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Original article

Investigation of the effect of irrigation management on morphological traits, yield and yield components of different genotypes of Quinoa (*Chenopodium quinoa* Willd.)

F. Fazeli[1], Gh.A. Akbari[2*], Gh.A. Akbari[2], A. Naderi Arefi[3], F. Benakashani[4]

1. *Ph.D. student of Agriculture-Ecology, University of Tehran, Aburaihan Campus, Tehran, Iran*
2. *Associate Professor, Department of Agriculture and Plant Breeding, University of Tehran, Aburaihan Campus, Tehran, Iran*
3. *Assistant Professor of cotton and fiber crop department, Tehran Agricultural and Natural Resources Research and Education Center, AREEO, Varamin, Iran*
4. *Assistant Professor, Department of Agronomy and Plant Breeding, University of Tehran, Aburaihan Campus, Tehran, Iran*

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Extended abstract

Introduction

In the near future, agricultural production will need to increase to feed the world's growing population with less fresh water available. Non-living stresses such as drought and salinity are common environmental factors that affect plant growth and are one of the most important factors determining the geographical distribution of vegetation and limiting the yield of agricultural products (Schulze et al., 2005; Gregory, 2006; Lin et al., 2006). One of the management options to minimize the impact of salinity and drought stress is to introduce species that tolerate these conditions with good adaptation in terms of quantitative and qualitative performance. Chenopodium quinoa is a crop that tolerates a combination of incompatible factors (Jacobsen et al., 2003). In this regard, in this study, the effect of irrigation cycle on morphological and physiological characteristics of different quinoa cultivars in Garmsar city was investigated.

Materials and methods

Plant materials including seeds of 3 new quinoa plant genotypes (Table 1) with variety of maturity and yield were obtained from Karaj Seed and Seedling Registration and Certification Research Institute. This experiment was carried out in 1397, in Garmsar Agricultural Research Station as a factorial in a randomized complete block design with 3 replications. Garmsar city with an average annual rainfall of 125 mm and an altitude of 850 meters above sea level has a hot and dry climate. The first factor was irrigation cycle at three levels (8, 12 and 16 days) and the second factor was genotype (Titicaca, Q26 and Q29). Due to the sensitivity of the plant at the time of germination and in order to establish it completely, the first two irrigations were performed equally for all treatments at intervals of 5 days.

Results and discussion

The results of analysis of variance showed that the effect of irrigation cycle and genotype on all studied traits (plant height, main cluster length, and main cluster weight, number of branches per plant, 1000-seed weight, and yield per hectare and harvest index) was significant at 1% probability level. Comparison of the mean interaction of irrigation intervals and genotype showed that there was a significant difference between treatments in grain yield, main cluster length and cluster weight.

[*]Correspondent author: Gholam Ali Akbari; E-Mail: gakbari@ut.ac.ir

Conclusions

Increasing population and the need for more food put additional pressure on the environment, especially water resources and agricultural ecosystems. One of the plants that has been considered today due to climate change is quinoa (Salehi and Dehghani, 2018). The purpose of this study was to investigate the management of water resources and select the appropriate genotype for cultivation in Garmsar region. The results indicate that until the introduction of superior cultivars, Titicaca genotype has good yield potential for cultivation in this city and similar areas. Also, despite the high yield in the interval of irrigation once every 8 days, for better management of resources, the interval of irrigation once every 12 days can be used.

***Keywords*:** Grain yield, Quinoa, Low irrigation, Water stress

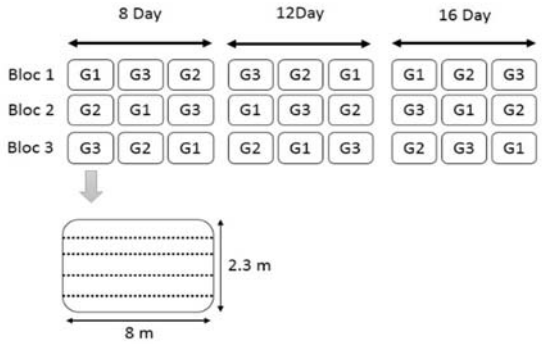

Fig 1. Plan map

Table1. Information of the studied genotypes

Source	Origin	Year of entry / production	Genotype name
Final Report Quinoa TCP	Denmark	2016	TITICACA
Final Report Quinoa TCP	FAO	2013	CHILE 2011-FAO (Q26)
Final Report Quinoa TCP	FAO	2013	CHILE 2011-FAO (Q29)

Table 2. Soil test results

soil pattern	Organic matter	Soil Salinity	PH	Absorbable potassium	Absorbable phosphorus	Nitrogen absorbable	Depth of sampling
	%	$dS.m^{-1}$			$mg.kg^{-1}$	ppm	cm
Silty loam	0.76	5.8	7.4	420	6.8	6.4	0-30

Table 3. Variance analysis of the effect of irrigation and genotype on the measured traits of quinoa

S.O.V	df	Height	Panicle length	Panicle weight	Branch per plant	1000 grain weight	Yield per hectare	HI
Block	2	31.81^{ns}	0.704ns	2.77^{ns}	0.259^{ns}	0.005^{ns}	133.77^{ns}	2.28^{ns}
Irrigation (I)	2	1482.7^{**}	117.81^{**}	1827^{**}	61.59^{**}	2.37^{**}	1153352.8^{**}	33.64^{**}
Genotype (G)	2	1078.48^{**}	14.03^{**}	573.8^{**}	3.704^{**}	0.043^{**}	62293.77^{**}	361.68^{**}
I × G	4	41.81^{ns}	5.20^{**}	106.5^{**}	0.09^{ns}	0.002^{ns}	1350.72^{**}	7.34^{ns}
Error	16	17.73	0.704	1.31	0.426	0.003	224.82	3.822
CV %		*3.82*	*3.76*	*0.902*	*4.88*	*2.4*	*0.78*	*4.46*

* and ** significant at the statistical level of 5% and 1%, respectively, ns is not significant

Table 4. mean comparison of simple effects of irrigation for the studied traits in quinoa

Irrigation intervals	Plant height	Number of branches per plant	1000-grain weight	HI
	cm		g	(%)
8 Day	120.66 [a]	15.88 [a]	2.63 [a]	46.00 [a]
12 Day	113.66 [b]	13.55 [b]	2.53 [b]	42.55 [b]
16 Day	95.77 [c]	10.66 [c]	1.69 [c]	36.85 [c]

In each column, means with similar letters have a significant difference based on the Duncan test at p<0.01

Table 5. Mean comparison of simple effects of genotype for the studied traits in quinoa

Genotype	Plant height (cm)	Number of branches per plant	1000-grain weight (g)	HI (%)
Titicaca	99.22 [c]	14.11 [a]	2.36 [a]	51.13 [a]
Q26	121.11 [a]	13.00 [b]	2.26 [b]	40.40 [b]
Q29	109.77 [b]	13.00 [b]	2.23 [b]	39.92 [b]

In each column, means with similar letters have a significant difference based on the Duncan test at p<0.01

Table 6. mean Comparison of the interaction of Irrigation×Genotype for the studied traits in quinoa plant

Irrigation intervals (day)	Genotype	Panicle length	Panicle weight	Yield per hectare
8	**Titicaca**	26.0 [a]	148.7 [a]	2247.7 [a]
	Q26	26.3 [a]	131.6 [b]	2130.7 [c]
	Q29	24.6 [ab]	129.5 [b]	2085.0 [d]
12	**Titicaca**	22.7 [b]	128.3 [bc]	2178.3 [b]
	Q26	23.3 [b]	127.6 [c]	2008.3 [e]
	Q29	20.6 [c]	126.7 [c]	2003.3 [e]
16	**Titicaca**	19.7 [c]	112.8 [d]	1468.3 [f]
	Q26	20.3 [c]	110.7 [d]	1380.0 [g]
	Q29	16.1 [d]	109.9 [d]	1233.3 [h]

In each column, means with similar letters have a significant difference based on the Duncan test at p<0.01