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INTERRELATIONSHIPS AMONG CERTAIN LEAF CHARACTERISTICS IN *CASSIA TORA* L.

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Introduction

Cassia tora L. is an annual species of gregarious habit with high productive potential. Net dry matter production per unit area in its populations within three months of its life-cycle is significantly greater than the annual production of the nearby perennial grasslands (Singh, 1969). Further, its dry matter yield is greater at 30-40° C as compared to that at 15° C (Singh, 1967). Since growth rate and dry matter production have been found to be related to such leaf characteristics as the total leaf area (Misra *et al.*, 1967) and chlorophyll content (Brougham, 1960; Bray, 1960; and Whittaker and Garfine, 1962) in a number of species and plant communities, the present investigation was conducted to assess the influence of two temperatures (15° C and 30°–40° C) on certain leaf characteristics of this species. Emphasis was laid on the evaluation of the interrelationships of these characteristics with a view to explain the high productive efficiency of this plant.

Materials and Methods

Plants were raised in earthenware pots from seeds collected from different localities during January 1965 in a phytotron (15° C) and in an adjoining glass-house (30°-40° C). Seeds collected in February 1966 from plants raised in the weed garden at Varanasi from the 1965 seed collection were also used for raising plants in order to compare them with those raised from original collection. Ten pots, with three plants in each, were maintained for different localities at both the temperatures. Seeds were sown on 23rd August 1966 and observations, reported here, were recorded between 11-14th October 1966.

All the leaves from sample plants were detached, with the help of a pair of scissors. Contact prints were obtained from these leaves on bromide paper for measurement of leaf area. Immediately afterwards the total leaves of each plant were separated into two equal halves,

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on fresh weight basis. One half was used for dry matter determination, through drying at 105° C for 24 hours. The other half was crushed in a glass mortar with 25 ml of 80% acetone and the mixture was centrifuged at 3,000 r.p.m. for 5 minutes. This process was repeated with another 15 ml aliquot of acetone. The supernatant clear liquid was transferred to a volumetric flask of 50 ml capacity and the volume was made up with acetone. Optical density of this solution was evaluated through a red filter having 610 mμ maximum in a Hilger's photo electric colorimeter. Values for leaf dry matter and optical density were converted to per plant.

Leaf area was determined from the contact prints with the help of a planimeter. Relationships among various leaf characteristics were studied through regression analysis (Croxton and Cowden, 1964). The significance of the correlation coefficients (r) was examined by t-analysis (Croxton and Cowden *loc. cit.*). Significance of the difference between various attributes at the two temperatures was also studied through t-test.

OBSERVATIONS

Total leaf dry weight.—It is indicated from table I that total dry weight of leaves per plant is higher for those raised at a temperature ranging from 30° to 40° C as compared to those raised at 15° C. This is true for plants raised from all the localities using original as well as seeds of later generation. The differences between the dry weight values at 15° C and 30°-40°C are significant both for plants of original collection and those of a later generation.

TABLE I

Leaf dry matter in C. tora *plants raised from seeds of different localities at two temperatures*

(Each value is the mean of 5 replicates)

Seed origin	Plants from original seeds (1965)		Plants from seeds of weed garden (1966)	
	15° C	30°-40° C	15° C	30°-40° C
Ahmedabad ..	0·018	0·181	0·021	0·168
Ujjain ..	0·016	0·180	0·026	0·190
Sagar ..	0·015	0·162	0·023	0·170
Varanasi ..	0·026	0·088	0·028	0·080
Patna ..	0·029	0·072	0·027	0·075
Delhi ..	0·020	0·230	0·016	0·238
Jammu ..	0·042	0·193	..	..
Africa (Ghana) ..	0·010	0·092	..	..
t-value ..	7·05*		4·81*	

Total leaf area *$P < 0·001$,

Average leaf area of one leaflet varies from 0·6 sq. cm. (African origin) to 1·0 sq. cm. (Jammu origin) at low temperature (Table II).

TABLE II

Leaf area of C. tora *raised from seeds of different localities at two temperatures*

(Each value is the mean of 5 replicates) (sq. cm.)

Seed origin	Plants from original seeds (1965)				Plants from seeds of weed garden (1966)			
	Area of leaflet		Total leaf area		Area of leaflet		Total leaf area	
	15 (°C.)	30–40 (°C.)	15 (°C.)	30–40 (°C.)	15 (°C.)	30–40 (°C.)	15 (°C.)	30–40 (°C.)
Ahmedabad	0·80	1·71	12·60	73·80	0·80	1·72	11·7	67·9
Ujjain ..	0·70	1·71	12·20	81·51	0·71	1·70	11·5	76·3
Sagar ..	0·80	1·60	14·20	76·20	0·70	1·70	12·3	72·8
Varanasi ..	0·80	1·70	12·30	62·80	0·70	1·70	13·5	57·9
Patna ..	0·90	1·50	15·10	50·20	0·86	1·40	13·6	46·8
Delhi ..	0·93	1·76	10·54	109·00	0·82	1·73	9·8	112·8
Jammu ..	1·00	1·80	19·60	110·30	..	..	..	..
Africa (Ghana)	0·60	1·50	8·80	51·70	..	..	..	..
t value ..	11·33*		13·65*		12·02*		6·45*	

* $P < 0{\cdot}001$

At higher temperature the average area of the leaflets is considerably greater, ranging from 1·4 (Patna) to 1·8 (Jammu) sq. cm.

Total leaf area per plant is also considerably higher, when plants are grown at higher temperature (Table II). From the data collected it is indicated that difference in seed origins is mainly due to number of leaves developed by the plants, because the variation in the average area of leaflets at any one temperature is not great. The influence of temperature is significant for both the area of leaflets, as well as the total leaf crop.

Optical density of chlorophyll extract.—Optical density of the leaf extract in acetone is lower in plants raised at low temperature (Table III). This is true both for the plants raised from original collection and those of a later generation. The difference in values obtained at the two temperatures is again statistically significant,

TABLE III

Optical density of the leaf extract in acetone from C. tora *raised from seeds of different localities at two temperatures*
(Each value is the mean of 5 replicates)

Seed origin	Plants from original seeds (1965)		Plants from seeds of weed garden (1966)	
	15° C	30°–40° C	15° C	30°–40° C
Ahmedabad ..	0·10	0·57	0·13	0·54
Ujjain ..	0·06	0·52	0·15	0·56
Sagar ..	0·08	0·58	0·16	0·58
Varanasi ..	0·16	0·34	0·14	0·34
Patna ..	0·18	0·28	0·16	0·29
Delhi ..	0·10	0·79	0·08	0·80
Jammu ..	0·22	0·63		
Africa (Ghana) ..	0·04	0·32		
t-value ..	4·78*		4·90*	

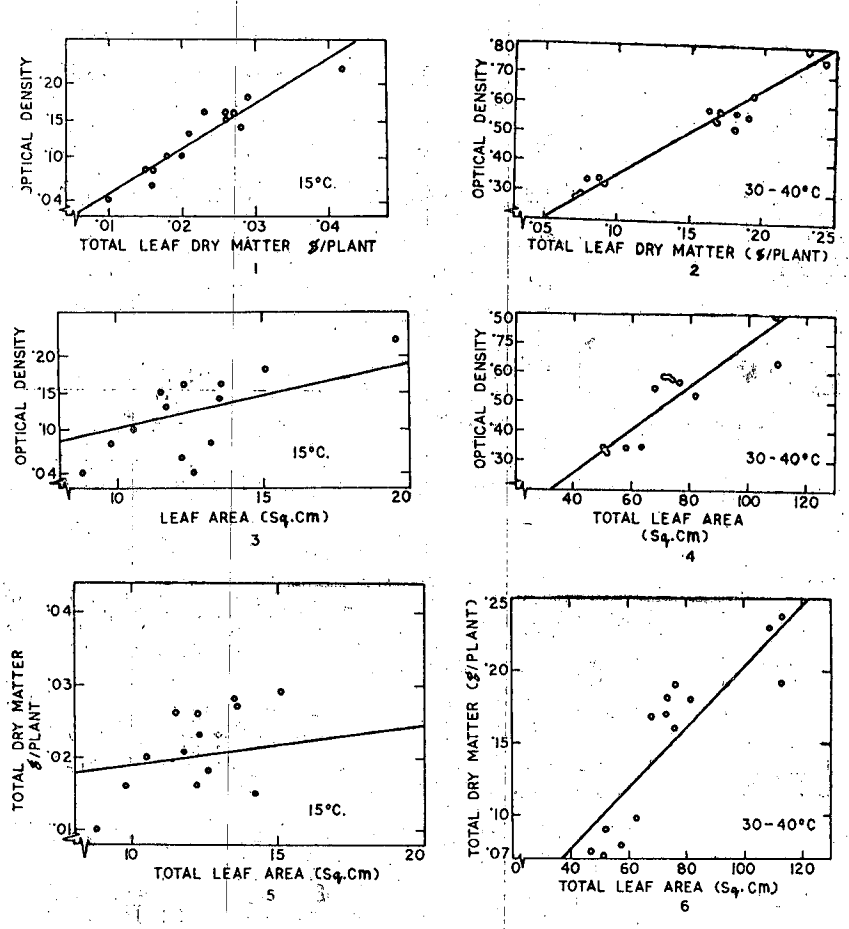
* $P < 0 \cdot 001$

DISCUSSION

From the foregoing, the effect of temperature on all the three leaf characteristics examined becomes obvious. Total leaf dry weight, total leaf area and optical density of the leaf extract in acetone are at their maximum when plants are grown at a temperature ranging from 30°–40° C. Since growth and dry matter production are related to such characteristics of leaf, it is evident that *C. tora* is favoured by high temperature. This explains the greater dry matter yield of this species at 30°–40° C (Singh, 1967).

The total leaf dry weight at 15° C is related to the optical density of the leaf extract according to $Y = -0 \cdot 005 + 5 \cdot 826 X$, where Y is the optical density and X is the total dry weight of the leaf crop (Fig. 1). This relation is statistically significant ($r = +0 \cdot 935$: $P < 0 \cdot 001$) indicating thereby that the dry matter of the leaves is a function of the optical density of the leaf extract. At the higher temperature also these two attributes are directly related ($r = +0 \cdot 978$: $P < 0 \cdot 001$) according to $Y = 0 \cdot 068 + 2 \cdot 93 X$ (Fig. 2). These relationships emphasize the influence of the amount of chlorophyll (through optical density) on the accumulation of dry matter in leaves.

The total leaf area at 15° C is related to the optical density of the leaf extract according to $Y = 0 \cdot 008 + 0 \cdot 0093\, X$, where Y is the optical density and X is the leaf area (Fig. 3). The relationship is statistically significant ($r = + 0 \cdot 643$; $P < 0 \cdot 05$). At 30°–40° C also these two attributes indicate positive relation ($r = + 0 \cdot 95$; $P < 0 \cdot 001$) according to $Y = - 0 \cdot 04 + 0 \cdot 0074\, X$ (Fig. 4). This significant relationship indicates that the plant is capable of increasing its leaf area in order to utilise the increased chlorophyll content for greater photosynthetic efficiency.



FIGS. 1–6. Fig. 1. Relationship between optical density of the leaf extract and total leaf dry matter at 15° C. Fig. 2. Relationship between optical density of the leaf extract and total leaf dry matter at 30°–40° C. Fig. 3. Relationship between optical density of the leaf extract and total leaf area at 15° C. Fig. 4. Relationship between optical density of the leaf extract and total leaf area at 30°–40° C. Fig. 5. Relationship between total leaf dry matter and total leaf area at 15° C. Fig. 6. Relationship between total leaf dry matter and total leaf area at 30°–40° C.

The total leaf area is related to the total leaf dry weight at 15° C according to $Y = 0 \cdot 0195 + 0 \cdot 00024\ X$ (Fig. 5), where Y is the total leaf dry weight and X is the total leaf area. This significant direct relation at low temperature ($r = + 0 \cdot 66$; $P < 0 \cdot 01$) is also exhibited at higher temperature ($r = + 0 \cdot 81$; $P < 0 \cdot 001$) where the leaf area is related to dry weight according to $Y = - 0 \cdot 007 + 0 \cdot 0021\ X$ (Fig. 6). This positive relationship indicates the effort of the plant at minimising the accumulation of dry matter within a limited leaf area. This feature is again beneficial for photosynthetic efficiency of the plant.

Out of the aforementioned correlations, only that between total leaf area and optical density is found to be significantly different at the two temperatures (Table IV). This test was made by calculating X/σ-value (Croxton and Cowden *loc. cit.*) and then computing the probability value (Croxton, 1949). This test indicates that temperature may significantly influence the relationship between leaf area and optical density in this species.

TABLE IV

Influence of temperature on the relationships amongst leaf characteristics of C. tora

Relationship	X/σ	Probability	Significance
Total leaf dry weight *vs.* Optical density	1·084	0·280	$P > 0 \cdot 05$
Total leaf area *vs.* Optical density	2·576	0·0098	$P < 0 \cdot 001$
Total leaf area *vs.* Total leaf dry weight	0·804	0·4009	$P > 0 \cdot 05$

The above observations clearly reveal that *C. tora* possesses certain important leaf properties which are favourable for high photosynthetic efficiency.

It is possible, therefore, to explain the high productivity of *C. tora* populations on the basis of the present study.

SUMMARY

C. tora plants grown at 30°–40° C exhibit higher values for the leaf characteristics studied as compared to those grown at 15° C. Dry weight of the leaf crop, total leaf area, and optical density of the leaf extract are interrelated positively amongst each other. These relationships indicate high productive potential of the species.

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