Minufiya J. Agric. Res. Vol. 33 No.2: 373 - 386 (2008)

EFFECT OF FOLIAR APPLICATION OF PROLINE ON GROWTH, CHEMICAL CONSTITUENTS AND YIELD OF COTTON PLANTS GROWN UNDER SALINE CONDITIONS

Alia A . M . Namich
Cotton Research Institute, Agricultural Research center, Giza. Egypt

(Received: Mar. 4, 2008)

ABSTRACT: *Proline is a naturally accumulated in many higher plants including cotton. Field studies suggested that proline may enhance cotton yield under salinity conditions. Thus, two pot experiments were conducted at the Agricultural Experimental Station of Agricultural Research Center (A.R.C.) in Giza to evaluate the effects of proline application on cotton in response to salinity stress. Seeds of Giza 90 cultivar were sown in pots of 40 cm in diameter on April 1st and 4th in 2005 and 2006 seasons. After complete emergence of seeding, thinning was carried out leaving one plant / pot. After 50 days from sowing plants were irrigated with saline solution of NaCl at concentration of 0, 4000, 8000 and 12000 ppm followed by tap water alternately during the whole season. Control pots were irrigated with tap water. At the start of flowering all pots were sprayed once with proline solution at 4 concentrations i.e, 0 , 50 , 70 and 100 ppm.*

The obtained results showed that:

Saline treatments decreased significantly plant height, No. of nodes and Fruiting branches, leaf area, dry matter accumulation of roots, stem and leaves. Also, it reduced the contents of non-reducing and total soluble sugars as well as the uptake of K^+, Mg^{2+} and Ca^{2+} in cotton leaves, and oil % and protein % in seeds. However, sharp increases were observed in proline contents and chloroplast pigments in leaf. So, the reduction in yield and yield components were observed in both seasons.

Spraying proline solution on cotton plants grown under normal and saline conditions increase all growth parameters and some chemical contents of leaves i.e., chlorophylls A and B, carotein, reducing, non-reducing and total soluble sugars, proline as well as uptake of K^+, Mg^{2+} and Ca^{2+}. Also, percentages of oil and protein in seeds. Proline application resulted significant increases in No. of flowers and bolls per plant, boll setting, lint %, boll weight, seed index and seed cotton yield / plant.

The interaction between salinity and proline applications showed that proline application reduced the extent of the harmful effects of salinity on growth, chemical composition of leaves, seeds and yield of cotton plants.

Key words: *Cotton, proline, Growth, yield, chemical composition.*

INTRODUCTION

Salinity is one of the major environmental factors which adversely affects cotton plant growth and development as well as final yield performance. Low precipitation, high surface evaporation, irrigation using saline water and poor cultural practices are among the major contributors for increasing salinity. Traditional methods for reclamation of saline soils such as leaching are not only difficult but also expensive and need more time-consuming. However, leaving the soil un-cropped for long time has uneconomic effects for growers. So, using special management practices to minimize the adverse effects of soil salinity on plant growth led to test some untraditional treatments such as application of amino acid proline, which represent an acceptable mean in this respect. Proline plays an adaptive role in the tolerance of plant cells to salinity by increasing the concentration of cultural osmotic components in order to equalize the osmotic potential of the cytoplasm. (Ashraf and Foolad, 2007). The harmful effects of salinity on growth and yield components of most genotypes of cotton were investigated by several investigators (Kamel *et al.*, 1995 ; Badran, 2006 and Ashraf and Foolad, 2007). Rathert (1983) evaluated the effect of salinity stress on carbohydrate metabolism and minerals in two Egyptian varieties. Kamel *et al.* (1995) and Badran (2006) stated that increasing salinity increased leaf Na^+, Cl^- and proline concentrations, and decreased the uptake of K^+, Ca^{2+} and Mg^{2+}.

Proline has been exogenously applied to a variety of crops in an effort to improve salt stress tolerance and yield. In rice plants grown under salt stress, accumulation of proline in the leaf was seemed to be a symptom of salt injury rather than an indication of salt tolerance (Lutts *et al.*, 1999). Similarly, assessment of proline accumulation and distribution during shoot and leaf development in two sorghum genotypes, contrasting in salt tolerance suggested that proline accumulation was a reaction to salt stress (de-Lacerda *et al.* 2003). Under salt stress, tobacco cultivars accumulated greater amounts of proline significantly reduced the level of free radicals and improved tolerance to 200 mm NaCl (Hong *et al.* 2000). Thus, the main goal of this study was to evaluate the potential use of proline to enhance yield and salinity tolerance in cotton.

MATERIALS AND METHODS

Two pot experiments were carried out at Giza in Cotton Physiology Section, Cotton Research Institute, A.R.C. to investigate: does Foliar applied proline affect endogenous proline and growth, yield of cotton plants grown under saline conditions.

Seeds of cotton cv. Giza 90 were sown in pots of 40 cm. in diameter, filled with clay loam soil. Sowing dates were April 1st and 4th in 2005 and 2006 throughout the two experimental seasons, respectively. All pots received adequate amounts of nitrogen fertilizer at a rate of 60 Kg N / fed. In split application, one after thinning and the other was applied two weeks after that. Watering was carried out using tap water for 50 days after sowing, hence forward plants were irrigated with saline solution of 4000, 8000 and 12000 ppm NaCl followed by tap water alternately during the whole season. Untreated pots (control) were irrigated regularly with tap water. At start of flowering all pots were sprayed with proline at 4 concentrations, i.e., 0, 50, 70 and 100 ppm. Each treatment (16 treatments) consisted of 10 pots, 5 pots in which were used for daily flower counting.

Characters Studied:

Growth Characters:

Final plant hight (cm), No. of main stem nodes, inter-node length (cm), No. of fruiting branches / plant and dry matter (roots , stems and leaves in gram).

Yield and yield components:

No. of flowers / plant , No. of open bolls / plant , boll shedding % , boll weight (gm), seed index (gm) and seed cotton yield / plant (gm).

Chemical constituents:

Samples of the fourth leaf from the plant apex were taken after 15 days from proline application to determine pigments conc. According to Arnon (1949), Sugars (A.O.A.C., 1975), proline (Bates *et al.*, 1973), nutrient contents (Chapman and Pratt, 1961). However, oil and protein contents were determined in seeds according to the methods described in A.O.A.C. (1975).

All data were subjected to the statistical analyses outlined by Snedecor and Cochran (1981), using the least significant differences (LSD) for means comparison.

RESULTS AND DISCUSSIONS

Soil analysis and level of salinity:

The Soil analysis presented in Table (A) show that the value of PH recorded a little decrease at the end of the season associated with the increased salinity level.

Table (A): Chemical analysis of the soil irrigated with saline water.

Time of Sampling	Soil depth cm	NaCL ppm	Anions, meg / L				Cations, meg / L				EC	PH
			CL^-	So_4^{--}	HCO_3^-	CO_3^{--}	Na^+	K^+	Mg^{++}	Ca^{++}		
Before Sowing	0 - 15	0	9.0	15.00	5.-	—	9.16	0.70	5.0	14.90	0.601	8.3
After Harvest	0 - 15	0	10.0	15.42	5.-	-	9.56	0.76	5.1	15.2	0.64	8.14
		4000	15.0	2.00	5.20	-	17.65	0.85	4.3	5.2	3.10	7.85
		8000	21.0	6.01	6.0	-	21.2	0.70	2.1	3.01	3.31	7.95
		12000	22.0	8.49	8.00	-	34.66	0.40	1.38	1.05	4.87	7.25

This might be due to the increase in electrical conductivity. On contrary, Ec increased parallel to the increase in salinity, which reached 4.87 (3116 ppm) indicating that the soil tended to be saline.

I. Growth and Dry Matter production:

A. Salinity:

Data presented in Table (1) reveal that irrigation of cotton plants with saline water exhibited an inhibitory effect on vegetative growth represented by plant height, No. and length of internodes, No. of fruiting branches, leaf area / plant as well as dry matter of roots, stem and leaves. Concerning the effect of salt conc., results showed that growth parameters significantly affected by increasing salinity conc. However, the decrease in plant height as a result of increasing salt conc. is mainly may be due to the decrease in number and length of internodes / plant. Similar results were attained by Kamel *et al.* (1995) and Badran (2006), who added that salinity may increase osmotic pressure of soil solution and decrease water absorption by root system and this may exert its effect on biosynthesis of hormones responsible for cell elongation. On the other hand, the marked decrease in dry mater production of all plant organs may be due to that reduction in photosynthesis activity and consequently reduce carbohydrate formation which requires to build up a new plant organs. The other expected causes of this reduction as described by Kent and Lauchli, (1985) describe that the reduction could be due to the shrinkage of cell contents, reduced development and differentiation of tissues, unbalanced nutrition, damage of membranes and disturbed avoidance mechanism. High sodium and chloride conc. Could suppress the uptake of K^+, Ca^{2+} and NO^{3-} and ultimate the growth (Gorham and Wynjones, 1993 and Javaid *et al*, 2005) added that the other possible reason of reduction in dry matter accompanied with increasing level of salinity may be the reduced of leaf emergence, leaf expansion and final leaf area.

B. Proline effect:

It is clear from data presented in Table (1) that foliar application of proline had a significant increase on all studied growth characters as compared with control in both seasons under normal or saline conditions except the dry weight of leaves in 2005 season. The pronounced increase in vegetative growth due to spraying proline may be a result of a corresponding increase in photosynthesis pigments, photosynthesis rate and carbohydrate content. Hare and Cress (1997) showed that proline plays role as an osomolytes for osmotic adjustment, buffering cellular redox potential (under stress conditions). It also may cause cytoplasmic acidosis and maintaining appropriate $NADP^+/NADPH$ ratios compatible with metabolism.

C. Interactions:

The interaction exerted significant effects on leaf area and dray matter of roots, stem and leaves in two seasons, and No. of internodes and No. of fruiting branches per plant in 2006 season (Table, 1).

Table (1): Effect of different levels of salinity water irrigation and proline application on growth of cotton Giza 90 cultivar.

Salinity (A)	proline (B)	Plant height (cm)		No. of internodes / stem		Internode Length (cm)		No. of fruiting branches / plant		Leaf area (cm)^2		Dry weight / plant (g)					
												Stem and branch		Roots		Leaves	
		2005	2006	2005	2006	2005	2006	2005	2006	2005	2006	2005	2006	2005	2006	2005	2006
Control	00 ppm	45.3	40.1	18.0	16.0	2.51	2.50	8.33	7.92	600	598	6.48	6.03	4.35	4.27	6.06	7.34
	Pro. 50 ppm	47.0	41.0	18.5	17.0	2.54	2.42	8.90	8.10	673	600	6.54	6.50	4.55	4.35	6.74	7.61
	70 ppm	47.2	42.2	19.0	17.0	2.48	2.48	9.11	9.00	680	650	7.49	6.90	4.73	4.60	7.61	8.30
	100 ppm	48.7	46.3	19.6	18.3	2.66	2.53	9.90	9.30	710	690	8.79	7.10	4.96	4.70	8.63	8.60
	Mean	47.1	42.4	18.8	17.07	2.55	2.48	9.06	8.58	665.75	634.5	7.32	6.63	4.64	4.48	7.26	7.96
4000 ppm	00 ppm	30.6	25.3	13.3	11.7	2.30	2.16	5.00	4.00	415	343	3.00	3.34	2.60	2.00	3.00	3.08
	Pro. 50 ppm	37.0	29.4	14.8	13.5	2.50	2.17	5.40	4.50	424	363	3.26	3.20	2.89	2.18	3.16	3.19
	70 ppm	38.1	29.6	15.1	14.0	2.52	2.11	5.90	4.90	434	424	4.29	3.90	3.49	2.62	4.47	4.20
	100 ppm	39.2	30.9	15.9	15.1	2.46	2.05	6.10	5.30	500	434	5.61	4.00	3.90	2.63	4.71	4.90
	Mean	36.20	28.8	14.8	13.57	2.44	2.12	5.60	4.67	443.25	391.0	4.04	3.61	3.22	2.35	3.83	3.84
8000 ppm	00 ppm	20.2	16.4	10.6	9.09	1.91	1.80	4.10	3.67	314	251	2.31	2.00	2.40	1.53	2.26	2.67
	Pro. 50 ppm	23.4	18.6	11.2	10.00	2.08	1.86	4.33	3.90	324	311	2.44	2.13	2.62	1.90	2.97	2.90
	70 ppm	24.5	19.8	11.4	10.60	2.14	1.87	4.80	4.00	351	324	3.17	2.90	2.63	2.00	3.25	2.98
	100 ppm	26.5	20.9	12.0	11.00	2.20	1.90	4.92	4.50	354	350	3.40	3.00	2.55	2.10	3.87	3.00
	Mean	23.7	18.93	11.3	10.17	2.08	1.85	4.53	4.01	335.75	309.0	2.83	2.50	2.50	1.88	3.08	2.88
12000 PPm	00 ppm	16.50	14.5	9.0	8.08	1.83	1.79	2.33	2.10	242	210	2.12	1.31	2.36	1.09	2.34	2.50
	Pro. 50 ppm	18.10	16.6	9.5	9.3	1.90	1.79	2.60	2.30	295	242	2.49	1.90	2.82	1.36	2.37	2.60
	70 ppm	19.20	18.9	10.1	10.3	1.90	1.83	2.90	2.70	300	265	3.00	2.10	2.89	1.82	2.63	2.80
	100 ppm	20.00	19.7	10.6	10.4	2.00	1.89	3.00	2.90	315	290	3.13	2.90	2.97	1.89	2.82	2.98
	Mean	18.45	17.42	9.80	9.52	1.90	1.82	2.70	2.50	576	251.8	2.81	2.05	2.76	1.54	2.54	2.72
(B)	00 ppm	28.2	24.1	12.7	11.2	2.1	2.1	4.9	4.4	393	350	3.47	3.17	2.93	2.22	3.42	3.90
	Pro. 50 ppm	31.4	26.4	13.5	12.5	2.3	2.1	5.3	4.7	429	379	3.68	3.43	3.20	2.45	3.81	4.08
	70 ppm	32.3	27.6	13.9	13.0	2.3	2.1	5.7	5.2	441	415	4.19	3.95	3.95	2.76	4.49	4.57
	100 ppm	33.6	29.5	14.5	13.7	2.3	2.1	6.0	5.5	469	441	5.23	4.24	3.60	2.83	5.01	4.87
L.S.D.	(A)	1.65	2.2	1.78	1.50	0.5	0.4	0.4	0.9	37	46	1.01	0.8	0.25	0.7	0.28	0.71
	(B)	1.70	1.9	1.45	0.96	N.S.	N.S.	0.7	0.8	51	56	1.03	0.5	0.40	0.8	N.S.	0.03
	A x B	N.S.	N.S.	N.S.	1.93	N.S.	N.S.	N.S.	1.6	103	100	2.07	1.2	1.10	1.2	1.53	1.47

II. Chemical constituents:

Data presented in Table (2) show that all chemical constituents of cotton leaf and seeds were significantly affected by salt and proline conc. as well as their interaction.

A. Salinity:

Results showed the significant increases in chlorophylls (a) and (b) and carotenes in leaves under different levels of salinity. The increase in total chlorophyll is mainly due to the increase in chlorophyll (a) rather than chlorophyll (b). In this concern, Ahmed *et al.* (1989) pointed out that water stress increased the amount of chlorophyll indicating a weakening of its bonding with protein complex. However, the significant decrease in carbohydrate contents was observed with increasing salinity levels. The reduction in sugars may be due to the reduction in uptake of K^+, Ca^{2+}, photosynthesis rate and increasing photorespiration under water deficit (Javaid and Khalil 2005). Such results were confirmed by Alia *et al.* (2007), who reported that salinity conditions decreased reducing and total soluble sugars in cotton leaves. Results also showed, the significant increase in proline content was recorded under salinity conditions as compared to its content in control ones. The values of increasing % in proline were 192, 207 and 285 % under 4000, 8000 and 12000 ppm NaCl, respectively as compared to the control level. The obtained results in this study are in accordance with findings reported by Kamel *et al.* (1995), Badran (2006) and Ashraf and Foolad (2007). The increase of proline content in salt-stressed cotton leaves may be due to the increase of protein hydrolysis as result of increasing the activity of hydrolytic enzymes (Nayyer and Walia, 2003), and/or to the increase of proline biosynthesis. Proline play as osmosis regulatory role as well as a protective function for enzyme in the cytoplasm by binding water to proteins and thus maintained their hydration (Stewart and Lee, 1974).

Result showed that increasing salting level stimulate the uptake and translocation of Na^+ and Cl^- into leaves, on other hand, displacement of K^+, Ca^{2+} and Mg^{2+} High sodium conc. displaced Ca^{2+} from the plasma-lemma resulting in loss of membrane integrity and efflux of cytosolic K^+ hence potassium concentration in leaves decreased may be attributed to potassium selectivity for absorption (Jeschke, 1984). However, the increase of chloride may be due to presence of high conc. of chloride in the substrate at high salinity. This show that the capability of cotton genotypes to maintain a low Cl^- conc. may be an important reason for their salt tolerance. It is assumed that successful osmotic adjustment and a better ionic balance regarding Na^+, K^+ and Cl^- in salt tolerant varieties contributed towards their better growth performance under saline conditions (Javaid and Khalil, 2005).

Table (2): Effect of different levels of salinity and proline application on chemical constituents of cotton leaves.

Salinity (A)	Treatments (B)	Chl. A	Ch. B	Total Chl.	Carot ene.	Total soluble sugar mg/gm	Reducing sugar mg/gm Dry wlt.	Non R.S. mg/gm Dry wlt.	Proline mg/gm Fresh wlt.	m. mol / g dry wt.				Cl.	Oil %	Protein %
										K	Na	Ca	Mg			
Control	00 ppm	3.52	2.26	5.78	0.35	20.00	17.00	3.00	3.72	1.7	0.04	4.06	0.44	0.03	20.3	22.60
	Pro. 50 ppm	3.85	2.61	6.46	0.37	21.10	17.30	3.80	4.72	1.8	0.04	4.19	0.52	0.03	20.4	22.99
	70 ppm	3.88	2.90	6.78	0.38	21.90	17.90	4.00	6.24	1.8	0.03	4.60	0.65	0.01	20.9	23.00
	100 ppm	4.40	3.82	8.22	0.52	22.30	18.00	4.30	7.12	2.0	0.03	4.90	0.92	0.01	21.0	23.10
	Mean	3.91	2.64	6.81	0.41	21.33	17.55	3.78	5.45	1.82	0.03	4.43	0.63	0.02	20.65	22.92
4000 ppm	00 ppm	3.61	2.54	6.15	0.38	19.10	14.53	4.57	8.65	1.30	2.50	2.00	0.41	2.90	17.30	19.01
	Pro. 50 ppm	3.82	2.79	6.61	0.39	20.00	14.60	5.40	17.06	1.60	2.30	2.30	0.44	2.10	17.50	19.20
	70 ppm	3.85	2.91	6.76	0.46	20.60	15.00	5.60	18.43	1.70	2.10	2.32	0.45	1.96	17.60	19.50
	100 ppm	4.80	3.81	8.61	0.53	21.10	15.10	6.00	19.7	1.70	1.48	2.50	0.52	1.80	18.00	21.13
	Mean	4.02	3.01	7.03	0.44	20.2	14.80	5.39	15.96	1.57	2.22	2.28	0.46	2.19	17.60	19.71
8000 ppm	00 ppm	3.73	2.69	6.42	0.40	17.27	9.86	7.42	9.35	0.90	2.80	2.002.1	0.39	2.95	16.50	18.29
	Pro. 50 ppm	3.98	2.89	6.87	0.41	18.00	9.90	8.10	18.37	0.96	2.60	0	0.40	2.50	16.90	18.75
	70 ppm	4.05	2.92	6.97	0.47	18.90	10.30	8.60	19.10	0.97	2.43	2.20	0.41	2.10	17.10	18.88
	100 ppm	4.10	3.90	8.00	0.57	19.30	10.60	8.80	20.16	1.00	2.40	2.29	0.42	2.00	17.30	18.88
	Mean	3.96	3.10	7.06	0.46	18.36	10.13	8.23	16.47	0.96	2.57	2.15	0.40	2.38	16.95	18.70
12000 ppm	00 ppm	3.93	2.80	6.73	0.46	9.13	3.10	6.03	19.47	0.70	3.10	1.90	0.22	3.30	15.74	17.57
	Pro. 50 ppm	3.95	2.90	6.85	0.48	9.70	3.50	6.20	19.90	0.73	3.00	1.95	0.32	2.96	16.00	18.29
	70 ppm	4.39	3.10	7.49	0.56	9.90	3.70	6.20	20.84	0.74	2.90	1.98	0.32	2.89	16.10	18.88
	100 ppm	4.41	4.00	8.41	0.58	10.60	4.10	6.50	23.84	0.77	2.86	2.01	0.36	2.87	16.30	18.88
	Mean	4.17	3.20	7.37	0.52	9.83	3.60	6.23	21.00	0.73	2.96	1.96	0.31	2.98	16.03	18.41
(B)	00 ppm	3.70	2.60	6.30	0.40	16.40	11.10	5.30	10.3	1.15	2.11	2.49	0.37	2.30	17.50	19.40
	Pro. 50 ppm	3.90	2.80	6.70	0.43	17.20	11.30	5.90	15.0	1.27	1.93	2.64	0.42	1.90	17.70	19.80
	70 ppm	4.00	3.00	7.00	0.47	17.80	11.70	6.10	16.2	1.30	1.87	2.78	0.46	1.74	17.90	20.10
	100 ppm	4.20	3.90	8.11	0.55	18.30	11.90	6.40	17.7	1.37	1.83	2.93	0.56	1.66	18.20	20.50
L.S.D.	(A)	0.16	0.19	0.24	0.03	1.13	1.12	0.24	0.44	0.03	0.03	0.13	0.02	0.09	1.70	0.24
	(B)	0.24	0.14	0.27	0.03	0.90	0.90	0.27	0.37	0.03	0.04	0.09	0.02	0.10	1.23	0.16
	A x B	0.49	0.29	0.59	0.18	1.40	1.30	0.39	0.74	0.16	0.11	0.16	0.03	0.14	2.20	0.25

B. Proline effects:

It is clear from data presented in Table (2) that foliar application of proline had significant increases in total chlorophylls, carbohydrate contents and ions of K^{+}, Mg^{2+} and Ca^{2+} in cotton leaves. Results showed also that proline application resulted in marked increase in endogenous proline content in leaves (45.6 – 71.8 %) of treated plants as compared to control. Oil and protein contents increased also significantly owing to proline application. In addition to the observations of Stewart and Lee (1974), proline may be a good storage of N because of its metabolic proximity having already conversion to glutamic acid, which considered a key compound in N metabolism. Furthermore, the conversation of proline to glutamic acid, two equivalents of NADPH are produced, making proline already available source of energy and reducing power. So, the increases in chlorophylls, carotene and carbohydrate in leaves, oil and protein in seeds, due to proline application could be attributed to increasing N and K in leaves. The importance of such two elements (N, K) are well confirmed for healthy growth of plants (Sangakkara *et al.*, 2000). However, the obtained results in this study correspond with the findings of Ashraf and Foolad (2007), who reported that exogenous application of proline enhance endogenous level of it and improve different characters of plants grown under water stress conditions.

C. Interaction:

Results showed that the interaction between proline and salinity exerted significant effects (Table, 2) on chlorophyll, carbohydrate, ions (K^{+}, Na^{+}, Cl^{-}, Ca^{2+}) and proline contents in cotton leaves. Similar results were obtained for oil protein in cotton seeds. The highest contents of proline (23.8 mg) was observed when it applied at 100 ppm under salinity at 12000 ppm, the lowest value (4.7 mg) was recorded for 50 ppm proline and normal condition (salinity zero). Such results were supported by the findings of Badran (2006). On the other hand, Na^{+} and Cl^{-} contents in leaves were increased by increasing salinity level, compared to control, while applying proline tended to reduce their concentrations. In this concern, Badran (2006) demonstrated that chloride salinity decreased the uptake of N, P, K and Ca by cotton plants comparing to control.

III. Yield and Yield Components:

A. Salinity :

Data presented in Table (3) revealed that salinity resulted in significant reduction attributed with increasing levels of salinity as compared with the control in yield components (No. of flowers and bolls / plant, boll weight, seed index, lint % and seed cotton yield / plant). However, the significant increase of shedding % was markedly observed. The relative higher production of flowers and the relative lower production of bolls showed that salinity enhanced shedding of bolls born on cotton plants. Shedding

Table (3): Effect of different levels of salinity water irrigation and proline application on yield and yield components in Giza 90 cultivar.

Salinity (A)	Treatments (B)	No. of flowers / plant		Shedding %		No. of open bolls / plant		Boll weight (gm)		Seed index (gm)		L %		Seed cotton yield / plant (gm)	
		2005	2006	2005	2006	2005	2006	2005	2006	2005	2006	2005	2006	2005	2006
Control	00 ppm	19.20	16.80	23.10	25.30	13.00	12.00	2.05	1.96	8.90	8.89	37.97	36.31	26.65	23.57
	Pro.50 ppm	19.60	17.30	22.60	23.10	13.00	12.10	2.20	1.94	8.90	8.93	38.51	37.97	28.00	23.93
	70 ppm	20.01	18.20	22.10	22.20	14.00	12.63	2.20	2.00	9.24	8.98	39.32	38.00	30.60	25.27
	100 ppm	20.30	19.30	22.00	22.10	14.60	13.34	2.30	2.12	9.38	9.01	39.88	38.30	33.00	28.29
	Mean	19.78	17.90	22.45	23.17	13.65	12.51	2.18	2.00	9.10	8.95	38.92	37.64	29.41	25.26
4000 ppm	00 ppm	13.60	13.00	27.01	27.30	8.90	8.90	1.72	1.69	8.00	8.20	36.31	35.07	15.30	13.80
	Pro.50 ppm	13.90	13.30	26.90	27.00	10.40	10.04	1.76	1.83	8.43	8.45	37.97	36.09	18.40	18.39
	70 ppm	14.10	13.90	26.30	26.10	11.10	10.37	1.80	1.87	8.58	8.48	38.51	37.51	20.01	19.41
	100 ppm	14.30	14.45	26.10	26.00	11.20	10.83	1.91	1.90	8.64	8.60	38.81	37.81	20.90	20.57
	Mean	13.97	13.66	26.58	26.60	10.40	10.03	1.79	1.82	8.41	8.43	37.90	36.62	18.65	18.04
8000 ppm	00 ppm	11.60	10.60	33.30	33.00	6.50	7.59	1.70	1.41	7.27	6.91	33.48	32.38	11.20	10.51
	Pro.50 ppm	12.10	11.10	32.90	32.60	8.10	8.30	1.72	1.67	7.35	7.00	36.07	35.48	13.90	13.87
	70 ppm	12.30	11.40	32.10	32.30	8.70	8.96	1.73	1.67	7.41	7.12	36.06	35.54	15.30	14.96
	100 ppm	12.45	12.10	32.00	32.10	9.50	9.43	1.76	1.71	7.58	7.30	37.54	36.07	16.72	16.12
	Mean	12.11	11.30	32.57	32.50	8.20	8.57	1.72	1.61	7.40	7.08	35.78	34.86	14.28	13.86
12000 ppm	00 ppm	9.00	8.80	45.00	44.30	5.90	5.20	1.14	1.28	6.33	5.91	31.60	30.30	6.72	6.78
	Pro.50 ppm	9.30	9.00	43.90	43.90	7.12	7.06	1.35	1.34	6.43	6.12	32.58	31.60	9.60	9.47
	70 ppm	9.90	9.13	42.30	43.30	7.30	7.00	1.55	1.53	6.53	6.30	33.21	32.00	11.00	10.65
	100 ppm	10.00	9.70	42.00	43.00	7.60	7.33	1.60	1.62	6.80	6.48	32.70	32.60	11.97	11.87
	Mean	9.55	9.16	43.3	43.62	6.48	6.64	1.41	1.44	6.52	6.20	32.52	31.62	9.82	9.69
(B)	00 ppm	13.35	12.30	32.10	32.50	8.57	8.40	1.7	1.6	7.6	7.5	34.80	33.50	14.96	13.70
	Pro.50 ppm	13.73	12.68	31.60	31.70	9.66	9.40	1.7	1.7	7.8	7.6	36.30	35.30	17.47	16.40
	70 ppm	14.08	13.16	30.70	31.00	10.27	9.70	1.8	1.8	8.0	7.7	36.80	39.70	19.27	17.60
	100 ppm	14.26	13.78	30.50	30.8	10.72	10.2	1.9	1.8	8.1	7.8	37.20	36.20	20.90	19.20
L.S.D.	(A)	0.40	0.20	1.30	1.59	1.10	1.78	0.25	0.27	0.39	0.51	0.21	0.27	3.32	4.51
	(B)	1.60	3.00	1.10	1.12	0.80	1.45	0.40	N.S.	0.17	0.29	1.50	1.40	2.92	2.61
	A x B	N.S.	N.S.	N.S.	N.S.	1.90	N.S.	N.S.	N.S.	0.49	0.58	N.S.	N.S.	N.S.	N.S.

percentages ranged from 22.4 to 43.6 % in two seasons, according to salinity level.

The harmful effects of salinity on cotton plant growth as well as chemical contents resulted in reduced yield and yield components. The reduction in yield ranged from 28.5% to 66.6% in two seasons, which may attributed to the increase in the osmotic pressure of soil solution, which reduces the ability of plants to absorb water and nutrients. These results are in good accordance with the findings of Ronde *et al.* (2000) Radwan *et al.* (2002) and Badran (2006).

B. Proline effect:

As shown in Table (3), foliar application of proline resulted in significant increase in yield and yield components in two seasons, except of boll weight in 2006 season. However, applying proline under normal and different levels of salinity tended to increase the No. of flowers and bolls / plant, boll setting, lint %, boll weight and seed cotton yield / plant. It is worth to note that 100 ppm of proline was superior as compared with other conc. (50, 70 ppm) under normal and salinity conditions. The increases in seed cotton yield were 16.7 ' 19.7 %, 28.8 ' 28.5 % and 37.9 ' 40.1 % when proline applied at 50 ' 70 and 100 ppm, respectively in both seasons (2005 and 2006) Such increases are mainly due to the improving of proline on growth characters (Table, 1) as well as enhancing the chemical contents (Table, 2). In additional to proline's function as osmolytes, thus restoring turgor pressure and reliving the requirement for additional osmolytes, and protect plants from stress through different courses, including contribution to detoxification of reactive oxygen species, protection of membrane integrity, and stabilization of enzyme / protein (Yancey *et al.*, 1982 and Bohnert and Jensery, 1996).

C. Interactions:

The interaction between salinity and proline exerted significant effects only on seed index in both seasons and number of bolls / plant in 2005 season (Table, 3). The positive effects of proline in all traits were more pronounced under salinity conditions, especially when it used at 100 ppm under various levels of salinity as compared to control. This could be due to that proline had a positive effects on enzyme and membrane integrity along with adaptive roles in mediating osmotic adjustment in plants grown under stress conditions (Ashraf and Foolad, 2007).

REFERENCES

Ahmed, F.M., M.S. Ismail and Abdel-Al (1989). Effect of drought conditions at bolling stage on some chemical constituents of cotton plant. J. Agron. and Crop Sci, 163: 167-173.

Alia, A.M. Namich, M.M.A. Kassem and Sanaa G. Gebaly (2007). Fffect of irrigation with saline water on some cotton cultivars. J. Agric. Sci., Mansoura Univ., 32 (7): 5117 – 5136.

Ashraf, M. and M.R. Foolad (2007). Roles of glycine betaine and proline in improving plant a biotic stress resistance. Environmental and Experimental Botany 59 (2): 206 – 216.

Arnan, D.I. (1949). Copper enzymes in isolated chloroplast. Plant physiol., 24: 1 – 15.

A.O.A.C. (1975). Official Methods of analysis of official Agricultural chemists 12th ed. Washington D.C.

Badran A.E. (2006). Bio-Metrical and Bio-Technological aspects to evaluate some Egyptian genotypes under stress conditions. Ph. D. Thesis, Agric., Cairo Univ.

Bates, L.S., R. P. Waldren and I. D. Teure (1973). Rapid determination of free proline for water stress. Plant and Soil, 39: 205-207.

Bohnert, H.J. and R.G. Jensery (1996) Strategies for engineering water stress tolerance in plants, Trends Biotechnol. 14: 89 - 97. Abstract / PDF (827k).

Chapman, H. D. and P. F. Pratt (1961). Methods of Analysis for Soil, Plants and Waters, Univ. California, Divison Agric. Sci.

De-Lacerda, J. Cambraia, M.A. Oliva, H.A. Ruiz and J.T. Prisco (2003). Solute accumulation and distribution during shoot and leaf development in two sorghum genotypes under salt stress. Enviro. Exp. Bot. 49 (2003), pp. 107 – 120.

Gorham, J. and R.G. Wynjones (1993). Utilization of Triticeae for improving solt tolerance in wheat. P. 27 - 33. In: Leith, H. and A.A. Massoum (eds.). Towards the rational use of high salinity tolerant plants. Kluwer Acad. Pub. The Netherlands.

Hare, P.D. and W.A. Cress (1997). Metabolic implications of stress – induced proline accumulation in plants. Plant Growth Requl. 21: 79 – 102.

Hong, K., Z Lakkineni, Zhang and D.P.S. Verma (2000). Removal of Feedback inhibition of L-pyrroline-5-carboxy late synthetase results in increased proline accumulation and protection of plants from osmotic stress. Plant Physiol. 122: 1129-1136. Full text via cross Ref.

Javaid Akhtar M. Anwar-Ul-Hag and Khalil Ahmed Muhammad (2005). Performance of cotton genotypes under saline conditions. Santa Cruz do Sul, vol. 17, No. 1, Jan./Jan. 2005. pp. 29 - 36.

Jeschke, W.D. (1984). K^+ - Na^+ exchange at cellular membranes, interacellular compartmentation of cation and salt tolerance. p. 37 - 66.

Kamel, Nadia H., M.A. Yossef, A.E. Saker and S.E. Kandil (1995). Effect of water deficit and salinity on some physiological processes of cotton plants. II- Effect of salinity on cotton plants at different developmental stages. Zagazig J. Agric. Res., 22 (3): 721 - 738.

Kent, L.A. and A Lauchli (1985). Germination and seedling growth of cotton salinity calcium interactions. Plant Cell Environ. 8: 115 – 159.

Lutts, S., V. Majerus and J. M. Kinet (1999). NaCl effects on proline metabolism in rice (oxyza sativa) seedlings, physiol, plant. 105 (1999), pp. 450-458. Full text via cross Ref.

Nayyar H. and D.P. Walia (2003). Water stress induced proline accumulation in contrasting wheat genotypes as affected by calcium and abscisic acid. Biol. Plant. 46 (2003), PP 275 – 279.

Radwan S.R.H., E.T. Kishk, S.A.N. Afiah and A.E.E. Badran (2002). Differential response of *Gossypium barbadense* L. germplasm for salt stress conditions. I- Mean performances and heritability. International symposium on optimum and Semi-Arid Regions: 303 - 311.

Rathert, G. (1983). Effect of high salinity stress on mineral and carbohydrate metabolism of two cotton varieties. Plant and Soil, 73: 247 - 256.

Ronde, J.A.D., A.D. Mescht, H.S.F. Steyn (2000). Proline accumulation in response to drought and heat stress in cotton. African Crop Sci. J., 8 (1): 85 - 92.

Sangakkara, U.R., M. Frehner and J. Nosberger (2000). Effect of soil moisture and potassium fertilizer on shoot, Water Potential, Photosynthesis and Partitioning of carbon in mungbean and Cowpea. J. Agron. Crop. Sci., 185: 201 - 207.

Snedecor, G.W. and W.G. Cochran (1981). Statistical Methods, 6th Edition Iowa Stat. Univ. Press, Ames, Lowa, USA.

Stewart, G.R. and J.A. Lee (1974). The role of proline accumulation in halophytes. Plants, 120: 279 - 289.

Yancey, P.H., M.B.Clark, S.C. Hands, R.D. Bowlus and G.N. Somero (1982). Living with water stress: evaluation of osmolyte systems, science 217: 1214 - 1222.

تأثير الرش بالبرولين على النمو والمكونات الكيمائية والمحصول لنبات القطن النامى تحت تأثير الملوحة

عاليه عوض محمود ناميش

قسم بحوث فسيولوجى القطن – معهد القطن – مركز البحوث الزراعية

الملخص العربى

يتراكم البرولين طبيعيا فى العديد من النباتات الراقية ومن ضمنها القطن. تقترح العديد من الدراسات الحقلية أن للبرولين دوراً فى زيادة محصول القطن تحت الظروف الملحية ، ولذلك أجريت تجربتان فى الأصص فى محطة البحوث الزراعية بالجيزة ، لتقدير تأثير البرولين على القطن تحت تأثير الإجهاد الملحى حيث زرعت بذور القطن للصنف جيزه ٩٠ فى أصص قطرها ٤٠ سم فى الأول والرابع من شهر إبريل خلال موسمى ٢٠٠٥ و ٢٠٠٦ على التوالى. تم خف النباتات (بعد تمام الأنبات) على نبات واحد فى الأصيص ، بعد ٥٠ يوم من الزراعة تم رى النباتات بمحلول ملحى من كلوريد الصوديوم بتركيزات (صفر و ٤٠٠٠ و ٨٠٠٠ و ١٢٠٠٠ جزء فى المليون) بالتبادل مع الرى العادى حتى نهاية الموسم ، وتم تخصيص عشرة أصص رويت بماء الصنبور كمعاملة مقارنة. وفى بداية التزهير رشت كل الأصص بالبرولين بأربع تركيزات (صفر – ٥٠ – ٧٠ – ١٠٠ جزء فى المليون) وكانت ملخص النتائج المتحصل عليها كما يلى :

- أدت معاملات الملوحه إلى نقص فى طول النبات وعدد العقد والأفرع الثمرية ومساحة الأوراق والوزن الجاف للجذور والسوق والأوراق ، وأدت أيضا الظروف الملحيه إلى نقص السكريات المختزله والغير مختزله والكليه وكذلك أمتصاص العناصر (البوتاسيوم و الماغنيسيوم و الكالسيوم) فى الأوراق والنسبة المئوية للزيت والبروتين فى البذره. بينما حدث العكس بالنسبة لمحتوى الأوراق من البرولين وصبغات الكلوروبلاست. وبناء عليه حدث نقص فى المحصول ومكوناته كنتيجة لزيادة الملوحه فى الموسميين.

- وعلى الجانب الآخر أدى رش نباتات القطن بالبرولين تحت ظروف الملوحه والظروف العاديه إلى زياده فى كل صفات النمو تحت الدراسة وبعض المكونات الكيمائيه فى الأوراق مثل كلوروفيل أ و ب والكاروتينات والسكريات المختزله والغير مختزله والذائبه الكلية ، وكذلك نسبة البرولين والعناصر الممتصه مثل البوتاسيوم والماغنيسيوم والكالسيوم ، والنسبة المئوية للبروتين والزيت فى البذور. كما أدى الرش بالبرولين إلى زياده معنويه فى عدد الأزهار واللوز بالنسبة للنباتات ، ونسبة اللوز العاقد والنسبة المئوية للشعر ومتوسط وزن اللوزه ، وزن ١٠٠ بذره ومحصول القطن الزهر للنباتات.
- وأظهر التفاعل بين الملوحه والرش بالبرولين إلى قلة التأثيرات الضارة للملوحه على النمو والمكونات الكيميائيه والنمو والمحصول .