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The Effect of Irrigation and Nitrogen upon the Yield and Quality of Dark Tobacco

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by

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TWO experiments have been conducted over a period of 9 years on the effect of different levels of moisture and nitrogen upon the yield and quality of dark tobacco.

These experiments were located on Ennis, Mountview, and Dickson silt loam soils at the Highland Rim Experiment Station. The Mountview and Dickson are upland soils while the Ennis is a creek-bottom soil.

A split-plot experimental design was used with moisture being the main plots and nitrogen the split plots. Irrigations were applied on the basis of moisture content of periodic soil samples except the evapotranspiration treatment which was based on calculated average daily evapotranspiration values. All fertilizers including nitrogen were applied broadcast before transplanting the tobacco.

Background Information

The moisture properties of the three soils are shown in Table 1. The Ennis soil had the highest available water holding capacity while the Mountview soil had the lowest. The lower available water holding capacity in the Mountview soil could be attributed to its higher clay content in the B horizon. The available water holding capacity for the Mountview, Dickson, and Ennis soils was 2.8, 3.0, and 3.6 inches, respectively, at 12 inches of depth.

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

Table 1. Moisture Release Data for Dickson, Ennis, and Mountview Soils

DICKSON SILT LOAM

Soil depth →	0-6 INCHES			6-12 INCHES			Total acre inches of water for 0-12"
Bulk density →	1.37			1.48			
Moisture Tension	Soil Moisture Weight %	Soil Moisture Volume %	Acre inches of water to reach Field capacity	Soil Moisture Weight %	Soil Moisture Volume %	Acre inches of water to reach Field capacity	
⅓ Atmosphere*	26.0	35.6	0	26.3	39.0	0	0
2 Atmospheres	11.8	16.2	1.16	16.9	25.1	0.83	1.99
5 Atmospheres	7.9	10.8	1.49	13.3	19.7	1.16	2.65
15 Atmospheres	5.6	7.7	1.68	11.2	16.6	1.34	3.02

ENNIS SILT LOAM

Bulk density	1.25			1.32			
⅓ Atmosphere*	29.7	37.1	0	28.8	38.0	0	0
2 Atmospheres	12.4	15.5	1.30	13.9	18.3	1.18	2.48
5 Atmospheres	7.2	9.0	1.69	7.8	10.3	1.66	3.35
15 Atmospheres	5.5	6.9	1.81	5.8	7.7	1.82	3.63

MOUNTVIEW SILT LOAM

Bulk density	1.27			1.48			
⅓ Atmosphere*	25.6	32.5	0	27.7	41.0	0	0
2 Atmospheres	11.7	14.9	1.05	16.7	24.8	.98	2.03
5 Atmospheres	8.4	10.6	1.31	13.3	19.6	1.28	2.59
15 Atmospheres	6.2	7.9	1.48	12.6	18.6	1.34	2.82

*Field Capacity.

The monthly rainfall from May through September during each growing season was below average during only 3 years of the experiment (1956, 1961, and 1963). In all other years of the experiment the rainfall was about 2 inches above the average (Table 2).

Table 2. Rainfall for the Highland Rim Experiment Station, Springfield, Tennessee, 1955-63, and the long-time average (1938-63)

Month	1955	1956	1957	1958	1959	1960	1961	1962	1963	Long-time average (1938-63)
May	5.67	4.38	5.70	4.24	4.83	4.62	4.15	3.37	2.60	4.12
June	4.66	2.48	3.35	2.23	1.41	7.34	4.62	3.55	3.10	3.36
July	1.45	4.57	2.61	7.08	3.58	3.28	3.46	5.80	5.99	4.16
August	4.15	2.79	2.07	2.99	5.31	1.53	1.39	2.36	4.37	3.26
September	3.12	0.60	5.68	3.26	4.56	3.45	1.78	3.88	1.12	2.98
5-month Total	19.05	14.82	19.41	19.80	19.69	20.22	15.40	18.96	17.18	17.88

The drought days calculated at the 2.00-inch moisture base from the rainfall data at the Springfield Station and the average daily evapotranspiration are shown in Table 3. The total drought days

Table 3. Drouth days for the Highland Rim Experiment Station, Springfield, 1955-63, 2.00-inch base

Month	1955	1956	1957	1958	1959	1960	1961	1962	1963
May	3	0	0	0	0	9	0	14	0
June	0	15	8	17	13	5	5	6	13
July	21	16	20	7	15	1	15	16	3
August	6	7	12	6	3	24	24	5	3
September	20	19	10	14	3	9	17	3	14
Total	50	57	50	44	34	48	61	44	33

throughout the May-September period do not vary greatly, although 1959 and 1963 had fewer drought days. The months of July and August are critical for dark tobacco production as it is during these months that much of the growth of tobacco is made. The number of drought days occurring during the July-August period was high in 1957 and 1961. Greatest response to irrigation would be expected in these years. The lowest number of drought days during the July-August period occurred in 1963 and 1959. It is during these years that one would expect little response to irrigation.

The number, amount, and dates of irrigation of the dark tobacco for each treatment during each of the years studied is shown in Table 4.

Tobacco Yields

During the first 4 years of the experiment, a significant response to irrigation was obtained in 2 of the 4 years (Table 5). In one of

Table 4. Number, amount, and dates of irrigation of dark tobacco at the Highland Rim Experiment Station, Springfield, Tennessee

Year and Soil Series	1955 Ennis			1956 Mountview			1957 Dickson			1958 Mountview			1959 Dickson			1960 Dickson			1961 Mountview			1962 Mountview			1963 Mountview		
Irrigation treatment	No. of irrigations	In. of water applied	Dates of irrigation	No. of irrigations	In. of water applied	Dates of irrigation	No. of irrigations	In. of water applied	Dates of irrigation	No. of irrigations	In. of water applied	Dates of irrigation	No. of irrigations	In. of water applied	Dates of irrigation	No. of irrigations	In. of water applied	Dates of irrigation	No. of irrigations	In. of water applied	Dates of irrigation	No. of irrigations	In. of water applied	Dates of irrigation	No. of irrigations	In. of water applied	Dates of irrigation
Irrigated at 5 atmospheres tension	-	-	-	1	2.7	8-11	1	2.6	7-28	1	2.7	8-20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Irrigated at 2 atmospheres tension	2	2.3	7-6	5	0.6	7-11	2	2.0	7-18	1	2.1	8-13	1	2.0	8-27	-	-	-	1	2.5	8-9	2	2.4	7-18	1	2.4	6-15
		2.4	8-2		2.1	7-26		2.0	8-10														2.4	7-21			
					2.1	8-7																					
					0.6	8-18																					
					1.4	9-5																					
Irrigated at 2/3 atmosphere tension	-	-	-	-	-	-	-	-	-	-	-	-	7	0.9	6-15	-	-	-	3	1.3	8-1	3	1.0	7-16	5	1.0	6-15
														0.9	7-3					1.3	8-7		1.0	8-4		1.0	6-29
														0.9	7-11					1.3	8-15		1.0	8-11		1.0	7-13
														0.9	7-14											1.0	7-26
														0.9	8-1											1.0	8-5
														0.9	8-14												
														0.9	8-26												
Irrigated on 1.1-inch base by evapotranspiration*	-	-	-	-	-	-	-	-	-	-	-	-	8	1.4	6-13	-	-	-	2	1.4	8-2	2	1.4	7-15	4	1.4	6-15
														1.4	6-19					1.4	8-11		1.4	7-23		1.4	6-28
														1.4	7-1											1.4	7-12
														1.4	7-10											1.4	8-6
														1.4	7-17												
														1.4	8-3												
														1.4	8-13												
														1.4	8-24												
Inches rainfall May-September	19.1			14.8			19.4			19.8			19.7			20.2			15.4			19.0			17.2		

*This requires that the calculated average daily evapotranspiration rates be subtracted from the moisture base each day. When this value reaches zero, water is applied. Rainfall and irrigation are treated as water added. Regardless of the amount of rainfall or irrigation, the upper limit is the moisture base.

Table 5. Effect of irrigation and nitrogen variables on the yield of dark tobacco, 1955-1958

Tmt. No.	Irrigation	Nitrogen	1955	1956	1957	1958	Average
		Lb./A			Pounds per acre		
1	No irrigation	80	2103	1984	1957	1777	1955
2	" "	140	2204	1947	2020	1821	1998
3	" "	200	2019	2153	2079	1933	2046
4	Irrigated at	80	2057	2322	2115	1901	2099
5	5 atmospheres	140	2022	2404	2297	1981	2176
6	tension	200	1946	2424	2509	2070	2237
7	Irrigated at	80	1995	2572	2181	1716	2116
8	2 atmospheres	140	2088	2575	2496	1815	2244
9	tension	200	2267	2777	2512	1895	2363
	Average for irrigation treatments across all levels of nitrogen						
	No irrigation		2109	2028	2019	1843	2000
	5 atmospheres tension		2008	2383	2307	1984	2171
	2 atmospheres tension		2116	2641	2396	1808	2240
	L. S. D. (5%)		N.S.	71	161	N.S.	.....
	(1%)		N.S.	108	244	N.S.	.....
	Average for nitrogen treatments across all levels of irrigation						
	80 pounds N per acre		2051	2292	2084	1798	2056
	140 " " " "		2105	2309	2271	1872	2139
	200 " " " "		2077	2451	2367	1966	2215
	L. S. D. (5%)		N.S.	81	109	90	.....
	(1%)		N.S.	111	150	124	.....

these years irrigating at 2 atmospheres tension gave significantly higher yields than irrigating at 5 atmospheres tension.

A significant response to nitrogen above 80 pounds of N per acre was obtained in 3 of the 4 years. No significant response to nitrogen rates higher than 80 pounds of N was obtained in 1955 when the experiment was conducted on the Ennis soil.

The second phase of the experiment involved 4 irrigation levels and 3 nitrogen levels during a 5-year period. A significant response to irrigation occurred only in 1962 on the Mountview soil where an increase of about 300 pounds per acre from irrigation was obtained (Table 6).

Table 6. Effect of irrigation and nitrogen variables on the yield of dark tobacco, 1959-1963

Tmt. No.	Irrigation	Nitrogen	1959	1960*	1961	1962	1963	5-yr. av.	4-yr. av.
		Lb./A				Pounds per acre			
1	No irrigation	100	2130	2314	1702	1915	2223	2057	2015
2	" "	150	2306	2368	1735	1952	2342	2141	2090
3	" "	200	2329	2480	1774	2043	2315	2188	2157
4	Irrigated at	100	2209	2314	1828	2148	2145	2129	2125
5	2/3 atmosphere	150	2382	2368	1903	2226	2286	2233	2220
6	tension	200	2480	2480	1948	2319	2450	2335	2307
7	Irrigated at	100	2102	2314	1674	2116	2058	2053	2052
8	2 atmospheres	150	2344	2368	1832	2251	2216	2202	2199
9	tension	200	2619	2480	1963	2443	2356	2372	2376
10	Irrigated by	100	2057	2314	1903	2201	2090	2113	2119
11	evapotranspiration	150	2333	2368	1950	2322	2201	2235	2243
12	procedure	200	2366	2480	2028	2319	2348	2308	2298

*No irrigations in 1960.

Average for irrigation treatments across all levels of nitrogen

No irrigation	2255	2387	1737	1971	2293	2129	2088
2/3 atmosphere tension	2357	2387	1893	2231	2293	2232	2217
2 atmospheres tension	2355	2387	1823	2270	2210	2209	2209
By evapotranspiration	2252	2387	1960	2281	2212	2218	2220
L. S. D. (5%)	N.S.	N.S.	N.S.	206	N.S.	.....	.....

Average for nitrogen treatments across all levels of irrigation

100 pounds N per acre	2124	2314	1777	2095	2129	2088	2078
150 " " " "	2341	2368	1855	2187	2261	2202	2188
200 " " " "	2448	2480	1928	2281	2367	2301	2284
L. S. D. (5%)	120	N.S.	76	62	101	.....	.....
(1%)	162	N.S.	103	85	138	.....	.....

A significant response to nitrogen was obtained during 4 of the 5 years of the experiment. The average yield during the last 5 years at the 100-pound nitrogen rate was about 2,100 pounds per acre. Increasing the nitrogen rate to 50 pounds per acre resulted in an increase of about 100 pounds of tobacco per acre. This relationship held true up to a total of 200 pounds of nitrogen per acre.

Dollar acre value

A summary of the dollar acre value for each phase of the experiment is shown in Tables 7 and 8. The relative response in dollars

Table 7. Effect of irrigation and nitrogen variables on the acre value of dark tobacco, 1955-1958

Tmt. No.	Irrigation	Nitrogen	1955	1956	1957	1958	Average
		Lb./A			Dollars per acre		
1	No irrigation	80	892	774	916	720	826
2	" "	140	969	758	982	756	866
3	" "	200	823	858	952	851	871
4	Irrigated at	80	850	914	978	794	884
5	5 atmospheres	140	874	987	1061	867	947
6	tension	200	785	975	1111	883	939
7	Irrigated at	80	827	1019	977	706	882
8	2 atmospheres	140	833	1055	1121	765	944
9	tension	200	934	1143	1155	805	1009
	Average for irrigation treatments across all levels of nitrogen						
	No irrigation		895	797	950	776	855
	5 atmospheres tension		837	959	1050	848	924
	2 atmospheres tension		865	1072	1084	759	945
	L. S. D. (5%)		N.S.	64	92	N.S.	
	(1%)		N.S.	96	N.S.	N.S.	
	Average for nitrogen treatments across all levels of irrigation						
	80 Pounds N per acre		856	902	957	739	864
	140 " " " "		892	933	1055	796	919
	200 " " " "		848	992	1072	846	940
	L. S. D. (5%)		N.S.	45	78	59	
	(1%)		N.S.	61	N.S.	80	

Table 8. Effect of irrigation and nitrogen variables on the acre value of dark tobacco, 1959-1963

Tmt. No.	Irrigation	Nitrogen	1959	1960*	1961	1962	1963	5-yr. av.	4-yr. av.
		Lb./A			Dollars per acre				
1	No irrigation	100	684	1053	710	772	945	833	778
2	" "	150	788	1087	738	743	970	865	810
3	" "	200	845	1177	752	831	914	904	836
4	Irrigated at 2/3	100	824	1053	772	824	887	872	827
5	atmosphere	150	907	1087	628	905	914	888	839
6	tension	200	961	1177	800	904	996	968	915
7	Irrigated at 2	100	683	1053	707	834	822	820	762
8	atmospheres	150	852	1087	781	886	908	903	857
9	tension	200	1041	1177	824	972	947	992	946
10	Irrigated by	100	785	1053	802	889	808	867	821
11	Evapotranspiration	150	892	1087	830	924	895	926	885
12	procedure	200	994	1177	848	874	963	971	920
	Average for irrigation treatments across all levels of nitrogen								
	No irrigation		772	1106	734	782	943	867	808
	2/3 atmosphere tension		897	1106	791	878	932	921	860
	2 atmospheres tension		858	1106	770	897	892	905	855
	By evapotranspiration		890	1106	827	896	889	922	875
	L. S. D. (5%)		N.S.	N.S.	N.S.	87	N.S.		
	(1%)		N.S.	N.S.	N.S.	N.S.	N.S.		
	Average for nitrogen treatments across all levels of irrigation								
	100 pounds N per acre		744	1053	747	830	865	848	797
	150 " " " "		860	1087	788	864	922	904	848
	200 " " " "		960	1177	806	895	955	959	904
	L. S. D. (5%)		59	N.S.	44	35	67		
	(1%)		80	N.S.	N.S.	48	N.S.		

*No irrigations in 1960.

to irrigation and nitrogen was similar to that obtained in pounds per acre yields.

Leaf quality

At nitrogen rates of 80 to 100 pounds per acre, the percentage of "A" leaf tended to increase with irrigation. At nitrogen rates of 150 to 200 pounds of N per acre this effect was less evident (Tables 9 and 10).

Table 9. Effect of irrigation and nitrogen variables on the quality of dark tobacco, 1955-1958

Tmt. No.	Irrigation	Nitrogen	Leaf grade groups			
			A	B	C	X
		Lb./A	%	%	%	%
1	No irrigation	80	24.6	38.0	15.0	22.4
2	" "	140	39.1	24.6	10.8	25.5
3	" "	200	33.3	26.0	21.1	19.7
4	Irrigated at	80	32.4	31.4	13.0	23.3
5	5 atmospheres	140	39.0	25.3	16.2	19.5
6	tension	200	31.8	28.2	19.8	20.3
7	Irrigated at	80	33.6	15.7	31.2	19.5
8	2 atmospheres	140	36.7	24.7	19.8	18.7
9	tension	200	39.4	24.1	18.9	17.7
	Average for irrigation treatments across all levels of nitrogen					
	No irrigation		32.3	29.5	15.6	22.5
	5 atmospheres tension		37.6	28.3	16.3	21.0
	2 atmospheres tension		36.6	21.5	23.3	18.6
	Average for nitrogen treatments across all levels of irrigation					
	80 pounds N per acre		30.2	28.4	19.7	21.7
	140 " " " "		38.3	24.9	15.6	21.2
	200 " " " "		34.8	26.1	19.9	19.2

Table 10. Effect of irrigation and nitrogen variables on the quality of dark tobacco, 1959-1963

Tmt. No.	Irrigation	Nitrogen	Leaf grade groups A	B	C	X
		Lb./A	%	%	%	%
1	No irrigation	100	10.1	36.8	9.9	43.2
2	" "	150	12.1	28.5	15.7	43.7
3	" "	200	3.6	39.4	19.1	37.9
4	Irrigated at	100	14.8	28.2	18.4	38.5
5	2/3 atmosphere	150	5.0	48.6	11.0	35.3
6	tension	200	16.4	23.9	24.7	35.1
7	Irrigated at	100	5.7	38.6	15.4	40.3
8	2 atmospheres	150	12.6	36.9	17.8	32.7
9	tension	200	14.1	29.2	21.1	35.6
10	Irrigated by	100	10.8	35.1	24.4	29.8
11	evapotranspiration	150	8.4	33.8	25.0	32.8
12	procedure	200	21.9	23.1	21.8	33.1
	Average for irrigation treatments across all levels of nitrogen					
	No irrigation		8.6	34.9	14.9	41.6
	2/3 atmosphere tension		12.1	33.6	18.0	36.3
	2 atmospheres tension		10.8	34.9	18.1	36.2
	By evapotranspiration		13.7	30.7	23.7	31.9
	Average for nitrogen treatments across all levels of irrigation					
	100 pounds N per acre		10.4	34.7	17.0	38.0
	150 " " " "		9.5	37.0	17.4	36.1
	200 " " " "		14.0	28.9	21.7	35.4

At nitrogen rates of 80 to 100 pounds per acre, irrigation had a tendency to decrease the percent of "B" leaf produced.

The percent of "C" leaf produced generally increased as the moisture level or amount of irrigation increased. This was true for most nitrogen levels, although the relationship was not true in all cases. The percent "C" leaf produced increased as nitrogen level increased but this effect became less pronounced at higher rates of nitrogen. The percent of "X" leaf produced was generally decreased by irrigation. However, the spread between the "X" leaf percentages at different irrigation levels became less as nitrogen levels were increased.

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