Effect of Salinity on Botanical Characters and Fiber Maturity of Three Egyptian Cotton Cultivars

M.T. Nawar, A.M. Zaher, K. El-Sahhar and S.A. Abdel-Rahim
Cotton Research Institute, Agric. Res. Center, Giza, Egypt
Agric. Botany and Plant Pathology Department, Faculty of Agriculture, Cairo University, Egypt

ABSTRACT

The objective of this study was to investigate to extent salinity affects the growth and other characters of three Egyptian cotton cultivars: Giza 77, Giza 75 and Giza 80. The salinity levels were 0, 2000, 4000 and 6000 ppm of either NaCl + $CaCl_2$ or NaCl + KCl. Germination speed and capacity were lower as the concentration of various were salts increased. Salinity reduced plant height and the number of the main stem internodes. Salinity reduced cotton lint yield by up to 50%; specific weight of seeds by up to 18%; fiber maturity ratio by up to 8.9%; ovule width by up to 35% and fiber ribbon width by up to 4.9% where 6000 ppm of NaCl alone was applied. The effects of NaCl were greater than the effects of NaCl + $CaCl_2$ or NaCl + KCl. The relationship between fiber maturity and ovule width at two days post anthesis with some other characters are investigated.

Introduction

Expansion of cotton requires more irrigation water. It is possible to use saline water from underground or drainage for irrigation when the River Nile is low. The area considered salt affected to different degrees is approximately 800,000 ha. mainly located in the northern Nile Delta and newly reclaimed lands at Alexandria and Fayoum. These areas could be devoted in crops that are tolerant to salt. Salinity decreases germination energy and germination percentage of cotton seed (Pulatov, 1970; Saxton and Gerad, 1985; Ustimenko *et al.*, 1983; Kent and Lauchli, 1985). Plant height was decreased by increasing salinity level (Dahnovie, 1957; Das and Mehrotre, 1971; Belousov, 1976; Thomas, 1980). Conversely, plant height was not affected by salinity level up to 4000 ppm (El-Gharib and Kadry, 1983). The viscosity of leaf protoplast was higher in cotton plant grown in saline soils (Kushnirenko, 1951) while surface size of epidermal cells and leaf thickness increased with increasing salinity in fine sandy loam culture (Gausman and Cardenas, 1968). The lowest values of ribbon width of cotton cv. Giza 75 was obtained by irrigation water containing 4000 ppm NaCl (Nawar, 1989). Ovule culture revealed that conditions present in a boll at 2 days post anthesis have an impact on subsequent fiber quality (Davidonis, 1994). Given the above conflicting evidence in the literature, the present study examined the potential of three recently released Egyptian cotton cultivars to tolerate the effect of sodium chloride with calcium chloride and potassium chloride either combined or separately.

Material and Methods

Seed samples of Giza 77, Giza 75 and Giza 80 were obtained from the Cotton Research Institute, Agricultural Research Centre, Giza, Egypt, where this study was carried out. Seeds were sown in pots 40 cm in diameter filled with clay loam. Each pot containing ten plants, thinned to three before flowering. Reduced to two at flowering. Pots were irrigated with two litres of salinised water at 2 to 4 day-intervals according to demand.

Sodium chloride was used either alone or in a mixture with potassium chloride (1:1) or calcium chloride (1:1) at 0, 2000, 4000 and 6000 parts per million (ppm). Each treatment was replicated four times in a randomized complete block design for the seasons 1986 and 1987. Data was subjected to analysis of variance. The combined data of both seasons has been used for presentation of the results.

At the end of the growing season the soil of each treatment was chemically analyzed to measure alteration in its constituents. The electrical conductivity of the saturated extract (EC) was determined. Results are given in Table 1: EC increased according to the increasing of salinity treatment. The following data were recorded during the experiment:

1) germination
   a) Germination speed, percentage of seeds germinated after 4 days,
   b) Germination capacity, percentage of seeds germinated after 12 days.
2) Plant height after five months from planting.
3) Number of internodes of the main stem.
4) Yield of cotton lint per plant.
5) Anatomical measures.
   a) Tap root,
   b) main stem,
   c) blade of leaf,
   d) flower bud and

e) boll
6) Specific weight of seeds.
7) Maturity ratio of cotton fiber.
8) Ribbon width of cotton fiber.

Results and Discussion

Germination speed and capacity. Germination rate was lower as the concentration at various salts increased. Different salt treatments of 6000 ppm recorded the lowest germination, (Table 2). The treatment of NaCl, at 6000 ppm recorded the lowest germination rate, followed by NaCl + $CaCl_2$; the treatment of NaCl + KCl showed the least effect. This ranking is consistent with effect of each treatment on soil EC (Table 1). Similar results were found after 12 days (Table 3). The recorded reduction in germination percentage might be due to the decrease of the water imbibed by seeds, in agreement with previous studies (Pulatov, 1970; Saxton and Gerard, 1982; Ustimenko *et al.*, 1983 and Kent and Lauchli, 1985).

Plant height. The plant became shorter as the salt concentration of different treatments got higher, (Table, 4). Cotton growth was decreased by 30% at 8000 ppm salts (Das and Mehrotra. 1971) while the absorption rate of water was significantly decreased with increasing salinity levels in direct proportion to plant growth (Pessarakli and Tucker, 1985). The effect of salinity was more pronounced at vegetative than at reproductive stage of growth. This study found that the lowest plant height was in the treatment of 6000 ppm of any salts, endorsing other results (Salih and Abdul Halim, (1985).

Average number of internodes of the main stem. Giza 75 consistently produced the highest number of internodes under tested saline treatments followed by Giza 80 with Giza 77 the least (Table 5). The number of internodes decreased as the salinity level increased. NaCl had the greatest effect.

The tap root. The anatomical structure of cotton root subjected to saline treatments was affected. While the protective tissue increased in thickness to combat the unsuitable conditions, the amount of vascular tissues decreased. This led to a similar harmful effect in the morphological characters as was previously mentioned. NaCl alone had a more pronounced effect than salt mixtures.

The main stem. The vegetative body of investigated cotton cultivars generally declined as a result of saline treatments. The decrease in the amount of vascular tissues resulting from saline treatments would be expected to be followed by a similar decrease in different morphological characters.

The leaf. The structure of leaf in the three cultivars was similarly affected by saline treatments. The effect of NaCl only was more pronounced than salt mixtures. The amount of tissues in both the mesophyll and the vascular bundles decreased in response to saline treatments.

The Flower. No change could be seen in flowers of investigated plants as a result of adopted treatments.

The Boll. The development of the boll commences with fertilization. The anatomical structure of the ovary was examined two days after fertilization in all studied treatments to determine the effect of saline treatments on developing bolls. No qualitative variation was found in the structure of young bolls among different treatments but the amount of tissues of different parts of the boll varied among studied treatments (Table 6). While the average thickness of the outer wall of the boll increased under saline treatments, the average width of either of the boll and the ovule decreased. Ovule culture revealed conditions present in a boll two days post anthesis that have an impact on subsequent fiber quality (Davidonis, 1994). The following regressions were fitted for ovule width against parameters::

EC = 561.32 - 0.4390 boll width after 2 days from anthesis. r = -0.9610

EC = 84.86836 - 0.38424 ovule width r = -0.7579

Seed cotton yield per plant (g) = -3.8960 + 0.09959 ovule width r = +0.7070

Lint cotton yield per plant (g) = -2.93049 + 0.0464 ovule width r = +0.9931

Fiber maturity ratio = 0.7480 + 0.0010857 ovule width r = +0.7350

Ribbon width (µ) of cotton fiber = 12.4256 + 0.009308 ovule width r = +0.8739

Specific weight of seeds (g) = 5.80969 + 0.02456 ovule width r = +0.7622

Specific seed weights. Increasing salinity decreased seed size (Table 7). This effect was equally true for all forms of salts and for all cultivars. These results are in agreement with those obtained by El-Saidi and Hegazy (1980), Koker *et al.*, (1974), Longenecker (1974) and Ustimcitko *et al.* (1983).

Yield of lint cotton per plant. Lint cotton yield varied according to year and cultivar (Table 8). The concentration of 6000 ppm NaCl decreased yield more than the other salt treatments. It was generally found that the lint cotton yield decreased as the salt concentration increased. Given these results, the reduction in yield could be attributable to the decline in both the number and weight of bolls, thus supporting earlier results (Nawar, 1975).

Maturity ratio of cotton fiber. The results show that maturity ratio decreased as salt concentration of different treatments got higher (Table 9). The decrease in maturity ratio is a result of shortening of boll maturity as well as decreasing ovule width, associated with the increase of salt level. Opposed to this, Nawar (1989) stated that the values of maturity ratio

decreased as the salinity increased up to 4000 ppm NaCl, but the values of maturity ratio did not follow a constant trend with other salts.

From the above result, the relationship of fiber maturity with specific weight of seeds (r = +0.9219) and EC (r = -0.9374), the following equations were fitted:

$Y_1 = -8.7511 + 20.27\ X_1$

where: Y_1 = specific weight of seeds. and X_1 = maturity ratio,

$Y_2 = 0.9732 - 0.0022892\ X_2$

where: Y_2 = Maturity ratio and X_2 = EC of soil.

Ribbon width of cotton fiber. Low values were observed by treatments of 4000 NaCl and 6000 ppm of all salts (Table 10). Nawar (1989) found that the lowest value of ribbon width of cotton cv. Giza 75 was obtained by irrigation water containing 3000 and 4000 ppm NaCl. The simple correlation coefficient between ovule width with ribbon width was 0.8739.

Conclusion

All botanical characters, lint yield, fiber maturity of the studied cotton cultivars were affected by saline conditions. Higher salinity levels showed a pronounced effect and NaCl alone had a greater effect than the other mixed salts. The reduction in the ovule width from saline treatments resulted in a decrease of fiber maturity and seed weight.

References

Belotisov, E.M. (1976): Effect of the proportion of mono- and bivalent cations in the chloride and sulphate type of salinity on development and mineral nutrient contents in cotton. Field Crop Abst., 29: 886.

Dahnovie, T. (1957): Effect of soil salinity on change in some cotton features. Field Crop Abst., II:292.

Das, S.K. and C.L. Mehrotra. (1971): Salt tolerance of' some agricultural crops during early growth stages. Ind. J. of Agric. Sci., 41: 882-888.

Davidonis, G.H. (1994): Cotton ovule culture: a tool for assessing fiber quality. World Cotton Res. Conf. 1. "Challenging the future", Brisbane, Australia, Vol. of Abst.

El-Gharib. E.A. and W. Kadry. (1983): Effect of potassium on tolerance of cotton plants to salinity of irrigation water. Ann. of Agric. Sci., Moshtohor, 20: 27-34.

El-Saidi. M.T and W.A. Hegazy. (1980): Effect of using saline water for irrigation at different growth stages on yield and some physiological processes of cotton plant. Agric. Res. Rev., Egypt., 58. 337-355.

Gausman, H.W. and R. Cardenas. (1968): Effect of soil salinity on external morphology of cotton leaves. Agron. J. 60:566-567.

Kent, L.M. and A. Lauchli. (1985): Germination and seedling growth of cotton. Salinity-calcium interaction. Plant Cell and Environ., 8:155-159.

Koker, S., M.Y. Tayel and I.F. Anter. (1974): The effect of salinity on cotton yield and quality. Egyptian J. of Soil Sci., 14: 137-148.

Kushnirenko, M.O. (1951): Adaptation of cotton to salinity during the vegetative period. Soils and Fert. 14: 1951.

Longenecker, D.E. (1974): The influence of high sodium in soils, upon fruiting and shedding boll characteristics, fiber properties and yield of two cotton species. Soil Sci., 118:387-396.

Nawar, M.T. (1975): The relationship between morphological and technological characters in some Egyptian cotton varieties. M.Sc. Thesis. Fac. Agric., Al Azhar Univ., Egypt.

Nawar, M.T. (1989): Effect of salinity on structural and physical fiber properties. Annals Agric. Sci., Fac. Agric., Ain Shams Univ. Egypt 34:161-167.

Pessarakli, M. and T.C. Tucker. (1985): Uptake of nitrogen-15 by cotton under salt stress. Soil Sci., Society of American J. 49: 149-152.

Pulatov, N.P. (1970): Growth, development and yield of cotton salinized soils in the central Fergana region. Nauchnye Turdy Tashkent Kogo Univ. 377: 318-323.

Salih, H.M. and R.H. Abdul-Halim. (1985): Effects of levels of two dominant salt types in Iraq on some components of cotton yield (*G. hirsutum* L.) J. of Agric. and Resources Res. 4:1-14.

Sexton, P.D. and C.J. Gerard. (1985): Emergence force of cotton seedlings as influenced by salinity. Agron. J., 74: 699-702.

Thomas, J.R. (1980): Osmotic and specific salt effects on growth of cotton. Agron. J. 72:407-12.

Ustimenko, G., A. Batenchuk and T. Bardakoti. (1983): Quality of cotton seeds in relation to the level of soil salinity. Klilopkovodstvo., 10:35-36.

Table 1. Electrical conductivity of the soil used in the present study at the end of either growing seasons.

		EC mmhos/ml (25oC)		
Treatment	ppm	1986	1987	Mean
Control		3.3	3.5	3.40
NaCl	2000	7.6	7.9	7.75
	4000	26.9	27.1	27.00
	6000	33.6	34.9	33.75
NaCl + $CaCl_2$	2000	6.9	6.3	6.60
	4000	24.4	23.1	23.75
	6000	30.5	30.2	30.35
NaCl + KCL	2000	6.0	5.9	5.95
	4000	23.0	22.6	22.80
	6000	25.4	27.4	26.40

Table 2. Germination speed (%) after 4 days of the three cultivars under different salt treatment.

Treatment	Ppm	Giza 77	Giza 75	Giza 80	Mean
Control		80.0 a	85.4 a	76.0 a	80.5 a
NaCl	2000	76.1 b	70.6 e	66.3 c	71.5 e
	4000	68.9 c	67.4 f	56.8 e	64.3 g
	6000	62.9 f	61.5	g 52.0 f	58.8 h
NaCl + $CaCl_2$	2000	78.3 ab	81.5 b	70.8 b	76.8 c
	4000	73.3 c	79.0 cd	62.0 d	71.4 e
	6000	70.1 de	77.0 d	54.8 e	67.3 f
NaCl + KCL	2000	78.9 a	82.4 b	73.6 a	78.3 b
	4000	76.9 b	80.4 bc	62.6 d	73.3 d
	6000	71.6 cd	77.3 d	55.9 c	68.3 f
Mean		73.6	76.2	63.1	71.0

L.S.D. (0.05) Treatments 1.2% Cultivar = 0.5% C.V.% = 1.86

Table 3. Germination (%) after 12 days of the three cultivars under salt treatment.

Treatment	Ppm	Giza 77	Giza 75	Giza 80	Mean
Control		88.1	94.6	80.3	87.7
NaCl	2000	80.8	83.3	69.1	77.7
	4000	73.0	77.1	62.9	71.0
	6000	71.3	69.3	53.4	64.6
NaCl + $CaCl_2$	2000	80.9	87.3	71.4	79.8
	4000	77.5	82.6	64.4	74.9
	6000	76.0	80.6	56.3	71.0
NaCl + KCl	2000	84.4	93.9	77.1	85.1
	4000	80.8	91.9	67.3	80.0
	6000	78.8	90.4	59.8	76.0
Mean		79.1	85.1	66.2	

L.S.D. (0.05): Treatments 0.8% Cultivars 0.3% C.V.% = 1.11

Table 4. Plant height (cm) of three cotton cultivars under different salt treatment, after five months of sowing.

Treatment	ppm	Giza 77	Giza 75	Giza 80	Mean
Control		55.5	60.7	56.0	57.4 a
NaCl	2000	47.6	55.8	52.6	52.0 bc
	4000	42.9	49.9	44.4	45.7 de
	6000	39.9	44.9	40.9	41.9 f
$NaCl + CaCl_2$	2000	50.4	58.3	53.1	53.9 ab
	6000	40.6	45.6	42.3	42.8 ef
NaCl + KCl	2000	51.8	59.0	54.4	55.0 ab
	4000	46.6	51.4	48.0	48.7 cd
	6000	43.0	46.3	43.0	44.1 ef
Mean		46.4	52.3	48.2	

L.S.D. (05): Treatments =3.5 cm   Cultivar = 1.5 cm   C.V%= 8.14

Table 5. Average number of internodes of the main stem at five months from sowing of the three cultivars under different salt treatments.

Treatment	ppm	Giza 77	Giza 75	Giza 80	Mean
Control		13.6	15.8	14.6	14.7 a
NaCl	2000	12.9	14.5	13.6	13.7 c
	4000	12.5	13.8	13.1	13.1 de
	6000	11.6	12.8	11.9	12.1 f
NaCl + CaCl2	2000	13.1	15.0	14.0	14.0 be
	4000	12.8	14.4	13.5	13.5 cd
	6000	12.1	13.4	12.5	12.7 e
NaCl + KCl	2000	13.5	15.3	14.4	14.4 ab
	4000	13.0	14.6	14.0	13.9 bc
	6000	12.5	13.9	12.9	13.1 de
Mean		12.8	14.3	13.5	

L.S.D. (0.05): Treatments 0.6   Cultivars = 0.2   C. V.% = 4.59

Table 6. Effect of the level 6000 ppm of different salts on certain anatomical characters of the boll, two days after fertilization of three cotton cultivars.

Cultivar	Character (micron)	Treatment			
		Control	NaCl	$NaCl + CaCl_2$	NaCl + KCl
Giza 77	Av. boll width	1264.8	1190.4	1220.2	1220.2
	Av. thickness of outer wall of the boll	171.1	178.6	171.1	171.1
	Av. ovule width	183.5	119.0	163.7	167.4
Giza 75	Av. boll width	1264.8	1190.4	1220.2	1220.2
	Av. thickness of outer wall of the boll	171.1	178.6	171.1	171.1
	Av. ovule width	183.5	119.0	163.7	167.4
Giza 80	Av. boll width	1272.2	1190.4	1220.2	1220.2
	Av. thickness of outer wall of the boll	171.1	178.6	171.1	171.1
	Av. ovule width	183.5	119.0	163.7	167.4

Table 7. Specific weight of seed (gm per 100 seeds) of three cultivars under different salt treatments.

Treatment	Ppm	Giza 77	Giza 75	Giza 80	Mean
Control		10.9	10.6	11.5	11.0 a
NaCl	2000	10.3	10.5	10.5	10.4 ab
	4000	10.0	10.3	10.2	10.2 bc
	6000	8.4	9.1	9.6	9.0 d
NaCl + $CaCl_2$	2000	10.4	10.1	10.6	10.5 ab
	4000	10.0	10.4	10.1	10.2 bc
	6000	8.9	9.4	9.6	9.3 d
NaCl + KCl	2000	10.6	10.5	10.6	10.6 ab
	4000	10.4	10.4	10.2	10.3 ab
	6000	9.6	9.2	9.6	9.5 cd

L.S.D. (0.05): Treatments = 0.3 C.V.% = 9.08

Table 8. Lint yield of three cultivars under different salt treatments (g/pl).

Treatment	ppm	Giza 77	Giza 75	Giza 80	Mean
Control		5.9	5.0	7.6	6.2 a
NaCl	2000	4.9	4.2	5.5	4.8 cd
	4000	3.9	3.8	4.6	4.1 c
	6000	2.9	2.4	3.9	3.1 f
NaCl + $CaCl_2$	2000	5.0	4.3	6.4	5.2 bc
	4000	4.2	4.1	6.0	4.8 cd
	6000	3.6	3.3	5.2	4.0 e
NaCl + KCl	2000	5.3	4.5	6.8	5.5 b
	4000	4.6	4.1	6.2	5.0 bcd
	6000	4.0	3.5	5.8	4.4 de
Mean		4.4	3.9	5.8	

L.S.D. (0.05): Treatments = 0.79 Cultivars = 0. 30 C.V.% = 16.54

Table 9. Maturity ratio of three cultivars with different salt treatments.

Treatment	ppm	Giza 77	Giza 75	Giza 80	Mean
Control		0.94 a	0.94 a	1.06 a	0.98 a
NaCl	2000	0.89 d	0.92 b	1.03 b	0.94 d
	4000	0.88 e	0.89 e	1.01 c	0.93 e
	6000	0.85 g	0.86 e	0.99 d	0.90 h
NaCl + $CaCl_2$	2000	0.91 b	0.93 ab	1.04 b	0.96 b
	4000	0.89 d	0.89 c	1.03 b	0.93 e
	6000	0.85 g	0.87 de	1.00 cd	0. 91g
NaCl + KCl	2000	0.92 b	0.93 ab	1.04 b	0.96 b
	4000	0.90 cd	0.92 b	1.03 b	0.95 c
	6000	0.86 f	0.88 cd	1.01 c	0.92 f
Mean		0.89	0.90	1.02	

L.S.D. (0.05): Treatments 0.01 C.V.% = 1.07

Table 10. Ribbon width (μ) of three cultivars with different salt treatments.

Treatment	ppm	Giza 77	Giza 75	Giza 80	Mean
Control		13.8	15.6	13.4	14.3 a
NaCl	2000	13.6	15.4	13.1	14.0 ab
	4000	13.4	15.3	12.8	13.8 bc
	6000	13.1	15.0	12.7	13.6 c
NaCl + $CaCl_2$	2000	13.7	15.5	13.1	14.1 ab
	4000	13.6	15.4	12.9	14.0 ab
	6000	13.3	15.2	12.8	13.8 bc
NaCl + KCl	2000	13.7	15.5	13.2	14.1 ab
	4000	13.7	15.4	13.0	14.0 ab
	6000	13.4	15.3	12.9	13.9 bc
Mean		13.5	15.3	13.0	

L.S.D. (0.05): Treatments = 0.4 μ C.V.% = 3.0