Utilization of Water Resources and Sustainable Crop Production

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While a shortage of water to sustain crop production systems is a major issue in many areas, irrigation with the leaching fraction is another issue for sustainable production. The use of deficit irrigation not only reduces water use but also enhances its use efficiency (Jensen et al., 2010). According to Ochoa et al. (2012) an increase in leaching fraction is associated with a significant decrease in salinity symptoms

The objective of this study was to compare some agronomic and physiological parameters of sunflowers irrigated using different amounts of water with various salinity levels. The study was carried out with sunflower plants in PVC soil columns with a diameter of 40 cm and length of 115 cm (Figure 1). Deficit irrigation (75% of the required water) and irrigation with leaching fraction (115% and 135% of the required water) and 5 salinity levels were used in 3 replications. The irrigation water salinities were 0.25 dS m^{-1} as a control treatment, 1.5 and 3.0 dS m^{-1} prepared from NaCl+$CaCl_2$ salts, and 1.5 and 3.0 dS m^{-1} prepared from NaCl+$CaSO_4$ salts as saline treatments. Soil water contents were determined with TDR probes installed at depths of 15, 45 and 75 cm in the columns.

Proline, superoxide dismutase (SOD), ascorbate peroxidase (APX), glutathione reductase (GR) and lipid peroxidase enzyme activity in sunflower were analyzed to evaluate the salt stress. Proline is produced particularly under abiotic stress conditions including salt stress. The SOD enzyme is an anti-oxidant enzyme produced in plant tissues under stress conditions to neutralize reactive oxygen species. The APX and GR enzymes detoxify peroxides, such as hydrogen peroxide, using ascorbate as a substrate. Lipid peroxidation is the oxidative degradation of lipids in cell membranes. Decreasing lipid peroxidase enzyme results in increasing malondialdehyde concentration, and finally cell damage.

Figure 1. Lysimeters.

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Deficit irrigation with saline water caused reductions in plant height, 1000 seed weight and yield, yet increased husk/in shell ratio considerably (Table 1). No difference was detected for the parameters investigated between the leaching fraction applications (115% and 135%) of both saline water types. The effect of saline water on plant agronomic and physiological properties in the leaching fraction applications was limited. The negative effect of the high electrical conductivity (EC) on soil salinization was overcome partially by irrigation with leaching fractions for sustainable production on these soils.

Deficit irrigation with salinized water supports crop production at some level yet caused soil profile salinization. On the other hand, irrigation with the leaching fraction supports sustainable crop production and food security when available water exists.

Table 1. Mean growth results for sunflowers with different irrigation water types and rates.

Treatments	Applied water* (%)	Plant height (cm)	Head diameters (cm)	1000 seed weight (g)	Husk/in-shell ratio	Seed yield (kg/ha)
Tap water (control)	75	158.7 a**	15.0 a	6.26 a	39.3 a	3015 b
	115	159.0 a	17.0 a	7.53 a	32.9 b	4385 a
	135	160.7 a	17.2 a	6.72 a	37.2 a	4380 a
1.5 dS/m EC $NaCl+CaCl_2$	75	113.7 b	13.8 b	6.83 a	63.3 a	2424 b
	115	167.0 a	17.5 a	7.76 a	30.1 b	4489 a
	135	167.0 a	16.8 a	7.53 a	30.6 b	4276 a
3.0 dS/m EC $NaCl+CaCl_2$	75	142.0 b	16.5 a	5.52 b	49.5 a	3532 b
	115	163.0 a	16.5 a	7.42 a	31.3 b	4310 a
	135	163.7 a	16.5 a	6.79 a	36.4 b	4138 a
1.5 dS/m EC $NaCl +CaSO_4$	75	158.0 a	15.8 a	6.51 a	66.1 a	3732 b
	115	162.3 a	16.2 a	7.48 a	31.3 b	4162 a
	135	164.0 a	17.0 a	7.53 a	31.1 b	4039 a
3.0 dS/m EC $NaCl+CaSO_4$	75	117.0 b	14.5 a	5.18 b	74.5 a	2635 b
	115	109.0 b	14.2 a	6.76 a	32.3 b	2445 b
	135	162.0 a	16.8 a	7.27 a	36.6 b	4402 a

*Percentage of the required water. **Means in same column followed by same lower case letter are not significantly different ($P<0.01$).

Plants responded to water scarcity and salt-induced oxidative stress with enzymatic defense systems. All the enzyme activities investigated showed similar trends. Enzyme activities were higher in the deficit irrigation treatments (75%) for all of the salinity levels than in the leaching with the leaching fraction treatments. As the amount of water and salinity level increased, the enzyme activities decreased concordantly. Chlorine salts in the irrigation water increased the enzyme activities in plants more than did the sulphate salts (Figure 2).

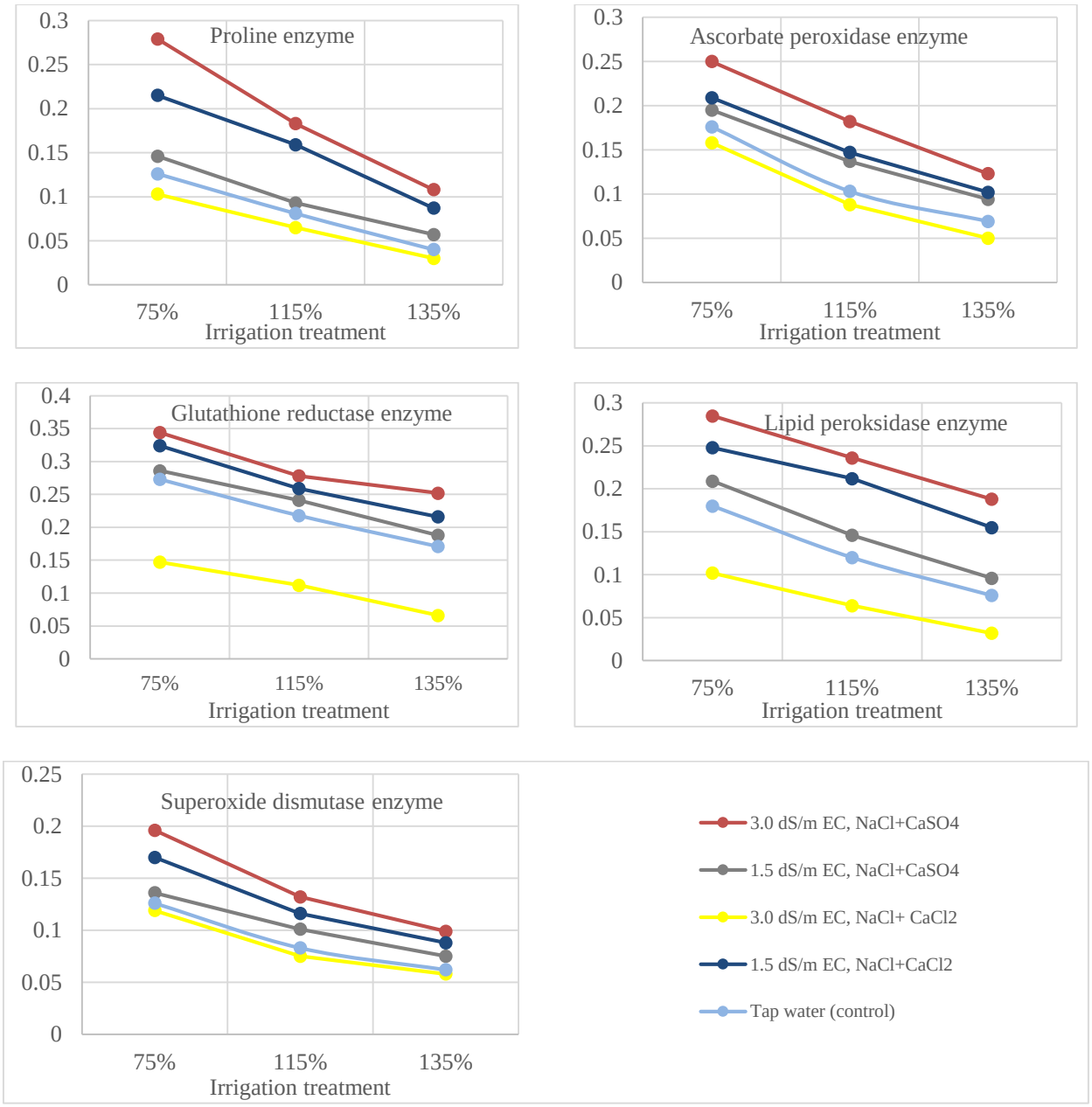

Figure 2. Enzyme activities under various irrigation regimes and salinity levels.

References

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