	Harvest	-----------------	-----------------	%-	-----------------	-----------------
NC 71	Normal	4 Harvests	50	0	0	0	0
NC 71	Normal	5 Harvests	25	0	0	50	0
NC 71	Normal+22	4 Harvests	50	0	0	0	0
NC 71	Normal+22	5 Harvests	100	0	0	0	0
Speight G 28	Normal	4 Harvests	50	0	0	50	0
Speight G 28	Normal	5 Harvests	25	0	0	75	0
Speight G 28	Normal+22	4 Harvests	25	0	0	75	0
Speight G 28	Normal+22	5 Harvests	75	0	0	25	0
McNair 944	Normal	4 Harvests	25	0	0	50	0
McNair 944	Normal	5 Harvests	50	0	0	50	0
McNair 944	Normal+22	4 Harvests	25	0	0	50	0
McNair 944	Normal+22	5 Harvests	50	0	0	50	0
K 326	Normal	4 Harvests	0	0	0	0	0
K 326	Normal	5 Harvests	25	0	0	25	0
K 326	Normal+22	4 Harvests	25	0	0	0	0
K 326	Normal+22	5 Harvests	25	25	0	0	0
Main Effect Means							
Variety							
NC 71						13	
Speight G 28						56	
McNair 944						50	
K 326						6	
LSD (P=.05)							
Variety			NS	NS	NS	32	NS
N-Rate			NS	NS	NS	NS	NS
Harvest			NS	NS	NS	NS	NS
Var * N			NS	NS	NS	NS	NS
Var * Harv			NS	NS	NS	NS	NS
N * Harv			NS	NS	NS	NS	NS
Var * N * Harv			NS	NS	NS	NS	NS

Table 15. Effect of treatment on cured-leaf color at Duplin County, 2002

Treatments			Color				
			KF	F	FR	K	N1BO
Variety	Topping Height	Harvest	---------------------------------------%---------------------------------------				
Speight 168	Normal	4 Harvests	0	25	50	25	0
Speight 168	Normal	5 Harvests	0	0	100	0	0
Speight 168	Normal+22	4 Harvests	0	0	50	25	0
Speight 168	Normal+22	5 Harvests	25	0	25	25	0
NC 71	Normal	4 Harvests	0	25	25	50	0
NC 71	Normal	5 Harvests	0	0	50	50	0
NC 71	Normal+22	4 Harvests	0	25	0	50	0
NC 71	Normal+22	5 Harvests	0	0	25	75	0
K 326	Normal	4 Harvests	0	50	50	0	0
K 326	Normal	5 Harvests	0	0	25	75	0
K 326	Normal+22	4 Harvests	0	0	0	75	0
K 326	Normal+22	5 Harvests	0	0	100	0	0
Main Effect Means							
Harvest							
4 Harvests				21	29		
5 Harvests				0	54		
LSD (P=.05)							
Variety			NS	NS	NS	NS	NS
N-Rate			NS	NS	NS	NS	NS
Harvest			NS	18	24	NS	NS
Var * N			NS	NS	NS	NS	NS
Var * Harv			NS	NS	NS	NS	NS
N * Harv			NS	NS	NS	NS	NS
Var * N * Harv			NS	NS	59	67	NS

Table 16. Effect of treatment on cured-leaf color at Forsyth County, 2002

Treatments			Color				
			KF	F	FR	K	N1BO
Variety	Topping Height	Harvest	---------------------------------------%---------------------------------------				
Speight 168	Normal	4 Harvests	25	50	0	25	0
Speight 168	Normal	5 Harvests	25	50	0	25	0
Speight 168	Normal+22	4 Harvests	0	100	0	0	0
Speight 168	Normal+22	5 Harvests	25	25	0	50	0
NC 71	Normal	4 Harvests	0	75	0	25	0
NC 71	Normal	5 Harvests	0	100	0	0	0
NC 71	Normal+22	4 Harvests	25	25	0	50	0
NC 71	Normal+22	5 Harvests	25	75	0	0	0
K 326	Normal	4 Harvests	50	50	0	0	0
K 326	Normal	5 Harvests	25	25	0	50	0
K 326	Normal+22	4 Harvests	50	25	0	25	0
K 326	Normal+22	5 Harvests	0	75	0	25	0
LSD (P=.05)							
Variety			NS	NS	NS	NS	NS
N-Rate			NS	NS	NS	NS	NS
Harvest			NS	NS	NS	NS	NS
Var * N			NS	NS	NS	NS	NS
Var * Harv			NS	NS	NS	NS	NS
N * Harv			NS	NS	NS	NS	NS
Var * N * Harv			NS	NS	NS	NS	NS

Table 17. Effect of treatment on cured-leaf color at Rockingham County, 2002

Treatments			Color				
			KF	F	FR	K	N1BO
Variety	Topping Height	Harvest	--------------------	--------------------	%	--------------------	--------------------
Speight 168	Normal	4 Harvests	25	0	0	75	0
Speight 168	Normal	5 Harvests	25	0	0	75	0
Speight 168	Normal+22	4 Harvests	0	0	0	100	0
Speight 168	Normal+22	5 Harvests	25	25	0	50	0
NC 71	Normal	4 Harvests	25	25	0	50	0
NC 71	Normal	5 Harvests	25	0	0	75	0
NC 71	Normal+22	4 Harvests	25	0	0	50	0
NC 71	Normal+22	5 Harvests	25	0	0	75	0
K 326	Normal	4 Harvests	0	25	0	50	0
K 326	Normal	5 Harvests	50	0	0	25	0
K 326	Normal+22	4 Harvests	25	0	0	75	0
K 326	Normal+22	5 Harvests	50	0	0	50	0
LSD (P=.05)							
Variety			NS	NS	NS	NS	NS
N-Rate			NS	NS	NS	NS	NS
Harvest			NS	NS	NS	NS	NS
Var * N			NS	NS	NS	NS	NS
Var * Harv			NS	NS	NS	NS	NS
N * Harv			NS	NS	NS	NS	NS
Var * N * Harv			NS	NS	NS	NS	NS

Table 18. Effect of treatment on cured-leaf color at the Border Belt Tobacco Research Station, 2003

Treatments			Color				
			KF	F	FR	K	N1BO
Variety	Topping Height	Harvest	-------------------	-------------------	%	-------------------	-------------------
NC 71	Normal	4 Harvests	0	100	0	0	0
NC 71	Normal	5 Harvests	0	100	0	0	0
NC 71	High	4 Harvests	0	100	0	0	0
NC 71	High	5 Harvests	25	75	0	0	0
Speight G 28	Normal	4 Harvests	0	100	0	0	0
Speight G 28	Normal	5 Harvests	0	100	0	0	0
Speight G 28	High	4 Harvests	0	100	0	0	0
Speight G 28	High	5 Harvests	0	100	0	0	0
McNair 944	Normal	4 Harvests	0	50	0	50	0
McNair 944	Normal	5 Harvests	0	100	0	0	0
McNair 944	High	4 Harvests	0	100	0	0	0
McNair 944	High	5 Harvests	0	75	0	25	0
K 326	Normal	4 Harvests	0	100	0	0	0
K 326	Normal	5 Harvests	0	100	0	0	0
K 326	High	4 Harvests	0	100	0	0	0
K 326	High	5 Harvests	0	100	0	0	0
Main Effect Means							
Variety							
NC 71						0	
Speight G 28						0	
McNair 944						19	
K 326						0	
Topping Height ∗ Harvest							
Normal ∗ 4 Harvests				88			
High ∗ 4 Harvests				100			
Normal ∗ 5 Harvests				100			
High ∗ 5 Harvests				88			
LSD (P=.05)							
Variety			NS	NS	NS	14	NS
Topping Hght.			NS	NS	NS	NS	NS
Harvest			NS	NS	NS	NS	NS
Var * Top Hght			NS	NS	NS	NS	NS
Var * Harv			NS	NS	NS	NS	NS
Top Hght * Harv			NS	16	NS	NS	NS
Var * Top Hght * Harv			NS	NS	NS	28	NS

Table 19. Effect of treatment on cured-leaf color at the Central Crops Research Station, 2003

Treatments			Color				
			KF	F	FR	K	N1BO
Variety	Topping Height	Harvest	----------------------	----------	%----------	----------	----------------------
NC 71	Normal	4 Harvests	75	25	0	0	0
NC 71	Normal	5 Harvests	100	0	0	0	0
NC 71	High	4 Harvests	100	0	0	0	0
NC 71	High	5 Harvests	100	0	0	0	0
Speight G 28	Normal	4 Harvests	100	0	0	0	0
Speight G 28	Normal	5 Harvests	100	0	0	0	0
Speight G 28	High	4 Harvests	100	0	0	0	0
Speight G 28	High	5 Harvests	100	0	0	0	0
McNair 944	Normal	4 Harvests	100	0	0	0	0
McNair 944	Normal	5 Harvests	100	0	0	0	0
McNair 944	High	4 Harvests	100	0	0	0	0
McNair 944	High	5 Harvests	100	0	0	0	0
K 326	Normal	4 Harvests	100	0	0	0	0
K 326	Normal	5 Harvests	100	0	0	0	0
K 326	High	4 Harvests	100	0	0	0	0
K 326	High	5 Harvests	100	0	0	0	0
LSD (P=.05)							
Variety			NS	NS	NS	NS	NS
Topping Hght.			NS	NS	NS	NS	NS
Harvest			NS	NS	NS	NS	NS
Var * Top Hght			NS	NS	NS	NS	NS
Var * Harv			NS	NS	NS	NS	NS
Top Hght * Harv			NS	NS	NS	NS	NS
Var * Top Hght * Harv			NS	NS	NS	NS	NS

Table 20. Effect of treatment on cured-leaf color at Rockingham County, 2003

Treatments			Color				
			KF	**F**	**FR**	**K**	**N1BO**
Variety	Topping Height	Harvest	-----------------	-----------------	%	-----------------	-----------------
Speight 168	Normal	4 Harvests	0	0	0	100	0
Speight 168	Normal	5 Harvests	0	0	0	75	25
Speight 168	High	4 Harvests	0	0	0	100	0
Speight 168	High	5 Harvests	50	0	0	50	0
NC 71	Normal	4 Harvests	0	0	0	75	0
NC 71	Normal	5 Harvests	25	0	0	50	0
NC 71	High	4 Harvests	0	0	0	75	0
NC 71	High	5 Harvests	0	0	0	100	0
K 326	Normal	4 Harvests	25	0	0	75	0
K 326	Normal	5 Harvests	0	0	25	75	0
K 326	High	4 Harvests	0	0	0	100	0
K 326	High	5 Harvests	0	0	0	75	0
LSD (P=.05)							
Variety			NS	NS	NS	NS	NS
Topping Hght.			NS	NS	NS	NS	NS
Harvest			NS	NS	NS	NS	NS
Var * Top Hght			NS	NS	NS	NS	NS
Var * Harv			NS	NS	NS	NS	NS
Top Hght * Harv			NS	NS	NS	NS	NS
Var * Top Hght * Harv			NS	NS	NS	NS	NS

Table 21. Effect of treatment on cured-leaf color at Edgecombe County, 2004

Treatments		Color				
		KF	**F**	**FR**	**K**	**N1BO**
Variety	Harvest	--%--				
Speight 168	4 Harvests	0	100	0	0	0
Speight 168	5 Harvests	25	50	0	25	0
NC 71	4 Harvests	0	100	0	0	0
NC 71	5 Harvests	25	75	0	0	0
K 326	4 Harvests	0	100	0	0	0
K 326	5 Harvests	0	100	0	0	0
NC 606	4 Harvests	0	100	0	0	0
NC 606	5 Harvests	0	75	0	25	0
Main Effect Means						
Harvest						
4 Harvests			100			
5 Harvests			75			
LSD (P=.05)						
Variety		NS	NS	NS	NS	NS
Harvest		NS	23	NS	NS	NS
Variety * Harvest		NS	NS	NS	NS	NS

Table 22. Effect of treatment on cured-leaf color at Rockingham County, 2004

Treatments			Color				
			KF	F	FR	K	N1BO
Variety	Topping Height	Harvest	-----------------	-----------------	%------	-----------------	-----------------
Speight 168	Normal	4 Harvests	0	0	0	100	0
Speight 168	Normal	5 Harvests	0	0	67	33	0
Speight 168	High	4 Harvests	0	0	33	67	0
Speight 168	High	5 Harvests	0	33	33	33	0
NC 71	Normal	4 Harvests	0	0	0	100	0
NC 71	Normal	5 Harvests	0	0	33	67	0
NC 71	High	4 Harvests	0	0	33	67	0
NC 71	High	5 Harvests	0	33	0	67	0
K 326	Normal	4 Harvests	0	0	67	33	0
K 326	Normal	5 Harvests	0	0	67	33	0
K 326	High	4 Harvests	0	0	100	0	0
K 326	High	5 Harvests	0	0	67	33	0
NC 606	Normal	4 Harvests	0	0	67	33	0
NC 606	Normal	5 Harvests	0	0	100	0	0
NC 606	High	4 Harvests	0	0	100	0	0
NC 606	High	5 Harvests	0	0	33	67	0
Main Effect Means							
Variety							
Speight 168					33	58	
NC 71					17	75	
K 326					75	25	
NC 606					75	25	
Topping Height ∗ Harvest							
Normal ∗ 4 Harvests					33		
High ∗ 4 Harvests					67		
Normal ∗ 5 Harvests					67		
High ∗ 5 Harvests					33		
LSD (P=.05)							
Variety			NS	NS	38	41	NS
Topping Hght.			NS	NS	NS	NS	NS
Harvest			NS	NS	NS	NS	NS
Var * Top Hght			NS	NS	NS	NS	NS
Var * Harv			NS	NS	NS	NS	NS
Top Hght * Harv			NS	NS	38	NS	NS
Var * Top Hght * Harv			NS	NS	NS	NS	NS

Table 23. Effect of treatment on cured-leaf color at the Upper Coastal Plain Research Station, 2004

Treatments			Color				
			KF	**F**	**FR**	**K**	**N1BO**
Variety	Topping Height	Harvest	--------------------	--------------------	%--------------------	--------------------	--------------------
NC 71	Normal	4 Harvests	0	50	0	50	0
NC 71	Normal	5 Harvests	25	25	0	0	0
NC 71	High	4 Harvests	0	25	0	75	0
NC 71	High	5 Harvests	25	50	0	25	0
Speight G 28	Normal	4 Harvests	0	75	0	25	0
Speight G 28	Normal	5 Harvests	0	25	0	75	0
Speight G 28	High	4 Harvests	0	75	0	25	0
Speight G 28	High	5 Harvests	0	25	0	75	0
McNair 944	Normal	4 Harvests	0	0	0	75	25
McNair 944	Normal	5 Harvests	50	0	0	25	25
McNair 944	High	4 Harvests	25	0	0	50	25
McNair 944	High	5 Harvests	25	0	0	50	25
K 326	Normal	4 Harvests	0	50	0	0	0
K 326	Normal	5 Harvests	0	75	0	25	0
K 326	High	4 Harvests	0	50	0	25	0
K 326	High	5 Harvests	25	25	0	50	0

Table 23. Continued

	Color				
	KF	**F**	**FR**	**K**	**N1BO**
	---------------------------------%	----------------------------------			
Main Effect Means					
Variety					
NC 71		38			0
Speight G 28		50			0
McNair 944		0			25
K 326		50			0
Harvest					
4 Harvests	3				
5 Harvests	19				
Variety ∗ Harvest					
NC 71 ∗ 4 Harvests				63	
NC 71 ∗ 5 Harvests				13	
Speight G 28 ∗ 4 Harvests				25	
Speight G 28 ∗ 5 Harvests				75	
McNair 944 ∗ 4 Harvests				63	
McNair 944 ∗ 5 Harvests				38	
K 326 ∗ 4 Harvests				13	
K 326 ∗ 5 Harvests				38	
LSD (P=.05)					
Variety	NS	34	NS	NS	17
Topping Hght.	NS	NS	NS	NS	NS
Harvest	16	NS	NS	NS	NS
Var * Top Hght	NS	NS	NS	NS	NS
Var * Harv	NS	NS	NS	51	NS
Top Hght * Harv	NS	NS	NS	NS	NS
Var * Top Hght * Harv	NS	NS	NS	NS	NS

Table 24. Effect of treatment on cured-leaf color at the Border Belt Tobacco Research Station, 2004

Treatments			Color				
			KF	F	FR	K	N1BO
Variety	Topping Height	Harvest	-----------------------------------	------------------	%	------------------	-----------------------------------
NC 71	Normal	4 Harvests	0	25	0	75	0
NC 71	Normal	5 Harvests	0	50	0	50	0
NC 71	High	4 Harvests	0	50	0	50	0
NC 71	High	5 Harvests	0	25	0	75	0
Speight G 28	Normal	4 Harvests	0	25	0	75	0
Speight G 28	Normal	5 Harvests	0	25	0	75	0
Speight G 28	High	4 Harvests	0	75	0	25	0
Speight G 28	High	5 Harvests	0	25	0	75	0
McNair 944	Normal	4 Harvests	0	25	0	75	0
McNair 944	Normal	5 Harvests	0	50	0	50	0
McNair 944	High	4 Harvests	0	25	0	75	0
McNair 944	High	5 Harvests	0	0	0	100	0
K 326	Normal	4 Harvests	0	50	0	50	0
K 326	Normal	5 Harvests	0	25	0	75	0
K 326	High	4 Harvests	0	50	0	50	0
K 326	High	5 Harvests	0	25	0	75	0
LSD (P=.05)							
Variety			NS	NS	NS	NS	NS
Topping Hght.			NS	NS	NS	NS	NS
Harvest			NS	NS	NS	NS	NS
Var * Top Hght			NS	NS	NS	NS	NS
Var * Harv			NS	NS	NS	NS	NS
Top Hght * Harv			NS	NS	NS	NS	NS
Var * Top Hght * Harv			NS	NS	NS	NS	NS

Table 25. Effect of treatment on yield at the Border Belt Tobacco Research Station, Central Crops Research Station, and Upper Coastal Plain Research Station, 2003 and 2004

Treatments			Location			
			2003		2004	
			BBTRS[a]	CCRS[b]	BBTRS	UCPRS[c]
Variety	Topping Height	Harvest	---kg/ha---			
NC 71	Normal	4 Harvests	2,279	2,437	3,814	3,450
NC 71	Normal	5 Harvests	2,399	2,637	3,888	3,454
NC 71	High	4 Harvests	2,407	2,568	4,101	3,672
NC 71	High	5 Harvests	2,532	2,607	4,213	3,509
Speight G 28	Normal	4 Harvests	1,824	1,897	3,651	2,765
Speight G 28	Normal	5 Harvests	1,787	1,845	3,545	2,889
Speight G 28	High	4 Harvests	1,787	2,036	3,858	2,781
Speight G 28	High	5 Harvests	1,887	2,224	3,860	2,947
McNair 944	Normal	4 Harvests	1,711	2,236	3,435	2,507
McNair 944	Normal	5 Harvests	2,084	2,094	3,271	2,789
McNair 944	High	4 Harvests	1,987	2,299	3,676	2,921
McNair 944	High	5 Harvests	2,021	2,196	3,740	2,636
K 326	Normal	4 Harvests	2,204	2,401	4,159	3,494
K 326	Normal	5 Harvests	2,116	2,523	4,031	3,501
K 326	High	4 Harvests	2,174	2,192	4,379	3,495
K 326	High	5 Harvests	2,268	2,235	4,291	3,523

Table 25. Continued

	Location			
	2003		2004	
	BBTRS	**CCRS**	**BBTRS**	**UCPRS**
	---------------------------------kg/ha---------------------------------			
Main Effect Means				
Variety				
NC 71	2,404	2,562	4,004	3,521
Speight G 28	1,821	2,001	3,729	2,845
McNair 944	1,950	2,206	3,530	2,713
K 326	2,190	2,338	4,215	3,503
Topping Height				
Normal	2,050		3,724	
High	2,133		4,014	
Harvest				
4 Harvests	2,046			
5 Harvests	2,137			
LSD (P=.05)				
Variety	100	207	191	170
Topping Hght.	71	NS	135	NS
Harvest	71	NS	NS	NS
Var * Top Hght	NS	NS	NS	NS
Var * Harv	NS	NS	NS	NS
Top Hght * Harv	NS	NS	NS	NS
Var * Top Hght * Harv	NS	NS	NS	NS

[a] Border Belt Tobacco Research Station
[b] Central Crops Research Station
[c] Upper Coastal Plain Research Station

Table 26. Effect of treatment on grade index[a] at the Border Belt Tobacco Research Station, Central Crops Research Station, and Upper Coastal Plain Research Station, 2003 and 2004

Treatments			Location			
			2003		2004	
			BBTRS[b]	CCRS[c]	BBTRS	UCPRS[d]
Variety	Topping Height	Harvest	-------------------------------------1-100----------------------------------			
NC 71	Normal	4 Harvests	82	67	77	60
NC 71	Normal	5 Harvests	82	65	76	55
NC 71	High	4 Harvests	80	66	79	56
NC 71	High	5 Harvests	80	65	74	61
Speight G 28	Normal	4 Harvests	76	60	77	63
Speight G 28	Normal	5 Harvests	77	52	76	60
Speight G 28	High	4 Harvests	79	49	77	69
Speight G 28	High	5 Harvests	75	54	76	71
McNair 944	Normal	4 Harvests	78	62	75	56
McNair 944	Normal	5 Harvests	82	62	74	57
McNair 944	High	4 Harvests	82	60	74	53
McNair 944	High	5 Harvests	77	62	74	56
K 326	Normal	4 Harvests	81	62	79	59
K 326	Normal	5 Harvests	80	62	78	62
K 326	High	4 Harvests	81	60	80	76
K 326	High	5 Harvests	80	56	78	58

Table 26. Continued

	Location			
	2003		2004	
	BBTRS	CCRS	BBTRS	UCPRS
	------------1-100------------			
Main Effect Means				
Variety				
NC 71	81	66	77	58
Speight G 28	77	54	77	66
McNair 944	80	61	74	56
K 326	81	60	79	64
Topping Height ∗ Harvest				
Normal ∗ 4 Harvests	79			
High ∗ 4 Harvests	80			
Normal ∗ 5 Harvests	80			
High ∗ 5 Harvests	78			
LSD (P=.05)				
Variety	2	5	2	7
Topping Hght.	NS	NS	NS	NS
Harvest	NS	NS	NS	NS
Var * Top Hght	NS	NS	NS	NS
Var * Harv	NS	NS	NS	NS
Top Hght * Harv	2	NS	NS	NS
Var * Top Hght * Harv	NS	NS	NS	NS

[a] Based on U.S. Government grades; 1-100, with 100 being the best.
[b] Border Belt Tobacco Research Station
[c] Central Crops Research Station
[d] Upper Coastal Plain Research Station

Table 27. Effect of treatment on price at the Border Belt Tobacco Research Station, Central Crops Research Station, and Upper Coastal Plain Research Station, 2003 and 2004

Treatments			Location			
			2003		2004	
			BBTRS[a]	CCRS[b]	BBTRS	UCPRS[c]
Variety	Topping Height	Harvest	-----$/kg-----			
NC 71	Normal	4 Harvests	3.96	3.78	3.82	3.62
NC 71	Normal	5 Harvests	3.95	3.75	3.80	3.51
NC 71	High	4 Harvests	3.93	3.78	3.84	3.63
NC 71	High	5 Harvests	3.91	3.72	3.61	3.60
Speight G 28	Normal	4 Harvests	3.77	3.67	3.77	3.57
Speight G 28	Normal	5 Harvests	3.81	3.58	3.71	3.54
Speight G 28	High	4 Harvests	3.86	3.55	3.77	3.58
Speight G 28	High	5 Harvests	3.79	3.59	3.73	3.54
McNair 944	Normal	4 Harvests	3.86	3.69	3.70	3.33
McNair 944	Normal	5 Harvests	3.97	3.69	3.65	3.34
McNair 944	High	4 Harvests	3.95	3.70	3.64	3.37
McNair 944	High	5 Harvests	3.86	3.67	3.73	3.15
K 326	Normal	4 Harvests	3.95	3.70	3.86	3.61
K 326	Normal	5 Harvests	3.93	3.70	3.84	3.65
K 326	High	4 Harvests	3.99	3.67	3.89	3.76
K 326	High	5 Harvests	3.93	3.61	3.82	3.56
Main Effect Means						
Variety						
NC 71			3.94	3.76	3.77	3.59
Speight G 28			3.81	3.60	3.75	3.56
McNair 944			3.91	3.68	3.68	3.30
K 326			3.95	3.67	3.85	3.65
LSD (P=.05)						
Variety			0.08	0.06	0.09	0.13
Topping Hght.			NS	NS	NS	NS
Harvest			NS	NS	NS	NS
Var * Top Hght			NS	NS	NS	NS
Var * Harv			NS	NS	NS	NS
Top Hght * Harv			NS	NS	NS	NS
Var * Top Hght * Harv			NS	NS	NS	NS

[a] Border Belt Tobacco Research Station
[b] Central Crops Research Station
[c] Upper Coastal Plain Research Station

Table 28. Effect of treatment on value at the Border Belt Tobacco Research Station, Central Crops Research Station, and Upper Coastal Plain Research Station, 2003 and 2004

Treatments			Location 2003 BBTRS[a]	Location 2003 CCRS[b]	Location 2004 BBTRS	Location 2004 UCPRS[c]
Variety	Topping Height	Harvest	----------$/ha----------			
NC 71	Normal	4 Harvests	9,032	9,254	14,579	12,505
NC 71	Normal	5 Harvests	9,476	9,874	14,794	12,113
NC 71	High	4 Harvests	9,452	9,704	15,755	13,314
NC 71	High	5 Harvests	9,904	9,699	15,199	12,649
Speight G 28	Normal	4 Harvests	6,869	6,946	13,776	9,877
Speight G 28	Normal	5 Harvests	6,815	6,615	13,445	10,242
Speight G 28	High	4 Harvests	6,902	7,250	14,564	9,948
Speight G 28	High	5 Harvests	7,151	7,981	14,431	10,423
McNair 944	Normal	4 Harvests	6,637	8,246	12,721	8,379
McNair 944	Normal	5 Harvests	8,265	7,729	11,925	9,326
McNair 944	High	4 Harvests	7,870	8,515	13,383	9,859
McNair 944	High	5 Harvests	7,816	8,051	13,936	8,243
K 326	Normal	4 Harvests	8,703	8,871	16,029	12,600
K 326	Normal	5 Harvests	8,308	9,323	15,503	12,782
K 326	High	4 Harvests	8,661	8,033	17,060	13,161
K 326	High	5 Harvests	8,920	8,055	16,388	12,572
Main Effect Means						
Variety						
NC 71			9,465	9,633	15,081	12,645
Speight G 28			6,935	7,198	14,053	10,122
McNair 944			7,647	8,135	12,992	8,951
K 326			8,648	8,570	16,245	12,778
Topping Height						
Normal					14,096	
High					15,089	
LSD (P=.05)						
Variety			484	794	870	711
Topping Hght.			NS	NS	615	NS
Harvest			NS	NS	NS	NS
Var * Top Hght			NS	NS	NS	NS
Var * Harv			NS	NS	NS	NS
Top Hght * Harv			NS	NS	NS	NS
Var * Top Hght * Harv			NS	NS	NS	NS

[a] Border Belt Tobacco Research Station
[b] Central Crops Research Station
[c] Upper Coastal Plain Research Station

Table 29. Effect of treatment on concentration of total alkaloids and reducing sugars at the Central Crops Research Station, 2002

Treatments			Total Alkaloids	Reducing Sugars
Variety	N-Rate	Harvest	----------%----------	
NC 71	Normal N	4 Harvests	2.31	13.9
NC 71	Normal N	5 Harvests	2.18	15.6
NC 71	Normal+22	4 Harvests	2.38	14.2
NC 71	Normal+22	5 Harvests	2.50	14.5
Speight G 28	Normal N	4 Harvests	2.08	13.5
Speight G 28	Normal N	5 Harvests	2.00	15.0
Speight G 28	Normal+22	4 Harvests	2.22	13.9
Speight G 28	Normal+22	5 Harvests	2.18	15.4
McNair 944	Normal N	4 Harvests	2.49	17.3
McNair 944	Normal N	5 Harvests	2.84	16.5
McNair 944	Normal+22	4 Harvests	2.68	14.9
McNair 944	Normal+22	5 Harvests	2.84	14.7
K 326	Normal N	4 Harvests	2.03	13.2
K 326	Normal N	5 Harvests	2.19	15.3
K 326	Normal+22	4 Harvests	2.24	12.5
K 326	Normal+22	5 Harvests	2.26	12.0
Main Effect Means				
Variety				
NC 71			2.34	14.5
Speight G 28			2.12	14.4
McNair 944			2.71	15.8
K 326			2.18	13.2
N-Rate				
Normal N			2.26	15.0
Normal+22			2.41	14.0
LSD (P=.05)				
Variety			0.17	1.2
N-Rate			0.12	0.80
Harvest			NS	NS
Var ∗ N			NS	NS
Var ∗ Harv			NS	NS
Var ∗ N ∗ Harv			NS	NS

Table 30. Effect of treatment on concentration of total alkaloids and reducing sugars at the Border Belt Tobacco Research Station and Central Crops Research Station, 2003

Treatments			Location			
			BBTRS[a]		CCRS[b]	
			Total Alkaloids	Reducing Sugars	Total Alkaloids	Reducing Sugars
Variety	Topping Height	Harvest	%			
NC 71	Normal	4 Harvests	2.03	17.7	1.04	25.5
NC 71	Normal	5 Harvests	1.83	19.3	1.14	25.1
NC 71	High	4 Harvests	1.80	16.4	0.93	25.6
NC 71	High	5 Harvests	1.74	18.6	0.95	25.1
Speight G 28	Normal	4 Harvests	1.57	19.2	0.83	24.0
Speight G 28	Normal	5 Harvests	1.65	17.8	0.81	24.2
Speight G 28	High	4 Harvests	1.68	17.7	0.83	24.2
Speight G 28	High	5 Harvests	1.61	17.9	0.82	24.3
McNair 944	Normal	4 Harvests	2.14	18.9	1.23	24.6
McNair 944	Normal	5 Harvests	2.20	19.6	1.20	25.0
McNair 944	High	4 Harvests	2.22	17.9	1.13	24.9
McNair 944	High	5 Harvests	2.15	18.9	1.22	25.2
K 326	Normal	4 Harvests	1.70	20.3	0.90	25.5
K 326	Normal	5 Harvests	1.64	19.6	0.88	25.1
K 326	High	4 Harvests	1.70	18.7	0.79	24.6
K 326	High	5 Harvests	1.57	19.3	0.78	25.1
Main Effect Means						
Variety						
NC 71			1.85	18.0	1.01	25.3
Speight G 28			1.63	18.1	0.82	24.2
McNair 944			2.18	18.8	1.19	24.9
K 326			1.65	19.5	0.84	25.3
Topping Height						
Normal				19.0		
High				18.2		
LSD (P=.05)						
Variety			0.13	1.1	0.10	0.70
Topping Hght.			NS	0.8	NS	NS
Harvest			NS	NS	NS	NS
Var * Top Hght			NS	NS	NS	NS
Var * Harv			NS	NS	NS	NS
Top Hght * Harv			NS	NS	NS	NS
Var * Top Hght * Harv			NS	NS	NS	NS

[a] Border Belt Tobacco Research Station

[b] Central Crops Research Station

Table 31. Effect of treatment on concentration of total alkaloids and reducing sugars at the Border Belt Tobacco Research Station and Upper Coastal Plain Research Station, 2004

Treatments			Location			
			BBTRS[a]		UPCRS[b]	
			Total Alkaloids	Reducing Sugars	Total Alkaloids	Reducing Sugars
Variety	Topping Height	Harvest	------------------	-------%	------------------	------------------
NC 71	Normal	4 Harvests	3.05	14.1	2.03	17.4
NC 71	Normal	5 Harvests	3.28	14.1	2.30	16.8
NC 71	High	4 Harvests	3.03	15.0	1.92	18.3
NC 71	High	5 Harvests	3.00	15.2	2.00	18.3
Speight G 28	Normal	4 Harvests	3.18	13.0	1.91	16.7
Speight G 28	Normal	5 Harvests	2.89	13.2	1.75	17.1
Speight G 28	High	4 Harvests	2.59	14.6	1.66	17.1
Speight G 28	High	5 Harvests	2.82	14.5	1.68	16.5
McNair 944	Normal	4 Harvests	3.00	15.6	2.06	18.2
McNair 944	Normal	5 Harvests	3.04	15.6	2.12	18.3
McNair 944	High	4 Harvests	2.75	16.0	2.10	17.6
McNair 944	High	5 Harvests	2.87	18.0	2.07	17.7
K 326	Normal	4 Harvests	2.88	15.2	1.81	18.8
K 326	Normal	5 Harvests	3.12	14.3	2.04	17.2
K 326	High	4 Harvests	2.74	15.9	1.88	18.5
K 326	High	5 Harvests	3.01	14.9	1.94	17.7
Main Effect Means						
Variety						
NC 71				14.6	2.06	17.7
Speight G 28				13.8	1.75	16.8
McNair 944				16.3	2.09	17.9
K 326				15.1	1.92	18.0
Topping Height						
Normal			3.05		2.00	
High			2.85		1.91	
LSD (P=.05)						
Variety			NS	1.6	0.12	0.8
Topping Hght.			0.17	NS	0.09	NS
Harvest			NS	NS	NS	NS
Var * Top Hght			NS	NS	NS	NS
Var * Harv			NS	NS	NS	NS
Top Hght * Harv			NS	NS	NS	NS
Var * Top Hght * Harv			NS	NS	NS	NS

[a] Border Belt Tobacco Research Station

[b] Upper Coastal Plain Research Station

Table 32. Percentage of tips assigned by color from 2002, 2003, and 2004

Color[a]	Tips[b]
	-----%-----
G	0
GK	5
V	16
KL	29
KF	28
KM	28
F	31
FR	52
K	42
N1BO	87

[a] Colors from G to N1BO are arranged relatively by degree of ripeness with G being unripe and N1BO being overripe.
[b] Percentage of companies that assigned a tip grade.

Effect of Lower-Leaf Removal and Harvest Method on the Agronomic Characteristics of Flue-Cured Tobacco

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ABSTRACT

Research was conducted at one location in 2003 and one in 2004 to evaluate the effect of lower-leaf removal on the yield and quality of flue-cured tobacco. Six treatments were included in the test in which the two controls involved no lower-leaf removal but were harvested three or four times. The other four treatments included a combination of removing the bottom four or eight leaves and harvesting the remainder of the leaves either two or three times.

For both years of research, the most significant decreases in yield and value per hectare occurred with removing eight leaves. This occurred regardless of the harvest method. Removing four leaves had a minimal impact on yield and value. No significant differences were observed in grade distribution in either year of lower-leaf removal research.

ADDITIONAL KEY WORDS

Tobacco, lower-leaf removal, harvest

INTRODUCTION

Due to the need to provide a blend desired by the consumer, high-quality leaf is desired by the tobacco industry. High-quality leaf that is key to blending the desired taste, generally comes from the upper-stalk regions of the plant. Other than a good filling value, which is the amount of tobacco occupying a given space, leaves from lower stalk positions contribute very little to a blended product. Primings and lugs offer the least flavor contribution and have the lowest nicotine content among all stalk positions (7). The cutter stalk position is generally used as a modifier, but only a ripe cutter grade can impart some flavor contribution (7).

Along with low demand due to poor flavor contribution and quality, lower-leaf stalk positions also contribute the least to overall yield. In 1972, Brown and Terrill (5) determined the relative yield for a twenty-leaf plant by stalk position. From the lowest stalk position to the highest, in four leaf increments, relative yield was 12.6%, 20.2%, 25.1%, 23.2%, and 18.2%. The lowest stalk position (the bottom four leaves) contributed the least to overall yield. Research conducted by White and Matzinger (10) showed similar results in that relative yield generally increased with higher stalk positions.

Lower-leaf regions of the plant are associated with low-demand leaf and the price per kilogram illustrates their reduced importance compared to other leaves from different stalk positions. In 2004, a leading manufacturer paid $0.81 less per kilogram for a first quality priming than it did for a first quality tip (2). When considering that the first quality tip was the highest price at $4.51 per kilogram , the $0.81 pay decrease results in an 18% pay difference between the two first quality stalk positions. Another leading manufacturer paid $0.66 less per kilogram for a first quality priming than for a first quality tip (1). This results in a 15% pay difference. Considering yield and price, the lower stalk positions have the lowest gross income of any stalk position on the tobacco plant.

Due to the low relative yields, less desirable chemical qualities, and low prices associated with leaves from the lower stalk positions, a number of lower-leaf removal studies have been conducted. Court and Hendel (6) showed that lower-leaf removal had a negative impact on yield when addition of upper-stalk leaves was not imposed while differences in total alkaloids and reducing sugars were not significant. Black (3) conducted research with mammoth (photoperiod-sensitive) cultivars and concluded that the addition of six upper-stalk leaves tended to overcompensate for the weight of the four leaves discarded from the bottom of the plant. Thus, based on the studies, the removal of less desirable lower-stalk leaves without the addition of upper-stalk leaves will result in decreased yield.

Other than the addition of upper-stalk leaves, lower-leaf removal in conjunction with harvest method could possibly aid in increasing leaf quality and gross income. A number of harvest studies, not including lower-leaf removal, have been conducted. Brown and Terrill (5) compared a normal harvest method to a once-over harvest and reported that tobacco from the normal harvest method had a greater yield, value, and price than that harvested by the once-over method. In contrast, Johnson (8) found that tobacco harvested in two or three equal primings produced yields similar to that harvested in six primings, but average market price was generally reduced with the two or three harvest method as compared to that from six primings. Overall, previous research has shown that gross income is greatest with multiple harvests due to yield and/or price increase.

The objective of this study was to determine the effect of lower-leaf removal and harvest method on the agronomic characteristics of flue-cured tobacco.

METHODS AND MATERIALS

In 2003, a field experiment was conducted at an on-farm location in Person County. In 2004, a field experiment was conducted at the Upper Coastal Plain Research Station. The cultivar NC 606 was utilized in Person County and K 346 was planted at the Upper Coastal Plain Research Station.

Treatments for 2003 research at the on-farm location in Person County and 2004 research at the Upper Coastal Plain Research Station were the same, involving lower leaf removal and harvest method variables (Table 1).

Table 1. Treatments imposed in the lower-leaf removal studies, 2003 and 2004

Treatment Number	Description
1	Control (4 equal harvests)
2	Control (3 equal harvests)
3	Remove 4 leaves and harvest 3 times
4	Remove 4 leaves and harvest 2 times
5	Remove 8 leaves and harvest 3 times
6	Remove 8 leaves and harvest 2 times

Treatments were arranged in a randomized complete block design with four replications. In 2003, the Person County field experiment consisted of four rows, 15.2 meters long. Plot rows consisted of two rows, 12.2 meters long at the Upper Coastal Plain Research Station. Plant spacing was 0.56 meters by 1.22 meters. Agronomic production methods recommended by the North Carolina Cooperative Extension Service (9) and normal production practices for each location were followed. Leaf removal was imposed at the time of topping (early flower stage). All plot rows of tobacco were harvested according to treatment and stalk position and then cured in rack type bulk curing systems. The leaves were then weighed by stalk position, assigned an Official U.S. Government grade, and yield and grade index (4) were calculated.

RESULTS

2003

Yield, price, and value differences were observed among treatments at Person County in 2003 while grade index was not significant (Table 2). Three and four harvest controls were higher yielding than removing four leaves and harvesting three times and both eight-leaf removal treatments. Price differences were small but statistically significant. Harvesting three equal times resulted in lower prices than removing eight leaves and harvesting three times, and removing four leaves and harvesting twice. Value differences were primarily a factor of yield differences where the three and four harvest controls were higher in value than removing four leaves/harvested three times and both eight-leaf removal treatments.

The percentage of tobacco that received lug (X), cutter (C), and leaf (B) grades did not differ due to treatment (Table 3). However, removing four leaves and harvesting three times was the only treatment that received an X grade, which is the most likely cause of a lower value per hectare than both control treatments and removing four leaves and harvesting twice.

2004

Yield, grade index, price, value, and reducing sugar significances were observed at the Upper Coastal Plain Research Station (Table 4). Three and four harvest controls were higher yielding and received a higher value per hectare than removing four leaves/harvested two times and both eight-leaf removal treatments. Removing eight leaves, whether harvesting two or three times, resulted in a lower yield and value per hectare than all other treatments. Three equal harvests and removing eight leaves/harvested two or three times received higher grade indices than removing four leaves and harvesting twice. Price differences were only observed with one treatment in which removing four leaves/harvested two times resulted in a lower price per kilogram than all of the other treatments except the control of three harvests. No differences related to treatment were observed in total alkaloid concentration. Although statistical differences were observed in the concentration of reducing sugars, differences were agronomically insignificant due to the small range of difference. None of the six treatments affected grade distribution (Table 5).

DISCUSSION

During 2003 and 2004 research, lower-leaf removal had a pronounced affect on yield and value per hectare. Harvest method, whether removing four or eight leaves or with no lower-leaf removal, did not significantly affect yield or value per hectare. Previous research has shown that lower stalk positions contribute the least to yield (5). However, removal of these leaves at the early flowering stage with the hypothesis that weight would be shifted to higher stalk positions to moderate potential yield loss proved to be false.

In 2003, removing four leaves resulted in a nine percent yield and an eleven percent value per hectare loss compared to a 23% yield and 22% value per hectare loss when removing eight leaves (Table 2). In 2004, removing four leaves resulted in a four percent yield and five percent value per hectare loss compared to a 21% yield and 20% value per hectare loss when removing eight leaves (Table 4). Although the removal of four lower-leaves was a more logical choice, with its smaller affect on yield and value, this practice along with removing eight leaves did not achieve the intended purpose of decreasing or eliminating lower stalk grades. Grade distribution differences were not observed at either test locations (Tables 3, 5).

One of the potential impacts of lower-leaf removal would be an increase in average price due to a shifting of grade distribution to upper-stalk grades. Such an increase would compensate for yield loss. However, increases in grade index and price per kilogram were small with the leaf removal treatments and showed a lack of consistency. The only difference in grade index was observed in 2004 in which both eight-leaf removal treatments were greater than removing four leaves and harvesting twice. Both eight-leaf removal treatments were only higher than removing four leaves and harvesting twice in 2003 and in 2004 removing eight leaves and harvesting three times was only higher than removing four leaves and harvesting three times. Compared to the controls, removing lower stalk leaves, whether four or eight, did not affect grades or price per kilogram enough to compensate for the yield loss as shown by the decline in value per hectare.

Since removing four or eight leaves did not statistically decrease or eliminate lug grades, other factors should be studied for their effect on grade distribution and reducing lower quality leaf grades. Although, when compared to no lower-leaf removal, removing eight leaves sometimes showed increases in grade index, price per kilogram, and saves about $400 in harvesting/handling labor, curing fuel, and electricity costs, this will not sufficiently compensate for the 20% percent or more yield and value per hectare loss. In order for grower income to remain the same, companies would have to substantially increase the average price per kilogram paid for upper-stalk leaves.

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Table 2. Effect of treatment on yield, grade index, price, and value at Person County, 2003

Treatments	Yield	Grade Index[a]	Price	Value
	kg/ha	1-100	$/kg	$/ha
Control (4 Harvests)	3,567 a	89 a	4.10 ab	14,806 a
Control (3 Harvests)	3,483 a	88 a	4.08 b	14,211 a
Remove 4 Leaves, Harvest 3 X	2,938 bc	90 a	4.10 ab	11,362 b
Remove 4 Leaves, Harvest 2 X	3,456 ab	90 a	4.15 a	14,357 a
Remove 8 Leaves, Harvest 3 X	2,809 c	88 a	4.15 a	11,651 b
Remove 8 Leaves, Harvest 2 X	2,645 c	90 a	4.12 ab	10,914 b

[a] Based on U.S. Government grades; 1-100 scale, with 100 being the best.
Means followed by same letter do not significantly differ (P=.05, LSD)

Table 3. Effect of lower-leaf removal on grade distribution at Person County, 2003

Treatments	X	C	B
	---	-%-	---
Control (4 Harvests)	0 a	47 a	53 a
Control (3 Harvests)	0 a	46 a	54 a
Remove 4 Leaves, Harvest 3 X	8 a	38 a	54 a
Remove 4 Leaves, Harvest 2 X	0 a	33 a	67 a
Remove 8 Leaves, Harvest 3 X	0 a	31 a	69 a
Remove 8 Leaves, Harvest 2 X	0 a	40 a	60 a

Means followed by same letter do not significantly differ (P=.05, LSD)

Table 4. Effect of treatment on yield, grade index, price, value, total alkaloids, and reducing sugars at the Upper Coastal Plain Research Station, 2004

Treatments	Yield	Grade Index[a]	Price	Value	Total Alkaloids	Reducing Sugars
	kg/ha	1-100	$/kg	$/ha	------------%------------	
Control (4 Harvests)	2,735 ab	65 ab	3.79 a	10,374 ab	1.69 a	20.6 ab
Control (3 Harvests)	2,901 a	70 a	3.77 ab	10,942 a	1.67 a	21.0 a
Remove 4 Leaves, Harvest 3 X	2,781 ab	66 ab	3.83 a	10,646 ab	1.74 a	20.6 ab
Remove 4 Leaves, Harvest 2 X	2,642 b	54 b	3.66 b	9,663 b	1.71 a	20.8 a
Remove 8 Leaves, Harvest 3 X	2,216 c	70 a	3.87 a	8,569 c	1.94 a	19.7 b
Remove 8 Leaves, Harvest 2 X	2,235 c	75 a	3.81 a	8,513 c	1.79 a	20.7 a

[a] Based on U.S. Government grades; 1-100 scale, with 100 being the best.
Means followed by same letter do not significantly differ (P=.05, LSD)

Table 5. Effect of lower-leaf removal on grade distribution at the Upper Coastal Plain Research Station, 2004

Treatments	X	C	B
	--	%	--
Control (4 Harvests)	25 a	24 a	51 a
Control (3 Harvests)	35 a	8 a	57 a
Remove 4 Leaves, Harvest 3 X	37 a	0 a	63 a
Remove 4 Leaves, Harvest 2 X	26 a	23 a	51 a
Remove 8 Leaves, Harvest 3 X	13 a	29 a	58 a
Remove 8 Leaves, Harvest 2 X	12 a	39 a	49 a

Means followed by same letter do not significantly differ (P=.05, LSD)