Effects of Saline Waters with Sprinkler and Furrow Irrigation on Yield Response of Cotton

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Abstract The climatic conditions of Iran requires that in order to optimize the use of water and to increase the irrigation efficiency, sprinkler irrigation systems should be used. On the other hand, water scarcity encourages the use of this type of irrigation systems which conserve irrigation water. Unfortunately, water scarcity is often accompanied by poor water quality. Under conditions of low water quality, sprinkler irrigation has deterimental effects due to leaf burn and defoliation. In order to quantify yield reduction under this type of water, an experiment was set up on the Agricultural Research Station, Varamin, Tehran, in a completely randomized block design. Irrigation water was applied through sprinkler and furrow systems with four tratment levels of salinity (0.63, 2.13, 3.97 and 7.8 dS/m) each having four replications to evaluate the extent of leaf injury, foliar absorption of Cl and Na ions and yield response. The evaluation of the chemical analysis of leaves on the sprinkled plots indicated that the rate of ion avsorption was increased during the growing season but on the furrow-irrigated plots, the rate of absorption was not significant. Ion absorption other than Cl and Na were not significant for both the sprinkler and furrow-irrigated plots. The yield reduction of cotton on the treatment levels of 3.97 and 7.8 dS/m on the sprinkler-irrigated plots were about 25 and 36 percent, respectively, compared to treatment level of 0.63 dS/m but, statistically speaking, there were no significant differences between the treatment levels of 0.63 and 2.13 dS/m. The yield reduction of cotton on the treatment level of 7.8 dS/m compared to treatment level of 0.63 dS/m on the furrow-irrigated plots was about 19 percent.
Key words: saline, irrigation, sprinkler, cotton, furrow

1. INTRODUCTION

Water scarcity encourages the use of irrigation systems which conserve water, especially when the scarcity is directly linked to lowered crop production or crop failure. Sprinkler irrigation has proven itself, under most field management situations, to require less water than the usual surface application methods. Unfortunately water scarcity is often accompanied by poor water quality. It is not only true for many parts of the world's arid lands, but also holds for the humid coastal areas that are forced to use brackish waters to relieve drought conditions.

Some crops, when irrigated by sprinkling, experience foliar injury and yield reductions that may not occur when they are surface or drip irrigated with water of simillar quality (Harding, et al., 1958; Mass, et al., 1982b). As the salinity quality of the sprinled water increases, crops become increasingly prone to salt injury as a result of foliar absorption of salts that accumulate on the leaf as the sprinkled water evaporates from the leaf surface (Maas, 1985).

Various studies have documented the potentially harmful effects of wetting the leaves of grapes (Francois and Clark, 1979) and of herbaceous plants (Bernstein and Francois, 1975; Busch and Turner, 1967; Goldberg and Shmueli, 1971; Maas, et al., 1982a; Nielson and Cannon, 1975) with saline water. Leaves of deciduous fruit and nut trees are believed to absorb chloride and sodium more readily than many herbaceaus crops. Ehlig and Bernstein (1959) found that leaves of sprinkled young plum trees were injured at a lower foliar concentration of chloride and sodium than the other tree. The absorption of salts by leaves is less selective (Aragües et al. 1994) and Na and Cl in the sprinkling water can enter the leaf in proportion to their concentration (Mass et al. 1982a,b).

Grathan et al. (1994) found that only in the youngest leaves sampled at the end of season from plant grown at high salinity was the Cl concentration in uncovered plants (foliar plus root-absorbed Cl) found to be more than twice that in covered plants (only root-absorbed Cl) indicating that most of the Cl in young leaves originated from foliar absorption.

Lees research has been done to demonstrate the effects of on field, forage or vegetable crops. The objective of this study was to evaluate the extent of foliar damage and the yield response of cotton as a result of wetting the foliage with water of various levels of salinity.

2. MATERIALS AND METHODS

The absence of works on cotton and the desire to see if saline water-sprinkling effects would correlate with cotton yield lead to the experiment repoted here.

The study was conducted on the Agricultural Research Station, Varamin, Tehran, in a completely randomized block design as shown in Figure 1 . The soil texture class of the study area was clay loam. Tables 1, 2a and 2b show the chemical properties of soil in the study area before and after experiment, respectively.

In the main experiment, four levels of saline water (EC of 0.63, 2.13, 3.97 and 7.8 dS/m were applied by sprinklers over the plant canopy. Four VYR-80 sprinklers fixed, one for each corner, equal of each plot (12 × 15 m^2) and adjusted for a 90 degree wetting pattern to the plot area. Water for sprinkled and furrow-irrigated plots was stoned in a large concrete (201.7 m^3) pool equiped with a pump to create necessary water pressure for the sprinklers.

In order to make a comparison of yield between the sprinkled and furrow-irrigated plots, the same experimental design was set up for furrow-irrigated plots (2.4 × 10 m^2). Plot detail for sprinkler experiment is shown in Figure 1.

Furrow and sprinkler plots were irrigated at equal intervals, an average of once every 10 days for a total of nine irrigation from April 30 to August 10, 1995. Four levels of salinity (Table 3) were applied with sprinklers having discharge of 0.22 L/S on four randomly-selected plots per treatment.

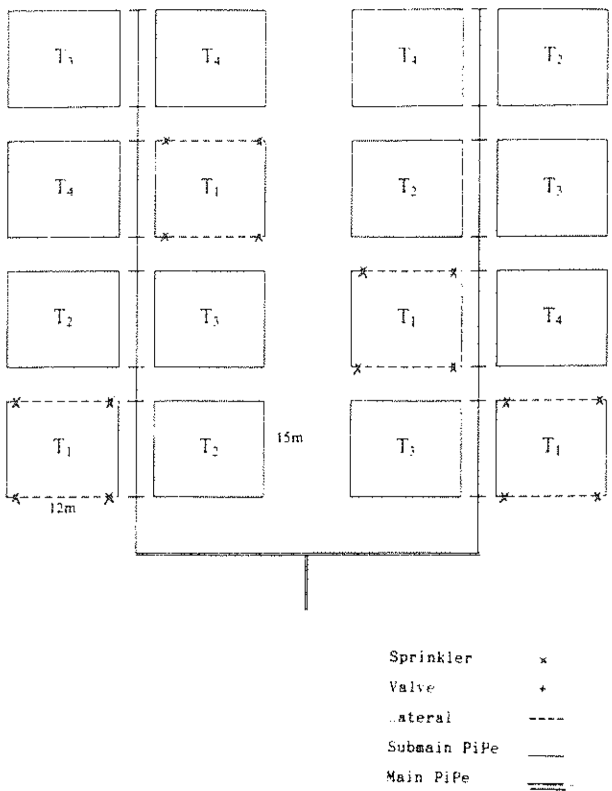

Figure 1. Layout of sprinkler irrigation system in field

Table 1. Initial chemical characteristics of the soil in the study area

Classification			Anions (meq/l)			Cations (meq/l)				
non-saline	ESP	SAR	Cl	HCo$_3$	Co$_3$	Mg	Ca	Na	ECe×10^3	pH
	1.66	2.0	3	3.6	0.0	4.4	8	5	1.6	8

Table 2a. Chemical characteristics of the soil at the end of experiment (sprinkler plots)

Factors evaluated	Treatment			
	T_1	T_2	T_3	T_4
pH	8.00	7.95	7.85	7.80
SAR	3.57	4.75	10.50	12.40
ESP	3.85	5.43	12.50	14.55
ECe	1.90	2.65	6.35	10.40
soil classification	very low saline	low saline	saline	saline

Table 2b. Chemical characteristics of the soil at the end of experiment (furrow plots)

Factors evaluated	Treatment			
	T_1	T_2	T_3	T_4
pH	8.05	7.8	7.85	7.8
SAR	4.96	14.8	18.20	38.8
ESP	5.70	17.1	20.30	35.8
ECe	1.72	5.7	6.65	13.0
soil classification	low saline	saline	saline	saline

Table 3 . Average chemical properties of waters sprayed on the cotton

Factors evaluated	Treatment			
	T_1	T_2	T_3	T_4
$EC \times 10^3$	0.63	2.13	3.97	7.80
SAR	1.52	9.12	15.50	36.90
SAR adj	3.29	19.33	3.63	87.82
Irrigation Water* Classification	C2S1	C3S2	C4S4	C4S4

* Classification is based on Wilcox diagram

Twenty leaves were sampled separately from each treatment before each spraying to determine different ions and two whole plants at biweekly intervals for measuring Leaf Area Index (LAI). The leaves were rinsed twice in distilled water, dried at 70 °c , and ground in a blender. Chloride was determined on acid extracts (0.1 M nitric acid in 1.7 M acetic) by the coulomtric-amperometric titration procedure and Na,Ca, Mg, and K were determined by atomic absorption spectrophotometry.

3. RESULTS AND DISCUSSION

Sline Water with sprinkler system

The accumulation of chloride and sodium in cotton leaves increased linearly during the growing period for all of the spray treatments. The rates of absorption of Cl and Na for all treatments are presented in Figures 2a and 2b. Concentration of Cl in the leaves was more than Na. Average composition of the ions other than Cl and Na in the cotton leaves are shown in Table 4 . The rate of absorption also increased with increasing the temperature during the growing season.

The absorption rates were linear functions of the salt concentration of the spray water for both ions. Since the concentration of Cl in each spray treatment was more than Na, Cl was absorbed faster than Na. The result also indicated that as the concentration of salinity increased, the LAI became less. Maximum LAI was 2.48 for treatment, T1 and 1.95 for T4 (Figure 3). This is most likely due to the absorption of more Na and Cl ions in the leaves of treatment T4 compared to treatment T1, which usually causes leaf injury and then early ripening. Statistical analysis based on four sameples from each treatment at each picking showed that the yied reduction under sprinkled plots on the treatment levels of 7.8 and 3.97 dS/m were about 38 and 25 percent, respectively, compared to treatment level of 0.63 dS/m . There were no significant differences as 5% significance level between the treatment levels of 0.63 and 2.13 dS/m.

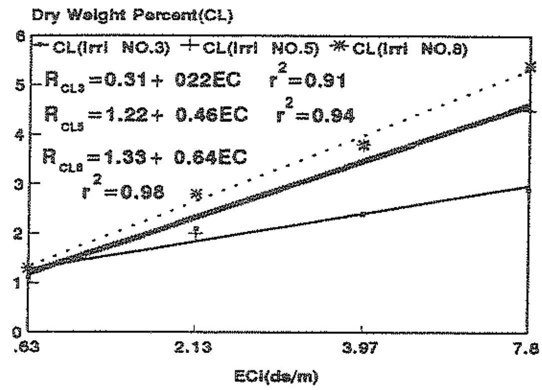

Figure 2a. Absorption rate of Cl in cotton leaves as a function of the salinity of spray water

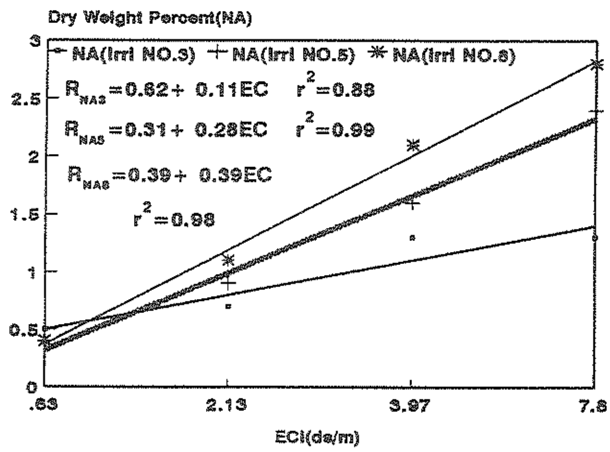

Figure 2b. Absorption rate of Na in cotton leaves as a function of the salinity of spray water

Table 4 . Concentration of K, Mg and Ca in dry leaves (dry weight percent) during irrigation seasen

Treatment	The Number of Irrigation								
	Third			Fifth			Eigth		
	K^+	Mg^{++}	Ca^{++}	K^+	Mg^{++}	Ca^{++}	K^+	Mg^{++}	Ca^{++}
T_1	1.9	0.8	4.0	1.9	0.6	4.6	1.3	0.9	4.2
T_2	2.0	0.9	5.4	2.7	1.0	5.5	1.1	0.8	5.0
T_3	1.6	0.8	3.7	1.7	0.9	4.0	1.3	1.1	3.4
T_4	1.8	0.7	4.6	1.4	0.6	3.7	1.2	1.1	3.5

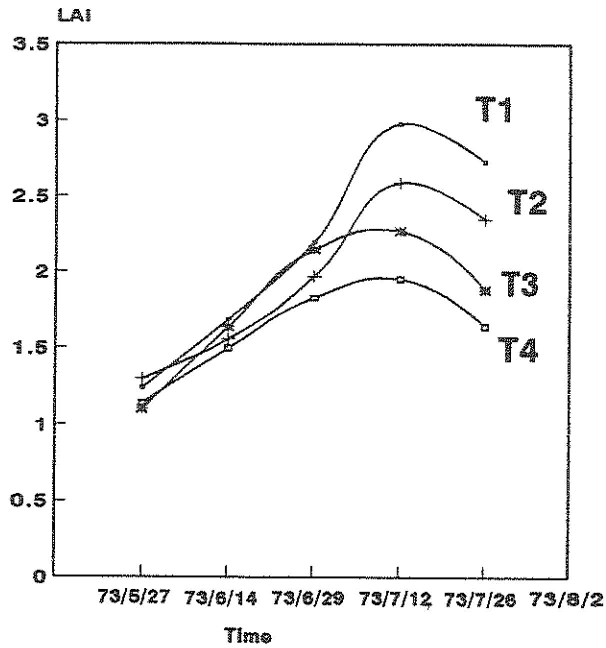

Figure 3. Variation of Leaf Area Index with time on the four treatment levels of sprinkler irrigation

Saline Water with Furrow System

The results obtained under this system indicated no significant differences at 5% significance level among treatment from viewpoint of ion absorption in the leaves. The results showed that Cl and Na absorption in leaves under furrow irrigation was much less than sprinkled plots. Concentration of Na, Cl, Ca, Mg and K in dry leaves during irrigation season for two treatments are shown in Table 5.

Table 5 . Concentration of different ions in dry leaves (dry weight percent) during irrigation season.

	The Number of Irrigation					
	Sixth		Seventh		Eigth	
Ions on the leaf	T_3	T_4	T_3	T_4	T_3	T_4
Na	0.2	0.2	0.2	0.3	0.2	0.3
Cl	1.7	1.8	1.7	2.0	1.4	1.8
K	1.9	1.5	1.6	1.6	1.3	1.5
Ca	4.8	4.8	4.4	4.9	4.8	4.8
Mg	0.9	0.9	0.8	1.0	0.8	1.0

The influnce of the sprinkler and furrow systems on cotton yields at first and second pickings are shown in Figures 4a and 4b. Total cotton yields under two different irrigation systems are shown in Fig. 4c and it was summarized in Table 6 .

Table 6 . Comparison of cotton yields under different salt concentrations in irrigation water of two different irrigation systems (Kg/ha)

Irrigation system	Treatment			
	1	2	3	4
Sprinkler	3638	3300	2744	2663
Furrow	4475	34285	4295	3612

Note : germination of cotton seeds under sprinkler system compared to furrow system was delayed about 20 days.

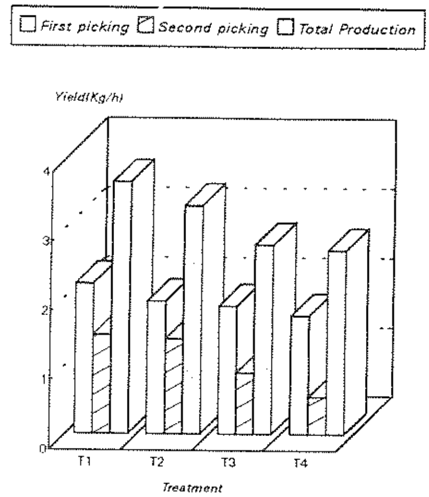

Figure 4a. cotton yield under sprinkler system

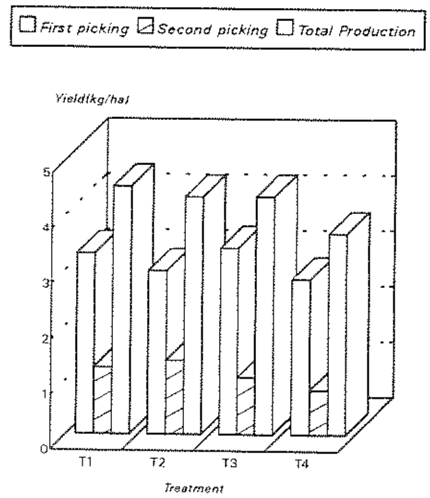

Figure 4b. cotton yield under furrow system

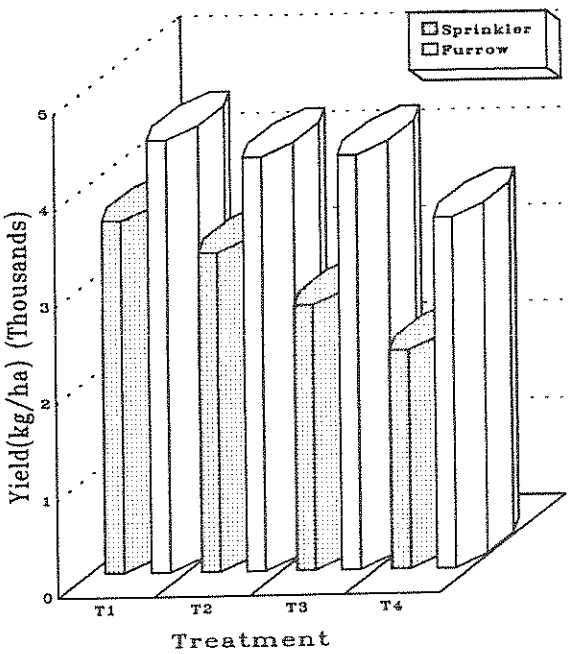

Figure 4c. comparison of cotton yield under sprinkler and furrow system

The results based on four samples from each treatment showed no significant differences (at 5% significance level) among treatments T1 to T3 but there was a significant difference between treatment T1 in compare to T4 at 1% significance level. The reduction between treatment levels of 0.63 and 7.8 dS/m was about 19 percent.

4. SUMMARY AND CONELUSIONS

The study of sprinkling cotton with fout levels of saline water was shown that sprinkler irrigation markedly affects both the sodium content in plant leaves and the crop yield. The cotton yield under sprinkled plots with four treatment levels compared to furrow-irrigated plots showed about 19, 23, 37 and 38 percent yield reduction, respectively. There ware no significant differences among treatments T1 to T3 under furrow irrigation. Ion absorption, especially Na and Cl, under furrow system was insignificant.

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