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INVESTIGATION INTO SOME PHYSIOLOGICAL PARAMETERS OF COTTON UNDER WATER STRESS

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ABSTRACT

Two cotton varieties, G. Cot. 10 (*G. hirsutum* L.) and G. Cot. 11 (*G. herbaceum* L.) were subjected to water stress during 75-130 days after emergence. Total leaf area and dry weight of shoot reduced drastically, more in G. Cot 10 than in G. Cot. 11. The per cent decrease in root weight was more prononuced in G. Cot. 11. The specific leaf weight, however, increased, more in G. Cot. 11 than in G. Cot. 10.

Higher amounts of free proline, free amino acids, chlorophyll and K accumulated under stress in the leaves of G. Cot. 11 imparted it greater degree af stress tolerance through high osmoticum. The values of nitrate reductase and relative water content, despite more *in vivo* decline in G. Cot. 11 remained higher than those in G. Cot. 10.

INTRODUCTION

In the Central Zone, comprising the states of Madhya Pradesh, Gujarat and Maharashtra, cotton is mostly grown rainfed. Low and erratic rainfall in these areas considerably affects the productivity of the crop. Most high yielding varieties/hybrids are low yielders under such conditions, because of poor tolerance to stress. Quick and reliable physiological and biochemical parameters of tolerance to water stress need to be identified for the crop improvement. Paleg and Aspinall (1981) and Kramer and Raper (1983) have reviewed such parameters. However, specific information on cotton is lacking. Therefore, the present investigation was taken to identify parameters and their relation with tolerance to water stress in cotton.

MATERIALS AND METHODS

The experiments were carried out in 14-kg pots with two varieties viz., G. Cot. 10 (*G. hirsutum* L.) and G. Cot. 11 (*G. herbaceum* L.). The plants were subjected to three cycles of water stress at 75, 95 and 115 days after emergence. Each stress cycle was alleviated by watering when the wilting of the top leaves was observed. The observations were recorded before the termination of the preceding stress cycle. Chlorophyll content was estimated by the method of Arnon (1959), free proline by that of Bates et al. (1973), free amino acid were determined after Lee and Takahashi (1966) and nitrage reductase *(in vivo)* after Jaworski (1976). The pH of the cell sap was estimated by the method of Dwivedi et al. (1980) and relative water content (RWC) by the method of Barrs and Weatherly (1962). For nitrogen, phosphorus, potassium and sodium, procedures of Jackson (1967) were used. All determinations were carried out in duplicate. Separate plants in duplicate from two replications were taken for dry matter, leaf area and root studies.

RESULTS AND DISCUSSION

The results indicated that several physiological parameters were affected by water stress and the performance of the two varieties was also different. The *herbaceum* variety G. Cot. 11 faired better than the *hirsutum* variety G. Cot. 10 as evident from shoot-weight and leaf area.

Water stress drastically reduced the dry weight of shoot and leaf area in both the varieties (Table 1). The magnitude of reduction in shoot over the irrigated was 61% and 54% in G. Cot. 10 and G. Cot. 11, respectively. The corresponding reduction in leaf area was 46% and 32%, respectively. The average size of leaf (area) as well as spceific leaf weight did not change due to stress in G. Cot. 10, however, it was considerably increased in G. Cot. 11. Although the root weight was more adversely affected in the stress tolerant variety G. Cot. 11, yet the weight was still higher in the G. Cot. 10 variety.

Table 1. Effect of water stress on growth and development of cotton

Treatments	Dry wt (g) per plant		Leaf area (cm^2)		Specific leaf wt
	Shoot	Root	Total per plant	Av per leaf	
G. Cot. 10					
Irrigated	20.85	1.13	995.6	23.9	5.23
Stress	8.21(61)	0.63 (44)	537.6 (46)	23.7	5.27
G. Cot. 11					
Irrigated	16.76	1.72	842.3	19.1	3.80
Stress	7.68 (54)	0 86 (50)	573.0 (32)	26.4	4.83

Figures in parentheses show per cent reduction over control (irrigated)

The pH of soil sap remained unaffected by stress in G. Cot. 11 but slightly lowered in G. Cot. 10. The relative water content declined in both the varieties but more in G. Cot. 11 (Table 2). A similar trend was observed for nitrate reductase activity and thus, it was not commensurate with the high performance of the variety, though the activity was higher in G. Cot. 11 than in G. Cot. 10. Cotton plant is considered to tclerate drought through osmoregulation (Hsiao et al., 1976 and Ackerson and Herbert, 1981). Cutler et al. (1977) and Elmore and McMichel (1981) reported that this adjustment is brought about by accumulation of proline, free amino acids, sugar, malate and several cations.

Table 2. Effect of water stress on some physiological parameters of cotton varieties

Variety and treatment	Relative water content	pH of cell	mg/g fresh wt			mg/g dry wt	
			Proline	Free Amino acid	Nitrate reductase (NO_2)	Chlo ro-phyll a	Chlo-rophyll b
G. Cot. 10							
Irrigated	74.05	3.98	0.092	1.184	15.95	2.56	2.63
Stress	48.60	3.91	0.918	1.736	11.65	2.38	2.43
G. Cot. 11							
Irrigated	78.05	3.99	0.058	0.986	43.40	2.97	2.58
Stress	41.05	3.99	0 876	1.736	20 00	2.77	2.86

The free amino acid as well as proline showed a higher accumulation under water stress in G. Cot. 11 as compared to G. Cot. 10 (Table 2). The varieties exhibited wide differences in tissue concentration of major nutrients in response to stress (Table 3). The nitrogen and potassium contents declined in G. Cot. 10 but in G. Cot. 11, the nitrogen was unaffected while the potassium enhanced. The sodium content decreased in both varieties, however, to a greater extent in G. Cot. 11. The phosphorus concentration, in contrast to sodium, increased under stress in both the varieties. Chlorophyll (a and b) contents declined in G. Cot. 10 but enhanced in G. Cot. 11 High build up of osmoregulants and greater stability of chlorophyll is considered to have maintained a higher growth level of G. Cot. 11 variety over G. Cot. 10.

Table 3. Effect of water stress on nutrient concentration (mg/g dry weight) in the leaves of cotton varieties

Variety and Treatment	N	P	K	Na	K : Na ratio
G. Cot. 10					
Irrigated	53.60	2.03	14.25	4.15	3.43
Stress	50.80	2.55	13.60	3.60	3.78
G. Cot. 11					
Irrigated	42.80	2.47	15.90	5.30	3.00
Stress	42.85	3.11	17.00	3.65	4.66

Lower uptake of Na^+ and higher uptake of K^+ is a desired trait for tolerance to stress (Janagoudar et al , 1983). The adverse effect of drought has been reported to be overcome by K application in various annual crops including cotton (cf. Balasimha, 1983).

The pH of the cell sap in the tolerant type (G. Cot. 11) did not change due to stress (Table 2). The precise role of pH in water stress is not known. Mass and Nieman (1978) opined that a relatively steady pH is the indication of a tolerant plant, which, in the present study, appears true for cotton as well.

The variety G. Cot. 11 which accumulated more K^+ also showed greater accumulation of free proline. However, in G. Cot. 10, only proline accumulation was observed. The relation between K^+ and proline in cotton varieties reported by Janagoudar et al. (1983) seems to hold true for G. Cot. 11 but not for G. Cot. 10.

Higher content of P was observed under stress in both the varieties. The N content was reduced in G. Cot. 10 but it remained unchanged in G. Cot. 11. The exact role of P or N in stress tolerance is not known and the reports are often contradictory (Verma, 1979; Rao and Ramamoorthy, 1981).

It is inferred that G. Cot. 11 better tolerated the stress by accumulation of K^+, free proline, free amino acid, stability of chlorophyll and restricted uptake of Na. Most of the characters are believed to be heritable and could be used in the screening of genotypes for stress tolerance.

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