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Original article

Effect of different salinity levels on germination indices of 20 new quinoa genotypes

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Extended abstract

Introduction

Iran's climate change to hot and dry, and the gradual salinization of arable soils on the one hand, and the good tolerance of the quinoa to drought, salinity and frost on the other hand, makes the use of quinoa as a suitable plant reasonable. This study was carried out with the aim of investigating 20 new cultivars of quinoa in vitro and also evaluating salinity tolerant cultivars for introduction and development in field preliminary experiments.

Materials and methods

In order to obtain tolerant cultivars of quinoa to salinity for field experiment conditions, as well as to study the effect of different salinity levels on seed germination indices of quinoa, a factorial experiment with four replications in a randomized complete block design with four replications in 2017 The Khuzestan Agricultural and Natural Resources Research Center was designed and implemented. Treatments included a combination of four salinity levels of zero, low, medium and high (0, 100, 200 and 300 mM NaCl, respectively) and 20 quinoa cultivars.

Results

Results showed that different salinity values had a significant effect on germination percentage, germination rate index, germination rate coefficient, mean germination time and seedling vigor index of different cultivars ($P < 0.001$). At zero salinity levels: Santamaria, Titicaca, Red carina, Q12, Q22, Q31, Q102 and 882051, at low and medium salinity levels: Santamaria, Titicaca, Red carina, Q12, Q22, Q31, Q101, Q102 and 882051, and at high levels: Santamaria, Titicaca, Q102, Q12 and 882051 showed superiority in all germination indices. In general, Santamaria, Titicaca, Q102, Q12, Q31, and 882051 cultivars were in the medium to strong group at different salinity levels. This indicates the stability of germination components of these cultivars under different environmental conditions. Therefore, this group of cultivars can be considered as promising cultivars for field experiments.

Conclusions

The results showed that the salinity stress affected the measured indices in this experiment and reduced these indices. Also, among the cultivars studied, Santamaria, Titicaca, Q102, Q12, Q31 and 882051 showed a good response among all the traits tested. And in response to salinity stress, they showed the

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lowest decrease among most of the traits, indicating the ability of these cultivars to withstand adverse salinity conditions and the ability to be introduced in early field trials.

***Keywords*:** Average germination time, Germination percentage, Germination rate coefficient, Germination rate index, Seedling vigor index

Table 1. **Analysis of variance of Kinova germination indices**

S.O.V	df	MS					
		GP	**GRI**	**CVG**	**MGT**	**SVI**	**SL**
No salinity							
Block	3	40.03^{ns}	65.10^{ns}	1505.92^{**}	0.13^{**}	2.60^{*}	1.99^{ns}
Genotype	19	1022.17^{**}	2330.97^{**}	904.85^{**}	0.09^{**}	16.25^{**}	7.22^{**}
Error	7	27.47	29.76	186.83	0.02	0.89	0.8
CV (%)	-	*8*	*7.6*	*5*	*11.9*	*15.8*	*11.8*
R^2	-	*0.92*	*0.96*	*0.65*	*0.64*	*0.86*	*0.76*
Low salinity							
Block	3	88.64^{ns}	81.71^{ns}	742.46^{**}	0.08^{**}	2.70^{*}	4.14^{**}
Genotype	19	803.23^{**}	2276.05^{**}	1452.59^{**}	0.17^{**}	15.64^{**}	13.83^{**}
Error	57	36.4	55.65	124.99	0.02	0.66	0.82
CV (%)	-	*9.4*	*10.6*	*4.3*	*10.5*	*15.7*	*13.6*
R^2	-	*0.88*	*0.93*	*0.81*	*0.79*	*0.89*	*0.85*
Medium salinity							
Block	3	42.94^{ns}	82.10^{ns}	446.90^{ns}	0.09^{ns}	0.25^{ns}	0.006^{ns}
Genotype	19	816.97^{**}	2518.89^{**}	1322.89^{**}	0.18^{**}	12.23^{**}	8.42^{**}
Error	57	62.39	55.98	306.73	0.03	0.72	0.43
CV (%)	-	*12.2*	*111*	*6.6*	*14*	*17.6*	*10.7*
R^2	-	*0.81*	*0.94*	*0.65*	*0.66*	*0.85*	*0.87*
High salinity							
Block	3	33.60^{ns}	26.70^{ns}	359.17^{ns}	0.10^{ns}	0.59^{ns}	0.53^{ns}
Genotype	19	867.68^{**}	2728.54^{**}	1141.26^{**}	0.29^{**}	11.08^{**}	9.55^{**}
Error	57	58.92	54.46	234.31	0.04	0.45	0.29
CV (%)	-	*12.4*	*12.8*	*7.1*	*13.3*	*17.5*	*10.89*
R^2	-	*0.83*	*0.94*	*0.69*	*0.72*	*0.89*	*0.92*

** ,* and ^{ns} indicate significant at 0.1% probability level, 5% probability and non-significance level, respectively

Table 2. Comparison of individual averages of cultivars per salinity level

Genotype	GP (%)	GRI	CVG	MGT	SVI	SL
			No salinity			
Santamaria	78.91 ^{ab}	93.99 ^{a}	95.04 ^{ab}	1.06 ^{g}	8.43 ^{b}	8.88 ^{bcd}
Sajma	71.20 ^{c}	75.66 ^{c}	59.01 ^{ghi}	1.86 ^{bc}	7.18 $^{b-e}$	8.04 $^{c-g}$
Titicaca	78.56 ^{abc}	92.87 ^{ab}	89.27 ^{abc}	1.128 ^{fg}	6.29 $^{d-g}$	6.57 ^{hij}
Giza 1	60.42 ^{d}	70.81 ^{cd}	80.81 $^{a-f}$	1.28 $^{d-g}$	5.91 ^{efg}	7.78 $^{d-h}$
Red carina	82.53 ^{ab}	96.50 ^{a}	90.61 ^{abc}	1.12 ^{fg}	6.45 $^{d-g}$	6.55 ^{hij}
Rosada	59.21 ^{de}	61.04 ^{e}	56.48 ^{hi}	1.81 ^{bcd}	4.01 ^{i}	5.42 ^{j}
Q26	62.10 ^{d}	71.96 ^{cd}	77.28 $^{b-g}$	1.36 $^{c-g}$	7.60 ^{bcd}	9.72 ^{ab}
Q29	28.58 ^{g}	19.44 ^{g}	66.18 $^{e-h}$	1.70 $^{b-d}$	2.15 ^{k}	9.05 ^{bc}
Q101	75.20 ^{bc}	90.13 ^{ab}	87.90 $^{a-d}$	1.18 ^{g}	6.63 $^{d-g}$	7.18 $^{f-i}$
Q102	79.40 ^{ab}	95.70 ^{a}	95.75 ^{ab}	1.05 ^{g}	6.53 $^{d-g}$	6.78 ^{ghi}
Q103	58.03 ^{def}	61.41 ^{e}	67.59 $^{e-h}$	1.65 $^{b-f}$	5.76 ^{fg}	8.05 $^{c-f}$
Q104	55.40 ^{def}	59.15 ^{e}	67.87 $^{e-h}$	1.55 $^{b-g}$	4.26 ^{hi}	6.24 ^{ij}
Q105	51.09 ^{f}	39.84 ^{f}	43.21 ^{i}	2.61 ^{a}	3.70 ^{ij}	6.11 ^{ij}
Q18	33.15 ^{g}	25.32 ^{g}	62.17 $^{f-i}$	1.61 $^{b-f}$	2.59 ^{jk}	8.63 $^{b-e}$
Q12	77.65 ^{abc}	90.29 ^{ab}	80.64 $^{a-f}$	1.24 ^{efg}	8.12 ^{bc}	8.51 $^{b-e}$
Q19	52.99 ^{ef}	47.12 ^{f}	58.80 ^{ghi}	1.94 ^{b}	4.25 ^{hi}	6.67 ^{hij}
Q22	81.67 ^{ab}	92.90 ^{ab}	81.67 $^{a-e}$	1.25 ^{efg}	6.85 $^{c-f}$	7.0 $^{f-i}$
Q31	76.45 ^{abc}	85.67 ^{b}	74.27 $^{c-h}$	1.37 $^{c-g}$	10.17 ^{a}	10.84 ^{a}
Q21	60.63 ^{d}	65.80 ^{de}	69.53 $^{d-h}$	1.56 $^{b-g}$	5.41 ^{gh}	7.18 $^{f-i}$
882051	83.78 ^{a}	97.72 ^{a}	97.06 ^{a}	1.03 ^{g}	7.26 ^{bcd}	7.36 $^{e-i}$
			Low salinity			
Santamaria	80.22 ^{a}	96.97 ^{a}	100 ^{a}	1.00 ^{h}	9.55 ^{a}	9.86 ^{ab}
Sajma	67.83 ^{bc}	78.91 ^{c}	77.25 $^{c-f}$	1.16 ^{defgh}	7.66 ^{b}	8.97 ^{bc}
Titicaca	79.68 ^{a}	94.15 ^{ab}	90.89 ^{abc}	1.05 ^{gh}	7.45 ^{b}	7.75 ^{cde}
Giza 1	62.32 ^{cd}	66.24 ^{d}	66.33 ^{efg}	1.26 ^{cde}	4.76 ^{ef}	6.27 $^{f-i}$
Red carina	78.87 ^{a}	94.35 ^{ab}	90.61 ^{abc}	1.05 ^{gh}	6.97 ^{bc}	7.28 ^{def}
Rosada	54.10 $^{d-g}$	58.29 ^{de}	74.24 ^{def}	1.18 $^{c-h}$	3.31 $_{ghi}$	5.23 $^{i-l}$
Q26	60.87 ^{cde}	67.10 ^{d}	67.41 ^{efg}	1.23 $^{c-g}$	5.52 ^{de}	7.21 $^{d-g}$
Q29	40.17 ^{hi}	24.06 ^{g}	36.43 ^{i}	1.73 ^{a}	2.46 ^{i}	6.00 $^{g-j}$
Q101	72.05 ^{ab}	86.25 ^{bc}	88.41 $^{a-d}$	1.07 ^{fgh}	4.40 ^{efg}	4.89 $^{j-m}$
Q102	79.12 ^{a}	95.38 ^{ab}	95.59 ^{ab}	1.02 ^{h}	3.78 ^{fgh}	3.92 ^{m}
Q103	62.21 ^{cd}	58.80 ^{de}	47.64 ^{hi}	1.48 ^{b}	4.44 ^{efg}	5.76 $^{h-k}$
Q104	53.51 ^{efg}	55.66 ^{ef}	65.96 ^{efg}	1.25 $^{c-f}$	2.80 ^{hi}	4.33 ^{lm}
Q105	49.73 ^{fg}	33.70 ^{g}	34.74 ^{i}	1.71 ^{a}	4.64 ^{ef}	8.00 ^{cd}
Q18	35.57 ^{i}	28.6 ^{g}	56.76 ^{gh}	1.34 ^{bc}	2.35 ^{i}	6.68 $^{e-h}$
Q12	78.63 ^{a}	90.82 ^{ab}	80.14 $^{b-e}$	1.12 $^{d-h}$	4.37 ^{fg}	4.55 ^{klm}
Q19	48.08 ^{gh}	45.82 ^{f}	56.86 ^{gh}	1.35 ^{bc}	3.81 ^{fgh}	6.89 $^{d-h}$
Q22	75.97 ^{ab}	87.00 ^{abc}	77.38 $^{c-f}$	1.14 $^{d-h}$	6.21 ^{cd}	6.67 $^{e-h}$
Q31	72.69 ^{ab}	87.39 ^{abc}	87.03 $^{a-d}$	1.08 $^{e-h}$	4.61 ^{ef}	5.05 $^{i-m}$
Q21	56.75 ^{def}	58.97 ^{de}	62.09 ^{fgh}	1.28 ^{cd}	7.72 ^{b}	11.11 ^{a}
882051	79.42 ^{a}	93.62 ^{ab}	90.42 ^{abc}	1.06 ^{gh}	6.63 ^{bcd}	6.90 $^{d-h}$

Table 2. Continued

Genotype	GP (%)	GRI	CVG	MGT	SVI	SL
Medium salinity						
Santamaria	79.133 ab	97.06 a	89.59 ab	1.06 h	9.48 a	9.89 a
Sajma	69.8 bcd	67.28 d	56.47 c-h	1.35 b-g	4.85 efg	5.62 f-i
Titicaca	72.79 abc	90.98 abc	82.94 ab	1.11 gh	5.51 c-f	6.17 efg
Giza 1	63.46 cde	61.13 def	57.72 c-g	1.42 b-e	5.05 d-g	6.33 def
Red carina	79.283 ab	94.91 ab	77.81 a-d	1.17 e-h	5.29 d-g	5.50 f-j
Rosada	54.60 ef	66.24 de	69.31 b-e	1.23 d-h	2.33 k	3.38 k
Q26	62.32 cde	67.58 d	72.02 a-e	1.20 d-h	4.80 e-h	6.14 efg
Q29	34.34 h	20.36 h	48.24 e-h	1.60 ab	2.74 jk	8.6 b
Q101	71.49 a-d	84.60 bc	83.25 ab	1.11 fgh	4.19 ghi	4.69 j
Q102	81.75 a	95.50 a	88.62 ab	1.07 h	6.63 bc	6.78 de
Q103	65.03 cde	50.64 fg	41.08 gh	1.59 ab	4.27 ghi	5.38 g-j
Q104	60.86 de	58.44 def	49.22 e-h	1.44 bcd	5.94 b-e	7.82 bc
Q105	46.22 fg	24.15 h	32.67 h	1.79 a	3.09 ijk	6.08 e-h
Q18	38.42 gh	27.45 h	44.42 fgh	1.51 bc	2.60 jk	6.69 de
Q12	78.55 ab	88.30 abc	75.76 a-d	1.16 fgh	5.75 b-e	6.00 e-h
Q19	47.94 fg	43.42 g	54.33 d-h	1.37 b-f	2.71 jk	4.8675 ij
Q22	76.65 ab	88.33 abc	66.24 b-f	1.27 c-h	6.72 b	7.16 cd
Q31	70.58 a-d	80.77 c	79.18 abc	1.14 fgh	4.55 fgh	5.17 hij
Q21	60.92 de	55.78 ef	49.94 e-h	1.44 bcd	3.64 hij	4.81 ij
882051	81.70 a	96.53 a	94.8 a	1.03 h	6.05 bcd	6.17 efg
High salinity						
Santamaria	70.74 bc	87.42 abc	78.13 a	1.15 i	5.59 a	6.44 bc
Sajma	64.88 dc	46.228 i	37.19 def	1.64 bcd	5.76 a	7.04 ab
Titicaca	80.81 ab	91.75 ab	64.01 abc	1.29 e-i	4.05 def	4.17 g
Giza 1	63.21 cd	60.09 fgh	41.64 def	1.56 cde	5.77 a	7.25 a
Red carina	82.66 a	63.39 efg	38.89 def	1.61 cd	5.19 abc	5.27 de
Rosada	49.66 ef	51.25 hi	43.30 cde	1.52 cde	2.60 gh	4.51 efg
Q26	57.87 de	53.22 ghi	44.65 cde	1.53 cde	3.51 efg	4.97 def
Q29	36.16 g	7.90 k	21.40 f	2.19 a	0.72 j	1.99 i
Q101	61.45 cd	68.09 ef	48.88 b-e	1.44 d-h	3.17 fg	4.24 fg
Q102	75.94 ab	90.82 ab	73.21 a	1.20 ghi	5.34 a	5.69 cd
Q103	58.66 de	34.68 j	27.80 ef	1.91 b	4.08 def	5.64 d
Q104	55.11 de	46.00 i	43.32 cde	1.55 cde	4.52 bcd	6.78 ab
Q105	42.19 fg	11.52 k	43.53 cde	1.77 bc	1.16 ij	2.58 hi
Q18	34.50 g	25.13 j	43.24 cde	1.55 cde	1.04 j	3.14 h
Q12	76.61 ab	79.82 cd	69.10 ab	1.23 f-i	4.38 cde	4.79 efg
Q19	44.05 fg	33.94 j	48.47 b-e	1.49 def	2.11 hi	4.35 fg
Q22	76.97 ab	73.11 de	49.30 b-e	1.47 d-g	3.09 g	3.27 h
Q31	64.64 cd	81.99 bcd	74.22 a	1.17 hi	5.90 a	7.41 a
Q21	61.75 cd	57.56 gh	50.25 bcd	1.43 d-h	3.34 fg	4.33 fg
882051	77.81 ab	93.2 a	83.06 a	1.11 i	5.38 a	5.63 d

Table 3. **Correlation coefficients of the tests and measured traits**

	GP	GRI	CVG	MGT	SVI	SL
GP	1					
GRI	0.88	1				
	<.0001					
CVG	0.43	0.71	1			
	<.0001	<.0001				
MGT	-0.42	-0.70	-0.90	1		
	<.0001	<.0001	<.0001			
SVI	0.71	0.69	0.43	-0.42	1	
	<.0001	<.0001	<.0001	<.0001		
SL	0.11	0.17	0.22	-0.27	0.73	1
	0.0573	0.0018	<.0001	<.0001	<.0001	

GP: Germination Percentage, GRI: Germination Rate Index, CVG: Coefficient of Velocity of Germination, MGT: Mean Germination Time, SVI: Seedling Vigor Index, SL: Seedling Lenght