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Original article

Assessment of seed germination and morphological characteristics of three quinoa (*Chenopodiom quinoa* Willd.) cultivars under salinity stress

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Extended abstract

Introduction

Quinoa, *Chenopodiom quinoa* Willd., is an annual plant native to South America and the Andes mountains. It is a plant from the spinach and sugar beet family and despite its high nutritional value it can be cultivated well and produces a suitable crop in conditions where lands have low or limited fertility. Due to the high tolerance of quinoa to salinity stress, this plant was selected for cultivation with unconventional water sources. Given the lack of conventional water in Iran, especially in the southern regions, the use of unconventional water and the identification of tolerant plants with the ability to grow in saline conditions are important. Accordingly, due to the limitation of non-saline water, the use of sea water in coastal areas and low-yield lands can lead to agricultural prosperity in these areas.

Materials and Methods

This investigation was conducted with the aim of evaluating the effect of different concentration of the diluted sea water on germination traits and some morphological parameters of three quinoa cultivars including Red-Carina, Q26, and Q29 as factorial arrangement in completely randomized design with six replications. The used different concentrations of salinity in this study were 1.5 (control), 3, 6, 9, 12, and 15 dsm-1. To evaluate the germination traits, seeds were sown in petri dishes and then 10 ml of different salinity levels were added and petri dishes were placed at 25 °C for one week and the number of germinated seeds was recorded daily. The radicle exit was the criterion for germination. At the end of the period, germination percentage, germination rate, mean daily germination, peak value, and germination value were recorded. To investigate the effect of salinity on the morphological characteristics of quinoa, seeds were sown in the pots containing field soil at a depth of 1.5 to 2 cm. After sowing the seeds in the pots, irrigation with tap water was done until the germination stage according to the plant's water requirement. After ensuring the establishment of the plants (in the 4-leaf stage), salinity treatments were applied. Then the different traits such as the plant height, the number of lateral branches, the number of leaves, the length and width and area of the leaves, the length of inflorescence and seed weight were measured. The obtained data were analyzed using SAS 9.1 software and the means were compared using PLSD at $p<0.01$.

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Results and Discussion

Based on the results of analysis of variance, there was a significant difference between the studied cultivars ($p<0.01$) in terms of germination percentage, germination rate, mean daily germination, and germination value, but salinity had no significant effect on germination percentage. The results also showed that no significant interaction between salinity and cultivar was observed in the percentage and germination rate as well as the peak value. The results of analysis of variance showed that the effects of salinity and cultivar on different morphological properties measured at $p<0.01$ were statistically significant, but the interaction of cultivar and salinity was significant only on the leaf length, width and area. The results showed that with increasing salinity from 9 to 12 and 15 dsm-1, a non-significant decrease was observed in germination rate compared to the control. With increasing salinity up to 15 dsm-1, the plant height, number of lateral branches, number of leaves, leaf length, and leaf area decreased and the highest yield was related to Q26 cultivar. Compared to the other two cultivars, the Q26 cultivar showed less sensitivity to salinity conditions in different traits such as leaf size and number, number of lateral branches, height before and after flowering.

Conclusion

In general, it can be said that salinity did not have an adverse effect on the germination rate of quinoa seeds and in some cases accelerated germination. However, at high salinity level, it affected some vegetative traits such as leaf and branch characteristics and inflorescence length. It seems that by performing a proper management in the field, the establishment and growth of this plant at levels of salinity can be guaranteed.

***Keywords*:** Germination rate, Sea water, Seed yield, Vegetative traits

Table 1. Analysis of variance of the effects of different salinity levels and quinoa cultivars on different traits.

Traits	Means of square				CV.%
	Salinity D.F=5	Cultivar D.F=2	Salinity × Cultivar D.F=10	Error D.F=36	
Germination percentage	28.2^{ns}	350.5^{**}	13.4^{ns}	24.3	5.4
Germination rate	5.38^{*}	46.13^{**}	1.34^{ns}	1.79	6.5
Mean daily germination	21.69^{**}	39.40^{**}	7.22^{**}	0.59	8.2
Peak value	253.4^{**}	1147.0^{**}	37.6^{ns}	44.2	9.0
Germination value	175256.8^{**}	589930.6^{**}	46899.9^{**}	8226.1	12.8
Leaf number	9.60^{**}	38.13^{**}	1.56^{ns}	1.29	7.9
Leaf length	3.83^{**}	0.62^{**}	0.29^{**}	0.06	5.5
Leaf width	4.05^{**}	1.10^{**}	0.24^{**}	0.06	6.8
Leaf area	263.9^{**}	68.2^{**}	19.8^{**}	4.1	11.8
Number of lateral branches	7.56^{**}	34.45^{**}	2.08^{ns}	1.05	9.0
Plant height before flowering	99.07^{**}	52.04^{**}	2.91^{ns}	2.76	10.4
Plant height at the time of flowering	316.4^{**}	206.2^{**}	16.0^{ns}	14.7	11.9
Plant height after flowering	1485.8^{**}	1080.1^{**}	50.0^{ns}	40.7	9.4
Inflorescence length	80.78^{**}	73.60^{**}	2.98^{ns}	2.83	12.0
Seed yield per plant	44.98^{**}	14.14^{**}	2.00^{**}	0.51	14.7

^{ns}, *, ** non-significant and significant at $p<0.05$ and $p<0.01$, respectively

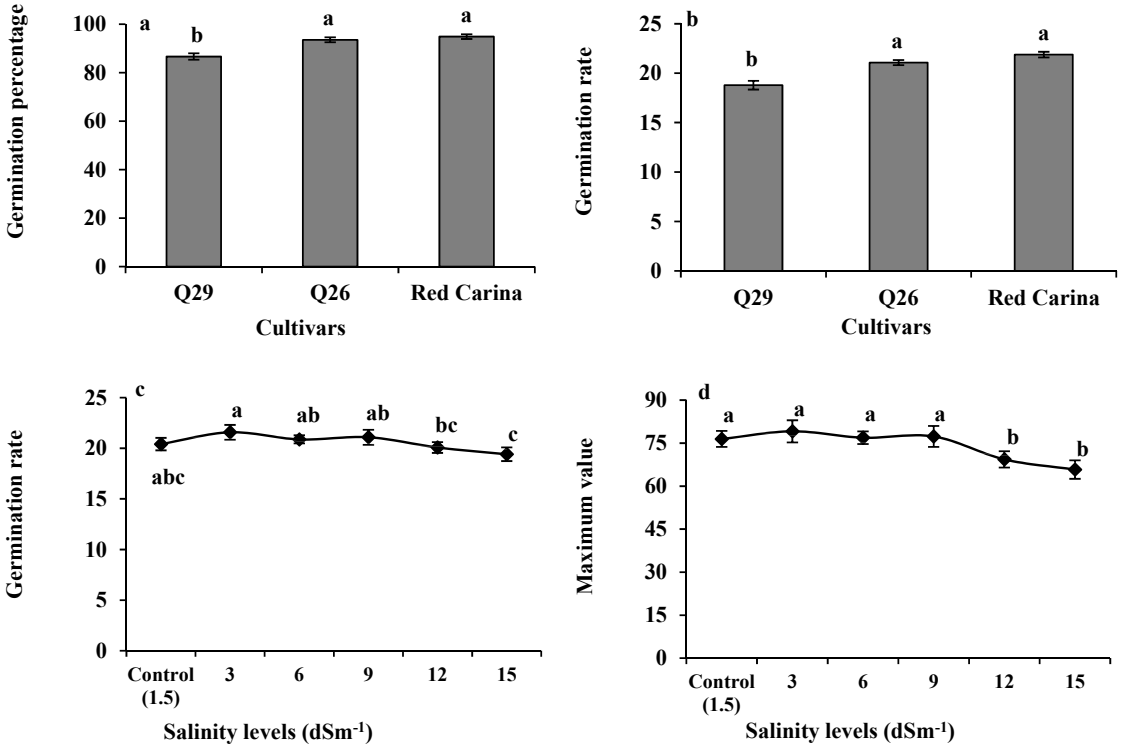


Fig. 1. Comparison of different quinoa cultivars in terms of germination percentage (a) and germination rate (b) and the effect of different salinity levels on germination rate (c) and maximum value (d).

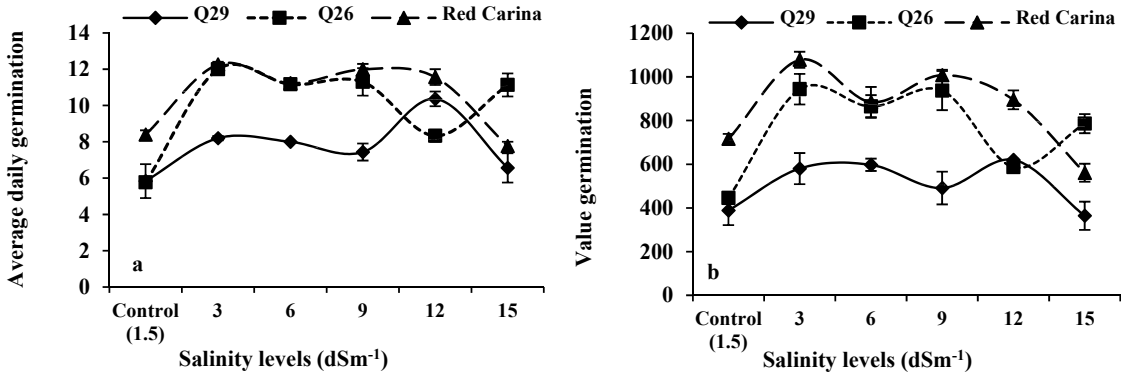


Fig. 2. Effect of interaction of different salinity levels and quinoa cultivars on average daily germination (a) and germination value (b) of quinoa seeds.

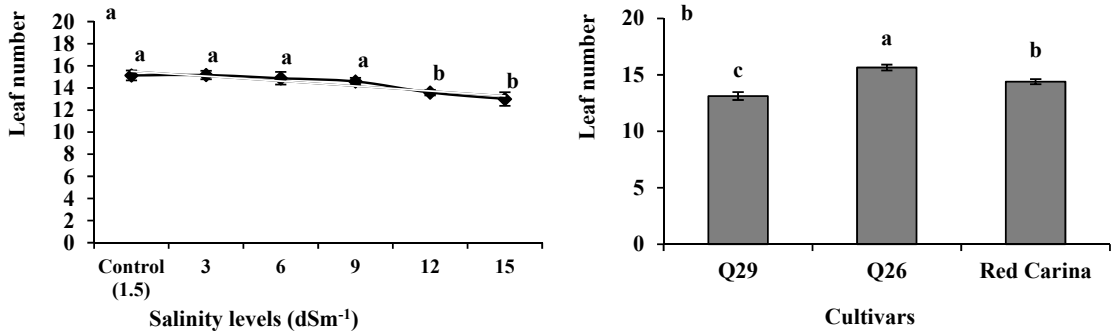
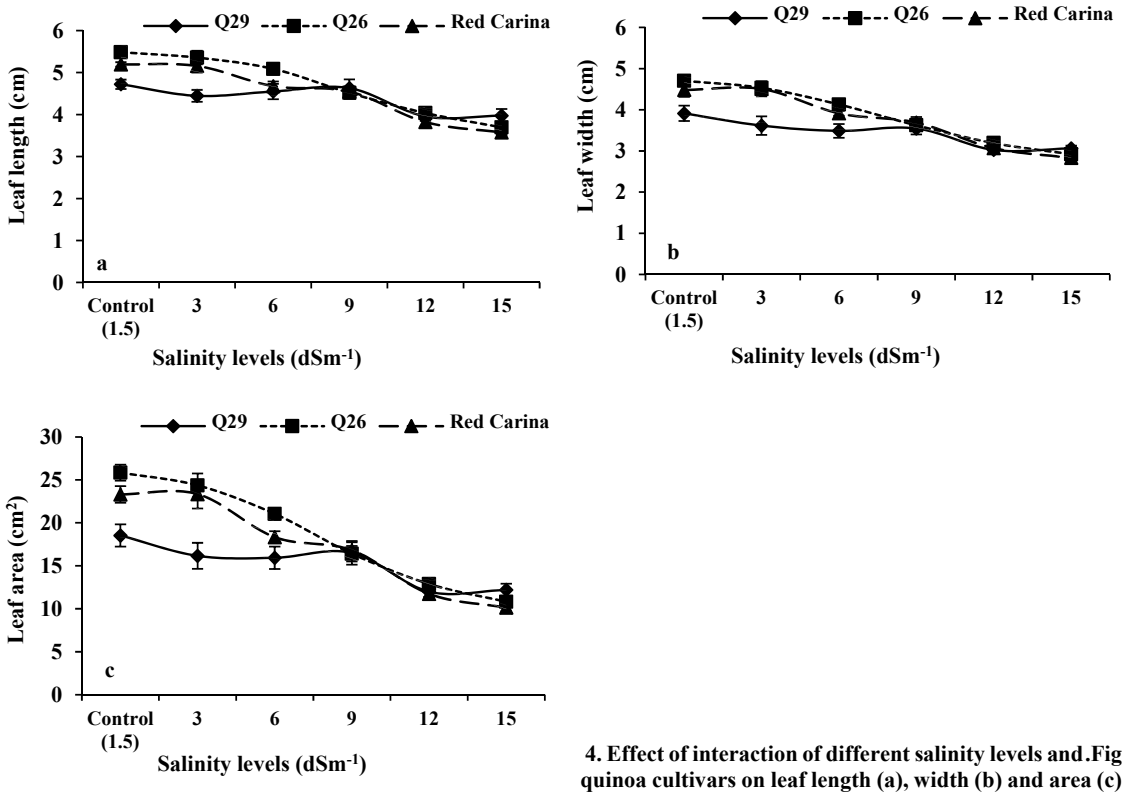


Fig. 3. Comparison of different cultivars of quinoa(a) and the effect of different salinity levels(b) on the number of leaves.



4. Effect of interaction of different salinity levels and.Fig quinoa cultivars on leaf length (a), width (b) and area (c)

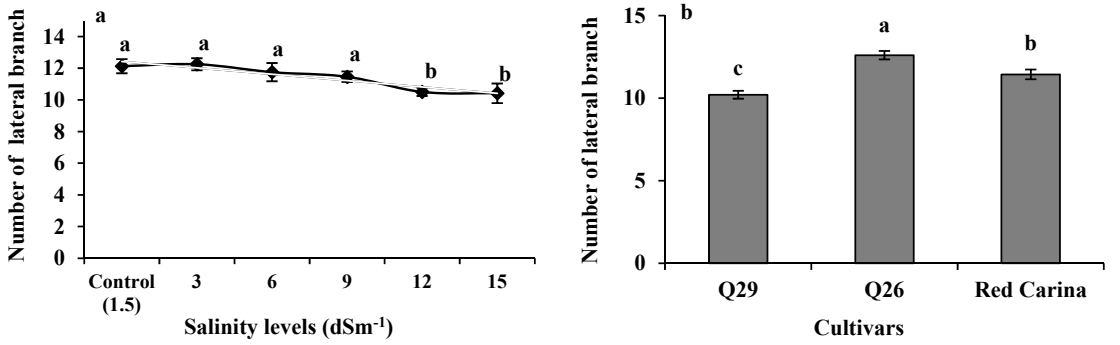


Fig. 5. Comparison of different cultivars of quinoa (a) and the effect of different salinity levels (b) on the number of lateral branches.

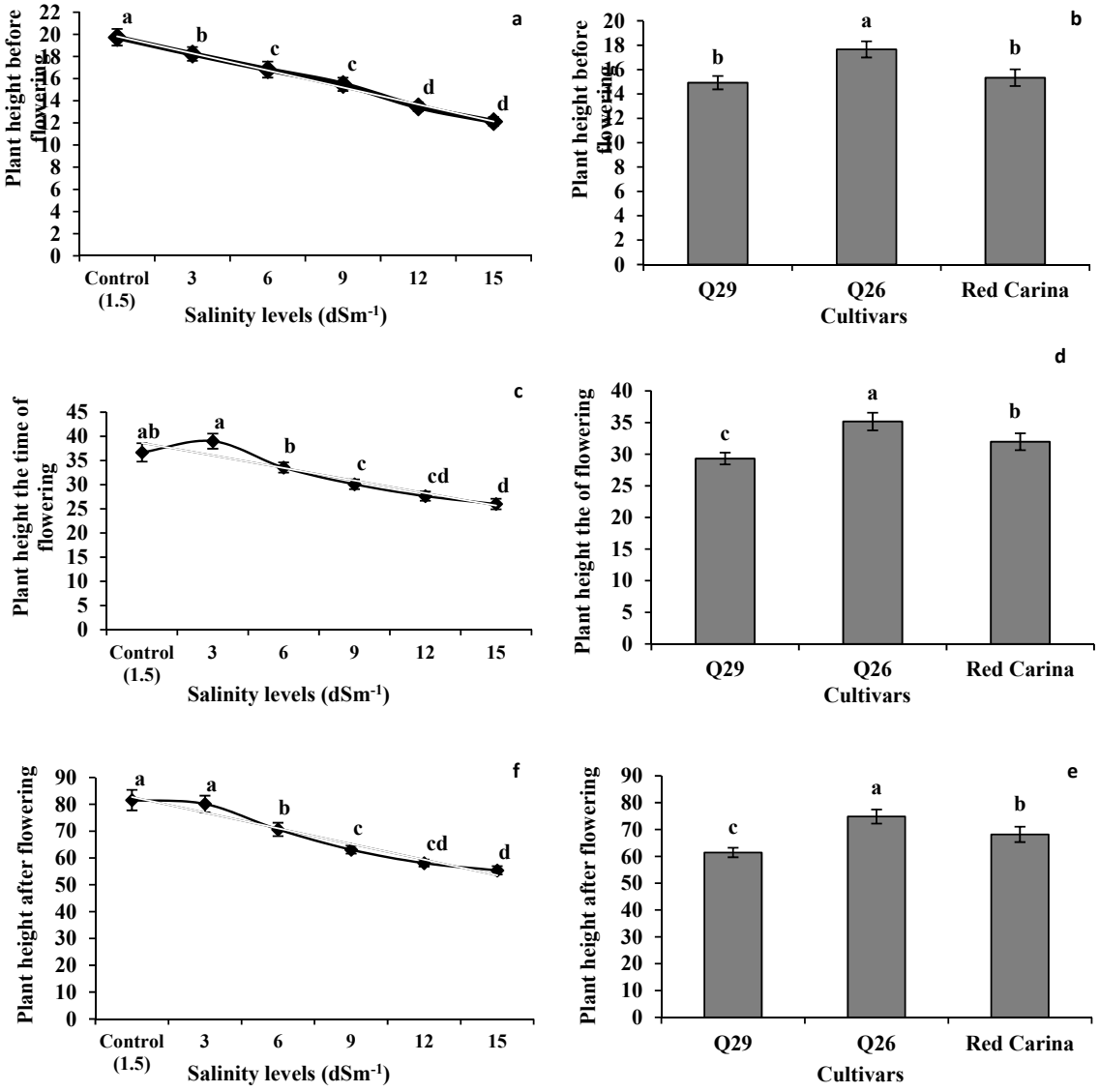


Fig. 6. Effect of different salinity levels and different cultivars of quinoa on plant height before (a, b), during (c, d) and after (e, f) of quinoa flowering

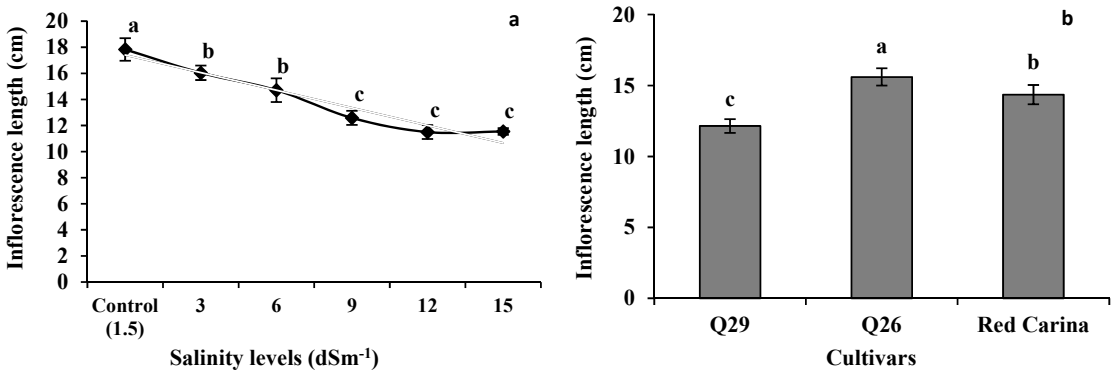


Fig. 7. Influence of different salinity levels (a) and different cultivars of quinoa (b) on the length of the inflorescence.

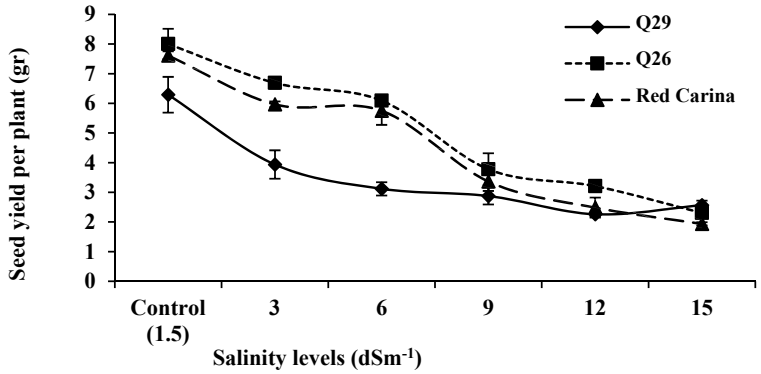


Fig. 8. Effect of interaction of different salinity levels and quinoa cultivars on grain yield in quinoa plant