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Original Research Article

Effects of Irrigation Water Salinity and *Kochia indica* Density on Sorghum and *K. indica* Dry Matter and Chemical Composition

Gholamhassan Ranjbar[1], Hossein Ghadiri[1*] and Ali Reza Sepaskhah[2]
[1] Department of Crop Production and Plant Breeding, College of Agriculture, Shiraz University, Shiraz 71441-65186, IRAN
[2] Department of Water Engineering, College of Agriculture, Shiraz University, Shiraz, 71441-65186, IRAN

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ABSTRACT

Under saline conditions weeds can reduce crop productivity by competing for essential resources. A field experiments were carried out to determine the effect of *Kochia indica* density and irrigation water salinity on sorghum and *K. indica* dry matter and chemical composition in 2012 and 2013. Treatments were irrigation water salinity levels (2, 6, 10 and 14 dS m^{-1}) and different *K. indica* densities: 0.0, 2.5, 3.3 and 5.0 plants m^{-2}. Results showed that sorghum shoot dry matter (SDM) markedly reduced with increasing the electrical conductivity of soil saturation extract (EC_e). Salt tolerance threshold value for sorghum SDM was obtained at EC_e 4.1 dS m^{-1}. Each unit increase in salinity levels above this point reduced SDM by 10.5%. Shoot dry matter of *K. indica* (KDM) was not affected by the irrigation water salinity levels. Sorghum shoot dry matter was significantly reduced as *K. indica* density increased. Concentrations of nitrogen, potassium, phosphorous, calcium, sodium and chloride of *K. indica* leaf were significantly higher than those observed in sorghum. It was concluded that *K. indica* could be a troublesome weed even in high salinity conditions, where sorghum competitiveness would be reduced.

Key Words: Competition, mineral concentration, salt tolerance threshold

Abbreviations: SDM: Sorghum shoot dry matter, KDM: *Kochia indica* dry matter, EC_e: Electrical conductivity of soil saturation extract, EC_{iw}: Irrigation water salinity, EC_{50}: Electrical conductivity that reduced dry matter by 50%.

INTRODUCTION

Salinity is a major factor limiting crop production in the world. It is estimated that about 20% of irrigated land is salt affected (Munns and Tester 2008). Similar to non-saline conditions, weeds can reduce crop productivity by competing for essential resources in saline conditions. Therefore, relative salt tolerance of the weed and crop can affect their relative competitiveness in saline conditions.

Despite its importance, little information is known about the competitiveness between weed and crop under saline water stress. Kim et al. (2004) studied the competitiveness of *Oryza sativa* L. cv. Nipponbare and *Echinochloa oryzicola* Vasing and *Setaria viridis* (L.) Beauv., under salt stress. They found that relative growth rate (RGR) significantly decreased in *O. sativa* more than in *E. oryzicola* and *S. viridis*. Comparatively, salt-tolerant *S. viridis* and *E. oryzicola* showed higher growth rate and lower Na accumulation in leaves as compared to the salt-sensitive *O. sativa*. Lee *et al.* (2004) studied shoot growth responses to salinity in 28 *Paspalum vaginatum* Swartz ecotypes and four hybrids of *Cynodon dactylon* (L.) × *C. transvalensis* Burtt-Davy under saline solution/sand culture in a greenhouse. Results indicated that there is substantial genetic based variation in salt tolerance within species. Marlis and Ungar (1990) indicated that salinity reduced seed germination and height of *Echinochloa crus-galli* (L) Beauv., with no seeds germinating at 2% NaCl. In fact, salt tolerant species have the ability to minimize the detrimental effects of salt by producing a series of anatomical, morphological, and physiological adaptations, such as an extensive root system and salt secreting glands on the leaf surface (Sinha *et al.* 1986).

Sorghum is a C_4 crop well adapted to semi-arid and arid regions (Koca *et al.* 2007) where salinity is the major problem. Although the crop tolerates salt moderately, salinity severely limits plant growth and productivity (Maas *et al.* 1986). On the other hand, the presence of competitor weed such as *Kochia* sp. can alter the production of the crop under saline conditions.

[*] Corresponding author: ghadiri@shirazu.ac.ir

Kochia indica wight was first introduced to Yazd region of Iran from Dubai around 2000 as a fodder crop during a collaboration program between Iran government and International Centre for Biosaline Agriculture (ICBA). Contrary to initial objectives, it has infested good portions of the central Iranian plateau, threatening summer crops as well as orchards. The success of this species is attributed to its fast growth (Singh and Yadava 1974) and its ability to remove proportionately higher amounts of nutrient than the accompanying crops (Mahmood 1997). *Kochia indica*, a relatively salt tolerant plant (Mahmood *et al.* 1996) is a superior competitor under varied soil conditions (Mahmood 1997). There is little information about the adverse effects of the plant on the crop productions. The objective of this study was to determine the effect of irrigation water salinity and *K. indica* densities on sorghum and *K. indica* dry matter and leaf concentrations of N, P, K, Na^+, Cl^- and Ca^{2+} in Yazd province (arid and semi-arid conditions).

MATERIALS AND METHODS

Experimental site and weather description

Field experiment were conducted during 2012 and 2013 at the Sadough Salinity Research Farm, National Salinity Research Centre, Yazd, Iran (32° 03′ 22′′ N, 54° 14′ 02′′ E, 1134 m above the mean sea level). The mean maximum and minimum temperatures of the growing seasons (May to October) were 35.1 and 20.5 °C for 2012 and 36.7 and 22.4 °C for 2013, respectively. The soil was well-drained sandy loam. Composite soil samples from the 0.6 m depth were collected and analyzed (Table 1). Chemical properties of the saline water used in the experiment are also shown in Table 2.

Table 1. Chemical analysis of the soil at the research field.

Trait	Unit	0-0.3 m	0.3-0.6 m	Trait	Unit	0-0.3 m	0.3-0.6 m
ECe*	dS m^{-1}	15.2	9.75	SAR†	-	22.0	19.2
pH	-	7.43	7.54	P	µg g^{-1}	15.1	9.62
Na^+	meq L^{-1}	108	0.60	K	µg g^{-1}	134	121
Mg^{2+}	meq L^{-1}	26.8	71.4	Zn	µg g^{-1}	1.49	0.87
Ca^{2+}	meq L^{-1}	21.6	14.0	Mn	µg g^{-1}	0.71	6.17
Cl^-	meq L^{-1}	136	13.6	Fe	µg g^{-1}	4.71	4.42
HCO_3^-	meq L^{-1}	3.00	82.5	O.C. ‡	%	0.35	0.31
SO_4^{2-}	meq L^{-1}	18.7	2.75	Total N	%	0.031	0.034

*Electrical conductivity of soil saturation extract, †Sodium adsorption ratio, ‡Organic carbon.

Table 2. Chemical properties of the used saline water.

Irrigation water salinity (dS m^{-1})	pH	Cations and anions in water sample (meq L^{-1})							
		CO_3^{2-}	HCO_3^-	Cl^-	SO_4^{2-}	Ca^{2+}	Mg^{2+}	Na^+	K^+
2	8.25	0.50	1.69	15	7.4	3.95	7.75	12.8	0.17
6	7.73	-	2.95	51	15.6	6.10	17.3	45.8	0.34
10	7.61	-	3.00	90	26.0	8.70	27.6	82.2	0.47
14	7.73	-	3.50	131	35.9	11.4	38.5	119.1	0.69

Experimental design and treatments

The experiments were designed as split-plots arranged as Randomized Complete Blocks with three replicates. Treatments were irrigation water salinity levels: 2, 6, 10 and 14 dS m^{-1} and different *K. indica* densities: 0.0 (weed free), 2.5, 3.3 and 5.0 plants m^{-2}. Sorghum (cv. Sepideh) seeds were planted on 6th and 17th June 2012 and 2013, respectively in plots having 6 rows × 7 m long with 0.5 m interrow spacing and 0.2 m interplant spacing within rows. Seeds of *K. indica* were planted by hand in the sorghum rows. After emergence, *K. indica* plants were thinned to the desired densities. Plants were irrigated with non-saline water (2 dS m^{-1}) until 20 days after sowing. Then irrigation water salinity treatments were imposed.

Field procedure

To assure adequate N fertility throughout the growing seasons, urea (46% N) was added at sowing, 30 and 60 days after planting at 180 kg N ha^{-1} based on the soil analysis. Different salinities of irrigation water were obtained by mixing appropriate proportions of two well waters (2 and 14 dS m^{-1}). During the growing season, all plots were irrigated at the same time based on the crop water requirement. Before each irrigation event, soil samples were taken to determine their gravimetric water contents (θ_m). Depth of net irrigation water (d_n) was calculated as follows:

$$d_n = \frac{(\theta_{FC} - (\theta_m \times \rho_b)) \times R_d}{100} \qquad (1)$$

where θ_{Fc} is the volumetric soil water content (%) at field capacity, ρ_b is the averaged bulk density in the soil profile in root depth, and R_d is the root depth varies during the growing season and was calculated as follows (Borg and Grimes 1986):

$$R_d = R_{d\max}[0.5 + 0.5\sin(3.03\frac{D_{ag}}{D_{tm}} - 1.47)] \qquad (2)$$

where R_{dmax} is the maximum root depth, D_{ag} is the days after germination, D_{tm} is the days from germination to maximum effective depth and the sine function is in radians. To consider depth of seed planting (*Pd*), equation 2 was changed to:

$$R_d = P_d + R_{d\max}[0.5 + 0.5\sin(3.03\frac{D_{ag}}{D_{tm}} - 1.47)] \qquad (3)$$

The application efficiency of all irrigation events was assumed as 70% (or 30% deep percolation). Therefore, the volume of water application for each main plot was calculated as follow for a determinate plot area as follows:

$$V_g = \frac{d_n}{0.70} \times 10000 \times P_a \qquad (4)$$

Where, *Vg* is the volume of water application for each main plot, and P_a is the determinant plot area. To determine electrical conductivity of soil saturation extract (ECe), a soil core per each main plot was taken to a depth of 0.9 m (0-0.3, 0.3-0.6 and 0.6-0.9 m increments) at planting, 30, 60 and 90 days after planting.

Plant sampling

Samples from sorghum flag leaf and *K. indica* youngest leaf were harvested on 10 and 19 August 2012 and 2013, respectively. The samples were washed, oven dried at 80° C for 48 h, ground and analyzed for Na^+, Cl^-, Ca^{2+}, N, P and K concentrations. For determine sorghum dry matter, two meter square of each sub-plot was destructively harvested by cutting plants at ground level. Three *K. indica* plants were selected randomly from each plot to determine average plant dry matter. Plants were oven dried at 80°C for 48 h and weighed.

Statistical analysis

Data were tested for homogeneity of variance prior to statistical analysis. Analyses were conducted separately for each year because the effects of year and year × treatments interactions were significant. Data were subjected to analysis of variance using PROC GLM in SAS software ($P<0.05$). Comparisons between chemical composition of sorghum and *K. indica* leaves were performed using a t-test.

To calculate sorghum response to salinity, 2-yr combined sorghum relative dry matter was plotted against both electrical conductivity of soil saturation extract and irrigation water salinity as presented by Maas and Hoffman (1977), using PROC NLIN method in SAS software. Relative values of sorghum dry matter (SDM) corresponding to the irrigation water salinity of 2, 6, 10 and 14 dS m^{-1} were calculated as the percent of the dry matter in the lowest salinity treatment (2 dS m^{-1}).

RESULTS

Soil salinity and applied water

Average electrical conductivity of the soil saturated extract (EC_e) for different irrigation water salinity treatments over the growing seasons was shown in Figure 1. Overall, the highest values of soil EC_e for the irrigation water treatments of salinity levels were observed in 0.3-0.6 m soil depth in both years, the only exceptions were EC_e for 2 dS m^{-1} at 0.6-0.9 m and for the irrigation water salinity of 14 dS m^{-1} at 0-0.3 m soil depth in 2013. Since soil water content is usually increased as salinity of the irrigation water increased, total amounts of water applied in salinity treatments were lower than that in non-saline conditions. This resulted in salt accumulation in the top layer of the soil in irrigation water salinity of 10 and 14 dS m^{-1}, therefore, EC_e of the these treatments at 0-0.3 m soil depth was increased. The total water applied at 2, 6, 10 and 14 dS m^{-1} salinity treatments were 8973, 7200, 6506 and 6460 m^3 ha^{-1} in 2012 and 8511, 7737, 6571 and 5689 m^3 ha^{-1} in 2013, respectively. Furthermore, the EC_e of the irrigation water salinity of 10 and 14 dS m^{-1} was higher in 2013 than 2012 due to gradual salt accumulation in soil in consecutive years.

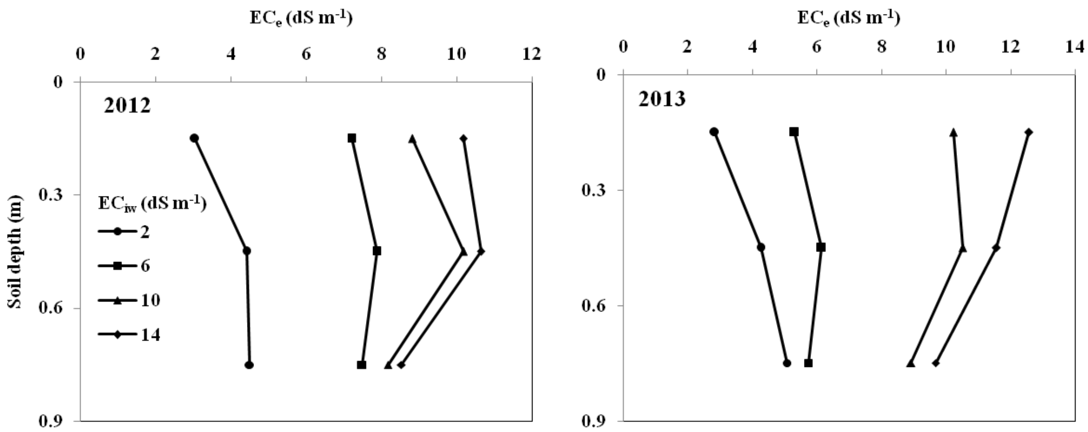

Figure 1. Average electrical conductivity of soil saturation extract (EC_e) as affected by the irrigation water salinity treatments in 2012 and 2013.

Plant dry matter

There was a rapid decline in sorghum relative dry matter with increasing soil and irrigation water salinity (Figure 2). Sorghum shoot dry matter (SDM) was highest at EC_e of 4.1 and 1.7 dS m^{-1} for soil and irrigation water salinity, respectively. Each unit increase in soil and irrigation water salinity above these points reduced SDM by 10.5% and 6.0 percent, respectively. Based on the equations of Figure 2a and b, EC_{50} (EC that reduced dry matter by 50%) for SDM corresponds to EC_e of 8.8 dS m^{-1} and EC_{iw} of 10.0 dS m^{-1}.

Effect of irrigation water salinity and *K. indica* density in both years and interaction of the factors in 2013 on the SDM were significant (Table 3). Means comparison in 2013 showed that in 2 and 6 dS m^{-1} irrigation water salinity levels, SDM decreased as *K. indica* density increased; however, the amounts of SDM in *K. indica* at density of 3.3 and 5 plants m^{-2} treatments were not significantly different (Table 4). In the higher irrigation water salinity levels (i.e. 10 and 14 dS m^{-1}), there were no significant differences among SDM in the presence of different *K. indica* densities. In all salinity levels, the highest SDM was observed in weed free treatment.

Contrary to the SDM, *K. indica* dry matter (KDM) was not affected by salinity levels in both years (Table 5). However, KDM was affected by *K. indica* density in 2013. *Kochia indica* at the densities of 3.3 and 5.0 plants m^{-2} reduced KDM by 5% and 10% compared to 2.5 plants m^{-2}, respectively. Mean values of KDM in 2013 related to *Kochia indica* densities of 2.5, 3.3 and 5.0 plants m^{-2} were 700, 664 and 631 g $plant^{-1}$, respectively.

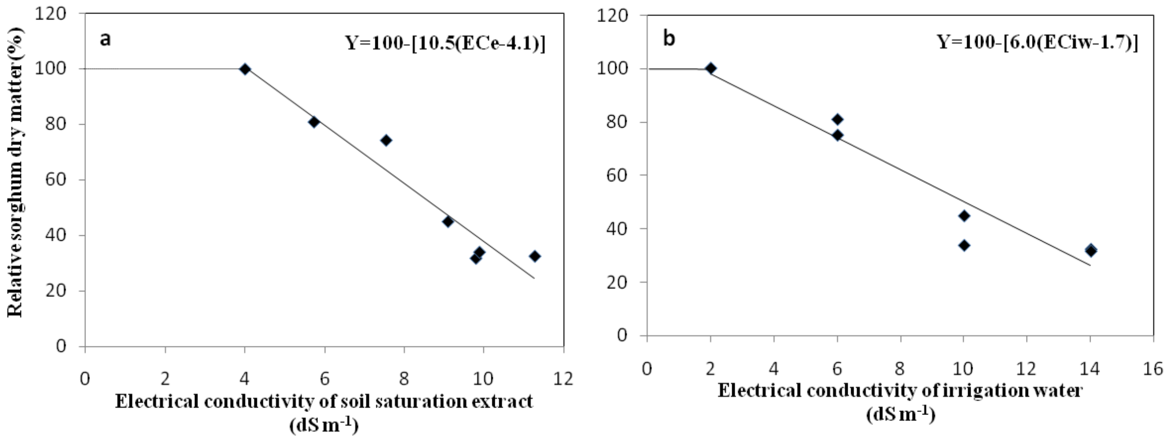

Figure 2. Sorghum relative dry matter reduction percent of two years (combined) related to a) electrical conductivity of soil extract (EC_e) and b) irrigation water salinity (EC_{iw}), Y axis values are the percent of dry matter at each salinity treatment compared to the lowest salinity treatment (2 dS m^{-1}).

Table 3. Mean squares for the effect of irrigation water salinity and *Kochia indica* densities on dry matter and leaf chemical composition of sorghum.

S.O.V.	df	Dry matter	N	P	K	Na^+	Cl^-	Ca^{2+}
				2012				
Block (R)	2	$1.57^{ns\dagger}$	10.2^{ns}	0.39^{ns}	3.56^{ns}	0.02^{ns}	5.35^{ns}	0.31^{ns}
Salinity (S)	3	11700^{**}	13.6^{ns}	0.39^{ns}	183^{**}	0.04^{ns}	32.9^{**}	3.74^{**}
S×R	6	90.9^{ns}	4.81^{*}	0.09^{ns}	10.3^{ns}	0.05^{*}	2.73^{*}	0.10^{ns}
Density (D)	3	1614^{**}	1.16^{ns}	0.14^{ns}	18.4^{ns}	0.01^{ns}	1.13^{ns}	0.14^{ns}
S×D	9	184^{ns}	1.62^{ns}	0.09^{ns}	9.25^{ns}	0.01^{ns}	0.40^{ns}	0.33^{ns}
Error	24	114	1.83	0.09	11.1	0.017	1.06	0.285
				2013				
Block (R)	2	321^{ns}	16.8^{ns}	0.15^{*}	4.88^{ns}	0.06^{ns}	0.62^{ns}	0.03^{ns}
Salinity (S)	3	18386^{**}	20.1^{ns}	0.13^{*}	70.8^{**}	0.14^{ns}	161^{**}	2.37^{*}
S×R	6	203^{*}	19.7^{ns}	0.02^{ns}	1.55^{ns}	0.04^{ns}	0.98^{ns}	0.42^{ns}
Density (D)	3	3415^{**}	3.14^{ns}	5.01^{**}	5.89^{ns}	0.05^{ns}	0.55^{ns}	0.32^{ns}
S×D	9	289^{**}	4.05^{ns}	0.11^{ns}	4.22^{ns}	0.03^{ns}	1.67^{ns}	0.24^{ns}
Error	24	77.4	8.63	0.09	4.87	0.055	2.64	0.365

†ns, *and **are non significant and significant at the 5% and 1% levels of probability, respectively.

Table 4. Interaction between irrigation water salinity and *Kochia indica* density on sorghum dry matter (g $plant^{-1}$) in 2013.

Irrigation water salinity (dS m^{-1})	*K. indica* density (plant m^{-2}) 0	2.5	3.3	5
2	144.29a†	122.04b	94.82c	95.56c
6	110.15a	85.81b	60.82c	50.78c
10	45.32a	34.77ab	29.38b	28.40b
14	44.48a	33.72ab	26.72b	22.05b

†Means followed by the same letter within each row were not significantly different (LSD, 0.05).

Leaf N, P and K concentration

Irrigation water salinity and *K. indica* density had no significant effect on either sorghum or *K. indica* leaf nitrogen (N) concentration in both years (Tables 3 and 5); however, *Kochia indica* density caused a small but significant increase in leaf N concentration of *K. indica* in 2012 (Table 5), increasing it from 42.9 g kg^{-1} leaf dry matter at 2.5 plants m^{-2} to 45.1 g kg^{-1} at 5 plants m^{-2}. Nitrogen concentration of *K. indica* leaves was significantly higher than that of sorghum leaves (Table 6), being almost double that of sorghum at all salinity levels in both years.

Effect of irrigation water salinity on leaf phosphorous (P) concentration of sorghum was significant in 2013 (Table 3), as P concentration of sorghum at 2 dS m^{-1} was significantly lower than the other salinity levels (Table 6). There was no significant effect of irrigation water salinity on P concentration of *K. indica* in both years (Table 5). Phosphorous concentration of sorghum and *K. indica* leaf was also affected by *K. indica* density in 2013 (Table 3) and 2012 (Table 5), respectively. Leaf P concentration of *K. indica* was marginally higher (8-39%) than that of sorghum in both years (Table 6).

Potassium (K) concentration of sorghum leaf was affected by the irrigation water salinity in both years (Table 3) such that leaf K concentration of sorghum at 14 dS m^{-1} was 71% higher than that obtained for 2 dS m^{-1} (Table 6). Potassium concentration of *K. indica* leaf was not affected by irrigation water salinity in both years (Table 5). *Kochia indica* density had no effect on leaf K concentration of sorghum (Table 3); however, it significantly reduced K concentration of *K. indica* in 2013 (Table 5). Potassium concentration of *K. indica* leaf was significantly higher than that of sorghum at all salinities (Table 6).

Table 5. Mean squares for the effect of irrigation water salinity and *Kochia indica* densities on dry matter and leaf chemical composition of *K. indica.*

S.O.V.	df	Dry matter	N	P	K	Na^+	Cl^-	Ca^{2+}
				2012				
Block (R)	2	35754 ^{ns†}	43.9 *	1.47 *	5.54 ^{ns}	0.22 ^{ns}	58.7 ^{ns}	1.08^{ns}
Salinity (S)	3	69766 ^{ns}	2.43 ^{ns}	0.48 ^{ns}	2.24 ^{ns}	0.85 ^{ns}	61.8 ^{ns}	0.76^{ns}
S×R	6	23575*	8.09 ^{ns}	0.15 ^{ns}	25.8**	26.1 ^{ns}	14.9 ^{ns}	0.70*
Density (D)	2	24390 ^{ns}	18.3*	0.71*	14.7 ^{ns}	46.1 ^{ns}	21.0 ^{ns}	0.80*
S×D	6	15363 ^{ns}	7.74 ^{ns}	0.18 ^{ns}	2.68^{ns}	5.96 ^{ns}	12.2 ^{ns}	0.89**
Error	16	8059	3.98	0.15	4.42	20.21	8.2	0.199
				2013				
Block (R)	2	15750 *	0.96 ^{ns}	0.07 ^{ns}	10.6 ^{ns}	50.0 ^{ns}	15.7 ^{ns}	4.38 ^{ns}
Salinity (S)	3	9510 ^{ns}	11.9 ^{ns}	0.13 ^{ns}	43.9 ^{ns}	138.4 ^{ns}	60.6 ^{ns}	10.04 ^{ns}
S×R	6	2987 ^{ns}	39.9 ^{ns}	0.05 ^{ns}	30.3 ^{ns}	147.1*	30.1 ^{ns}	9.42 ^{ns}
Density (D)	2	13909*	39.2 ^{ns}	0.05 ^{ns}	82.5**	65.9 ^{ns}	2.90 ^{ns}	1.59 ^{ns}
S×D	6	1919 ^{ns}	21.3 ^{ns}	0.06 ^{ns}	11.9 ^{ns}	17.3 ^{ns}	4.21 ^{ns}	2.88 ^{ns}
Error	16	2363	22.4	0.03	11.9	52.4	40.7	15.94

†ns, *and **are non significant and significant at the 5% and 1% levels of probability, respectively.

Table 6. Effect of irrigation water salinity on N, P and K concentration (g kg^{-1}) of sorghum and *Kochia indica* leaf

	N		P		K	
Irrigation water salinity (dS m^{-1})			**2012**			
	Sorghum	*K. indica*	Sorghum	*K. indica*	Sorghum	*K. indica*
2	22.7†	43.9‡	5.23	5.95	8.39	27.2
6	24.9	44.8	5.03	5.45	9.1	28.0
10	24.8	44.8	5.25	5.86	11.3	28.4
14	24.6	43.9	5.47	5.90	17.0	27.9
SE*	**0.7507**	**1.0940**	**0.1018**	**0.1479**	**1.0959**	**0.9554**
			2013			
2	24.8	39.8	2.04	2.76	10.7	27.9
6	25.1	39.2	2.08	2.91	13.3	31.2
10	24.4	40.7	2.26	3.04	16.3	30.5
14	22.1	38.0	2.35	2.83	15.0	33.3
SE	**1.5191**	**2.4303**	**0.0477**	**0.0886**	**0.4260**	**2.1177**

*Standard error, †Data are the main effect of irrigation water salinity treatment, ‡Means of *K. indica* at each salinity level is significantly greater than that of sorghum (t-test, P<0.05 for P means and P<0.01 for N and K).

Leaf Na^+, Cl^- and Ca^{2+} content

Effects of irrigation water salinity and *K. indica* density treatments on the leaf Na^+ concentration of sorghum (Table 3) and *K. indica* (Table 5) were not significant in both years. Leaf Na^+ concentration of *K. indica* was significantly higher than that of sorghum (Table 7). Averaged over two years, leaf Na^+ concentrations of *K. indica* were nearly 100 fold greater than that of sorghum (Table 7).

As irrigation water salinity increased leaf Cl^- concentration of sorghum was significantly increased in both years (Tables 3 and 7). *Kochia indica* density had no significant effect on Cl^- concentration of either sorghum or *K. indica* (Tables 3 and 5), and changes in salinity also failed to change chloride concentration in *K. indica*. Leaf Cl^- concentrations of *K. indica* were nearly twice as high as those recorded in sorghum (Table 7).

Irrigation water salinity affected leaf calcium (Ca^{2+}) concentration of sorghum in both years (Tables 3 and 7) but had no effect on *K. indica* (Table 6 & 7). *Kochia indica* density had no significant effect on leaf Ca^{2+} concentration of sorghum (Table 3). Leaf Ca^{2+} concentration of *K. indica* was again significantly higher than that of sorghum (Table 7).

Table 7. Effect of irrigation water salinity on mineral concentration (g kg^{-1}) of sorghum and *Kochia indica* leaf

	Na^+		Cl^-		Ca^{2+}	
Irrigation water salinity (dS m^{-1}**)**	**2012**					
	Sorghum	*K. indica*	Sorghum	*K. indica*	Sorghum	*K. indica*
2	0.44[†]	33.3[‡]	6.03	13.7	3.68	9.43
6	0.46	34.0	6.94	16.8	3.44	9.62
10	0.44	33.0	9.57	19.2	4.36	9.34
14	0.57	32.1	8.92	19.3	3.03	8.93
SE[*]	**0.0773**	**1.9991**	**0.5653**	**1.4852**	**0.1095**	**0.3215**
	2013					
2	0.53	60.2	5.80	21.0	3.35	10.9
6	0.55	56. 8	7.39	21.4	2.91	11.8
10	0.75	61.8	9.67	24.4	3.48	9.39
14	0.68	66.2	14.2	26.4	3.99	9.95
SE	**0.0649**	**4.6662**	**0.3387**	**2.1090**	**0.2222**	**1.1809**

[*]Standard error, [†]Data are the main effect of irrigation water salinity treatment, [‡]Means of *K. indica* at each salinity level is significantly greater than that of sorghum (t-test, P<0.01).

DISCUSSION

Results of the present study showed that salinity markedly reduced sorghum dry matter (SDM). The mean EC_{50} (EC_e that reduced dry matter by 50%), for SDM corresponds to an EC_e of 8.8 dS m^{-1}, was in agreement with Francois *et al.* (1984), who found an EC_e 9.3 dS m^{-1} for sorghum. This value is much less than the 11.0 dS m^{-1} derived from data presented by Maas (1985). However, this value was higher than the 5.0 dS m^{-1} reported by Igartua *et al.* (1995). In the present study, sorghum was moderately tolerant to salinity as earlier reported by Francois et al. (1984) and Maas (1985). However, the crop has been classified as being moderately sensitive to salinity by Igartua *et al.* (1995), though these authors used inbred lines in their experiments which were less vigorous than the hybrid used in the present study.

Kochia indica densities decreased SDM in all salinity levels; however, as irrigation water salinity increased, there were no significant differences among SDM in the presence of *K. indica* (Table 4). It seems that up to 6 dS m^{-1}, SDM was affected by both irrigation water salinity and *K. indica* density, however, in irrigation water salinity of 10 and 14 dS m^{-1}, SDM was affected more by salinity than *K. indica* densities. There was no significant difference among SDM in the present of *K. indica*.

Our study showed that *K. indica* leaf concentrations of N, P and K were higher than sorghum. Although nutrients clearly promote crop growth, many studies have shown that, in some cases, fertilizers benefit weeds more than crops (eg. Blackshaw and Brandt 2009). The increase in weed competition when it obtained higher nutrients than crop has been suggested to be related to an increase in the efficiency of nutrient accumulation and use by weeds, as well as, seedling survival rate and fecundity (Malicki and Berbeciowa 1986). The movement of the nutrients in the soil could also affect weed crop competition. Movement of phosphorus and potassium is slow compared with nitrogen. Competition for phosphorus and potassium is, therefore most likely to occur after plants are mature and have extensive, overlapping root development. It seems that differences between the two plants in response to N, P and K nutrients may be due to the rapid growth and development of *K. indica* (Singh and Yadava 1974) that obtain nutrient from different soil profiles and promotes weed growth over sorghum; thus it might be expected to become stronger competitors when fertilizers are applied at various growth stage of the crop. Study results demonstrate that this was indeed the case with *K. indica*. Mahmood (1997) also indicated that *K. indica* in mixed culture with *Leptochloa fusca* (kallar grass) obtained proportionately higher amounts of nutrients under varying levels of soil moisture and salinity.

The data from the present study confirmed that *K. indica* as a weed absorbs more minerals than sorghum. A similar study conducted by Malicki and Berbeciowa (1986) on wheat, barley, sugarbeet, and rapeseed showed that the mineral concentration of most weeds was higher than that of wheat or barley. In most plants, Na^+ and Cl^- are effectively excluded by roots while water is taken up from the soil. Halophytes, the natural flora of highly saline soils, are able to maintain this exclusion at higher salinities than glycophytes (Munns and Tester 2008). It seems that *K. indica*, a relatively salt tolerant plant (Mahmood *et al.* 1996), use soil minerals as an osmotic compounds to balance the concentration of the external medium (Munns and Tester 2008), enabling the plant to maintain high growth rates under various soil conditions. This capability makes the plant to be a superior competitor in the neighboring of the crop (Mahmood 1997). Results indicated that when salinity exists in the media, *K. indica* would be better able to compete for resources as compared to sorghum. The information could be used to advise crop producers for weed management and the importance of *K. indica* control under saline conditions.

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