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Agronomic Attributes of Drought Resistance Mechanism In Tobacco (*Nicotiana Tabacum* L.)*

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ABSTRACT

The expressivity of the agronomical traits viz., days to flower, plant height, number of curable leaves, leaf area, cured leaf yield and non-wilting score of 17 tobacco genotypes in relation to three soil moisture levels observed from a 2-season, i.e., E_1 and E_2 study is reported. The irrigation levels were nonsignificant for all traits. Differences due to years were significant for days to flower and all genotypes flowered earlier during drought year. The genotypes differed for all traits. The significant interaction between genotypes and years revealed the possibility to select genotypes with regard to different traits for normal season or drought season or even to select genotypes nonsensitive to seasonal fluctuations. The *bidi* tobacco genotypes G1, G2, G3, G4, G6, G7 and G10 having non-wilting ability were found to be drought resistant.

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INTRODUCTION

Tobacco is a rainfed crop in heavy as well as light soils of India. Most of the light soil areas of India where it is grown are drought prone, hence the problem of instability of yields over time scale needs to be investigated. Knowledge based on the relative potencies of the yield and its components under different soil moisture stresses would be of much help to select tobacco varieties for drought prone areas as well as for the formulation of breeding programmes to evolve suitable genotypes having drought resistance.

Very little is known about the mechanism of drought resistance of tobacco. The expressivity of certain agronomical traits in relation to soil moisture stress is presented in this paper.

MATERIALS AND METHODS

The study was conducted at the Bidi Tobacco Research Station, Gujarat Agricultural University, Anand Campus, Anand. The meteorological data recorded for two seasons study viz., 1973-74 (E_1) and 1974-75 (E_2) presented in Table 1 indicate that E_1 was a normal season with a total rainfall of 1095.5 mm, while E_2 was a dry season with a

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TABLE 1

Meteorological data.

Year/Month	*Total monthly rainfall, mm*	*Average temperature °C*		*Average vapour pressure, mm*	
		Maximum	*Minimum*	*8.30 a.m.*	*5.30 p.m.*
1973-74 (E_1)					
June	72.39 (4)*	37.35	27.96	28.83	37.28
July	166.87 (16)	32.18	26.36	24.91	28.26
August	343.92 (18)	30.91	26.07	23.45	27.20
September	488.70 (19)	29.57	24.53	22.45	26.18
October	21.34 (1)	34.64	23.06	20.91	29.93
November	—	31.07	15.20	14.82	26.76
December	2.28 (1)	28.06	14.45	12.24	20.91
January	—	28.31	17.12	10.05	22.07
February	—	29.63	12.55	10.67	20.95
March	—	37.65	18.72	18.08	36.63
1974-75 (E_2)					
April	6.10 (1)	40.52	22.79	24.09	42.76
May	25.91 (3)	40.10	25.44	27.94	42.95
June	23.62 (4)	38.15	27.80	29.11	38.97
July	106.68 (7)	34.40	27.02	26.79	32.55
August	25.91 (6)	33.31	26.11	25.43	31.08
September	139.45 (6)	34.96	26.00	26.02	34.81
October	17.02 (3)	34.72	22.79	23.42	30.27
November	—	31.91	13.16	13.82	24.90
December	—	28.47	13.22	11.83	22.42
January	—	27.34	9.83	10.35	20.61
February	—	30.05	12.95	11.71	22.89
March	—	34.78	15.42	13.90	30.46

*Figures in parentheses indicate number of rainy days.

total precipitation of 344.7 mm. About 747 tobacco genotypes were screened at seedling stage for their stomatal number, epidermal cell number and stomatal indices number of both upper and lower epidermis layers during 1972-73 to select the experimental material. The genotypes falling under the tail ends of the spectrum for each character were planted in the field and further studied for their stomatal characteristics at the mature plant stage for confirmation. Based on these observations, 16 genotypes (Table 2) excluding control cultivar

TABLE 2

Mean values for different agronomical characters as influenced by irrigations and genotypes.

Treatments	*Days to flower*			*Plant height (cm)*			*Curable leaves number*		
	1973–74	**1974–75**	*Pooled*	**1973–74**	**1974–75**	*Pooled*	**1973–74**	**1974–75**	*Pooled*
Irrigations									
I_0	92.00	61.65	76.83	95.88	90.06	92.97	25.84	24.45	25.15
I_{30}	89.45	63.10	76.28	94.80	89.60	92.20	25.84	25.00	25.42
I_{60}	85.75	62.41	74.08	101.13	90.94	96.03	25.34	23.86	24.60
S.Em.	2.10	1.31	1.76	2.45	2.48	1.36	0.44	0.44	0.17
C.D. at 5%	ns	ns	ns	ns	ns	ns	ns	ns	ns
C. V. %	16.80	14.95	16.47	18.02	19.61	18.79	12.31	12.72	12.52
Years	89.07	62.39		97.27	90.20		25.67	24.44	
S. Em.	1.01			1.42			0.25		
C.D. at 5%	3.29			ns			ns		
Genotypes									
G1	87.82	63.33	75.58	49.18	50.75	49.97	17.41	18.63	18.02
G2	89.48	56.55	73.02	100.26	87.70	93.98	25.73	22.78	24.26
G3	102.04	74.15	88.10	173.01	158.94	165.98	32.71	32.24	32.48
G4	94.11	71.19	82.66	153.87	114.31	134.09	37.12	28.61	32.87
G5	92.37	66.82	79.59	121.71	106.19	113.96	25.97	23.16	24.57
G6	76.89	58.14	67.52	91.33	89.76	90.55	19.71	19.60	19.66
G7	84.44	60.49	72.47	75.93	75.25	75.59	18.93	19.48	19.21
G8	72.14	49.85	61.00	71.56	63.99	67.78	17.92	17.11	17.52
G9	77.57	55.51	66.55	41.29	40.44	40.87	16.96	18.00	17.48
G10	91.19	57.77	74.48	83.79	100.12	91.96	18.96	20.83	19.89
G11	83.26	59.73	71.49	103.94	88.65	96.30	26.98	24.18	25.58
G12	96.57	63.73	80.15	116.19	104.98	110.59	29.81	27.67	28.74
G13	108.08	68.66	88.37	142.89	125.07	133.98	33.63	30.24	31.94
G14	85.38	63.52	74.45	91.96	93.19	92.58	27.90	27.11	27.51
G15	104.91	65.35	85.13	71.63	65.47	68.56	26.44	25.50	25.97
G16	96.23	71.29	83.77	86.16	91.60	88.88	34.97	36.91	35.94
G17	71.70	54.43	63.07	78.89	76.78	77.84	25.24	23.40	24.32
S. Em.	2.82	1.80	3.33	3.28	2.88	6.11	0.73	0.58	1.27
C. D. at 5%	7.90	5.04	9.22	9.21	8.09	16.94	2.05	1.64	3.52
C. V. %	9.48	8.63	9.36	10.12	9.58	9.89	8.55	7.17	7.93
Genotypes x Years									
S. Em.	2.36			3.09			0.60		
C. D. at 5%	6.54			8.56			1.84		

Leaf area (cm^2)			*Cured leaf yield* (kg/ha)			*Non-wilting scores* (**1974-75**)	
1973–74	**1974–75**	*Pooled*	**1973–74**	**1974–75**	*Pooled*	*Original value*	*Trans-formed value*
635.20	1126.20	880.68	1941	1822	1881	0.55	0.99
649.04	1081.04	865.04	2030	1793	1911	0.61	1.02
872.00	1246.08	1059.04	2444	1793	2119	0.67	1.05
52.55	63.69	29.23	207.4	103.7	133.3		0.03
ns	ns	ns	ns	ns	ns		ns
52.21	39.51	44.60	70.9	39.2	60.1		18.52
718.76	1151.12		2133	1807			
33.71			88.9				
ns			ns				
956.88	1299.60	1128.32	2504	1867	2178	1.00	1.22
741.24	1389.40	1065.40	2741	2341	2548	1.00	1.22
888.12	1322.00	1105.12	3348	2389	2919	0.89	1.16
776.80	1181.04	978.96	3259	2074	2667	0.89	1.16
1023.64	1396.72	1210.24	3259	2252	2756	1.00	1.22
900.00	1401.12	1150.64	2993	1985	2489	1.00	1.22
809.08	1185.72	997.44	2074	1896	1985	1.00	1.22
768.76	1220.28	994.56	2133	1585	1867	1.00	1.22
701.84	1049.44	875.68	1719	1630	1674	0.89	1.16
688.36	1391.56	1040.04	1926	1926	1926	0.88	1.16
762.00	1174.96	768.52	1837	1556	1704	0.11	0.77
530.96	932.08	731.56	1511	1630	1570	0.22	0.82
507.44	938.76	723.12	1244	1556	1393	0.00	0.71
674.12	1209.40	941.84	1807	1644	1733	0.33	0.88
490.80	857.64	674.28	1200	1526	1363	0.11	0.77
390.24	629.68	509.96	948	1244	1096	0.00	0.71
608.36	987.60	798.04	1852	1407	1630	0.00	0.71
44.72	62.23	56.45	177.8	118.5	237.0		0.05
125.48	174.61	156.48	489	356	667		0.13
18.66	16.21	17.39	24.1	20.8	22.9		13.26
54.19			148.2				
150.21			414.8				

Anand 2 were selected wherein major emphasis was given to high and low stomatal frequencies to detect the existence of relationship, if any, between the stomatal frequency and drought resistance.

The gradient of soil drought condition was developed by using the following irrigation levels :

(i) No irrigation—Control (I_0)

(ii) Irrigating the field when available soil moisture reduced to 30 per cent—(I_{30})

(iii) Irrigating the field when available soil moisture reduced to 60 per cent (I_{60})

Tobacco being a deep rooted annual plant, soil moisture measurements were made from the depth of 20-30 cm for maintaining proper moisture regimes. Soil moisture determination (Thermo-gravimetric method) and measurement of the quantity of water to be applied to bring the soil to field capacity were done following the procedures suggested by Dastane (1972). The experiment was conducted using split plot design with three replications wherein irrigation treatments were relegated to main plots. The gross and net size of the main plots were 20.7 m × 12 m and 15.3m × 7.5 m, respectively. A single row of ten plants represented the subplot. The inter and intra row spacings were 90 cm and 75 cm repsectively. All cultural operations were followed according to the general method of *bidi* tobacco cultivation. The plants were topped after first flower opening three leaves below the bald sucker. Harvesting was done by priming method and the leaves were sun-cured. Three plants were selected randomly from each plot and the mean value was computed for the following characters:

Days to flower was recorded from transplanting to the cow foot flower opening. Plant height was measured in cm after topping from ground level to the topped point. Number of curable leaves represented the total harvested leaves from a plant. Leaf area of seventh, eighth and nineth leaves from the bottom were measured in cm^2 using a calibrated frame and the mean value was computed. Cured leaf yield of each plot obtained from all pickings was weighed in kg. Non-wilting at mid-day was scored using the scale, zero (wilting) and one (non-wilting) on plot basis during 1974-75 only. Square root transformation of the data was done prior to analysis with the function $\sqrt{x+\frac{1}{2}}$, where x represents the score and the data were analysed (Snedecor and Cochran, 1967).

RESULTS AND DISCUSSION

The study revealed that the irrigation levels were nonsignificant for all characters (Table 2) during individual years as well as on pooled basis. These results are at variance with previous workers who found that high soil moisture (i) hastened flowering (Anitia and Ille, 1958; Fukuzumi *et al.*, 1971; Kincaid *et al.* 1967; Yakovuk and Okazov, 1969), (ii) increased the height of tobacco plant (Atkinson *et al.*, 1969; Chang and Chou, 1975; Matusiewics, 1956; Mehrotra *et al.*, 1970; Nishikawa and Ichishima, 1954), (iii) increased the leaf number (Fukuzumi *et al.*, 1971; Matusiewics, 1956; Mehrotra *et al.*, 1970; Nishikawa and Ichishima, 1954) and (iv) enhanced leaf area (Atkinson *et al.*, 1969; Janawade, 1974; Kincaid *et al.*, 1967; Kincaid *et al.*, 1968; Ligon and Benoit, 1966; Mehrotra *et al.*, 1970; Necesito, 1972; Nishikawa and Ichishima, 1954; Postiglions, 1958) which may be due to the differences in agro-ecological conditions under which the different experiments were coducted. With regard to cured leaf yield, though many researchers reported positive response of high soil moisture to yield, few (Anon,. 1965; Fukuzumi *et al.*, 1971; Nishikawa and Ichishima, 1954; Rostron, 1966) could not find differences in dry matter of tobacco leaves in relation to soil moisture regimes. As regards the wilting of the plants, it appears that it was influenced by their genetic make up rather than soil moisture regimes studied. The *bidi* tobacco genotypes (G 1 to G 10) had higher endurance against wilting and differed significantly from the rest, the differences among them were, however, not significant.

The differences due to seasons were significant only for days to flower. All genotypes flowered early during dry season (Table 1) indicating their tendency to flower early during drought season to complete the reproductive phase so as to tide over the adverse drought condition.

The differences among genotypes were significant for all the agronomical characters for individual years as well as on pooled basis. The genotypes x irrigations interaction was nonsignificant for all traits for individual years as well as on pooled basis, indicating the non-differential response of genotypes to the levels of soil moisture stress studied. Similarly, the second order interaction genotypes x irrigations x years was also nonsignificant for all characters.

The genotypes x years interaction was significant for all traits suggesting that the genotypes responded differentially to the divergent seasons (Table 1). The higher magnitude of vapour pressure during September and October in E_2 over the corresponding period in E_1 might have hastened flowering in E_2 season.

The seasonal influence on the manifestation of plant height in tobacco was differential. Genotypes G_2 to G5 and G11 to G13 grew significantly taller during normal season (E_1), while G10 had put up more height during dry season (E_2). Rest of the lines were stable in the expression of this trait during both the years.

With regard to the number of curable leaves, lines G1, G3, G6 to G9, G14, G15 and G17 were stable irrespective of seasons whether normal or drought. Cultivars G10 and G16 produced significantly more leaves during dry season (E_2), while the remaining exhibited a trend to put up more leaves during normal season (E_1).

For leaf area, the genotypes responded differentially to the environmental conditions that prevailed during the normal and drought seasons. As all the genotypes flowered earlier in E_2 than E_1, they were topped earlier. The post-topping leaf growth might have played a predominant role in the increase of leaf area during E_2. It has been a common observation in such drought resistance studies that the dynamic processes of water in the soil-plant-atmosphere continuum are affected by many soil, plant and environmental factors (Hagan *et. al.*, 1959). The soil moisture data (Table 3) reveal that though the I_{60} treatment

TABLE 3

Soil moisture data of the experimental plots.

Treatments	*Initial average soil moisture per cent*	*Final average soil moisture per cent*	*Number of irrigations given*	*Quantity of water given ha cm*
1973-74 (E_1)				
I_0	61.29	50.87		
I_{30}	(100-30)			
I_{60}	(100-60)		3	24.43
1974-75 (E_2)				
I_0	68.11	33.16		
I_{30}	(100-30)		1	15.03
I_{60}	(100-60)		3	34.46

received an average quantity of 24.43 ha cm (E_1) and 34.46 ha cm (E_2), and I_{30} treatment 15.03 ha cm of water during E_2, yet the moisture regimes did not show significant differences for the agronomic characters studied, more so for leaf area, the principal vegetative growth factor.

The meteorological data (Table 1) indicate that during September, October and December of E_2, the vapour pressure showed higher magnitude than the corresponding period of E_1 revealing the existence of more humid conditions and consequently increase in leaf area during E_2. Very good dew condensation was observed (though quantitatively not measured) during E_2 (dry season) which might have increased the vapour pressure and thereby helped the plants to circumvent the effect of soil drought which in turn led to the increase in leaf area even in the drought year. Balcar (1958) traced the importance of dew on tobacco plant, while Vaadia and Waisel (1963) concluded that the atmospheric moisture condensed on the leaf surface as liquid water is absorbed through open cuticle. Amrell (1955) and Neas (1955) have reported beneficial effect of higher atmospheric humidity on the water economy of the plant.

As regards cured leaf yield, genotypes G2, G7 and G9 through G16 had high plasticity over seasonal fluctuations, while the remaining genotypes produced significantly more yield during E_1 than E_2 season indicating their susceptibility to drought. The differential response of genotypes to seasons suggests the possibility to select genotypes non-sensitive to seasons or suitable for normal or drought season for these traits.

Assessment of drought resistance through soil moisture regimes for agronomical traits:

There was no differential response of three soil moisture regimes to the agronomical characters studied. Briggs and Shantz in 1914 and Maximov and Alexendrov in 1917 (Raheja, 1951) from their investigations on water requirements of crop plants and other Xerophytic species concluded that there did not exist any direct proportionality between drought resistance and water requirement of plants. But during recent years many workers, while studying several crop plants have recorded a positive response of high soil moisture to yield and its components, more so with the cereals (Asana and Mani, 1958; Asana and Saini, 1962; Denmead and Shaw, 1960; Vincent and Woolley, 1972). Since the reproductive part is the economic produce in cereals, water has evidently a definite role throughout the life cycle of the plant and hence the seed yield is more vulnerable to soil moisture deficiency.

Tobacco crop where leaf is the economic product, mostly requires water during the early stage after transplanting for its establishment and later on after topping for leaf expansion and poundage. Though most of the workers have opined a positive response of irrigation to yield and its attributes, some (Anon., 1965; Fukuzumi *et. al.*, 1971; Nishikawa and Ichishima, 1954; and Rostron, 1966) could not observe the response of irrigation to yield. It appears that the response of tobacco plants to irrigation depends upon the interaction of soil, plant and environmental conditions. The nonsignificant genotypes x irrigations interactions and significant genotypes x years interactions for days to flower, plant height, number of curable leaves, leaf area and cured leaf yield reveal that the genotypes behaved uniformly in relation to the levels of soil moisture stress studied, but when seasons were taken into consideration, the genotypes did show differential response to drought and normal years as the soil-plant-atmosphere continuum varied from season to season.

These results suggest that tobacco crop under the agro-climatic conditions of Anand tract need not be irrigated after establishment during a normal year. Even during drought year, the crop could be grown successfully if favourable good dew fall prevails to maintain high vapour pressure during the active period of plant growth.

Thus, the mechanism of drought resistance in tobacco from this study displays early flowering and non-wilting ability against the high temperatures at mid-day.

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