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Effect of Soil pH and Potash on the Yield and Quality of Dark Tobacco

University of Tennessee Agricultural Experiment Station

W. L. Parks

Lawson Safley

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ACKNOWLEDGEMENT

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Effect of Soil pH and Potash on the Yield and Quality of Dark Tobacco

by

W. L. Parks and Lawson Safley[1]

A tobacco experiment using the Madole variety and involving three soil pH levels and three potassium levels was conducted on a Dickson silt loam soil at the Highland Rim Experiment Station over a 6-year period. The initial soil pH values ranged from 4.6 to 5.8 and at the end of the first 4 years of the experiment, agricultural limestone was applied to the entire experimental area at the rate of 3 tons per acre. This application of lime raised the pH of all plots for the last 2 years of the experiment.

A split plot experimental design with two replications was used with soil pH as the main plot and potassium levels as split

[1]Professor of Agronomy, University of Tennessee, and Superintendent of the Highland Rim Experiment Station, respectively.

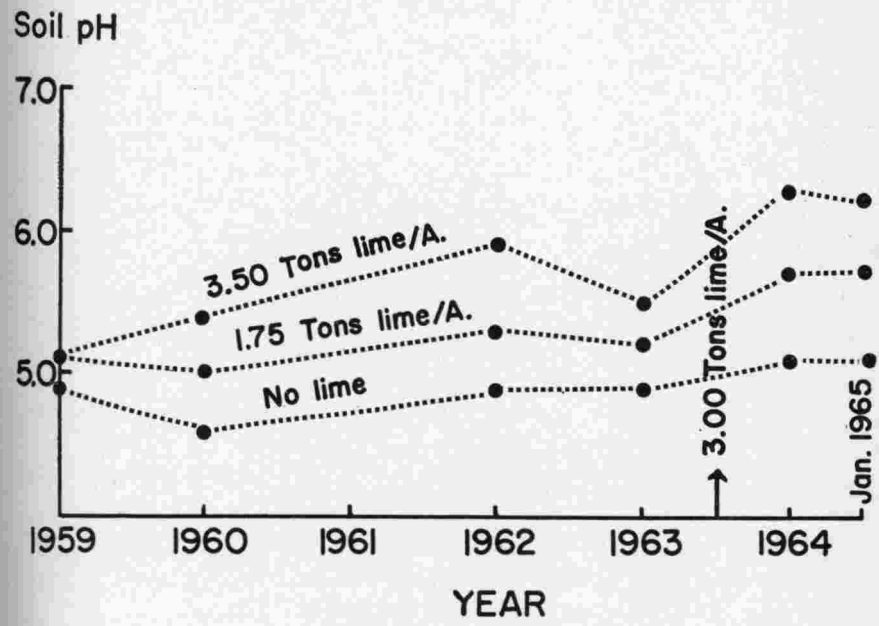

Figure 1. Soil pH values for each lime treatment each year.

plots. Nitrogen and phosphorus were applied broadcast at rates of 120 pounds of N and 100 pounds of P_2O_5 per acre respectively. The plants were spaced 38 inches apart in 42-inch rows, giving about 4,000 plants per acre.

SOIL TEST VALUES

The average soil test values from samples collected as the experiment progressed are shown in Figures 1 and 2. Figure 1 shows the changes in soil pH values from lime applications of 0, 1.75, and 3.50 tons per acre when the experiment was begun.

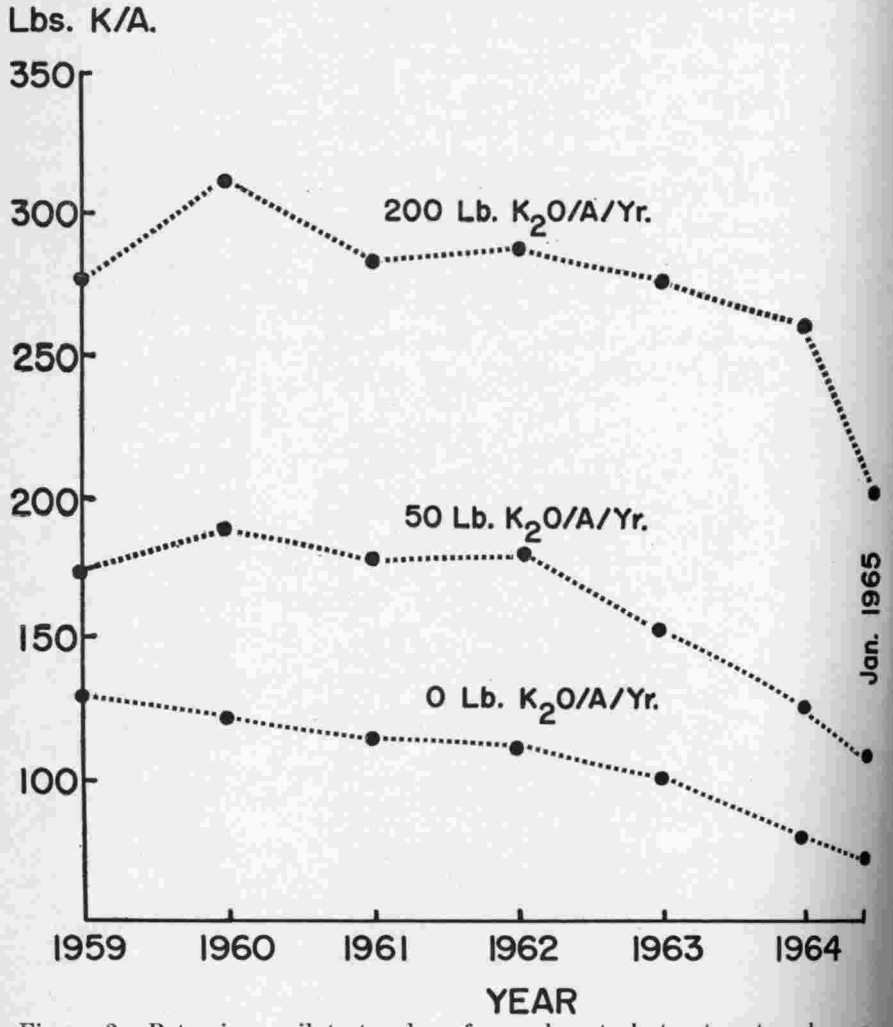

Figure 2. Potassium soil test values for each potash treatment each year.

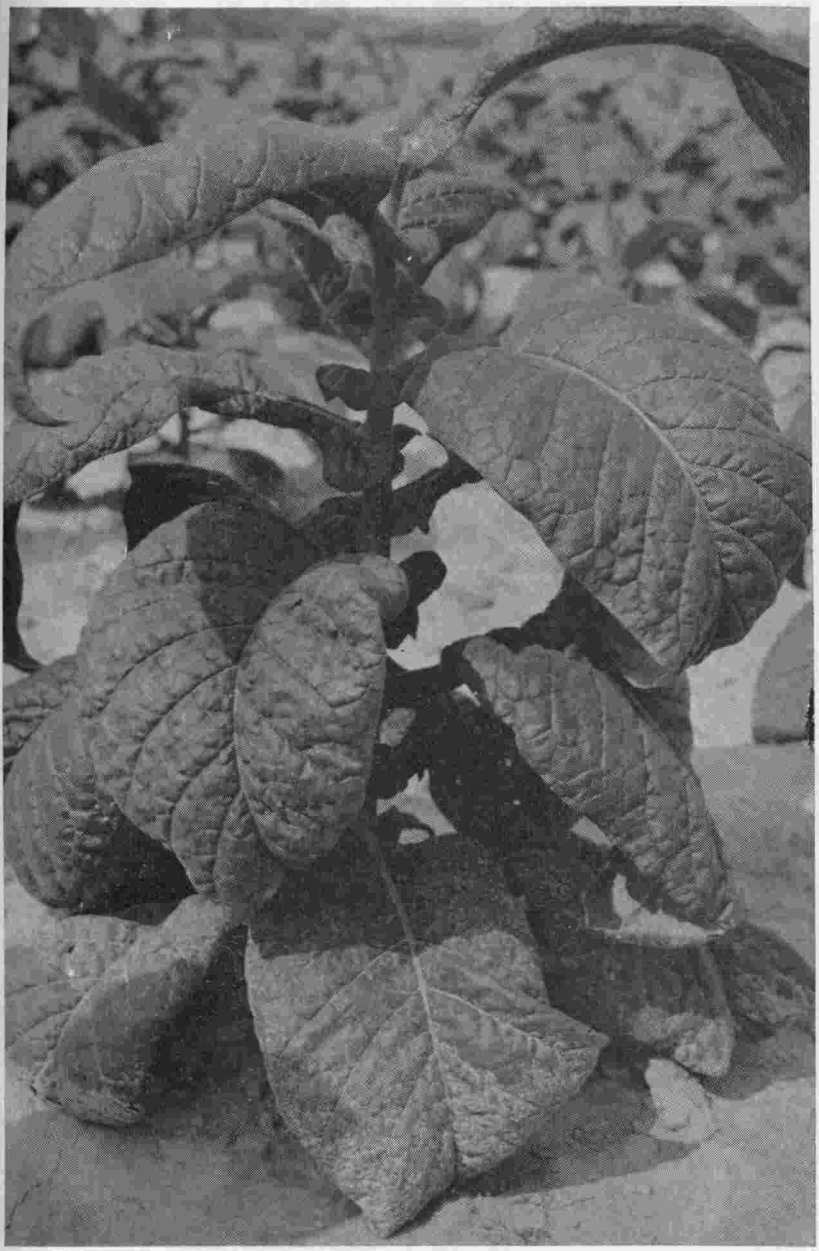

Figure 3. A typical potassium-deficient dark tobacco plant in the treatment receiving no potassium.

Generally, the soil pH differences between the different treatments was 0.3 to 0.4 units. The later application of 3 tons of lime per acre increased this difference among treatments to about 0.6 units during the last 2 years of the experiment.

Generally, the pH of the more acid plots ranged from 4.6 to 4.9. The plots receiving 1.75 tons of lime initially had a pH range from 5.0 to 5.3, while the plots receiving 3.50 tons per acre of lime initially had a pH range from 5.4 to 5.8. The later lime application of 3 tons per acre increased the pH of these plots to about 5.1, 5.7, and 6.3, respectively.

The soil test values for potassium are shown in Figure 2. The soil test values for the plots receiving no potassium gradually decreased and reached a low level of 100 to 110 pounds of exchangeable potassium per acre. The plots receiving 50 pounds of K_2O per acre tested about 150 pounds per acre each year. The plots receiving 200 pounds of K_2O per acre tested between 200 and 300 pounds each year, and generally produced the highest yield of tobacco with the best quality. Higher potassium removals as a result of higher yields during the last 2 years of the experiment resulted in decreased soil potassium levels.

YIELDS

The yields obtained through the 6 years of the experiment are shown in Table 1. The average yields ranged from 1,130 pounds per acre on the treatment having a pH of 4.6 to 4.9 and receiving no potash to 2,300 pounds per acre on the treatment having a pH of about 5.1 and receiving 200 pounds of K_2O per acre.

The Effect of Soil pH

During the first 4 years of the experiment, the highest yields were produced on the plots having a pH of 5.4 to 5.8. When the pH was 5.0 to 5.3 and 4.6 to 4.9, the average yields were decreased 100 and 120 pounds per acre, respectively.

In the last 2 years of the experiment, when the pH of all plots had been raised by adding 3 tons of lime per acre, the higher pH plots (about 6.3) produced the lowest yields. At the lower pH values of 5.7 and 5.1, tobacco yields were 300 and 400 pounds per acre higher, respectively. This marked yield reduction on the plots with a pH above 6.0 may have been due to black root rot infection, as soil pH conditions of near 6.0 or above favor the growth

Table 1. Yields of dark tobacco as affected by three potassium levels at three soil pH levels

Soil pH	Lbs. K_2O/A	1959	1960	1961	1962	4-yr. av.		1963	1964	2-yr. av.
	0	1323	839	1047	1309	1130		1917	1760	1839
4.6-4.9	50	1758	1154	1269	1842	1506		2133	2189	2161
(No lime)	200	1809	1204	1574	1925	1628		2244	2355	2300
	0	1424	1302	1395	1628	1437		2033	1684	1859
5.0-5.3	50	1914	1462	1628	1655	1665		2159	2042	2101
(1.75 tons lime/A)	200	2035	1609	1787	1955	1847		2008	2123	2066
	0	1690	1269	1359	1498	1454		1522	1470	1496
5.4-5.8	50	2075	1615	1680	1922	1823		1777	1748	1763
(3.5 tons lime/A)	200	2200	1722	1850	2069	1960		1684	1972	1828
					pH Average					
4.6-4.9 No lime		1630	1066	1297	1692	1421		2098	2102	2100
5.0-5.3 1.75 tons lime/A		1791	1457	1603	1746	1649		2067	1949	2008
5.4-5.8 3.75 tons lime/A		1989	1535	1630	1825	1745		1661	1730	1696
L.S.D. (5%)		N.S.	299	N.S.	N.S.	129		N.S.	113	178
(1%)		—	—	—	—	183		—	—	280
					K_2O Average					
	0	1479	1137	1267	1478	1340		1824	1638	1731
	50	1916	1410	1526	1806	1665		2023	1993	2008
	200	2015	1512	1737	1983	1812		1979	2150	2065
L.S.D.	(5%)	106	175	205	226	74		N.S.	103	86
	(1%)	160	265	310	355	100		—	155	121

3 Tons Lime/A applied to all Plots

of the black root rot organism and the Madole variety is not resistant to this disease.

The extremely acid plot (below pH 5.0) produced low yields even with adequate fertilization. As the soil pH was increased to near 5.8, tobacco yields also increased. Further increases in the soil pH resulted in a small yield decrease.

The Effect of Potassium

Low yields were produced each year when no potassium was added and the plants on these plots showed visible symptoms of potassium deficiency as shown in Figure 3. Significant yield increases were observed every year of the experiment except 1963; this was the first crop year following the 3 tons per acre lime application. During the first 4 years of the experiment, 200 pounds of K_2O per acre resulted in about 500 pounds per acre yield increase over the treatments receiving no potash. However, after the 3 tons per acre lime application, the yield difference between these two treatments was approximately 300 pounds per acre.

The highest yields produced each year were on the plots receiving 200 pounds of K_2O per acre, and no significant potassium-soil pH interaction was observed during any year.

DOLLAR ACRE VALUE

The dollar acre values were computed from the average prices received each year for the respective grades of tobacco produced and are shown in Table 2.

The Effect of Soil pH

The lowest dollar acre value occurred where no potassium was applied on the extremely acid soil. During the first 4 years of the experiment, tobacco from the limed plots had a significantly higher value than that from the unlimed plots in only 1 year. For the 4-year average, the value of tobacco from the extremely acid plots was significantly lower, but no significant difference in value was found between the two higher pH treatments.

After the 3 tons of lime per acre were applied to all plots, the dollar acre value decreased as the pH increased. The differences were significant for 1964 and for the 2-year average.

These results illustrate the effects of extreme soil acidity upon the quality of dark tobacco as well as the effect of liming the soil to a pH too high for optimum production.

Table 2. Dollar acre values of dark tobacco produced at three potassium levels and three soil pH levels

Soil pH	Lbs. K_2O/A	1959	1960	1961	1962	4-yr. av.		1963	1964	2-yr. av.
	0	531	342	414	541	457		848	629	739
4.6-4.9	50	742	481	548	773	636		954	887	921
(No lime)	200	717	517	730	816	695		1063	990	1027
	0	549	542	581	454	532		888	599	744
5.0-5.3	50	798	658	733	684	718		1009	821	915
(1.75 tons lime/A)	200	797	715	816	843	793		908	877	893
	0	637	539	548	553	569		600	509	555
5.4-5.8	50	871	751	761	785	792		803	685	744
(3.50 tons lime/A)	200	836	786	878	857	839		776	833	805
					pH Average					
4.6-4.9 No lime		663	446	564	710	596		955	835	895
5.0-5.3 1.75 tons lime/A		714	638	710	660	681		935	766	851
5.4-5.8 3.50 tons lime/A		781	692	729	732	734		726	676	701
L.S.D. (5%)		N.S.	N.S.	113	N.S.	76		N.S.	53	95
(1%)		—	—	—	—	107		—	—	150
					K_2O Average					
	0	572	474	514	516	519		778	579	679
	50	804	630	680	747	715		922	798	860
	200	783	672	808	839	776		915	900	908
L.S.D. (5%)		69	87	91	58	33		116	38	54
(1%)		104	132	137	88	44		—	58	76

3 Tons Lime/A applied to all Plots

The Effect of Potassium

Potassium additions significantly increased the dollar acre value for all years. In 3 of the 6 years, the 200-pound per acre treatment did not have a significantly higher value than the 50-pound per acre treatment. For the 4-year average, the 200-pound per acre treatment gave a significantly higher value than the other two treatments, and they lacked only $6 per acre of being significant for the average of the last 2 years.

Highest dollar acre values were obtained when the soil pH was between 5.2 and 5.6, and annual applications of 200 pounds of K_2O per acre were made.

Leaf Types Produced by the Different Fertilizers and Lime Treatments

The percent leaf distribution within Groups, Quality, and Color are shown in tables 3.1 through 3.9.

The Effect of Soil pH

No trends in percentage leaf distribution among Groups or Quality factors could be attributed to changes in soil pH. Increasing the soil pH did result in changes in the color of the tobacco as noted by increased leaf percentage of L and F colors with a corresponding decrease in D and M colors.

The Effect of Soil Potash

Increasing the rate of potash increased the percentage of C tobacco and decreased the percentage of B and X tobacco. Quality was improved by increasing potash as the percentage of 1, 2, and 3 tobacco increased, while the percentage of 4 and 5 tobacco decreased. Potash additions also produced lighter colored tobacco, as it increased the percentage of L and F tobacco and decreased the percentage of D and M tobacco.

TABLE 3. PERCENT DISTRIBUTION WITHIN GROUPS, QUALITY, AND COLOR OF DARK TOBACCO AS AFFECTED BY SOIL pH AND POTASH LEVEL AT THE HIGHLAND RIM EXPERIMENT STATION, SPRINGFIELD, TENNESSEE

Table 3.1. Lime—none, 1959; 3 tons per acre in 1963; fertilizer 120-100-0 each year

GROUP	1959	1960	1961	1962	4-yr. av.	1963	1964	2-yr. av.
A	—	—	—	—	—	—	—	—
B	42.4	46.1	40.7	32.0	40.3	48.8	31.6	40.2
C	—	—	—	—	—	—	—	—
X	57.6	53.9	59.3	68.0	59.7	51.2	33.9	42.6
N	—	—	—	—		—	34.4	17.2
QUALITY								
1	43.5	—	—	—	10.9	32.2	—	16.1
2	8.2	—	25.9	—	8.5	36.2	8.6	22.4
3	19.3	52.5	16.4	37.7	31.5	7.2	35.9	21.6
4	—	11.9	27.8	26.7	16.6	—	14.3	7.2
5	29.0	35.6	29.9	35.5	32.5	24.4	6.7	15.6
0	—	—	—	—		—	34.4	17.2
COLOR								
L	—	—	—	—	—	—	—	—
F	—	—	—	—	—	—	—	—
D	100.0	39.5	100.0	47.1	71.7	100.0	65.6	82.8
M	—	60.5	—	18.1	19.7	—	—	—
G	—	—	—	17.5	4.4	—	34.4	17.2
VF	—	—	—	17.4	4.4	—	—	—

Table 3.2. Lime—none, 1959; 3 tons per acre in 1963; fertilizer 120-100-50

GROUP	1959	1960	1961	1962	4-yr. av.	1963	1964	2-yr. av.
A	8.4	—	—	—	2.1	7.0	—	3.5
B	48.6	22.3	21.2	68.8	40.2	52.9	29.4	41.2
C	8.7	55.3	22.1	—	21.5	4.5	13.5	9.0
X	34.4	22.4	56.7	31.2	36.2	35.7	34.7	35.2
N	—	—	—	—	—	—	22.4	11.2
QUALITY								
1	—	—	8.1	—	2.0	—	—	—
2	36.1	18.6	51.9	17.5	31.0	21.9	35.8	28.9
3	27.0	40.6	20.8	52.3	35.2	63.4	21.2	42.3
4	19.1	18.3	—	8.9	11.6	—	20.5	10.3
5	17.8	22.4	19.2	21.2	20.2	14.7	—	7.4
0	—	—	—	—	—	—	22.4	11.2
COLOR								
L	—	—	—	—	—	—	—	—
F	—	—	19.6	29.2	12.2	80.6	11.8	46.2
D	100.0	49.2	70.0	13.6	58.2	6.6	57.7	32.2
M	—	39.4	10.3	50.5	25.1	—	—	—
G	—	11.4	—	—	2.9	4.7	22.4	13.6
VF	—	—	—	6.7	1.7	8.1	8.1	8.1

Table 3.3. Lime—none, 3 tons per acre in 1963; fertilizer, 120-100-200 each year

GROUP	1959	1960	1961	1962	4-yr. av.	1963	1964	2-yr. av.
A	12.3	—	—	—	3.1	12.6	—	6.3
B	24.0	—	—	32.2	14.1	14.7	—	7.4
C	39.3	75.5	57.3	44.1	54.1	54.8	63.9	59.4
X	24.4	24.5	42.7	23.7	28.8	17.9	27.6	22.8
N	—	—	—	—	—	—	8.5	4.3
QUALITY								
1	—	—	30.7	—	7.7	9.2	8.9	9.1
2	—	—	41.4	—	10.4	24.3	28.2	26.3
3	53.6	75.2	17.0	58.6	51.1	37.5	23.9	30.7
4	39.5	9.3	6.0	41.4	24.1	23.5	22.2	22.9
5	6.8	15.5	4.9	—	6.8	5.4	8.2	6.8
0	—	—	—	—	—	—	8.5	4.3
COLOR								
L	—	16.6	15.3	—	8.0	—	—	—
F	—	13.3	31.4	61.6	26.6	64.9	9.3	37.1
D	91.8	23.6	53.3	2.5	42.8	10.3	38.4	24.4
M	—	28.1	—	29.5	14.4	—	—	—
G	8.2	10.5	—	—	4.7	4.4	16.7	10.6
VF	—	7.9	—	6.4	3.6	20.4	35.6	28.0

Table 3.4. Lime—1.75 tons per acre in 1959, 3 tons per acre in 1963; fertilizer, 120-100-0 each year

GROUP	1959	1960	1961	1962	4-yr. av.	1963	1964	2-yr. av.
A	—	—	—	—	—	—	—	—
B	40.9	36.6	18.1	35.7	32.8	51.0	38.6	44.8
C	—	18.7	15.6	—	8.6	—	—	—
X	59.1	44.7	66.3	32.6	50.7	36.4	29.7	33.1
N	—	—	—	31.7	7.9	12.5	31.7	22.1
QUALITY								
1	35.1	—	24.2	31.7	22.8	54.4	—	27.2
2	13.4	9.4	25.7	—	12.1	12.3	15.8	14.1
3	12.1	53.4	11.9	39.7	29.3	11.4	38.6	25.0
4	8.1	7.6	11.9	28.5	14.0	6.5	14.7	10.6
5	31.3	29.6	26.3	—	21.8	15.4	15.0	15.2
0	—	—	—	—		—	15.9	8.0
COLOR								
L	—	—	14.2	—	3.6	12.5	—	6.3
F	—	—	—	—	—	72.0	—	36.0
D	100.0	38.4	73.7	53.1	66.3	15.4	84.1	49.8
M	—	61.6	12.0	—	18.4	—	—	—
G	—	—	—	37.5	9.4	—	15.9	8.0
VF	—	—	—	9.4	2.4	—	—	—

Table 3.5. Lime—1.75 tons per acre in 1959; 3 tons per acre in 1963; fertilizer, 120-100-50 each year

GROUP	1959	1960	1961	1962	4-yr. av.	1963	1964	2-yr. av.
A	—	—	—	—	—	11.9	—	6.0
B	46.8	29.3	1.8	20.3	24.6	35.6	24.6	30.1
C	—	52.2	49.0	39.4	35.2	11.5	29.6	20.6
X	53.2	18.5	49.2	40.3	40.3	40.9	25.5	33.2
N	—	—	—	—	—	—	20.4	10.2
QUALITY								
1	17.6	—	—	—	4.4	19.9	—	10.0
2	24.4	—	29.4	22.0	19.0	23.2	23.9	23.6
3	39.1	54.5	46.8	57.5	49.5	34.7	28.0	31.4
4	—	36.1	—	—	9.0	5.3	27.7	16.5
5	19.0	9.4	23.8	20.5	18.2	17.0	—	8.5
0	—	—	—	—	—	—	20.4	10.2
COLOR								
L	—	30.8	49.2	—	20.0	—	—	—
F	—	9.1	50.8	35.0	23.7	98.6	—	49.3
D	100.0	31.8	—	14.7	36.6	—	43.4	21.7
M	—	28.3	—	40.3	17.2	—	—	—
G	—	—	—	2.6	0.7	1.4	27.4	14.4
VF	—	—	—	7.4	1.9	—	29.2	14.6

Table 3.6. Lime—1.75 tons per acre in 1959; 3 tons per acre in 1963; fertilizer, 120-100-200 each year

GROUP	1959	1960	1961	1962	4-yr. av.	1963	1964	2-yr. av.
A	17.8	—	—	—	4.5	—	—	—
B	27.0	4.7	1.7	17.6	12.8	29.0	—	14.5
C	30.5	70.8	40.8	49.6	47.9	45.3	83.7	64.5
X	24.7	24.6	57.5	32.7	34.9	25.7	9.5	17.6
N	—	—	—	—	—	—	6.8	3.4
QUALITY								
1	—	—	21.3	—	5.3	—	5.4	2.7
2	4.6	9.5	42.4	18.4	18.7	24.6	18.6	21.6
3	48.8	39.6	18.5	67.2	43.5	47.8	34.8	41.3
4	20.9	44.1	9.8	—	18.7	15.3	25.0	20.2
5	25.7	6.8	8.0	14.5	13.8	12.3	9.5	10.9
0	—	—	—	—	—	—	6.8	3.4
COLOR								
L	—	26.7	46.5	—	18.3	—	—	—
F	—	25.4	47.1	57.0	32.4	83.1	—	41.6
D	89.1	13.1	6.4	1.2	27.5	—	52.1	26.1
M	—	8.2	—	41.9	12.5	—	9.2	4.6
G	10.9	—	—	—	2.7	2.9	16.3	9.6
VF	—	26.5	—	—	6.6	14.0	22.4	18.2

Table 3.7. Lime—3.50 tons per acre in 1959, 3 tons per acre in 1963; fertilizer, 120-100-0 each year

GROUP	1959	1960	1961	1962	4-yr. av.	1963	1964	2-yr. av.
A	—	—	—	—	—	—	—	—
B	40.3	33.8	33.2	42.7	37.5	46.8	49.1	48.0
C	—	—	—	4.7	1.2	—	2.7	1.4
X	59.7	66.2	66.8	52.6	61.3	39.2	10.9	25.1
N	—	—	—	—	—	14.1	37.3	25.7
QUALITY								
1	19.5	9.9	—	—	7.4	13.2	—	6.6
2	26.5	4.3	37.4	—	17.1	43.6	7.2	25.4
3	6.1	43.4	21.3	56.0	31.7	16.9	25.4	21.2
4	16.9	7.9	12.5	13.4	12.7	2.1	16.4	9.3
5	31.1	34.5	28.8	30.6	31.3	24.1	13.6	18.9
0	—	—	—	—	—	—	37.3	18.7
COLOR								
L	—	—	—	—	—	—	—	—
F	—	55.2	43.7	7.9	26.7	—	—	—
D	100.0	29.5	27.5	38.2	48.8	100.0	59.9	80.0
M	—	15.4	28.8	33.5	19.4	—	—	—
G	—	—	—	17.4	4.4	—	37.3	18.7
VF	—	—	—	2.9	0.7	—	2.7	1.4

Table 3.8 Lime—3.50 tons per acre in 1959, 3 tons per acre in 1963; fertilizer, 120-100-50 each year

GROUP	1959	1960	1961	1962	4-yr. av.	1963	1964	2-yr. av.
A	—	—	—	—	—	—	—	—
B	40.2	27.0	17.6	16.5	25.3	52.6	11.6	32.1
C	—	27.8	18.0	54.0	25.0	—	41.1	20.6
X	59.8	45.2	64.4	29.5	49.7	38.1	28.1	33.1
N	—	—	—	—	—	9.2	19.2	14.2
QUALITY								
1	35.8	17.6	23.4	—	19.2	37.7	9.4	23.6
2	10.4	41.4	26.9	5.7	21.1	31.0	22.7	26.9
3	30.5	21.4	31.9	61.9	36.4	8.9	33.4	21.2
4	10.8	—	—	19.3	7.5	11.0	24.7	17.9
5	12.4	19.5	17.7	13.2	15.7	11.3	—	5.7
0	—	—	—	—	—	—	9.8	4.9
COLOR								
L	—	38.1	53.1	—	22.8	9.2	—	4.6
F	—	39.9	46.9	26.0	28.2	57.8	—	28.9
D	100.0	10.5	—	20.4	32.7	15.8	32.0	23.9
M	—	11.5	—	40.1	12.9	—	—	—
G	—	—	—	—	—	2.6	43.7	23.2
VF	—	—	—	13.4	3.4	14.6	24.2	19.4

Table 3.9. Lime—3.50 tons per acre in 1959, 3 tons per acre in 1963; fertilizer, 120-100-200 each year

GROUP	1959	1960	1961	1962	4-yr. av.	1963	1964	2-yr. av.
A	1.9	—	—	—	0.5	—	—	—
B	40.2	13.1	—	10.1	15.9	1.8	4.2	3.0
C	11.7	63.5	53.4	68.7	49.3	48.8	64.9	56.9
X	46.2	23.4	46.6	21.2	34.4	49.4	17.2	33.3
N	—	—	—	—	—	—	13.7	6.9
QUALITY								
1	—	—	28.2	—	7.1	20.6	13.7	17.2
2	25.1	30.6	34.8	3.0	23.4	47.6	35.1	41.4
3	16.1	43.8	25.4	63.7	37.3	16.9	34.1	25.5
4	50.6	9.9	—	20.4	20.2	1.8	17.2	9.5
5	8.1	15.7	11.6	12.9	12.1	13.1	—	6.6
0	—	—	—	—		—	—	
COLOR								
L	—	29.5	46.6	—	19.0	—	7.0	3.5
F	—	25.2	53.4	42.9	30.4	65.6	1.8	33.7
D	90.5	11.8	—	22.2	31.1	25.3	39.1	32.2
M	—	20.5	—	23.8	11.1	—	7.5	3.8
G	9.5	—	—	6.7	4.1	1.8	6.7	4.3
VF	—	13.1	—	4.4	4.4	7.3	37.9	22.6

SUMMARY AND CONCLUSIONS

Soils with a pH range from 5.4 to 5.8 appear to be most desirable for dark tobacco production. When the soil pH is below or above this range, the yield and dollar acre value of the tobacco is reduced. Dark tobacco grown in extremely acid soils generally produced much lower yields of tobacco that had a lower dollar acre value.

Maintaining an adequate supply of potassium through annual additions of 200 pounds of K_2O per acre, along with proper levels of nitrogen and phosphorus to maintain a desirable nutrient balance, will produce high yields of good-quality dark tobacco.

Extremely acid soils produced a B or X tobacco of poor quality and a dark or mixed color. Increasing the soil pH and potash level resulted in a lighter colored tobacco of better quality. Potash also increased the relative amount of C tobacco.

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