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Morpho-Physiological Response of Cotton (*Gossypium hirsutum* L.) Cultivars to Variable Edaphic Conditions

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Abstract

An experiment was conducted to determine the response of five cotton (*Gossypium hirsutum* L.) varieties to varying concentrations of NaCl i.e., 3 (control), 10, 15 and 20 dS/m. The experiment was laid down in a completely randomized design (CRD) with two factorial arrangement. Plant height, leaf area, biomass and chlorophyll contents decreased with increase in soil salinity while carotenoids, anthocyanins and flavones increased. Cultivars NIAB-98 and CIM-443 were found to be more salt tolerant as compared to CIM-482, FH-900 and BH-118.

Keywords: Cotton, Carotenoids, Flavones, Anthocyanins

Introduction

Salinity is a major external factor, which causes substantial changes in the morphology and physiology of plants. It affects plant growth directly through its interaction with metabolic rates and pathways within plants. It checks nutrient availability indirectly and affects plant growth at all stages of development but sensitivity varies from one growth stage to another (Shannon, 1997; Ashraf and Ahmed, 2000).

Salt stress induces the modification of carotenoid concentration and chlorophyll degradation in salt sensitive plants (Singh and Singh, 1999). In contrast, an increase in chlorophyll contents has been observed for tolerant species. At lower salinity level, there was an enhancement in chlorophyll a and b contents but under increased salt concentration, there was a decrease in total chlorophyll and carotenoid contents in cotton (Ding *et al.*, 1995). Carotenoids decrease more slowly than chlorophylls (Kuznetsov *et al.*, 1991). Accumulation of flavonids is also important in the tolerance of abiotic stress Justsen *et al.*, 1999).

Keeping in view the above facts, this research was designed to investigate the effect of moderate and severe salinity levels on five cotton varieties at early growth stages particularly emphasized on the changes in plant secondary products.

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Material and Methods

Five cotton varieties i.e. CIM-443, CIM-482, NIAB-98, FH-900 and BH-118 were used to investigate the effect of NaCl salinity on various morphological and physiological parameters. Investigation was carried out in polyethylene-lined earthen pots having 30 cm diameter and filled with 10 kg air dried sieved soil. Saturation percentage (34%) and electrical conductivity of soil extract (ECe), (3.00 dS/m) were determined before sowing. The pots were arranged in completely randomized design with factorial arrangement. The plants were subjected to 3 (control), 10, 15 and 20 dS/m of NaCl developed in installments by adding 3 dS/m per day, forty days after germination, while normal field soil (3.0 dS/m) acted as control. Tap water was used for irrigation and all agronomic practices were carried out as recommended for cotton crop. Three plants of each variety from each treatment were uprooted 20 days after the initiation of salt treatment and evaluated for various morphological and physiological parameters.

The chlorophyll (Chl.a & Chl.b) and carotenoids were measured by method of Arnon (1949) and Davis (1976). The anthocyanins and flavones contents were determined according to the method of Justesen *et al.* (1996). The data were subjected to statistical analysis for comparison.

Results and Discussion

One of the most prominent effects of salinity like other stresses was on the visual morphological characters. Although there was a remarkable reduction in various parameters of five cotton varieties under the saline conditions but the effect was more pronounced for the high salt treatment (20 dS/m). Salinity decreased leaf area and plant height (Table 1). The most affected genotypes were FH-900 and CIM-482. It has been reported earlier that height of plant, stem thickness, shoot and root weight decreased with increasing substrate salinity in cotton (Qadir and Shams, 1997; Rehman *et al.*, 2001).

Although *Gossypium hirsutum* is regarded as a tolerant species compared to various other glycotypes (Maas *et al.*, 1994), considerable reduction was recorded in biomass produced by various cultivars.

Table 1: Effect of salinity (NaCl) on morphological parameters of five cotton cultivars.

Varieties(V)	Treatments (T)	Plant height (cm)	Plant leaf area (cm^2)	Leaf dry weight (g)	Stem dry weight (g)	Root dry weight (g)
NIAB-98	control	46.33	88.45	8.067	2.070	1.387
	10 dS/m	43.33	72.48	7.333	1.913	0.733
	15 dS/m	38.00	59.40	6.667	1.560	0.540
	20 dS/m	32.00	57.31	5.667	1.187	0.357
CIM-443	control	40.66	56.64	5.533	1.635	0.237
	10 dS/m	34.33	55.03	4.733	1.014	0.225
	15 dS/m	33.33	36.37	3.233	1.276	0.169
	20 dS/m	30.00	37.07	2.700	0.693	0.133
CIM-482	control	38.33	65.47	5.667	1.125	0.331
	10 dS/m	37.00	34.27	4.933	1.577	0.260
	15 dS/m	33.33	30.35	3.533	1.097	0.252
	20 dS/m	25.66	25.57	2.267	0.947	0.223
FH-900	control	32.00	48.30	4.400	0.993	0.227
	10 dS/m	29.33	34.17	3.533	0.661	0.130
	15 dS/m	25.00	25.73	2.667	0.643	0.117
	20 dS/m	21.00	22.53	2.033	0.536	0.030
BH-118	control	41.66	66.90	7.867	0.959	0.331
	10 dS/m	38.00	60.80	4.167	0.458	0.283
	15 dS/m	31.67	51.63	3.467	0.604	0.278
	20 dS/m	29.00	34.37	2.800	0.011	0.206
LSD for V		2.19	0.26	0.12	1.84	0.47
LSD for T		1.96	0.23	0.11	1.64	0.42
LSD for V x T		3.80	0.52	0.24	3.67	0.95

Table 2: Effect of salinity (NaCl) on some pigments of five cotton cultivars.

Varieties (V)	Treatments (T)	Chl. a (mg/g f. wt.)	Chl. b (mg/g f. wt.)	Carotenoids (mg/g f. wt.)	Anthocyanin (mg/g f. wt.)	Flavones (mg/g f. wt.)
NIAB-98	control	19.80	19.95	0.046	4.693	7.95
	10 dS/m	18.16	16.92	0.059	5.253	8.09
	15 dS/m	16.30	14.05	0.072	7.170	8.74
	20 dS/m	13.17	13.15	0.088	8.120	9.25
CIM-443	control	21.72	18.85	0.036	3.563	7.93
	10 dS/m	19.28	16.86	0.063	4.623	8.64
	15 dS/m	17.76	16.12	0.084	5.817	8.73
	20 dS/m	11.75	12.13	0.092	7.720	10.10
CIM-482	control	13.38	18.63	0.030	4.110	7.93
	10 dS/m	11.13	11.72	0.050	5.320	8.47
	15 dS/m	8.77	10.34	0.052	6.373	8.72
	20 dS/m	8.70	8.090	0.068	9.793	9.08
FH-900	control	25.50	25.66	0.039	3.413	7.98
	10 dS/m	16.84	20.26	0.055	4.243	8.65
	15 dS/m	14.59	13.88	0.067	6.950	8.71
	20 dS/m	11.18	11.97	0.106	9.247	8.87
BH-118	control	18.88	17.85	0.050	3.860	8.08
	10 dS/m	15.29	14.33	0.067	4.743	8.44
	15 dS/m	12.92	13.79	0.057	7.633	8.76
	20 dS/m	11.07	11.78	0.096	10.300	9.22
LSD for V		0.60	0.79	1.92	0.50	0.41
LSD for T		0.53	0.71	1.72	0.44	0.32
LSD for VxT		1.19	1.58	3.33	0.99	0.48

Ahmad *et al.* (1995) reported that seed germination, dry matter production and yield of cotton crop decreased with increasing NaCl concentration. Under the effect of salinity, NIAB-90 and CIM-443 gave the maximum dry matter yield showing their tolerance against NaCl salinity while, FH-900 exhibited the highest decrease in dry matter yield as compared with other cultivars. The effect of salinity is mainly associated with a depressed growth of shoot than root (Raghar and Pal, 1994).

Chlorophyll contents decreased due to salt stress in all varieties (Table 2). NIAB-98 and CIM-443 managed to display greater contents of Chl. a & Chl. b under stress conditions than other cultivars. Similarly, salinity caused a reduction in chlorophyll contents in cotyledonary leaves of cotton (Munjal and Goswami, 1995). Carotenoids increased in leaves of all varieties. It has been earlier reported that carotenoids are usually less efficiently degraded and enhance the stress tolerance (Munjal and Goswami, 1995; Pushpam and Rangasamy, 2000).

Anthocyanins increased in all cultivars with increasing levels of salinity. BH-118 excelled all the cultivars regarding anthocyanin content followed by CIM-482 and FH-900. Flavones also exhibited similar behavior to anthocyanins under saline conditions in forming higher concentration with increased salinity. Their highest amount was noted in CIM-443 while NIAB-98 and BH-118 with almost same concentration stood next in descending order. Environmental stresses usually cause a great adverse effect on the levels of various pigments. However, there are certain pigments which show greater appearance or accumulation under environmental stress conditions among these are the anthocyanins that are reported to play a role in the environmental stress tolerance of various plants (Justesen. *et al.*, 1997). The results of the present investigation justified this statement to some extent as the concentration of this pigment increased in all cultivars with increasing salinity level; however, this increase could not be correlated to the level of tolerance shown by different cultivars. The highest concentratin was recorded in cultivar BH-118 that stood at the bottom for biomass production while the most tolerant cultivar NIAB-98 ranked intermediate regarding anthocyanin accumulation.

NIAB-98 and CIM-443 was found to be salt tolerant cultivars than the other three used in these studies. This was attributable to their better growth and greater contents of chlorophylls and carotenoids than the other cultivars.

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