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Original article

Investigation of irrigation by sugarcane drainage water on soil quality specifications and yield of 20 genotypes of wheat in south of Khuzestan

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Extended abstract

Introduction

According to the growing human need for food production, using of unconventional water is defined as one of the strategies for overcoming the water crisis in the world. Drainage water recirculation for producing economic sustainable agricultural products can be very useful to management of drainage water environmental impact and adapt with water crisis in the world. For this purpose, overcoming on salinity stresses and preservation of soil quality during cultivation are so important. Studying on salinity effect of irrigation water on wheat yield and soil salts has a long history in the world but genotype and climatic conditions are very influential on the results, so do this research can be very useful. This research has been conducted to determination the best genotype of wheat and analysis of soil behavior in the study of solutes in it.

Materials and methods

This research was conducted in 2018-2019 in an experimental farm of AmirKabir Agro-Industry Sugarcane Company using split plot design with randomized complete block with three replications, yield reaction of 20 genotypes of wheat to irrigation with sugarcane drainage water farms was investigated. Also applied water volume, farm water requirement and drainage water effect on soil salts were analyzed. Main plots was irrigation water quality with two quality: 1- fresh water with EC=1.3 dS m^{-1} and 2- sugarcane drainage water with EC=7.0 dS m^{-1}. Sub plots were 20 genotypes of bread and durum wheat which is cultivated in 8 lines and 20 cm distance. Water requirement was determined by 10-years climate data and wheat crop coefficient and calculated using FAO Penman-Monteith method. Field irrigation management was performed based on water requirement information and considering soil physics, leaching requirements and effective rainfall. Extracted information included volume of applied water, salt and moisture soil samples, water and drainage water quality samples, physical soil specifications, grain yield, biological yield, spike per square meter, grain per spike, 1000-grain weight and flowering date.

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Results and discussion

Results showed that using sugarcane drainage water reduced the mean yield by 9.7% and decreased irrigation water productivity from 1.08 to 0.97 kg m^{-3}. There is no significant difference between Bow, Shoele, Narin, Bloudan, Sarang, Irna, Spn and Pishtaz varities for using Karun River and drainage water in terms of grain yield, biological yield, spike per square meter, grain per spike, 1000-grain weight and flowering date, so it can be concluded that these genotypes are stable in different environmental conditions. Stress tolerance index varied from 0.57 to 1.22 among different genotypes. 1-63-31 and Narin genotypes had the highest and the lowest tolerance indices, respectively. Bam and Shoele genotypes were in the mean group with 0.92 and 0.89, respectively. Overall, Sistan, 1-63-31, Bow, Shoele, Sirvan, Sarang, Irna, Khalil, Barat, and Pishtaz with an index above the mean index (0.90) are among the most tolerant and it can be concluded that they can be considered as the most tolerant figures. Also Barat genotype had maximum applied water and total water productivity with fresh water irrigation which were 1.35 and 1.14 kg m^{-3} and Sistan had maximum water productivity for drainage water in these parameters which were 1.16 and 0.98 kg m^{-3}. Soil results showed that using agricultural drainage water for irrigation not only led to changing farm soil from non-saline to saline condition, it closes to become sodic. Under drainage water cultivation conditions, soil quality will be compromised, which will require new development of irrigation management, leaching and cropping patterns. In these conditions, accurate knowledge of the time and amount of water required for wheat, irrigation with high efficiency and application of appropriate amount of leaching water with proper field drainage, can be effective.

Conclusions

This research was conducted to reaction investigation of various genotypes of wheat in condition of using sugarcane drainage water. Due to the fact that in the middle of autumn and late winter, the drainage of sugarcane fields is low and in this period, most of wheat water requirement is supplied by rainfall and the most important irrigation events start after winter in Khuzestan, so wheat had been chosen for this research. Results showed that yield decrease in drainage water farm for 20 studied genotypes was about 9.8% which is varies between 30.6% for ChamranII to 8.6% for Sistan genotypes. Applying drainage water as irrigation water can cause negative effects on farm soil quality in short term and studying of this behavior by using simulating models can be very useful. For reduction of negative effect of drainage water on soil quality, it is necessary to pay enough attention to the amount and time of irrigation at the last 2 or 3 irrigation events.

Keywords: Sugarcane drainage water, Water productivity, Water requirement, Wheat, Yield.

Table 1. Farm soil specifications

Soil Texture	Depth	Porosity	Bulk density	F.C	P.W.P
	cm	%	gr cm^{-3}	%-Volumetric	
Clay	0–25	54	1.53	36.3	22.0
Loam-Clay	25–50	55	1.67	41.0	18.4
Loam-Clay	50–75	52	1.77	39.6	18.4
Clay	75–100	52	1.87	34.8	18.4

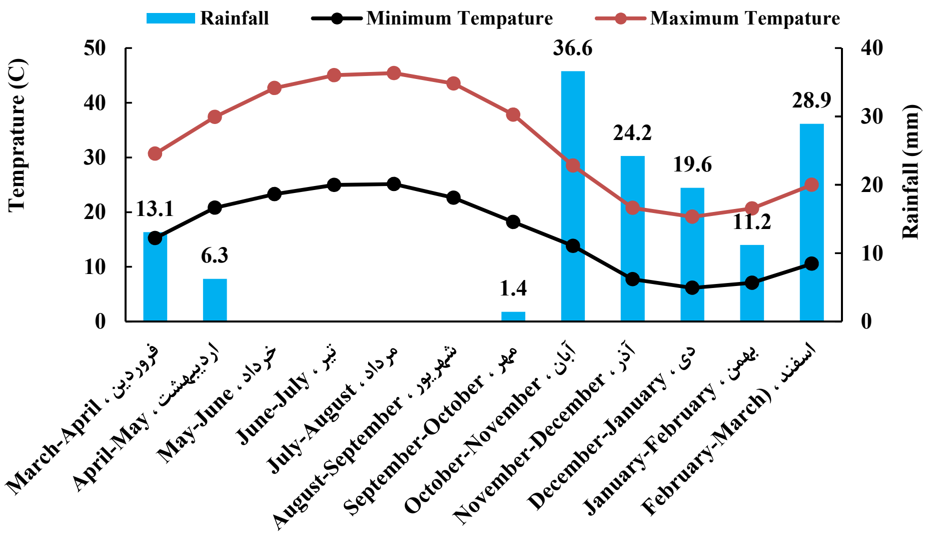

Fig. 1. Average of Climate data of studied area

Table 2. Average of water and drainage water specifications

Water Quality	SAR_{adj}	SAR	SO_4^{2-}	HCO_3^{1-}	Cl^-	Mg^{2+}	Ca^{2+}	Na^+	TDS	pH	EC	Water Quality Class
	-- (meq $L^{-1})^{0.5}$ --		------------------- meq L^{-1} -------------------						mg L^{-1}		dS m^{-1}	
Karun water	5.6	8.3	4.3	0.4	1.5	2.1	2.4	1.4	1115	7.6	1.7	C3-S2
Sugarcane drainage water	8.3	7.9	20.4	1.7	2.6	13.9	14.3	2.8	4695	7.9	7.0	C4-S3

Table 3. Explanation coefficient and coefficient of variation statistics and analysis of variance of grain yield, biological yield, spike per square meter, grain per spike, 1000-grain weight and flowering date of different wheat genotypes

S.O.V	df	Flowering date	1000-grain weight	Grain per spike	Spike per square meter	Biological yield	Grain yield
Block	2	9.4 ns	1.0 ns	98.4 ns	8677.8 ns	9955819 ns	204642 ns
Water quality (A)	1	0.000 ns	3.0 ns	53.3 ns	89216.5 *	5689807 ns	8269800***
Ea	2	0.000	7.8	30.6	3420.0	2306947	56493
Genotype (B)	19	166.7 ***	100.2 ***	105.8 ***	16743.9 ***	15212973***	2429315***
Interaction (A*B)	19	0.000 ns	13.0 ns	52.1 ***	6534.9 ***	5252855 *	397710*
Eb	76	3.8	8.9	17.6	2137.1	2913013	212586
CV(%)	-	*2.1*	*7.7*	*11.6*	*12.9*	*12.7*	*9.5*
R^2	-	*0.92*	*0.76*	*0.71*	*0.77*	*0.65*	*0.79*

Crossing Interaction: Irrigation water levels for each genotypes

Water Quality	df	Mean squared error					
Karun Water	19	-	-	82.6***	14632.0 ***	9740671***	1641017***
Sugarcane Drainage Water	19	-	-	75.2***	8646.5 ***	10725159***	1186009***

***, *, ns: are significance at the probability level of 0.1%, 5% and non-significance, respectively.

Table 4. Comparison between grain yield, biological yield, spike per square meter and grain per spike of different wheat genotypes

	Grain per spike				Spike per square meter			
Genotype	**Pr > |t|**	**Difference**	**Saline Water**	**Karun Water**	**Pr > |t|**	**Difference**	**Saline Water**	**Karun Water**
Sistan	0.0003	-13.0	47.3	34.3	0.247	44.3	363.3	407.7
1-63-31	0.251	-4.0	40.3	36.3	0.012	97.3	363.3	460.7
Bow	0.443	-2.7	41.3	38.7	0.074	69.0	358.7	427.7
Bam	0.009	-9.3	45.7	36.3	0.000	144.3	302.0	446.3
Shoele	0.292	-3.7	35.3	31.7	0.072	69.3	285.7	355.0
Narin	0.127	5.3	28.7	34.0	0.917	4.0	266.0	270.0
Bloudan	0.127	5.3	36.0	41.3	0.669	-16.3	307.0	290.7
Shabrang	0.023	8.0	38.3	46.3	0.365	-34.7	272.3	237.7
Tirgan	0.058	-6.7	30.7	24.0	<.0001	160.3	312.7	473.0
Chamran 2	0.105	5.7	34.3	40.0	0.502	25.7	329.0	354.7
Dez	0.007	-9.7	32.7	23.0	<.0001	163.7	277.7	441.3
Shoush	0.152	-5.0	39.0	34.0	0.020	90.3	351.7	442.0
Sirvan	0.292	3.7	32.3	36.0	0.284	-41.0	413.7	372.7
Sarang	0.058	6.7	28.0	34.7	0.269	-42.3	431.3	389.0
Irna	0.443	-2.7	36.7	34.0	0.143	56.3	370.3	426.7
Mehrgan	0.251	-4.0	37.0	33.0	0.002	121.0	285.7	406.7
Khalil	0.848	-0.7	38.0	37.3	0.034	82.0	357.3	439.3
Spn	0.631	-1.7	38.3	36.7	0.237	45.3	231.0	276.3
Barat	1.000	0.0	39.7	39.7	0.035	81.7	364.7	446.3
Pishtaz	0.631	1.7	34.0	35.7	0.438	-29.7	400.7	371.0

Table 4. Continued

	Biological yield Kg/ha				**Grain yield** Kg/ha			
Genotype	**Pr > |t|**	**Difference**	**Saline Water**	**Karun Water**	***Pr > |t|**	**Difference**	**Saline Water**	**Karun Water**
Sistan	0.034	-2992	14469	11477	0.351	-350	5508.3	5158.3
1-63-31	0.757	432	16669	17101	0.168	519	5391.7	5910.7
Bow	0.389	-1205	14531	13325	0.180	504	5081.3	5585.3
Bam	0.670	594	13831	14425	0.123	582	4616.7	5198.3
Shoele	0.766	-415	14070	13655	0.934	31	4825.3	4856.3
Narin	0.072	-2536	12787	10251	0.236	446	3638.0	4083.7
Bloudan	0.724	-493	12499	12006	0.806	-92	4044.0	3952.3
Shabrang	0.010	-3675	14299	10624	0.118	590	4025.0	4614.7
Tirgan	0.098	2329	10964	13293	0.612	190	4098.0	4287.7
Chamran 2	0.097	2336	10788	13124	<.0001	1687	3827.3	5514.7
Dez	0.402	1170	11558	12728	0.380	329	3756.3	4085.3
Shoush	0.689	-558	14424	13867	0.299	390	4498.0	4887.7
Sirvan	0.732	-478	13991	13513	0.050	744	5216.7	5960.7
Sarang	0.179	-1887	14940	13053	0.077	669	5031.7	5700.3
Irna	0.072	-2538	16298	13759	0.011	973	5079.3	6052.3
Mehrgan	0.975	43	13094	13138	0.002	1186	4135.3	5321.0
Khalil	0.487	-970	16241	15271	0.279	406	5254.3	5660.7
Spn	0.464	-1023	10802	9779	0.251	431	3756.3	4187.7
Barat	0.009	3731	11334	15065	0.000	1458	4958.3	6416.7
Pishtaz	0.680	-575	15889	15314	0.609	-192	5200.0	5008.3

* If Pr > |t| is greater than 0.05, the assumption of equality of the mean of the two treatments is rejected and there are no statistically significant differences.

Table 5. Applied water of farm and crop water requirement

Water Qualiy	10-years climate data water requirement	Net water requirement of cultivation season	Effective rainfall	Applied water volume	Salinity
	--m³ ha⁻¹--				dS m⁻¹
Karun	6120	4960	870	4760	1.7
Sugarcane drainage water	6120	4960	870	4760	7.0

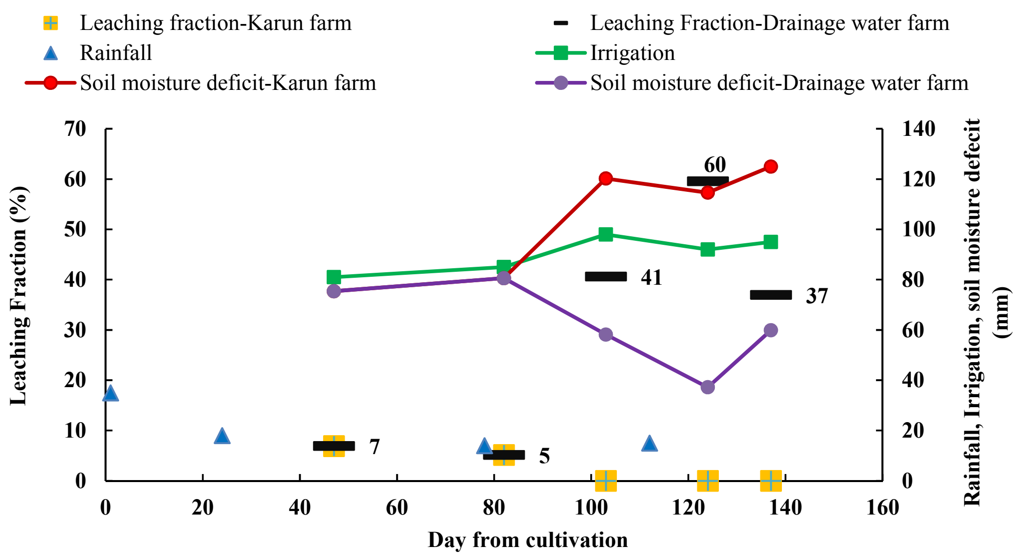

Fig. 2. Variation of rainfall, irrigation, moisture deficit and leaching fraction

Table 6. Salt balance Values

Water Qualiy	Salt: Leached	Residual	Entering	Initial	Deficit or excess Water	Water requirement	Applied water+Effective rainfall
		ton ha⁻¹			%	----------------m³ ha⁻¹----------------	
Karun	2.1	13.7	4.0	11.8	13.5	4960	5630
Sugarcane drainage water	1.1	37.4	26.7	11.8	13.5	4960	5630

Table 7. Soil quality variations

Water Qualiy	Parameter	After cultivation	Before cultivation
Karun	EC_e	4.1	3.4
	ESP	5.8	4.4
	Soil type	Saline-Non sodic	Non-saline and non-sodic
Sugarcane Drainage Water	EC_e	7.6	3.4
	ESP	8.9	4.4
	Soil type	Saline-Non sodic	Non-saline and non-sodic