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Biochemical and physiological response of quinoa to application of different levels of nitrogen and salinity of irrigation water

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Extended abstract

Introduction

In order to investigate the effects of nitrogen application and irrigation of sugarcane fields on grain yield and physiological and biochemical characteristics of quinoa (Gizavan cultivar) including relative leaf water content, chlorophyll index, catalase enzyme activity, superoxide dismutase, proline concentration and Field experimental grain yield in the cropping year 2018 was performed in the form of split plots in a randomized complete block design with three replications. The results showed that the maximum amount of chlorophyll index and grain yield were obtained in the application of 150 kg N ha^{-1} with one irrigation with sugar-cane. Application of 150 and 225 kg N ha^{-1} under salinity stress caused a significant increase in the activity of catalase and superoxide dismutase enzymes.

Materials and method

In this experiment, four levels of nitrogen fertilizer (0, 75, 150, 225 kg ha^{-1}) from urea fertilizer source as the main factor and three levels of irrigation water including control (Karun water with salinity of 2.5 dS m^{-1}) and irrigation One in between (Karun-sugarcane drainage) and irrigation with sugarcane drainage (with salinity of 7.5 dS m^{-1}) was considered as a sub-factor.Seed sowing was done on November 6, 2018 in the form of barley and stack (on the grout line) and by hand. Each plot consisted of 6 planting lines 4 m long. The distance between the two plants was 7-10 cm and the distance between the lines was 50 cm. Irrigation treatments were applied in three to five leaf stage (seedling establishment stage). Before irrigation, soil moisture samples were taken and irrigation was done to reach the moisture content of the field capacity. For drainage irrigation, saline water of Mirza Kuchak Khan agro-industrial drains of Khorramshahr with salinity between 6 to 8 dS m^{-1} was used. Plastic cover was used during rain. The final harvest was made in late February at the time of physiological maturation.At the flowering stage, samples of the leaves were prepared and immediately transferred to the laboratory for physiological and biochemical measurements.

Results and discussion

The results of analysis of variance showed that the effects of nitrogen and salinity levels and their interaction at the level of one percent probability on the measured properties of quinoa were significant.The highest average relative leaf water in Karun irrigation and nitrogen fertilizer treatment was 225 kg ha^{-1} (89.16%) and the lowest average of the mentioned trait was observed in drainage and

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nitrogen fertilizer treatment of 0 kg ha^{-1} (70.76%).In the present study, salinity stress decreased the relative water content of the leaves by affecting water absorption because the relative water percentage of plant tissue is one of the most important components of plant water status. Quinoa has been shown to have the ability to accumulate salt ions in its tissues to control and regulate leaf water potential, and this reaction has enabled plants to maintain cell turbulence and limited transpiration under saline conditions, thus preventing physiological damage to quinoa under stress.due to the accumulation of more than 70% nitrogen in the chloroplast of plant leaves, the increase in nitrogen in the plant was accompanied by an increase in the concentration of chlorophyll and leaf nitrogen. Salinity stress due to irrigation with drainage and high accumulation of sodium in the plant has reduced the chlorophyll index and photosynthesis rate of quinoa and finally possibly the accumulation of oxygen free radicals in the plant has increased the activity of catalase enzyme with urea fertilizer catalase activity in all Salinity levels of irrigation treatments have increased due to the presence of nitrogen in the structure of the enzyme. The mechanism of the effect of salinity on the response of antioxidant enzymes is not yet fully understood.

Conclusions

In general, the results of this study indicate that changes in nitrogen levels more than irrigation levels had an effect on chlorophyll index, relative leaf water content and quinoa grain yield and the average salinity had a significant effect on increasing grain yield. Higher amounts of nitrogen increased but also led to a significant increase in grain yield. Nitrogen has improved the destructive effects of salinity stress in quinoa and increased enzyme activity in high salinity has increased plant tolerance. Due to high genetic diversity and adaptation to different climates, high nutritional value and high efficiency of resource use, quinoa can be a suitable plant for using unconventional water and soil resources of Khuzestan province.

***Keywords*:** Catalase, Chlorophyll, Proline, Superoxide dismutase

Table 1. Some physical and chemical properties of the soil

Depth	Soil Texture	pH	EC	Available Phosphorus	Cl*	K*	Na*	Ca^{2+} + Mg^{2+}*	Total Nitrogen	SAR
cm			dS m^{-1}	mg kg^{-1}	----------------mg L^{-1}------------------				%	
0-25	Cl	7.98	5.05	14.45	918	17.5	667	1025	0.038	7.23
25-50	Cl	8	2.55	14.15	569	6.24	305	334	0.024	5.81
50-75	S C L	8.01	2	13.81	438	5.46	266	304	0.022	5.33

Table 2. Properties of the water used for the study

Source of water	EC	pH	SAR	Cl^-	Ca^{2+}	Mg^{2+}	Na^+	NO_3 NO_2
	dS m^{-1}			---------------------meq L^{-1}----------------------				mg L^{-1}
Karun	2.41	7.79	9.03	16.70	3.6	3.26	16.72	3.23
Sugar-cane rainaged	7.56	7.99	9.92	40.46	16.87	16.40	40.40	4.87

Table 3. Analysis of variance (mean squares) Effects of nitrogen and salinity levels on some properties of quinoa

S.O.V	df	chlorophyll content	RWC	CAT Activity	SOD Activity	Proline	Grain yield	Biological yield
Replication	2	158.97	2.23	128.33	0.39	0.002	8624	3716
Salinity (S)	2	82.87**	558.18**	1789.48**	78.49**	0.74**	209587**	2036845**
Error 1	4	9.16	0.3	36.97	0.17	0.005	3610.01	14747
Nitrogen(N)	3	114.53**	78.48**	1331.14**	12.62**	0.0041**	6200663**	20856454**
S × N	6	19.93**	0.43**	86.93**	1.003**	0.00066*	22727**	548998**
Error 2	17	57.85	80	499.91	11.90	0.09	1128776	4121785
CV (%)		4.01	0.4	3.79	0.308	1.61	5.76	5.65

ns and **:* Non-significant and significant at 1%,5% probability level, respectively

Table 4. Comparison of the average simple effects of nitrogen and salinity levels on some properties of quinoa

		RWC	chlorophyll content	CAT Activity	SOD Activity	Proline	Grain yield	Biological yield
		%		---U mg^{-1} protein---		mg.g^{-1} FW	--------kg ha^{-1}-----------	
N kg.ha^{-1}	**0**	33.22^{c}	78.68^{c}	43.82^{d}	3.35^{c}	0.59^{c}	540.78^{d}	3407^{c}
	75	37.05^{b}	83.85^{b}	48.62^{c}	4.55^{b}	0.59^{b}	1367^{c}	5782^{b}
	150	40.97^{a}	84.76^{a}	65.87^{b}	5.86^{a}	0.6^{b}	2330^{a}	6465^{a}
	225	40.38^{a}	84.93^{a}	68.03^{a}	5.78^{a}	0.64^{a}	2198^{b}	6766^{a}
	LSD0.05	1.50	0.33	2.12	0.3	0.009	91.88	284.7
Salinity	**Karun**	39.57^{a}	78.25^{a}	42.78^{b}	1.94^{b}	0.43^{b}	1618^{b}	5873^{a}
	Karun and Sugar-cane	39.27^{a}	86.73^{a}	61.12^{a}	6.51^{a}	0.49^{b}	1736^{a}	5812^{a}
	Sugar-cane drainage	34.87^{b}	75.19^{b}	65.88^{a}	6.21^{a}	0.89^{a}	1472^{c}	5131^{b}
	LSD0.05	3.43	0.62	6.89	0.47	0.08	86.10	246.6

Means followed by similar letters are not significantly different at 0.05 probability level

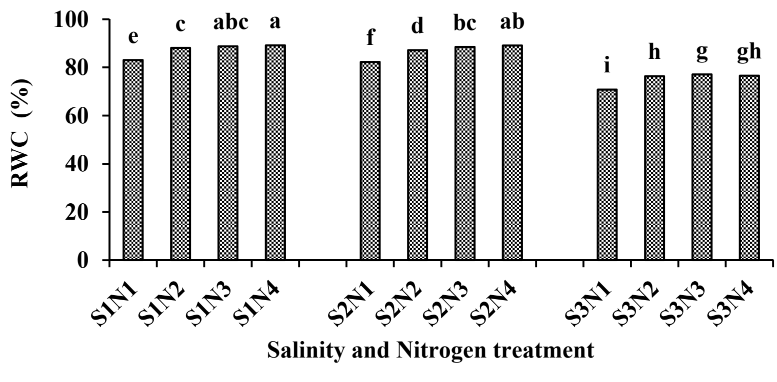

Fig. 1. The effect of nitrogen levels and salinity on quinoa Relative water content. Nitrogen treatments: N 1-4 (0 (control), 75, 150, 225 kg ha^{-1}). Salinity treatments: S1-3 (Karun water irrigation, intermediate (once Karun and once sugarcane drainage) and sugarcane drainage irrigation)

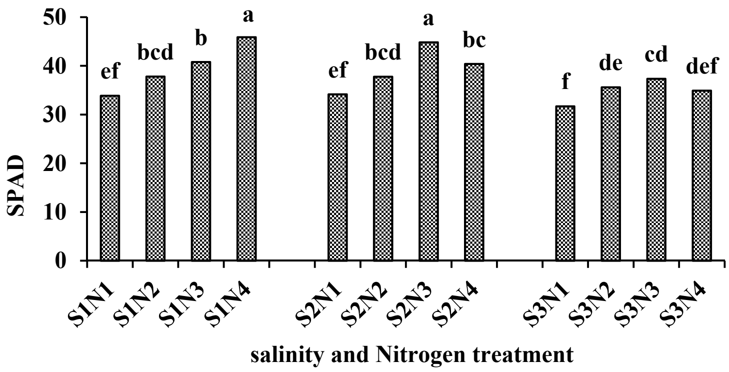

Fig. 2. The effect of nitrogen levels and salinity on quinoa chlorophyll conten. Nitrogen treatments: N 1-4 (0 (control), 75, 150, 225 kg ha^{-1}). Salinity treatments: S1-3 (Karun water irrigation, intermediate (once Karun and once sugarcane drainage) and sugarcane drainage irrigation

Table 5. Interaction effect of Salinity and Nitrogen on some parameters of quinoa plant

Salinity	Nitrogen	CAT Activity	SOD Activity	Proline
		---------------------------U.mg^{-1} protein------------------------		
Karun	0	30.03^{g}	1.20^{e}	0.42^{f}
	75	37.93^{f}	1.90^{d}	0.43^{ef}
	150	47.30^{e}	2.26^{d}	0.43^{f}
	225	54.43^{d}	2.4d^{0}	0.45^{def}
Karun and Sugar-cane	0	39.56^{f}	4.613^{c}	0.48^{c-f}
	75	51.70^{ed}	5.94^{b}	0.48^{cde}
	150	74.0^{bc}	7.86^{a}	0.49^{cd}
	225	70.23^{c}	7.63^{a}	0.51^{c}
Sugar-cane drainage	0	47.20^{e}	4.25^{c}	0.87^{b}
	75	56.23^{d}	5.82^{b}	0.87^{b}
	150	78.0^{ab}	7.44^{a}	0.89^{b}
	225	81.10^{a}	7.32^{a}	0.95^{a}
$LSD_{0.05}$		4.63	0.56	0.053

Means with similar letters in each column indicate no significant difference in the probability level of 0.05 based on LSD test

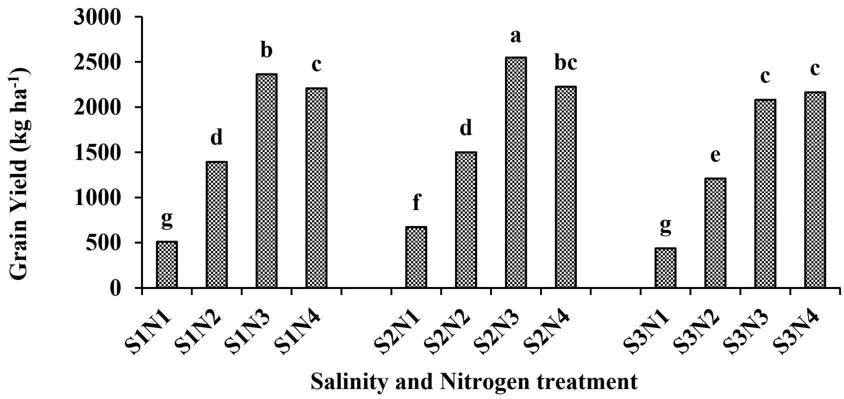

Fig. 3. The effect of nitrogen levels and salinity on quinoa grain yield. Nitrogen treatments: N 1-4 (0 (control), 75, 150, 225 kg ha^{-1}). Salinity treatments: S1-3 (Karun water irrigation, intermediate (once Karun and once sugarcane drainage) and sugarcane drainage irrigation)

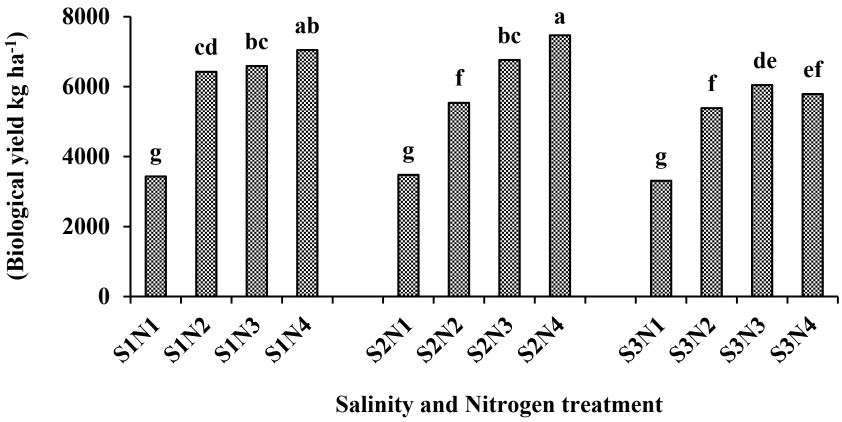

Fig. 4. The effect of nitrogen levels and salinity on the biological yield of quinoa. Nitrogen treatments: N 1-4 (0 (control), 75, 150, 225 kg ha^{-1}). Salinity treatments: S1-3 (Karun water irrigation, intermediate (once Karun and once sugarcane drainage) and sugarcane drainage irrigation)