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## **Burley Tobacco Quality, Yield and Chemical Composition as Affected by Time of Harvest**

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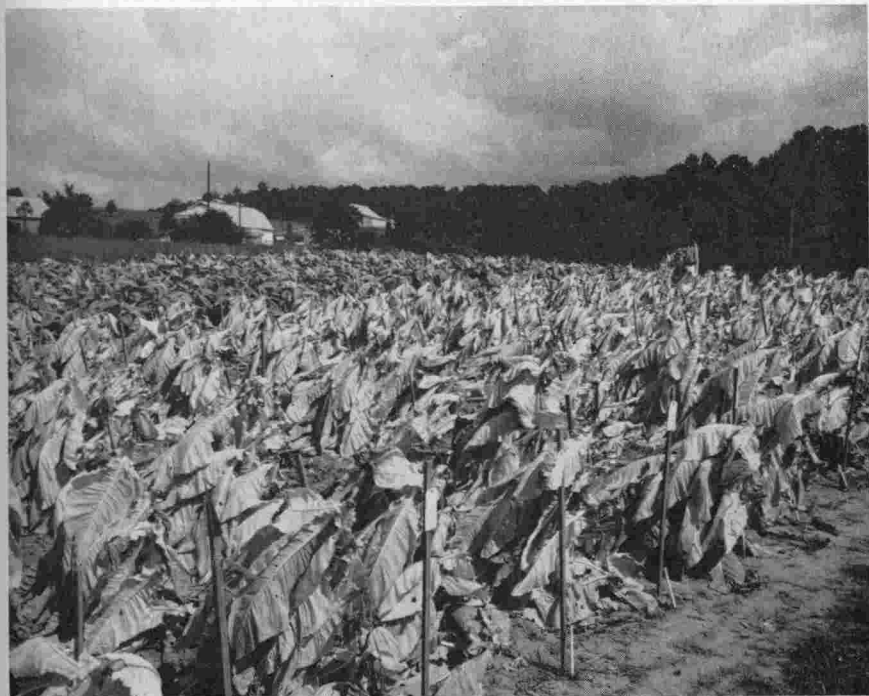
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# BURLEY TOBACCO QUALITY, YIELD AND CHEMICAL COMPOSITION AS AFFECTED BY TIME OF HARVEST

H. E. Heggestad and D. R. Bowman



THE UNIVERSITY OF TENNESSEE  
AGRICULTURAL EXPERIMENT STATION

in cooperation with

THE BUREAU OF PLANT INDUSTRY,  
SOILS AND AGRICULTURAL ENGINEERING,  
U. S. DEPARTMENT OF AGRICULTURE

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# BURLEY TOBACCO QUALITY, YIELD AND CHEMICAL COMPOSITION AS AFFECTED BY TIME OF HARVEST<sup>1</sup>

H. E. Heggstad and D. R. Bowman<sup>2</sup>

## INTRODUCTION

The stage of maturity at which burley tobacco is harvested has a pronounced effect upon yield, grade quality, and smoking properties. Moreover, the relative maturity of tobacco is closely associated with changes in chemical composition, affecting smoking quality and usage of certain grades in cigarette manufacture which is the principal use of burley tobacco. Although blends vary, approximately one-third of the tobacco in cigarettes consists of "smoking" grades of burley.

The optimum time of harvesting depends upon several factors including weather conditions, development of diseases, soil fertility, cultural practices, growers' judgment of maturity, and labor available for harvest. During a normal or good growing season, burley is at optimum maturity and should be harvested when the middle leaves of most plants are yellowed.

At least three significant causes for variation in maturity of harvested leaves are recognized. First, unfavorable growing conditions, causing premature "firing" of lower leaves, may make early harvest necessary; that is, the grower's decision to harvest usually is a compromise between preventing undue loss of lower leaves and obtaining more maturity and higher quality in the upper leaves. Second, there is variation in maturity due to differences in rate of plant growth within rows transplanted and harvested at the same time, some plants showing bloom much earlier or later than others. This cause of variation may be of minor importance if healthy plants of uniform size are transplanted under the most favorable conditions for growth. Third, there is variation in maturity closely associated with the normal differences in leaf position on the stalk. The older bottom leaves normally are yellow and ripe three to four weeks before the top leaves become yellow; and, with stalk-

<sup>1</sup>Grateful acknowledgement is made to the Research Department of the American Tobacco Company, which provided the analytical data for Figures 9 through 13; to members of the Division of Tobacco, Medicinal and Special crops, especially Dr. R. N. Jeffrey and Dr. C. W. Bacon for review of the manuscript and for their helpful suggestions; to Superintendent J. Hugh Felts of the Tobacco Experiment Station at Greeneville for assistance in conducting field experiments; to R. E. Wright and M. Ogle Neas for assistance in preparation of graphs; and to the Federal Grading Service, Tobacco Branch, Production and Marketing Administration for appraisal of grade quality of the tobacco.

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cut, unprimed tobacco such as burley, all leaves are harvested at the same time. When stripping and making several grades based primarily upon appearance of leaves, growers usually place in a given grade leaves of about the same maturity coming from similar positions on the stalk.

Investigations reported herein are concerned with the effects of harvesting, at several stages of maturity, upon quality, yield, and chemical composition under conditions which normally exist in eastern Tennessee. The studies include both very immature and overmature tobacco.

### LITERATURE REVIEW

Some effects of harvesting burley tobacco at different stages of maturity have been studied in Kentucky. Jeffrey (7) in 1946 reported that yield and quality are increased by harvesting approximately 10 days after the stage when the lower part of the plant shows proper maturity. In 1950, following an extensive study on this problem with tobacco harvested at early, midseason, and mature stages, Byers, Bortner and Bach (3) stated: "For harvesting unprimed tobacco the optimum time is after the midseason and prior to mature harvest in normal seasons, and at the midseason stage of maturity in harvest seasons of excessive moisture."

The chemical composition of Havana tobacco as related to leaf position on the stalk was reported in 1939 by Swanback (11), and in 1940 by Hanmer, Street and Anderson (5). Recently Bowman and Nichols (2) conducted similar analytical studies using two varieties of burley tobacco. The leaf-by-leaf determinations on both Havana and burley types have shown gradual changes in chemical composition of leaves from bottom to top of plants. The lower leaves may contain no more than one-third the nicotine and total nitrogen of upper leaves. Significant differences in the content of other organic and certain inorganic compounds were found related to leaf position on the stalk.

Moseley, Harlan and Hanmer (9) studied the relation of nitrogenous fractions to smoking quality of burley tobacco, correlating chemical composition with recognized standards of quality based upon physical appearances. Analyses were presented for each of six farmers' grades to show variation in chemical composition of tobacco produced in different geographical districts and in different seasons. The chemical and physical characteristics of both desirable and undesirable cigarette smoking tobaccos were discussed.

According to these investigators, "Good quality of burley tobacco is related, in general, to a low content of total volatile bases, a high ratio of nicotine to total volatile bases, and a reasonably high mineral content."

### PROCEDURE

The experimental tobacco for investigations reported herein was grown in 1948 and 1950 on a reddish-brown, fertile soil classified as Emory silt loam. Fertilization and cultural practices which are commonly used to obtain high yields and good quality tobacco were adopted. A crimson clover cover crop and barnyard manure, applied at the rate of 10 tons per acre, were turned under about four weeks before transplanting. Additional fertilization included 500 pounds of 3-9-6 commercial fertilizer per acre, applied as a broadcast treatment, and 300 pounds per acre as row fertilization. The amount of rainfall during both growing seasons was about normal for eastern Tennessee, being well distributed and favorable for production of high yields of well-ripened tobacco. In both seasons, there was a moderate development of *Cercospora* or "frog-eye" leaf-spot, which normally is present in eastern Tennessee and in some other portions of the burley belt. Relatively few leaves were lost from the plants, although bottom leaves were fired considerably at the latest harvests.

In 1948, Kentucky 16 was grown on all plots; and in 1950 a recently developed variety, Burley 1, having about  $\frac{1}{4}$  more leaves and producing better average grade quality than the older variety, Kentucky 16, was grown. A comparison of these varieties based upon yielding ability, grade quality, and acre value was made by Heggestad and Clayton (6).

Because the time of topping is the starting point for the harvesting treatments, and since there is considerable variation in topping procedures employed by growers, an explanation of the procedure followed with this experiment is of considerable importance. In 1948, with the variety Kentucky 16, all except a few late plants were topped when approximately 20% of the plants in the field showed some open bloom. Kentucky 16, which normally produces 23 leaves per plant, was topped, leaving about 18-19 leaves. A few late plants were topped relatively low about four days later. A similar topping procedure was used in 1950 with Burley 1, except that the first topping was made when about 5% of plants in the field showed open bloom. Burley 1, which normally produces about

30 leaves per plant, was topped, leaving about 24-25 leaves. Late plants were topped five days after the first topping. The plants of both varieties were suckered at approximately 10-day intervals, depending upon the rate of sucker growth.

Beginning one week after the first topping, the tobacco was harvested at six-day intervals for seven successive periods. Plots were 1/100-acre in size, and each treatment was included in each of four randomized blocks. Harvesting was done in the usual manner by stalk cutting. As soon as it was wilted the tobacco from each treatment was hung on adjacent tiers of the same curing barn. Curing conditions were generally favorable during both 1948 and 1950 seasons.

After leaves had cured, they were removed from the stalks and separated into six farm grades (Figure 1). The tobacco in each grade from each plot was weighed to determine relative yields.

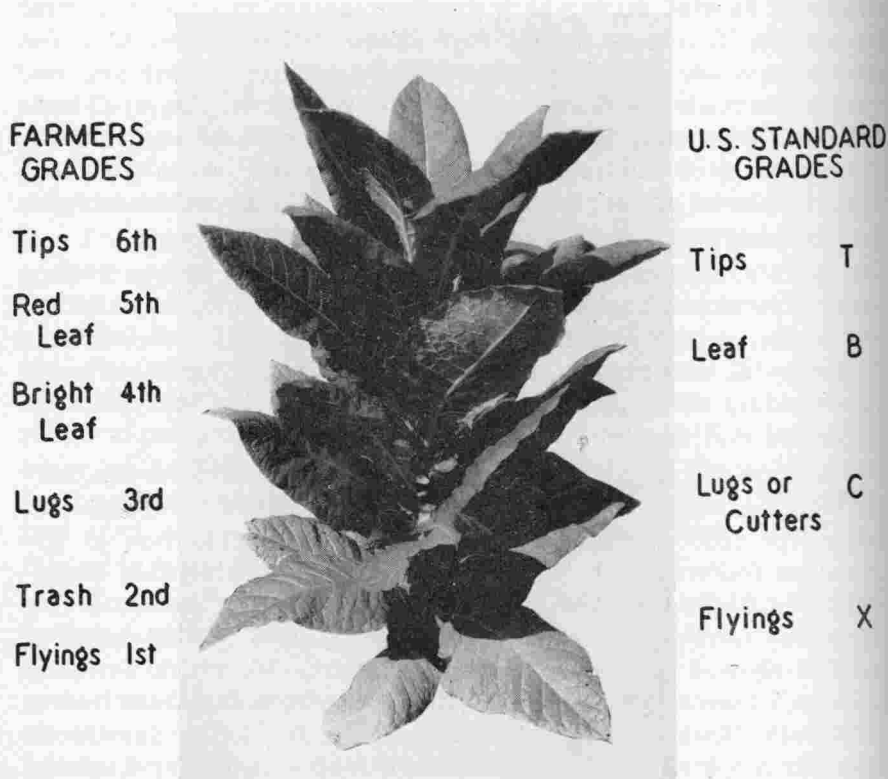


Figure 1.—Plant of Burley 1 variety, showing approximate stalk position of Farmers' Grades and groups of U. S. Standard Grades.

It was later appraised by an experienced Federal tobacco grader for evaluation of grade quality. Prices designated for each grade in both 1948 and 1950 experiments were the 1950 season's average prices for all burley markets. Grade indices were also computed, using a grade index system based on average prices of six pre-war years; however, statistical analysis revealed similar but greater differences in value between treatments, based upon average prices for these grades in the 1950 season. Consequently, only the latter evaluation of quality is used in this report. The relative amount of smoking tobacco, including all flyings, cutters, and tan-leaf grades, according to the U. S. Standard Grades Classification<sup>3</sup>, was determined for each time of harvest.

Samples were taken for chemical analyses from the second, third and fourth farm grades in all replications. These farm grades, referred to later in this report as trash, lugs, and bright leaf

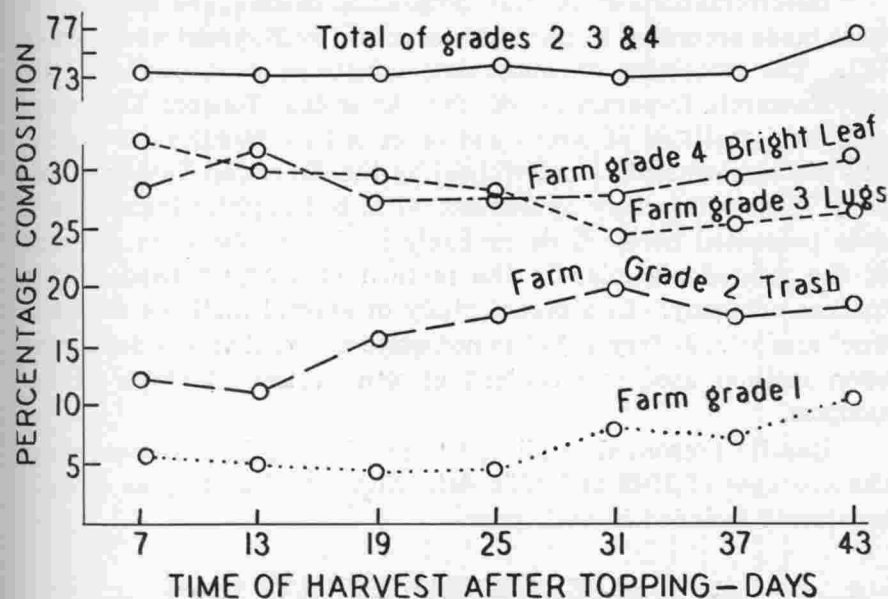


Figure 2.—The effect of time of harvest on amount of tobacco in second, third and fourth farm grades which were sampled for chemical analysis. Percentage in first grade included to show relative position of grades on the stalk.

<sup>3</sup>Key to U. S. Standard Grades:

**Groups**

T—Tips  
B—Leaf  
C—Lugs or Cutters  
X—Flyings  
N—Nondescript

**Quality**

1—Choice  
2—Fine  
3—Good  
4—Fair  
5—Low

**Color**

L—Buff or straw  
F—Tan  
FR—Reddish-tan  
R—Red  
D—Dark Red  
G—Green

For example: B3F means leaf, good quality, and tan color.



leaf, include approximately 75% of the tobacco at each harvest date (Figure 2). In 1948, one representative leaf in each of these grades from each plant in the plot was taken for the chemical sample. In 1950, all leaves in each grade from 15 representative plants per plot were taken for the chemical sample. Samples of approximately the same weight were secured by each sampling procedure. In preparing the samples for analyses, the midribs were removed and one of the leaf halves was saved for chemical analyses. The other half was used in measuring fire-holding capacity or "leaf-burn." The leaf was ignited by holding it against a glowing loop of electrically heated nichrome wire. The duration of burn was measured in seconds with the aid of a metronome. Fifty leaves in each sample were burn tested. The midribs and the half-leaf strips which were saved for chemical analyses were weighed and the yield of "strip" computed.

Determinations of nicotine, potassium, calcium and magnesium were made according to methods described by Bowman and Nichols (2). The remaining chemical determinations were conducted by the Research Department of the American Tobacco Company, analytical methods of which are described by Moseley, et al (9). The nicotine content as determined by the American Tobacco Company is in satisfactory agreement with, but slightly higher than, data presented here. This probably is due to inclusion of more of the related alkaloids in the method of analysis used by the tobacco company. In a recent study of several methods of "nicotine" analysis, Jeffrey (8) obtained quite different values depending upon method used and content of non-nicotine alkaloids in the samples.

Results presented in all of the graphs herein are based upon the averages of 1948 and 1950 data with four replications of each treatment included in each year.

## EXPERIMENTAL RESULTS

**Yield.**—In 1948, the total yield of tobacco per acre increased 336 pounds from first to fourth harvest (25 days after topping) when the yield was 2,273 pounds (Table 1). A reduction of 245 and 527 pounds per acre resulted when harvest was delayed 37 and 43 days, respectively, after topping. The yields at the first, sixth and seventh or final harvest were significantly lower than yields at either fourth or fifth harvest.

TABLE 1.—The effect of time of harvest on total yield, yield of smoking tobacco, price, and value per acre in 1948 and 1950 experiments.

1948 Experiment (Kentucky 16)						1950 Experiment (Burley 1)					
Date of harvest	Days after Topping	Yield lbs./A	Smoking <sup>b</sup> tobacco lbs./A	Price <sup>c</sup> \$/cwt	Value \$/A	Date of harvest	Days after Topping	Yield lbs./A	Smoking <sup>b</sup> tobacco lbs./A	Price <sup>c</sup> \$/cwt	Value \$/A
	days	pounds	pounds	dollars	dollars		days	pounds	pounds	dollars	dollars
Aug. 13	7	1937**	1334	50.31**	976**	Aug. 17	7	1893**	1694*	59.35**	1124**
Aug. 19	13	2082	1424	51.98**	1086*	Aug. 23	13	1967**	1747*	61.35**	1207**
Aug. 25	19	2196	1480	54.84	1206	Aug. 29	19	2065*	1825*	61.69*	1274*
Aug. 31	25 <sup>a</sup>	2273	1618	55.90	1276	Sept. 4	25 <sup>a</sup>	2284	2083	63.16	1444
Sept. 6	31	2282	1621	54.69	1249	Sept. 10	31	2046*	1868	63.25	1295*
Sept. 12	37	2028*	1292	54.44	1114*	Sept. 16	37	2010*	1769*	62.79	1262*
Sept. 18	43	1746**	1101*	55.42	969**	Sept. 22	43	1920**	1606**	60.99**	1173**
L.S.D. at	.05	220	339	2.54	145	L.S.D. at	.05	210	294	1.31	145
L.S.D. at	.01	302	465	3.48	199	L.S.D. at	.01	287	404	1.80	200

<sup>a</sup>Considered to be the normal harvest period.

<sup>b</sup>Includes all X, C, and BF grades.

<sup>c</sup>Based on 1950 season's average prices.

\*Significant difference compared to normal harvest period (25 days).

\*\*Very significant difference compared to normal harvest period (25 days).

In 1950, the total yield per acre increased 391 pounds from first to fourth harvest when the yield was 2,284 pounds. Yields were significantly lower for all harvests made either before or after the fourth harvest. Considering average results from both seasons, total yields increased about 16% during the 18-day period between first and fourth or normal harvest. Total yields decreased approximately 20% in the 18-day period between fourth and seventh or final harvest.

**Grade Quality.**—Yields of “smoking grades” were best in 1948 when harvested at the fourth and fifth periods, being 1,618 and 1,621 pounds per acre, respectively (Table 1). In 1950 a high yield of 2,083 pounds of these grades was obtained at the fourth harvest period. The increase in smoking grades from first to the fourth or optimum harvest, was 284 pounds in 1948, and 389 pounds in 1950. In both seasons there was a reduction of approximately 500 pounds per acre in yield of smoking grades from the fourth to seventh, or final harvest.

A study was made of the assigned U. S. Standard Grades<sup>4</sup> to determine the percentage composition according to group, quality and color for each time of harvest. As might be expected, there was a gradual increase in the amount of “flyings” from early to latest harvest. This increase was from 15% at first harvest to 30% at the seventh harvest. This may be attributed to firing of an increased number of lower leaves during the ripening period. Because of the large size of the tobacco, and relatively low, early topping, practically no tip leaves—leaves shorter than 16 inches—appeared after the first harvest.

Some effects of harvesting at different stages of maturity were noted on the color of the cured leaf. Lowest percentage of buff color (lightest possible) was obtained at the first harvest, and highest percentage of buff came from the third harvest. Considering combined amounts of both buff and tan colored tobacco, there was practically no change until after the fifth harvest. By the sixth and seventh harvest, however, there was a marked decrease in percentage of tan grades with comparable increases in reddish-tan tobacco. The amounts of red and dark-red leaves remained relatively constant. An appreciable quantity of “leaf” grades showing green discoloration was found at the first harvest. The tobacco in the “cutter” grades from the earliest harvest, especially in 1950, showed a distinct pinkish cast. Furthermore, immature leaves

<sup>4</sup>See footnote page 7.

from the upper portion of the plant of the first harvest darkened after curing; whereas, fully mature tobacco from later harvests showed very little change in color even after one year in storage.

Highest percentage of first and second quality tobacco, and lowest percentage of fifth quality tobacco were obtained at the fourth or middle harvest period. The earliest harvest yielded no first and second quality tobacco but more tobacco in fourth and fifth quality grades than any of the other treatments.

**Price.**—Quality evaluation based on average prices for the 1950 season showed the highest value, \$55.90 per hundredweight, at the fourth harvest period in 1948. The highest value, \$63.25 per hundredweight was received at the fifth harvest in 1950 (Table 1). Lowest average prices were received at the first harvest of both years, indicating a higher percentage of poor, undesirable tobacco at that time. Average prices for first and second harvests were significantly lower than for fourth or optimum harvest in both seasons.

**Acre Value.**—In each year, the maximum value per acre, \$1,276 in 1948, and \$1,444 in 1950, was reached at the optimum or fourth harvest, 25 days after topping. Second highest returns were from the fifth harvest period (Table 1). In each season, as a consequence of improvements in yield and average price, there was an increase of approximately \$300 per acre from first harvest to fourth harvest. Conversely, value per acre decreased approximately \$300 from fourth to the seventh or final harvest.

**“Strip” Yield.**—The yield of “strip” is an important factor in the economy of cigarette manufacturing. The midribs of leaf, lug, and in most cases trash grades, are removed and not used in cigarettes. The trash grade showed a regular decrease in yield of “strip” from 74% to 69% from first harvest to sixth harvest, 37 days after topping (Figure 3). In contrast, the bright leaf grade increased regularly in yield of “strip” from 68% to 73% from first to seventh harvest. It is apparent from these results that the “strip” yield is greatest when leaves are fully mature; however, if they become overripe, as in the trash grade, the lamina tends to shatter and “strip” yield is reduced.

**Duration of Burn.**—The duration of burn or “fire holding capacity” was highest for trash, intermediate for lugs, and lowest in

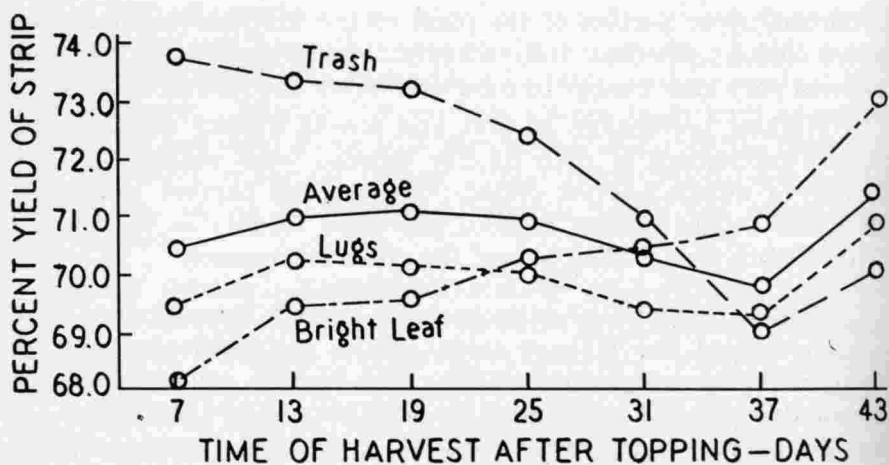


Figure 3.—The effect of time of harvest on percentage yield of leaf lamina, "Strip."

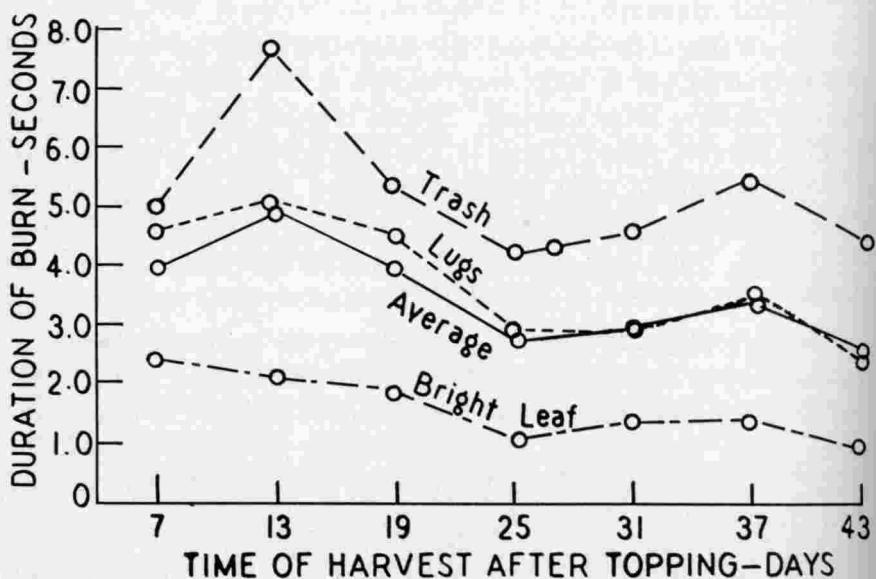


Figure 4.—The effect of time of harvest on duration of burn.

the bright leaf grades irrespective of the time of harvest (Figure 4). The best burn for the trash and lug grades was secured at the second harvest date. In general, the average burn of all three grades was better at the early harvests than at later harvests.

**Potassium.**—Considering average values for the three grades, potassium decreased from early harvest to a low level at the fourth harvest, 25 days after topping; then it apparently increased

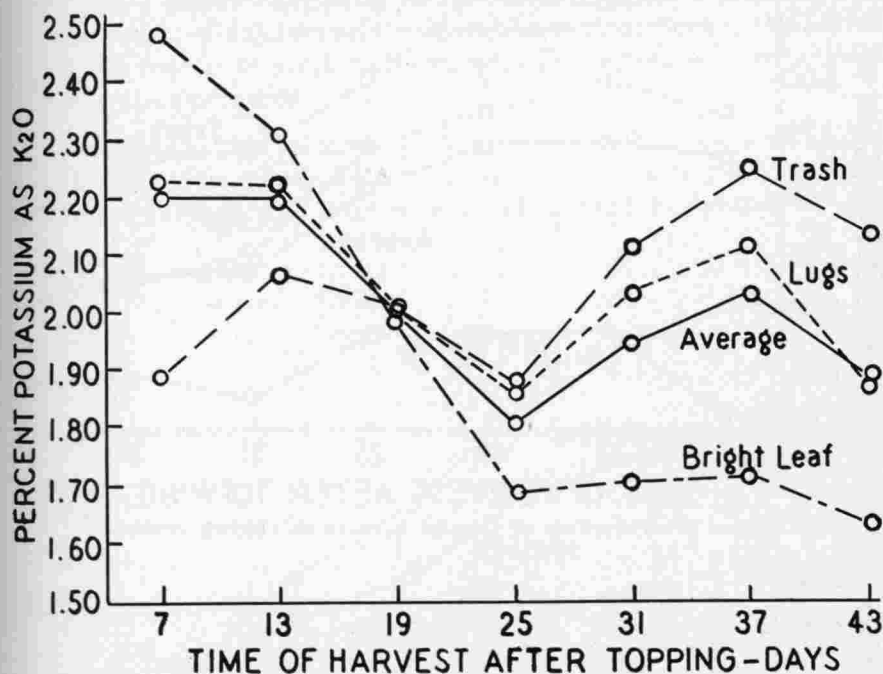


Figure 5.—The effect of time of harvest on potassium content.

(Figure 5). The decrease in potassium concentration which occurred prior to fourth harvest suggests that the amount of potassium moving into the leaves was less than the increment of dry weight. Moreover, the concentration of potassium decreased most rapidly in the leaf grade where, after topping, increases in dry matter are known to be greater than with grades lower on the plant.

The curve showing average potassium content for the three grades follows the same general pattern as the corresponding curve in Figure 4, showing duration of burn. Correlation of these two factors, which is apparent from these data, has been established by other investigators. The potassium content of all samples was relatively low for burley.

**Calcium and Magnesium.**—In general, the percentage of calcium and magnesium declined from early to late harvest (Figures

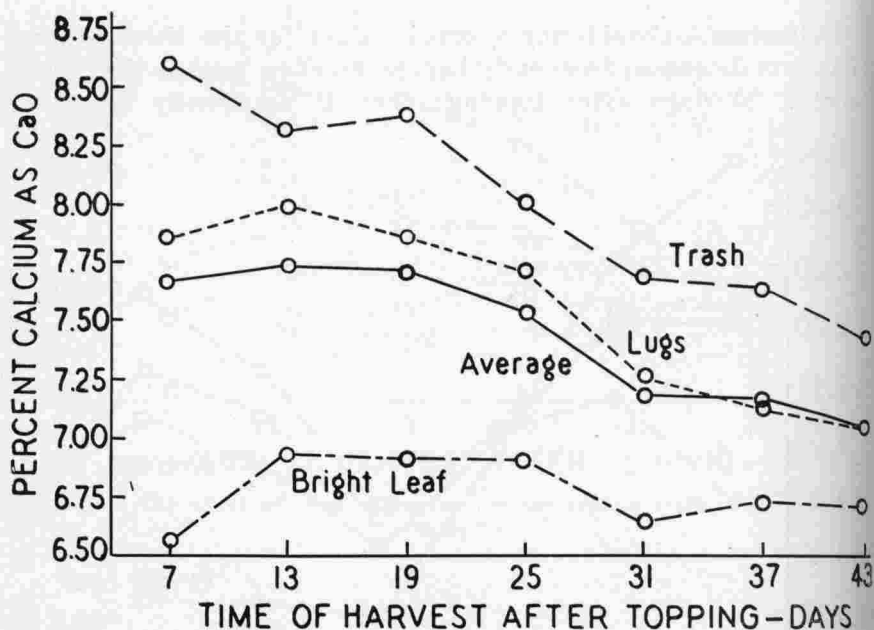


Figure 6.—The effect of time of harvest on calcium content.

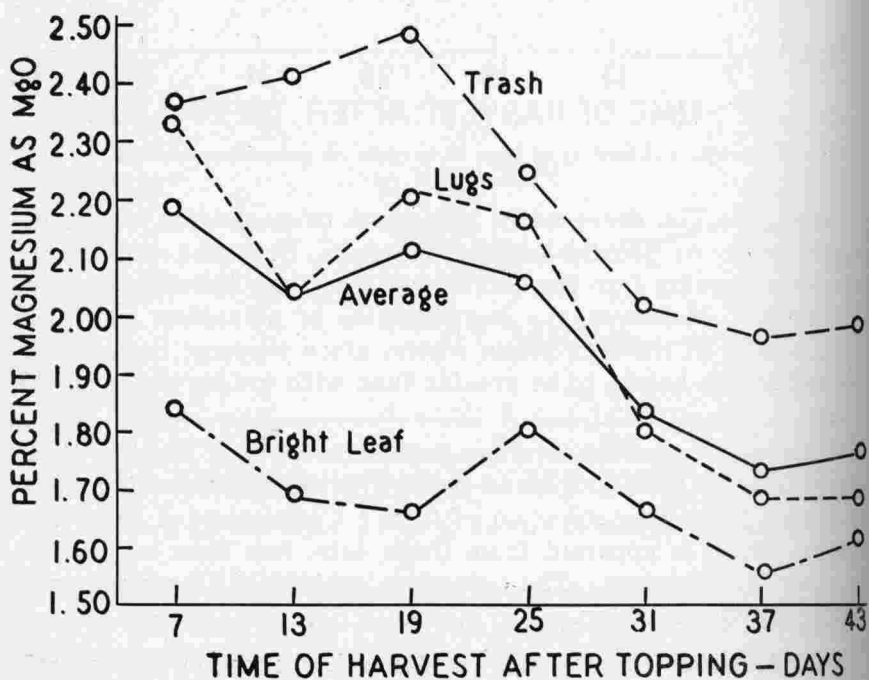


Figure 7.—The effect of time of harvest on magnesium content.

6 and 7). The content of these constituents was highest in the lower leaves, which were already formed when the rate of calcium and magnesium absorption was greatest. A comparison of Figures 5, 6, and 7 shows that each of the different grades decreased in concentration of calcium and magnesium content during the period from the fourth to sixth harvest, when an increase in potassium concentration occurred.

**Nicotine.**—The amount of nicotine in trash, lugs, and bright leaf increased regularly with maturity from first harvest to sixth harvest (Table 2 and Figure 8). Statistical evaluation of the

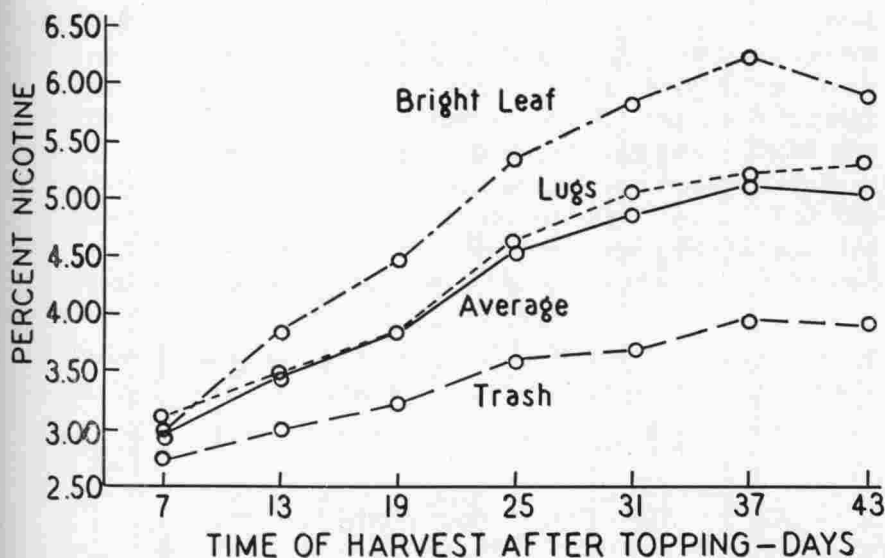


Figure 8.—The effect of time of harvest on nicotine content.

1948 and 1950 data revealed that the average nicotine content for all grades was significantly higher at the fourth harvest period than at any of the three earlier harvest periods.

Figure 8 shows a greater difference between nicotine content of trash, lugs, and bright leaf as the plants become more mature, ranging between 2.7% and 3.1% at the first harvest, and between 4.1% and 6.3% at the sixth harvest.

Because nicotine content increases gradually from bottom to top of the plant, it is evident that the amount of tobacco from each plant included in the different farm grades would affect the nicotine content for the grades as shown in Table 2. In 1948, the trash



TABLE 2.—The effect of time of harvest on nicotine content of trash, lugs, and bright leaf grades in 1948 and 1950 experiments.

1948 Experiment (Kentucky 16)						1950 Experiment (Burley 1)					
Date of harvest	Days after Topping	Nicotine content				Date of harvest	Days after Topping	Nicotine content			
		Trash	Lugs	Bright leaf	Average			Trash	Lugs	Bright leaf	Average
		per cent	per cent	per cent	per cent			per cent	per cent	per cent	per cent
Aug. 13	7	3.13**	3.55**	3.24**	3.31**	Aug. 17	7	2.33**	2.67**	2.73**	2.58**
Aug. 19	13	3.35*	3.85**	3.94	3.71**	Aug. 23	13	2.65*	3.17**	3.79**	3.20**
Aug. 25	19	3.58	4.18*	4.46	4.07*	Aug. 29	19	2.88	3.56*	4.52**	3.65**
Aug. 31	25 <sup>a</sup>	3.84	4.65	4.94	4.48	Sept. 4	25 <sup>a</sup>	3.41	4.67	5.81	4.63
Sept. 6	31	4.13	5.15*	5.81	5.03**	Sept. 10	31	3.28	5.01	5.92	4.74
Sept. 12	37	4.28*	5.14*	5.79	5.07**	Sept. 16	37	3.63	5.40	6.73*	5.25
Sept. 18	43	4.49**	5.16*	5.63	5.09**	Sept. 22	43	3.34	5.51*	6.23	5.02
L.S.D. at .05		0.42	0.46	1.03	0.34	L.S.D. at .05		0.58	0.82	0.90	0.73
L.S.D. at .01		0.58	0.64	1.42	0.47	L.S.D. at .01		0.79	1.12	1.23	1.00

<sup>a</sup>Considered to be the normal harvest period.

\*Significant difference compared with tobacco harvested at middle period (25 days).

\*\*Highly significant difference compared with tobacco harvested at middle period (25 days).

lugs and bright leaf (i.e., farm grades 2, 3, and 4) averaged 18.3%, 21.9%, and 23.6%, respectively, of the total weight of leaves (Appendix I). In 1950, the average amounts in these grades were 14.4%, 34.7%, and 35.0% respectively. Consequently, the bright leaf grade in 1950 included leaves higher on the stalk than in 1948, which would partially account for the higher levels of nicotine, especially in late harvests, of this grade in 1950.

**Total Volatile Bases.**—The percentage of total volatile bases includes nicotine, ammonia and other volatile nitrogenous materials. It is considered by some workers to be a measure of smoking strength and body which is related to leaf thickness, gumminess and texture (9). Values are lowest in the trash grade and highest in the upper portion of the plant. In these experiments, as shown by Figure 9, total volatile bases increased regularly in the trash grade from .531 at the first harvest to .736 for the sixth harvest made 30 days later. In the lugs and bright leaf grade, there was an initial decrease; then the total volatile bases increased to a maximum of .983 at the sixth harvest for lugs and 1.215 at the fifth harvest for bright leaf. The values for total volatile bases for bright leaf were approximately twice the values for this constituent for trash throughout the 43-day harvest period.

**Ratio of Nicotine to Total Volatile Bases.**—A high ratio of nicotine to total volatile bases gives indication of maturity and is

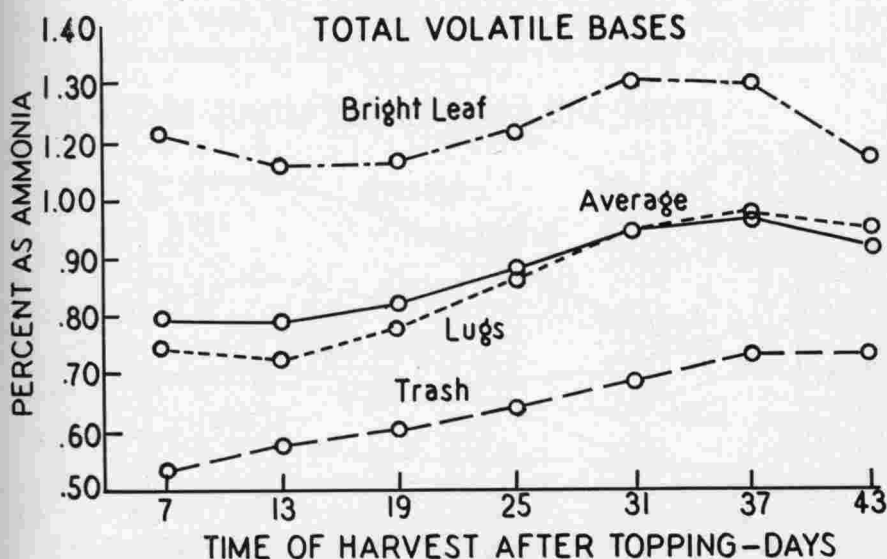


Figure 9.—The effect of time of harvest on amount of total volatile bases.

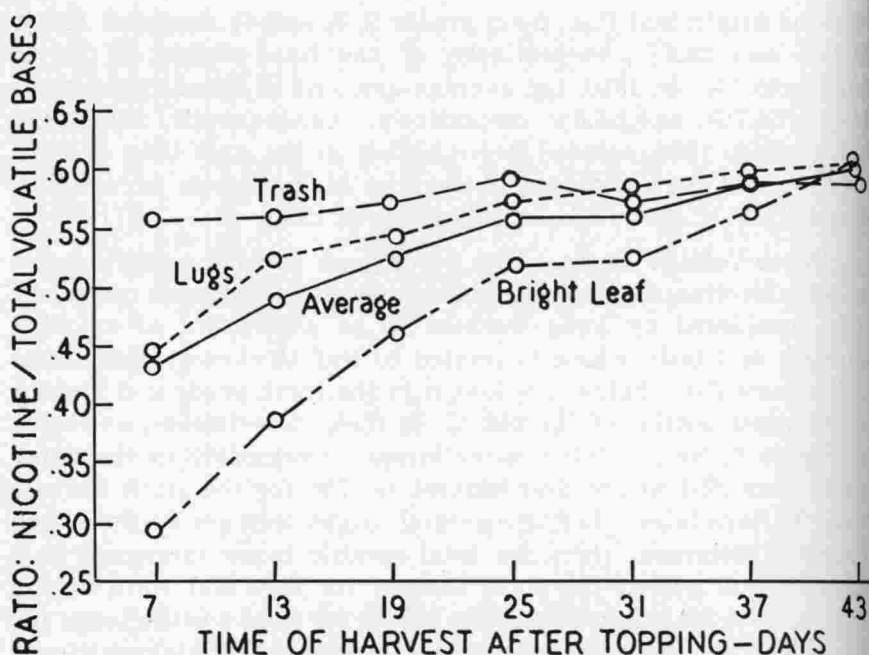


Figure 10.—The effect of time of harvest on the ratio of nicotine to total volatile bases.

believed to be reflected in smoothness and palatability of the smoke (9). Data presented graphically in Figure 10 show a ratio of .56 for trash at the earliest harvest, and the ratio increases only slightly

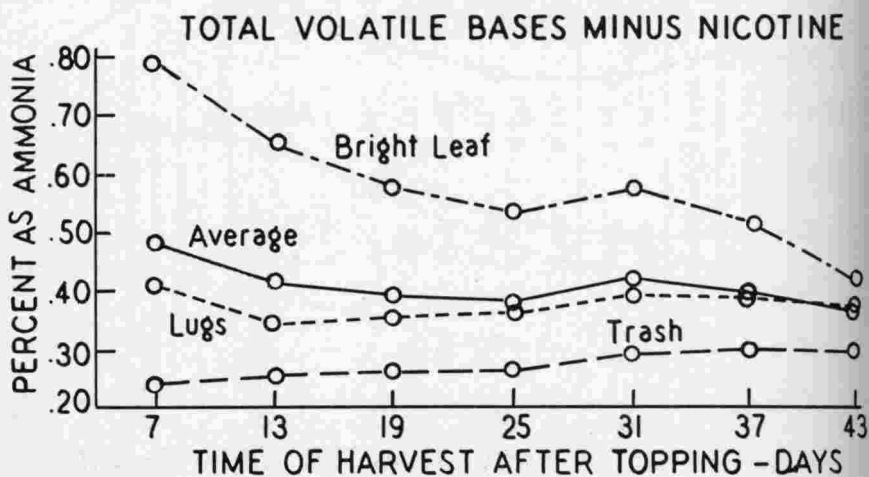


Figure 11.—The effect of time of harvest on total volatile bases minus nicotine.

with increased time of harvest after topping. The ratio .29 for the bright leaf grade was very low at the first harvest; however, by the seventh or final stage of harvest the values for trash and bright leaf were about the same, being .59 and .61, respectively.

**Total Volatile Bases Minus Nicotine.**—The values obtained in this manner are consistently lowest for trash and highest for bright leaf as shown in Figure 11. In the leaf grade there was a decrease of about 50% in this fraction; that is, from .80 to .42, with increased time for maturity after topping. In both the trash and lug grades the values are more nearly constant throughout the harvest period, ranging only from .24 to .30 for trash, and .41 to .35 for lugs.

**Ash Content.**—Good smoking quality burley normally has a relatively high ash content. The data show that ash content decreases with maturity (Figure 12). It is highest in the trash, and lowest in the bright leaf. Ash percentage in the trash grade decreased from a high of 27.16% at first harvest to a low of 21.61% at seventh harvest. The lug and bright leaf grades reached a maximum at the second harvest period, then decreased to the seventh harvest. The reduction in ash content may be attributed to the fact that leaves in the different grades came from positions

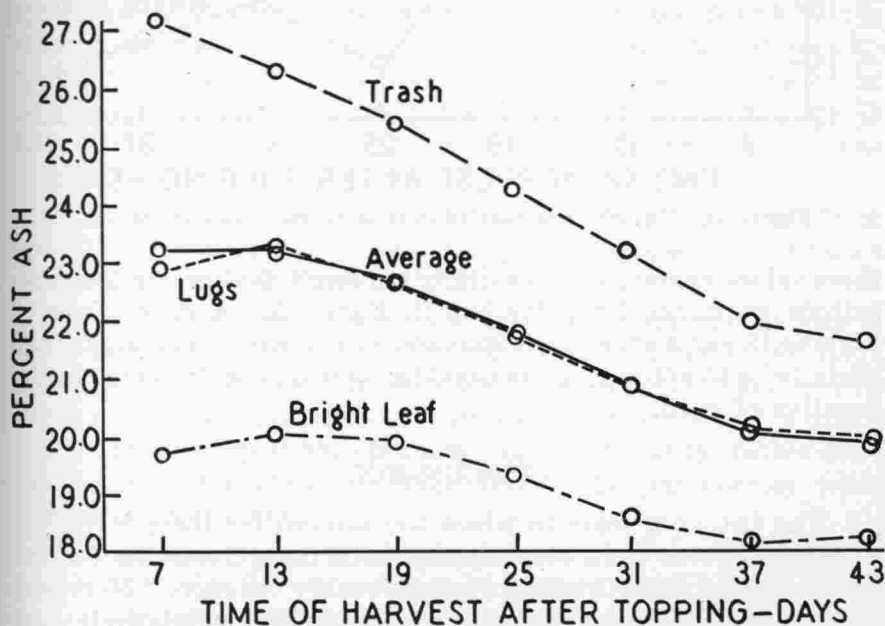


Figure 12.—The effect of time of harvest on the ash content.

gradually higher and higher on the stalk as time of harvest was delayed. Translocation of potassium and certain other mineral constituents to upper leaves, as supplies necessary for growth become limited, may have caused some reduction in ash content of the more mature leaves.

**Alkalinity of Ash.**—The alkalinity of ash is closely associated with the burning properties of tobacco according to Garner, et al (4). It is largely a measure of potassium in relation to amounts of sulphates and chlorides. Data presented in Figure 13 show that

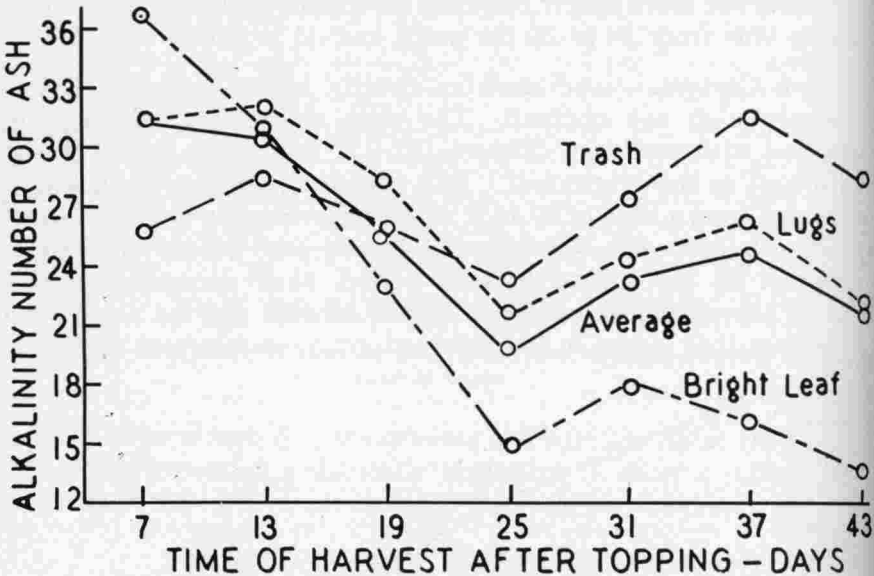


Figure 13.—The effect of time of harvest on the alkalinity of ash.

these values expressed as alkalinity number follow nearly the same pattern as values for potassium in Figure 5. A comparison of Figures 13 and 4 shows that increases or decreases in alkalinity are likely to be followed by corresponding increases or decreases in the duration of burn.

## DISCUSSION

The two crop years in which the tobacco for these investigations was grown were very similar, both being favorable for the production of high yields of good quality tobacco. Moreover, tobacco was harvested at regular intervals over a relatively long period of time without much loss of lower leaves because of firing.

The data on yield, grade quality and chemical composition showed the same general pattern for the two seasons in which experiments were conducted; consequently, the data were combined to show average results of harvesting tobacco at seven stages of maturity. Even under conditions favorable for growth as in the 1948 and 1950 seasons, a difference of six days in time of harvest after topping caused significant changes in crop value and chemical composition.

The optimum time for harvest, based upon crop value, was 25 days after topping.

In 1951, a season with below-normal rainfall after topping, and with premature firing, highest dollar value per acre was received 19 days after topping or six days earlier than during the more favorable seasons of 1948 and 1950. These results parallel those obtained by other investigators (1, 3, 7) working with air-cured tobacco. However, none of these investigators studied the effects of maturity with as many different times of harvest distributed over a six-week period after topping.

In these experiments, due to improvement in grade quality and yield, the crop value increased approximately \$300 per acre from the first to the fourth, or optimum, harvest. This was followed by a decrease of \$300 per acre in crop value from the fourth to the seventh harvest. Some growers have a tendency to cut tobacco while it is too green. This may be due in part to the absence of definite criteria for fixing the harvest date. Furthermore there is fear of loss of leaves through firing, and loss of part of the crop because of insects, diseases, and unfavorable weather.

The practice of cutting while tobacco is too green results in lower yields, lower grade quality, and a higher percentage of tobacco having poor smoking characteristics.

It is evident that growers also may suffer appreciable loss in value per acre by delaying harvest too long in order to get more maturity in top leaves. Growers would receive maximum returns per acre if they began early enough to permit harvest of a major portion of the crop at the optimum stage of maturity, rather than beginning at the optimum stage and completing harvest when tobacco is overmature.

A satisfactory way to avoid loss of lower leaves, while delaying harvest for a few days to secure more maturity in the upper leaves, is to make one or more primings. This study seems to confirm other workers who have advised that burley should be primed at

least once, removing three to four bottom leaves per plant. Recent studies with burley tobacco made in Kentucky and North Carolina (3, 10), show that priming is especially profitable during periods of high prices for tobacco. Priming makes it possible to harvest more leaves in the optimum stage of maturity, judging by both chemical and physical characteristics.

Certain desirable chemical changes were found to occur as the leaves at different positions on the stalk reached the optimum stage of maturity. With overmaturity, as in latest harvests, the lugs and leaf grades developed very high nicotine content, making them less desirable for use in cigarette blends. Analytical results rather than any observed physical properties of the leaf revealed that tobacco from latest harvests is undesirable for use in cigarettes. In contrast, immature tobaccos are quite easily identified by their physical characteristics, and they bring relatively low prices, as shown in Table 1, because of poor smoking quality.

### CONCLUSIONS

Comparisons were made between tobaccos at seven stages of maturity, following harvests made at six-day intervals beginning one week after topping. Results show, irrespective of harvest date, that the lower leaves on the plants have physical properties and chemical composition presently desired for use in cigarette manufacture. Although actual values and rates of change vary, depending upon conditions of growth, these results show general trends which may be expected as a consequence of maturity differences.

In 1948 and 1950, the maximum value per acre was received at the fourth harvest, 25 days after the plants were topped. Conditions were favorable during both seasons for growing and curing. A few days earlier harvest would be more profitable when grown under conditions causing premature firing; for example, a similar test conducted in 1951 indicated the optimum harvest to be 19 days after topping.

Tobacco improved in both yield and grade quality from first to fourth harvest, increasing in value about \$17.00 per acre per day during the 18-day period.

Yield of cigarette smoking grades increased 287 and 389 pounds per acre in 1948 and 1950, respectively, from first to fourth harvest. In both seasons, yield of smoking grades decreased approximately 500 pounds per acre from fourth to seventh harvest.

In general, the duration of burn was better at the early harvests than at later harvests. It was highest in trash, intermediate in lugs, and lowest in the bright leaf grade.

“Strip” yield for trash decreased about 5% from first to sixth harvest; whereas, the bright leaf grades increased about 5% in “strip” yield from first to sixth harvest.

Potassium concentration decreased from first harvest to lowest level at fourth harvest, and then apparently increased from the fourth to the sixth harvest date. Average calcium concentration was highest at the second harvest and declined to lowest level at the final stage. Magnesium concentration was more variable than calcium; however, the highest average value was shown at first harvest and lowest at sixth harvest.

Average nicotine content of trash, lugs and bright leaf grades increased 55% from first to fourth harvest, and 72% from first to seventh harvest—43 days after topping.

Total volatile bases was considerably lower for trash than for lugs and bright leaf at all harvest dates. This fraction increased regularly in trash from .531 at first harvest to .736 at sixth harvest.

Ratio of nicotine to total volatile bases was relatively high for the trash grade at all stages of harvest, ranging from .56 to .59. At first harvest, the bright leaf grade showed a low ratio of .29; however, it was increased to .61 by seventh harvest. The lugs grade was intermediate.

Total volatile bases minus nicotine was consistently lowest for trash and highest for bright leaf. At the first harvest, the values for trash and bright leaf were .24 and .79 compared to .30 and .42, respectively, for seventh harvest.

Ash content of trash, lugs, and bright leaf was 27.2%, 22.8% and 19.7%, respectively, at first harvest. It decreased gradually until seventh harvest, when the same grades showed an ash content of 21.6%, 20.0% and 18.2%, respectively.

Values for alkalinity of ash followed approximately the same pattern, with respect to harvest date, as values for potassium content, both determinations showing close association with leaf-burn.



APPENDIX I *The percentage of the tobacco in the first four farm grades as related to harvesting dates.*

1948 Experiment (Kentucky 16)							1950 Experiment (Burley 1)						Average for both Experiments							
Date of harvest	Days after Topping	Percentage in farm grades					Date of harvest	Days after Topping	Percentage in farm grades					Percentage in farm grades						
		1 <sup>a</sup>	2 <sup>b</sup>	3 <sup>c</sup>	4 <sup>d</sup>	Total			1 <sup>a</sup>	2 <sup>b</sup>	3 <sup>c</sup>	4 <sup>d</sup>	Total	1 <sup>a</sup>	2 <sup>b</sup>	3 <sup>c</sup>	4 <sup>d</sup>	Total		
		%	%	%	%	%			%	%	%	%	%	%	%	%	%	%	%	%
Aug. 13	7	6.9	15.1	23.9	23.3	69.2	Aug. 17	7	4.7	9.7	41.5	33.6	89.5	5.8	12.4	32.7	28.5	79.4		
Aug. 19	13	6.0	11.5	21.5	29.2	68.2	Aug. 23	13	4.4	10.9	38.8	34.6	88.7	5.2	11.2	30.2	31.9	78.5		
Aug. 25	19	4.4	15.6	27.2	20.2	67.4	Aug. 29	19	4.8	16.4	32.3	35.0	88.5	4.6	16.0	29.8	27.6	78.0		
Aug. 31	25	5.2	19.1	22.1	20.5	66.9	Sept. 4	25	4.3	16.8	34.9	25.0	91.0	4.8	18.0	28.5	27.8	79.1		
Sept. 6	31	10.9	19.9	19.5	20.9	71.2	Sept. 10	31	5.9	20.5	30.1	35.4	91.9	8.4	20.2	24.8	28.2	81.6		
Sept. 12	37	7.9	22.2	19.0	24.5	73.6	Sept. 16	37	7.0	13.4	32.4	35.3	88.1	7.5	17.8	25.7	29.9	80.9		
Sept. 18	43	12.6	24.5	20.3	26.7	84.1	Sept. 22	43	9.5	13.0	33.1	35.8	91.4	11.1	18.8	26.7	31.3	87.9		
Average		7.7	18.3	21.9	23.6	71.5	Average		5.8	14.4	34.7	35.0	89.9	6.8	16.3	28.3	29.3	80.7		

<sup>a</sup>Farm grade 1, the "flyings" grade, removed from bottom of the plant.

<sup>b</sup>Farm grade 2, the "trash" grade, in analytical data presented.

<sup>c</sup>Farm grade 3, the "lugs" grade, in analytical data presented.

<sup>d</sup>Farm grade 4, the "bright leaf" grade, in analytical data presented.

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