Pak. J. Biotechnol. Vol. 7 (1-2) 51-55 (2010) ISSN. 1812-1837

RESPONSES OF DIFFERENT COTTON GENOTYPES UNDER SALINE STRESSED CONDITIONS

Noor-e-Saba, Ikram-ul Haq, M Umar Dahot and Mahtab Hussain

Institute of Biotechnology and Genetic Engineering (IBGE), University of Sindh, Jamshoro, Pakistan E-mail:

ABSTRACT

Salinity is a major growth limiting abiotic factors. In this aspect an experiment was performed to assess the effect of salinity on growth of different cotton genotypes under natural conditions. NIAB-78, NIAB-HF and Cris-9 were grown under 100 mM NaCl stress with refrence to control (0 mM NaCl). Plant biomass, number of leaves and leaf area were decreased. The concentrations of K^+ were also decreased in all genotypes but Na^+ and Cl^- increased. Reducing sugars were highly increased in salt stressed plants while total carbohydrates and protein contents were also increased slightly. With decrease in chlorophyll contents, yield and yield characters were also reduced due to saline stress. The genotype Cris-9 was considered best under control as well as stressed conditions than both NIAB-78 and NIAB-HF genotyoes.

INTRODUCTION

Cotton (*Gossypium hirsutum* L.) belongs to *Malvaceae* family, comprised on more than 50 wild, cultivated and lint-less species. Today salinity is an increasing abiotic potential plant growth stress factor. Similarly, salt tolerance is a natural plant ability to grow in vegetative form and complete its life cycle under saline environmental conditions. These forms of soil contain relatively higher concentrations of salts, specifically NaCl, while some other salts including calcium salts with carbohydrates and sulphates. Salt tolerance characters not only vary among plant species but also considerably between genotypes (Mass and Hoffman, 1977).A potential salt tolerance differences is closely related to plant growth rates among the genotypes.

Higher concentrations of salts (NaCl) in soil cause to reduce in yields of a number of crops. Over 45 million ha irrigated agricultural area is salt-affected due to poor irrigation system in the world (Anonymous,2005).Since saline conditions has been limiting agriculture production as ranged up to 40% (Serrano and Gaxiola, 1994). Nowadays, selections of salt tolerant cultivars are the basic needs to utilize salt affected soils and to meet world's increasing population demands (Holmberg and Bulow, 1998; Chaum and Kirdmanee, 2009; Noreen et al., 2009). Cotton exhibits moderate salt tolerance and ranked at 2nd behind to barley (Soltanpour and Follett, 1995). However, differential mechanisms for salt-tolerance have been observed in large number of cultivars of this crop also (Gosset et al., 1994; Khan et al., 1995). During this study, three genotypes of cotton were evaluated for their salt-tolerance potential under open air conditions in wire-house.

MATERIALS AND METHODS

Experiment was designed to conduct in wire-house conditions during 2007-2008. Seeds of three cotton genotypes (NIAB-78, NIAB-HF and Cris-9) were delinted with commercial H_2SO_4 and washed with tap water thoroughly. They were soaked in water for almost 6 hours under dark conditions and sown in rows under two variant environmental conditions like as control (00mM NaCl) and salt stressed (100mM NaCl).

Data was collected at two plant growth stages; a. Late-vegetative stage (almost 2-months old plants) and b. Maturity or harvest stage. The morpho-physiological data was collected at flowering stage of the growing plants. From top to down 5th leaf of plants from each culture were selected for these studies. They were weighed for fresh weight and its leaf area also calculated. Chlorophyll and total carotenoids also determined by following Arnon (1949); Nagata and Yamashita (1992) methods. Various biochemical contents like protein (Lowery et al., 1951) total and reducing sugars (Montgomery, 1961; Miller,1959) and anionic (Na^+, K^+ and Cl^-) concentrations were also determined (Allen et al., 1986; Malavolta et al., 1989). At plant maturity stage, yield and yield parameters, i.e., total seed weight and numbers of seeds per plant were determined.

RESULTS AND DISCUSSION

According to represented data, vegetative growth rate (root and shoot) was decreased in salt (NaCl) stressed plants. The growth rate was higher for Cris-9 than other cultivars under saline conditions (Table-I). Similarly, reduction in growth rate was also observed in other crops (Kingsbury et al., 1984). Salt effect on relative growth rate (RGR) varied because of tolerance level of cultivar as well as the tissues involved. There genotypic variation among the cultivars exists for all investigated para-meters from control to salt treatment levels (Table-I). There mean values of the observed traits were affected by both genotypic variations and increased saline stresses.

Photosynthetic pigments or chlorophyll concentrations (Chl *a*, *b* and Chl *ab*) in growing plants were decreased under salinity stress. It was observed that Chl *a* was more sensitive to salinity than Chl *b*. Total chlorophyll contents were decreased in all genotypes, while carotenoids increased in the saline stressed plants. Maximum chlorophyll contents (*ab*) were determined in NIAB-78, while chlorophyll *b* in NIAB-HF and in control plants. Each in all cotton genotypes were decreased in salt stressed plants (Table-I).

Maximum Total Sugar, reducing sugars and total protein contents were observed in NIAB-78 and Cris-9 genotypes. While lower concentration was observed in NIAB-HF genotype in both of control and salt stressed plants. Meanwhile, total sugars and protein contents were slightly decreased in salt stressed cultures but reducing sugars were increased at higher rates especially in Cris-9. In the growing plants, a number of biochemical function reported in co-ordination manner to regulate multiple biological processes in the tissues. Such combinations of the biological reactions are leading to specific environmental adaptations in them as involved in regulation of plant development through regulation of osmotic adjustment, photosynthesis and antioxidative defensive systems (Foyer and Noctor, 2005; Munns and Tester, 2008).

Among the NaCl stressed plants, increase in Na^+ and Cl^- concentrations was also observed that could be due to higher concentration of Na^+ as well as Cl^- in soil medium. Maximum Na^+ and Cl^- were observed in NIAB-78 and NIAB-HF varities but lowest in Cris-9 either plant growing in control or NaCl stressed soil (Table I). While K^+ were reversed among the genotypes growing on control or NaCl stressed conditions. Such nutritional imbalance conditions in the plants under abiotic stresses lead to disturb normal physiological processes in them. Under NaCl stresses, passive and selective uptake of cations like as Na^+ and or K^+ in the cells occur. Mostly, uptake of Na^+ always remained higher with the decline of K^+ concentrations in the plants occur. Meanwhile, abundance or higher concentrations of Na^+ inhibits the growth rate of plants (Ashraf and Ahmad, 2000; Kaya et al., 2001; Abid et al., 2002; Hussain et al., 2003; Munns et al., 2006). Under saline stressed conditions, an absolute or relative growth rate as well as yield and yield characters are usually the final and ultimate goal. Similarly, salt-tolerant cotton genotypes like as Cris-9 had higher plant biomass as well as certain bio-components than other salt-sensitive at vegetative growth stage. Meanwhile, yield and yield efficiency was higher in NIAB-78 and Cris-9 than NIAB-HF. On the basis of present data, it was evaluated together and concluded that Cris-9 genotype is salt tolerant at vegetative phase as well as on maturity stage or in yield parameters. However, NIAB-78 is less tolerant than Cris-9, while NIAB-HF remained salt sensitive. Meanwhile, Cris-9 considered as moderate salt tolerant cotton genotypes.

Table-1: Bio-morphological responses of different cotton genotypes under saline stressed conditions.

#s	Characters	NIAB-78		NIAB-HF		Cris-9	
		Control	*100mM NaCl*	*Control*	*100mM NaCl*	*Control*	*100mM NaCl*
a. Morphological parameters							
1.	No. of leaves	41.34±0.62	19.98±1.30	41.56±2.12	29.01±1.82	42.87±1.86	32.17±2.28
2.	5^{th} leaf fresh weight (g)	0.25±0.01	0.552±0.07	0.24±0.008	0.61±0.006	0.556±0.004	0.767±0.065
3.	5^{th} leaf area $(cm)^{-2}$	15.73±0.312	23.69±1.22	15.79±0.94	22.69±0.91	16.29±0.87	30.44±1.13
b. Chlorophyll contents **($mg\ g^{-1}$)**							
1.	Chlorophyll *a*	0.435±0.006	0.307±0.005	0.42±0.008	0.285±0.004	0.363±0.009	0.286±0.006
2.	Chlorophyll *b*	0.205±0.003	0.131±0.004	0.238±0.013	0.124±0.003	0.191±0.002	0.129±0.002
3.	Chlorophyll *ab*	0.651±0.02	0.427±0.006	0.63±0.014	0.4123±0.007	0.568±0.012	0.526±0.014
4.	Total carotenoids	569.7±21.5	846±10.54	520.33±14.11	722±12.74	554±9.074	753.7±5.78
c. Bio-contents ($mg\ g^{-1}$)							
1.	Total Sugar	0.882±0.01	0.754±0.006	0.845±0.05	0.728±0.05	0.784±0.05	0.641±0.009
2.	Reducing sugars	0.737±0.001	1.127±0.174	0.344±0.04	0.613±0.33	1.606±0.189	2.142±0.07
3.	Total proteins	0.177±0.009	0.16±0.004	0.166±0.018	0.153±0.02	0.204±0.01	0.183±0.01
4.	Na^+	57.77±3.41	98.02±10.88	45.17±2.50	121.57±25.63	55.74±27.60	142.44±3.10
5.	K^+	25.79±0.101	20.69±3.22	26.22±0.17	11.04±4.24	23.54±1.02	20.38±0.288
6.	Cl^-	187.1±9.09	338.66±13.7	113.1±14.6	314.7±52.1	187.9±5.31	227.0±7.57
d. Yield and yield parameters							
1.	No. of seeds	36.33±0.882	29.67±2.60	34.67±2.45	24.02±5.17	40.67±2.19	37.33±0.882
2.	Total seed weight (g)	12.31±0.28	9.18±1.72	10.61±0.24	4.04±1.73	9.19±0.37	8.144±0.08

REFERENCES

Abid, M., F. Ahmad, N. Ahmad and I. Ahmad, Effect of phosphorus on growth,yield and mineral composition of wheat in different textured saline sodic soils. *Asian J. Plant Sci*. **1**: 472-475 (2002).

Allen, D.J., D.A. Eisner, P.G. Morris, J.S. Pirolo and J.L.Smith, Metabolic consequences of increasing intracellular calcium and force production in perfussed ferret hearts. *J. Physiol.*, **376**:121-141 (1986).

Anonymous, Global Network on Integrated Soil Management for Sustainable Use of Salt affected Soils. Rome, Italy: FAO Land and Plant Nutrition Management Service. Available online at http://www. fao.org /ag/agl/agll/spush (2005).

Arnon, D.I., Copper enzymes in isolated Chloroplast.*Plant Physiol.***24**:1-15 (1949).

Ashraf, M. and S. Ahmad, Influence of sodium chloride on ion accumulation, yield components, and fiber characteristics in salt-tolerant and salt-sensitive lines of cotton (*Gossypium hirsutum* L.). *Field Crops Res*. **66**: 115-127 (2000).

Cha-um,S. and C. Kirdmanee, Effect of salt stress on proline accumulation, photo-synthetic ability and growth characters in two maize cultivars. Plants. *Pak.J.Bot.* **41**(1): 87-98 (2009).

Foyer, C., and G. Noctor, Oxidant, anti-oxidant signalling in plants: a re-evaluation of the concept of oxidative stress in a physiological context. *Plant cell Environ.* **28**:1056-1071 (2005).

Gossett, D.R., E.P. Millhollon and M.C. Lucas, Antioxidant response to NaCl stress in salttolerant and salt-sensitive cultivars of cotton. *Crop Sci*. **34**: 706-714 (1994).

Holmberg, N. and L. Bulow, Improving stress tolerance in plants by gene transfer. *Trends Plant Sci.* **3:** 61-66 (1998).

Hussain,N., A. Ali, A.G. Khan, Obaid-ur-Rehman and M. Tahir, Selectivity of ions absorption as mechanism of salt tolerance in rice. *Asian J. Plant Sci*. **2**: 445-448 (2003).

Kaya,C.H., Kirnak, and D. Higgs, The effects of supplementary potassium and phosphorus on physiological development and mineral nutrition of cucumber and pepper cultivars grown at high salinity (NaCl). *J. Plant Nutr.* **24**: 25-27(2001).

Khan, A.N., R.H. Qureshi, N. Ahmad and A.Rashid, Response of cotton cultivars to salinity in various growth development stages. *Sarhad J. Agric.* **11**:729-731(1995).

Kingsbury,R.W., E.Epstein and R.W. Pearcy, Physiological responses to salinity in selected lines of wheat. *Plant Physiol.* **74**: 417-423(1984).

Lowry, O.H., N.N. Rosebrough, A.L. Farr and R.J. Randell, Protein measurement with Folin Phenol reagent. *J. Biol. Chem*. **193**: 256-257(1951).

Maas, E.V. and G.J. Hoffman, Crop salt tolerance-current assessment. *J. Irrig. Drain. Eng.* **103**: 115-134 (1977).

Malavolta,E., G.C.Vitti and S.A. Oliveira, The evaluation of the nutritional state of the plants: principles and applications, *Piracicaba*, Braz. Ass. Res. Potash and Phosphate, Pp. 201 (1989).

Miller, G.L., Use of dinitrosalicylic acid reagent for the determination of reducing sugar. *Anal. Chem.* 31: 426-429 (1959).

Montogomery, R., Further studies of the phenol sulphuric acid reagent for carbo-hydrates, *Biochem. Biophs Act*., **48**: 591-593 (1961).

Munns, R., R.A. James and A. Lauchli, Approaches to increasing the salt tolerance of wheat and other cereals. *J. Exp. Bot*. **57**: 1025-1043 (2006).

Munns, R., and M. Tester, Mechanisms of salinity tolerance. *Annu. Rev. Plant Biol.* **59**: 651-681 (2008).

Nagata,M. and Yamashita, Simple method for simultanous determination of chlorophyll and caroteniods in tomato fruit. *J. Japan. Soc. Food Sci. Technol*. **39** (10): 925-928 (1992).

Noreen, S., M. Ashraf, M. Hussain and A. Jamil, Exogenous application of salicylic acid enhances antioxidative capacity in salt stressed sunflower (*Helıanthus annuus* L.) Plants. *Pak. J. Bot.* **41**(1): 473-479 (2009).

Serrano,R. and R.Gaxiola, Microbial models and salt tolerance in plants. *Crit. Rev. Plant Sci.* **13**: 121-138 (1994).

Soltanpour, P.N. and R.H. Follett, Crop tolerance to soil salinity.Colorado State University Cooperative Extension Fact Sheet No.0.505 (1995).