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Effects of Amount and Application Time of Saline Water on Fibre Quality Characteristics of Cotton

Abstract
Compared with good quality water, the use of saline water increases the amount of water used for crop growth. An increased amount of saline water affects fibre quality. A field study was conducted to determine the effects of amount and application time of saline water on the fibre characteristics of cotton. Irrigation was carried out by a line-source sprinkler, which allowed the crop to be irrigated at different levels. All of the fibre characteristics measured were significantly and negatively affected by the saline water applied at VGP and FBF, whereas at BO, strength and length were the only fibre characteristics that were significantly and positively affected by the saline water applied. Osmotic potential (Ψ) at different growth stages and mean seasonal osmotic potentials significantly by the second power affected trash, trash area and ginning out-turn. The results showed that the saline water amountthe , soil osmotic potential and evapotranspiration (E_T) had a squaring effect on fibre characteristics.

Key words: *Cotton, fibre characteristics, water quality, evapotranspiration, soil salinity*

RESEARCH AND DEVELOPMENT

Introduction

The constraints of inadequate quantity and quality of freshwater resources, and increased demand on freshwater by industrial, agricultural and municipal activities have forced many sectors to seek new strategies. For instance, farmers in many arid and semi-arid regions of the world have to use poor quality waters for irrigating their crops. Use of poor quality waters requires many changes from standard irrigation practices: a) improvements in water management, b) maintenance of the soil's physical properties to assure soil tilt and adequate soil permeability to meet crop water and leaching requirements, and c) selection of appropriately salt-tolerant crops [1].

Differences in the salt tolerance of different crops and their cultivars exist, and have been extensively reported. Breeding and growing crop varieties capable of producing high yields even under high levels of soil and/or water sodicity can have a considerable relevance to agricultural production. This is particularly important in the case of cotton, an important crop which tolerates high levels of salinity in arid and semi-arid regions [2].

Cotton is an important industrial crop, produced in quantities of as much as 16.8×10^6 t, on 33 million ha in about 70 countries. The studies showed that the threshold value for soil salinity was 7.7 dS m^{-1}, and the slope was 5.2 dS m^{-1} for cotton [3]. Use of saline water with EC 7.8 to 9.4 dS m^{-1} has decreased cotton yield in Uzbekistan [4].

There is a lack of information about the effect of a sodic environment in the soil created by sustained sodic irrigations on the growth of cotton plants and the quality of the fibre of different cotton cultivars. Good-quality fibre is a key factor in cotton production, and is a desirable trait for its export market [5].

In view of various studies relating to the assessment of the effect of salinity on the fibre characteristics of cotton, the high salinity of the rooting medium was reported to adversely affect lint percentage, stable length, fibre fineness and fibre maturity [6, 7].

In most crop production systems, yield and financial return to the producer depend on the quantity and quality of the marketable components harvested. In the USA, price marketability and the utility value of cotton fibre are determined by the cotton classing system through which micronaire, length, short fibre content and strength/elongation are measured by High Volume Instrument (HVI) testing [8]. Many studies have been conducted to determine the effects of increased amount of saline water on yield and the yield components of cotton. However, limited information has so far been issued on the response of fibre characteristics to an increasing amount of saline water. The purpose of this study was to determine the effects of amount and application time of saline water on the fibre quality characteristics of cotton.

Materials and Methods

This study was carried out at the Experimental Field of Cukurova University

(36° 59'N, 35° 18'E) in the 1998 growing period. The soils of the experimental area were developed from alluvial deposits, covering a large area. The soil of the study area was clay-loam of the Mutlu series. The cation exchangeable capacity of the soils varies between 66.24 and 68.77 me/100 g. The pH values change from 7.15 to 7.58. The organic matter content is generally under 1.5%. Rainfall varies between 366 to 2000 mm, and the average yearly rainfall is 775 mm. During the study, from May to September, the total rainfall was 109.5 mm.

Irrigation water was analysed to determine water quality with respect to pH, electrical conductivity (EC), and sodium adsorption rate (SAR) [9]. The EC, pH and SAR values of the irrigation water were 6.5 dSm^{-1}, 7.58, and 51.21 respectively.

The cotton variety was Cukurova-1518, which responds better than other varieties to irrigation and white fly (Besimia tabacci Genn.). The seeds were machine-planted on 5 May 1998. The experimental units consisted of four row plots with a row length of 6 m and a row width of 0.70 m. The experiment was fertilised with 1.6 kg ha^{-1} of nitrogen and 0.6 kg ha^{-1} of phosphorus.

During the experiment, the osmotic potential caused by saline water in the cotton root zone was calculated depending on the concentration of soluble salt. For this purpose, Equation 1 was employed [10].

$$\Psi = -0.36 EC_e \quad (1)$$

In these equations, Ψ is osmotic potential (atm.), and EC_e is electrical conductivity of soil saturation extract, dS m^{-1}. The growth period was divided into three stages: the vegetative growth period (VGP), from three real leaves to flowering stages; the flowering and boll formation stage (FBF), from the first flowers' appearance to the opening of the boll; and the opening of the bolls (OB), from the first appearance of the boll to the last harvest [11].

For the irrigation of the cotton, the line-source sprinkler irrigation technique was used with four replications [12]. The system consisted of eight parallel laterals placed 12 m apart. The water amount in the sub-plots varied depending on the duration of the laterals' operation. For example, the $D_1D_3D_t$ sub-plot received the highest amount of irrigation water during VGP, as it was the closest sub-plots to the lateral (D_1). However, the same sub-plot received the lowest irrigation water during FBF (D_3). Finally, during the OB period, both laterals were operated together to provide full irrigation (D_t).

The first irrigation in the experiment was applied when 60% of the initial soil water in the 120 cm soil depth at sub-plot A_2 was depleted. The following irrigations were applied when the soil water in 60 cm soil depth at sub-plot A_2 was depleted. The irrigation was terminated at the point where the deficient water in 60 cm depth was compensated, and 10% of this level was exceeded. The soil water was monitored by taking soil samples twice a week from the beginning to the end of the growing season.

The evapotranspiration of cotton was measured by the water balance equation [13] as given below.

$$E_T = I + R + Cr - Dp - Rf \pm \Delta s \quad (2)$$

Where E_T is actual crop water consumption (mm), I is the irrigation water level (mm), R is precipitation (mm), Cr is the capillary rise (mm), Dp is loss by deep percolation (mm), Rf is the runoff (mm), Δs is the water change in the soil profile (mm). The Cr and Rf values were neglected due to the fact that the runoff lost was avoided by making raised beds of 40 cm in heights around the experimental plots, and also because the water table level was too low.

The first harvest was performed when approximately 60% of the bolls were opened, and the second harvest was made 5 weeks later. The fibre data was obtained from hand-harvested cotton in the middle two rows in each plot to prevent side-ef-

Table 1. *The effects of irrigation water amount (IR), osmotic potential (Ψ) and evapotranspiration (ET) on mean fibre characteristics of cotton in different sub-plots.*

Sub plots	Mean			Fibre characteristics														
	IR	Ψ	E_T	Gin.	SCI	Mic.	Str.	Len.	Unf.	SFI	Elg.	Cnt.	Area	CSP	Rd	+b	T
$A_1A_1A_1$	586	0.507	439	0.382	115.5	4.93	25.6	27.2	83.5	6.88	3.83	31.2	1.20	1956	71.4	9.15	3.00
$A_2A_2A_2$	560	0.664	481	0.383	122.0	4.63	27.8	27.8	82.8	7.45	3.33	69.0	1.83	1989	69.9	9.33	3.25
$A_3A_3A_3$	299	0.646	331	0.377	110.3	4.75	24.8	25.9	83.0	8.10	3.40	38.7	0.83	1928	71.2	8.88	2.50
$B_tB_tB_t$	690	0.742	455	0.379	116.7	4.85	27.1	27.6	82.5	7.92	3.75	51.7	1.36	1962	70.4	9.19	2.92
$C_1C_tC_t$	589	0.729	457	0.382	109.0	4.97	25.8	27.8	82.1	8.38	3.63	35.2	1.63	1917	69.8	9.67	3.00
$C_2C_tC_t$	593	0.828	465	0.379	118.3	4.67	27.1	28.3	82.3	7.83	4.10	49.2	1.13	1985	70.6	9.87	2.67
$C_3C_tC_t$	535	0.675	455	0.397	112.5	4.73	24.9	27.8	82.6	7.65	4.05	28.2	1.33	1958	71.1	9.70	3.00
$D_1D_3D_t$	469	0.791	436	0.369	117.0	4.43	26.2	27.6	82.3	8.15	3.73	34.5	1.45	2008	71.5	9.15	3.00
$D_2D_2D_t$	575	0.637	487	0.364	113.7	4.73	25.8	27.1	82.7	7.88	3.48	58.2	2.08	1941	69.9	9.20	3.75
$D_3D_1D_t$	538	0.581	472	0.375	114.2	5.05	27.0	27.2	82.6	8.00	3.20	54.2	1.68	1945	71.1	8.88	3.50
$E_tE_1E_3$	600	0.703	481	0.367	119.7	4.50	27.1	28.1	82.1	8.08	4.10	45.5	1.25	2019	71.4	9.25	3.00
$E_tE_2E_2$	646	0.707	498	0.367	113.5	4.72	26.9	27.1	81.9	8.83	3.60	49.5	1.18	1954	70.9	9.28	2.75
$E_tE_3E_1$	481	0.759	403	0.368	113.2	4.75	26.0	27.6	82.2	8.28	4.28	47.2	1.43	1981	71.7	8.98	3.00
$F_tF_tF_1$	694	0.715	437	0.369	117.5	4.45	26.1	28.5	81.9	8.18	4.60	49.2	0.85	2042	72.3	9.28	3.00
$F_tF_tF_2$	785	0.776	445	0.358	120.7	4.50	27.5	27.9	82.2	8.08	4.00	40.2	1.23	2031	71.7	9.03	2.75
$F_tF_tF_3$	591	0.775	486	0.364	117.7	4.60	26.8	27.5	82.7	7.75	3.65	47.7	1.75	1981	69.9	8.90	3.25
$G_1G_tG_1$	625	0.718	395	0.368	129.7	4.13	28.3	28.1	83.0	7.05	4.45	53.2	2.35	2059	70.6	9.38	4.00
$G_2G_tG_2$	585	0.727	406	0.371	114.2	4.70	27.5	27.9	81.4	9.13	3.83	56.7	1.65	1969	71.1	9.53	3.50
$G_3G_tG_3$	520	0.789	442	0.373	120.7	4.63	26.8	28.4	82.8	7.08	4.35	41.7	1.45	2020	71.4	9.38	3.25

Gin.: ginning out-turn, SCI: spinning conversion index, Mic.: micronaire, Len.: length, Unf.: uniformity, SFI: short fibre index, Elg.: elongation, Cnt.:trash count, CSP: count strength product, Rd: reflectance degree, +b: yellowness, T: trash fects. The following fibre properties for each sample were determined with HVI: fibre length in millimetres, measured as 2.5 (2.5% SL); fibre uniformity (%), determined as the ratio of the mean length to upper-half mean length; fibre strength as force (cN/tex) necessary to break the fibre bundle; micronaire reading as fineness of the fibre expressed in standard micronaire units (dtex); reflectance degree (Rd %) and yellowness (+b) depicts the degree of cotton pigmentation; ginning out-turn; spinning conversion index (SCI); short fibre index (SFI); fibre elongation (%) as a measure of elasticity; trash count, trash area; count strength product (CSP); trash (%). The experimental design was a randomised complete block in a split plot design with four replications. Analysis of variance was performed for all data using a general linear model procedure [14]. The fibre characteristics were regressed with the amount of irrigation water and the osmotic potential.

Results and discussion

Weather conditions at the experimental site during the growing season were favourable for cotton growth and development. Planting was delayed until early May (compared to the mid-April planting norm in the region) because of wet weather in mid-spring (April) in 1998. This was followed by dry conditions shortly after planting, with abundant rainfall during May. Temperatures were higher than normal but not excessively hot, which through mid-June promoted growth, squaring and boll setting. When temperatures are lower for cotton growth, bolls that mature later in the season require a longer period for fibre growth and development, and usually produce lint of lower quality, which is also reflective of the water stress required to optimise defoliation and harvesting conditions [15].

In the present study, saline water was applied once at VGP, 2 times at FBF and once at BO. The highest amount of irrigation water was applied at FBF. Of the sub-plots, sub-plots $F_tF_tF_2$ received the highest amount of water, whereas $A_3A_3A_3$ had the lowest amount of water. The results showed that standard deviations of count strength product, trash count, length, elongation micronaire, trash and ginning out turn tended to increase with the increasing amount of saline water, whereas strength and uniformity tended to decrease.

The measured fibre quality characteristics affected by the amount of saline water are given in Table 1. The regression analysis carried out between the total amount of applied saline water at different growth periods and the fibre characteristics showed quadratic relationships (Figure 1a and b). Strength ($R=0.56^{**}$), length ($R=0.68^{**}$), +b ($R=0.45^{*}$), trash ($R=0.53^{*}$) and trash area ($R=0.51^{*}$) increased with the increasing amount of saline water until a certain level, and a further increase in water amount had no effect. The other fibre parameters measured were not significantly affected by the amount of applied saline water.

The response of fibre characteristics to the increased amount of saline water was similar to that of the lint yield to an increased amount of saline water. Water applied at VGP and FBF development stages significantly and negatively affected all of the measured fibre characteristics, whereas water applied at BO positively affected only the strength and length of fibre. Regression analysis revealed that the CSP, SCI, Rd and +b of fibre increased with the application of saline water at the FBF development stage. The correlation coefficient with the water amount and the CSP, SCI, Rd and +b were $R=0.51^{*}$, $R=0.46^{*}$, $R=0.51^{*}$ and $R=0.49^{*}$ respectively (Table 2). However, uniformity, SFI, trash and area increased with the amount of water applied at the VGP growth stage. The amount of water applied at the VGP growth stage was significantly correlated with uniformity ($R=0.47^{*}$), SFI ($R=0.58^{**}$), and trash area ($R=0.44^{*}$). Fibre strength, one of the most important fibre characteristics, was positively affected by the water applied at VGP, FBF and BO growth stages. However, strength values increased linearly with the increasing amount of water applied at VGP, whereas strength increased with the increasing water amount until a certain level at the FBF and BO stages, and no further strength increase was recorded with additional water. Similar to strength, the water amount had a linear effect on length at the FBF growth stage, and a quadratic effect at the BO growth stage.

Table 2. *Regression equations between fibre characteristics and the amount of irrigation water and osmotic potential in different growth stages ($y=a\ x^2 + b\ x + c$); VGP - vegetative growth period, FBF - bell formation stage, BO - opening of the bolls.*

Fibre quality parameters	Independent variable	VGP			FBF			BO		
		a	b	c	a	b	c	a	b	c
Gin.	Amount of Irrigation Water				$-6x10^{-7}$	0,0003	$0,34^{*}$			
SCI					$7x10^{-5}$	-0,003	112^{*}			
Str.		$-1x10^{-4}$	0,045	$22,18^{*}$	$-3x10^{-8}$	0,007	$24,60^{*}$	-0,001	0,25	$12,92^{*}$
Len.		$-1x10^{-4}$	0,050	$23,12^{**}$	$-5x10^{-6}$	0,007	$26,09^{*}$	-0,0006	0,13	$19,80^{*}$
Unf.		$-5x10^{-8}$	-0,005	83,34*						
CSP					0,002	-0,769	$2036,19^{*}$			
Rd					$5x10^{-5}$	-0,027	$74,24^{*}$			
+b					$-2x10^{-5}$	0,010	$7,98^{*}$			
T		$-8x10^{-5}$	0,03	$1,02^{**}$						
Mic.	Osmotic potential	-6,74	-6,01	$5,94^{*}$	-1,562	0,69	$4,88^{*}$			
Str.		-46,77	39,88	$18,56^{**}$						
Len.		-25,20	22,35	$22,96^{**}$	-10,202	16,93	$21,05^{**}$			
Unf.		19,10	-17,34	$86,21^{**}$	26,926	-35,08	$93,71^{**}$			
Elg.								-3,1098	7,4767	$-0,4756^{*}$
Cnt.		-410,23	353,08	$-25,46^{*}$				145,23	-311,49	$209,99^{*}$
CSP		-1532,30	1313,70	$1715,10^{*}$	294,14	-138,84	$1945,9^{*}$			
Rd								-8,1697	18,023	$61,23^{*}$

*, ** significant at 0.05 and 0.01 probability level, respectively. Gin.: ginning out-turn, SCI: spinning conversion index, Mic.: micronaire, Len.: length, Unf.: uniformity, SFI: short fibre index, Elg.: elongation, Cnt.: trash count, CSP: count strength product, Rd: reflectance degree, +b: yellowness, T: trash.

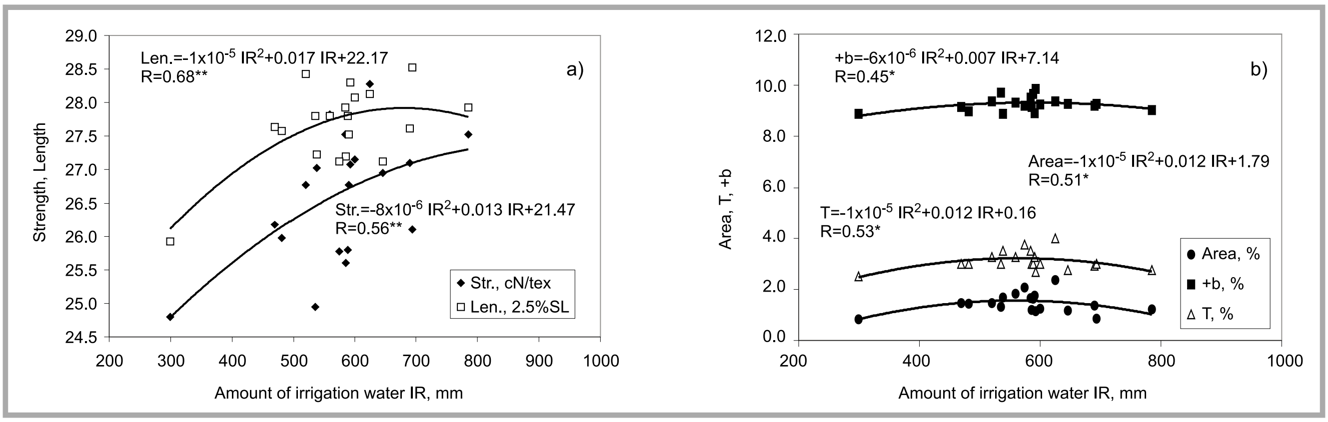

Figure 1. *The relationship between the amount of irrigation water and fibre characteristics; a) strength and length; b) area, +b and T.*

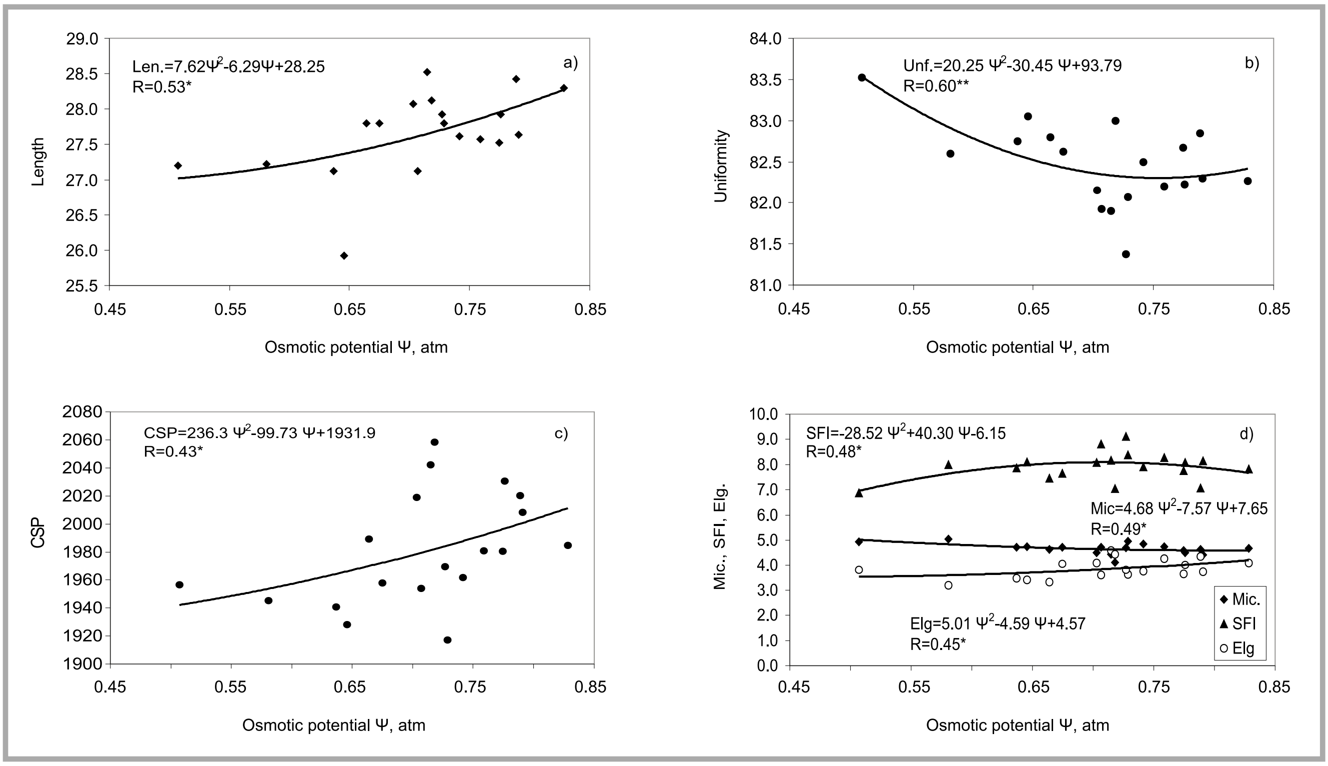

Figure 2. *The relationship between the osmotic potential and fibre characteristics; a) length, b) uniformity, c) CSP, d) micronaire, SFI and elongation.*

Like the saline water amount, water application at different growth stages gave similar results of fibre characteristics. Fibre length and strength are governed by moisture. Fibre length was one of the fibre characteristics most affected by saline water application at 16 to 20 days after flowering. On the other hand, fibre strength was one of the fibre characteristics most affected by saline water application between the period from the boll development and three to four days prior to BO. Ample moisture between initial BO and 50% BO can provide key reserves for fibre strength and length development [16, 17].

A water salinity of 6.5 dS m^{-1} increased the Ψ values. Regression analyses showed there were quadratic relationships between Ψ and fibre characteristics. The SCI, trash, area and ginning out-turn of the fibres were significantly and negatively affected from Ψ at different growth stages and mean seasonal Ψ. As with the water amount, Ψ had little effect on fibre characteristics at the BO stage compared to the VGP and FBF stages. Only Ψ affected Rd (R=0.44*) and elongation (R=0.50*) by the second power of the BO stage. At both the VGP and FBF stages, significant correlations between fibre characteristics and Ψ were obtained. At the VGP stage, Ψ significantly correlated with the CSP (R=0.47*), uniformity (R=0.58**), strength (R=0.59**), length (R= 0.58**) and micronaire (R= 0.44*). However, at the FBF stage, Ψ significantly correlated with CSP (R=0.44*), uniformity (R=0.62**), strength (R=0.44*), length (R=0.66**) and micronaire (R=0.46*). Osmotic potential (Ψ) affects the SFI value (R=0.43*) by the second power only at FBF stage, whereas the count value, also by the second power at all growth stages.

The relationship between mean Ψ and fibre quality was investigated, and some important correlation coefficients were obtained. The highest correlation coefficient (R=0.60**) was obtained between Ψ and uniformity. The correlation coeffi-

Table 4. Correlation coefficients of fibre characteristics.

Para-meter	Gin	SCI	Mic.	Str.	Len.	Unf.	SFI	Elg.	Cnt.	Area	CSP	Rd	+b
SCI	-0.17												
Mic.	0.22*	-0.51**											
Str.	-0.21*	0.71**	-0.18										
Len.	-0.09	0.58**	-0.21*	0.40**									
Unf.	0.07	0.67**	0.03	0.23*	0.26*								
SFI	-0.04	-0.77**	0.04	-0.32*	-0.51**	-0.96**							
Elg	-0.12	0.36**	-0.58*	-0.04	0.27*	0.11	-0.18*						
Cnt	-0.10	0.09	0.08	0.45**	0.06	-0.07	0.05	-0.44**					
Area	-0.03	0.03	0.10	0.25*	0.14	-0.02	-0.02	-0.37**	0.66**				
CSP	-0.21	0.82**	-0.72*	0.39**	0.61**	0.39**	-0.52**	0.64**	-0.23*	-0.23*			
Rd	-0.01	0.13	-0.18	-0.21*	0.11	0.08	-0.10	0.54**	-0.65**	-0.62**	0.51**		
+b	0.12	0.07	-0.02	0.13	0.25*	-0.05	-0.03	-0.07	0.18	0.10	-0.14	-0.21*	
T	0.02	0.03	0.12	0.20	0.16	0.02	-0.06	-0.31*	0.53**	0.89**	-0.20	-0.48**	0.09

*, ** significant at 0.05 and 0.01 probability level respectively. Gin.: ginning out-turn, SCI: spinning conversion index, Mic.: micronaire, Len.:length, Unf.: uniformity, SFI: short fibre index, Elg.: elongation, Cnt.: trash count, CSP: count strength product, Rd: reflectance degree, +b: yellowness, T: trash.

cient of the CSP, length, SFI, micronaire, and elongation with Ψ were similar (Figure 2. a-d). Previous studies showed that increased soil salinity significantly and negatively affected most of the fibre characteristics of cotton [6, 7, 18, 19].

The relationships between the E_T rates and the fibre characteristics of cotton were given in Table 3. All of the measured fibre characteristic values of cotton increased with the increasing E_T until a certain level, but they did not change with any further increase in E_T. Among fibre characteristics, length was one of those most affected. Regression analysis showed that the fibre length was highest when E_T reached 827 mm, and a further increase in E_T did not increase fibre length. The CSP, Rd and elongation values reached the highest levels when their E_T values were 836 mm, 958 mm and 862 mm respectively.

The correlation coefficient of fibre characteristics are given in Table 4. The CSP was one of the highly correlated fibre parameters with the other measured fibre parameters. On average, the correlation coefficient among the primary fibre parameters (which are CSP, micronaire, strength, length elongation SFI and SCI) were higher. As in primary fibre quality parameters, the correlation coefficient among the secondary fibre parameters (which are ginning out-turn, trash, trash area, trash count, Rd and +b) were higher.

Table 3. Regression equations between fibre characteristics and Evapotranspirations ($y=a x^2 + b x +c$).

Fibre quality parameters	a	b	c	R
Length	-0.0002	0.166	-7.899	0.78**
Elongation	-0.0001	0.086	13.590	0.64**
Count strength product	-0.0087	7.274	484.410	0.50*
Reflectance degree	-0.0001	0.0096	52.740	0.56**

Conclusion

The application of saline water between the period from the VGP and at the end of the FBF stages significantly reduced the fibre characteristics of cotton. Reductions in fibre quality characteristics increased with the increased amount of saline water. The negative effects of saline water on fibre quality characteristics could be alleviated by the application of reduced amount of saline water at the early growth stages, and the gradually increased amount of saline water at the crop's later growth stages , without significantly affecting fibre quality characteristics.

References

1. Oster, J.D., 1994. Agriculture Water Management, 25: 271-297.
2. Bajwa, M.S., Choudhary, O.P., Josan, A.S., 1992. Agriculture Water Management, 22:345-356.
3. Halevy, J. and Bazelet, M., 1989. Fertilizing for high yield and quality cotton. I.P.I. Bulletin 2. International Potash Institute. Bern/Switzerland, 55 pp.
4. Bressler, M.B., 1979. Joint Commission. Science Technology Cooperation, Water Resources Burden Reclamation, Denver. 20 pp.
5. Choudhary, O. P., Josan, A.S., Bajwa, M.S., 2001. Agriculture Water Management 49: 1-9.
6. Latif, A. and Khan, M.A., 1976. Pakistan Cottons, 20, 2: 91-104.
7. Razzouk, S., Whittington , W.J., 1991. Field and Crops Research, 26, 305-314.
8. Behery, H.M., 1993. International Cotton Advisory Committee Review Article No. 4, CAB International, Wallingford, UK.
9. USSL: 1954, Diagnosis and improvement of saline and alkali soils U.S. Department of Agriculture. Agricultural Handbook. 60. U.S.A. p 160.
10. Bresler, E., Mc Neal, B.L., Carter, D.L., 1982. Saline and sodic soils. Principles-dynamics-modeling. Springer-Verlag, Berlin. 25 pp.
11. Doorenbos, J., Kassam, A.H., 1979. Yield response to water. FAO No. 33 Rome, 193 pp.
12. Hanks, R.J., Keller, J., Rasmussen, V.P., Wilson, G.D., 1976. Soil Science Society American Journal, 40(3): 426-429.
13. Walker W. R. and Skogerboe G. V. 1987. Surface Irrigation: Theory and practice. Prentice-Hall. Inc. Englewood Cliffs, New Jersey, p 375.
14. SAS Institute, 1997. SAS/STAT software: Changes and enhancements through release 6.12. SAS Inst., Cary, NC.
15. Grimes, D.W. and El-Zik, K.M., 1990. Cotton. In: Stewart, B.A., Nielsen, D.R. (Eds.), Irrigation of Agricultural Crops-Agronomy Monograph No. 30. ASA-CSSA-SSSA, 677, South Segoe Road, Madison WI 53711 USA, pp. 741-748
17. Bragg, C.K. and Shofner, F.M., 1993. Textile Research Journal, 63: 171-176.
18. Ashraf, M. and Ahmad, S., 2000. Field Crops Research, 66, 115-127.
19. Rhoades, J.D., Bıngham, F.T., Letey, J.V.D., 1988. Hilgardia 56, 5: 1-45.

Received 07.04.2004 Reviewed 10.10.2004