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Original article

Effect of foliar application of jasmonic acid and drought stress on yield and some agronomic and physiologic traits of quinoa (*Chenopodium quinoa* Willd) cultivars

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Extended abstract

Introduction

Quinoa plant (*Chenopodium quinoa* Willd) is a grain- like crop with high nutritional values and resistant to abiotic stresses such as drought and salinity stress. Drought stress is one of major stresses, which had the undesirable effects on qualitative and quantitative yield of crops in arid and semi-arid regions of the world. On the other hand, Jasmonate (Jasmonic acid), are a new plant growth regulator that plays an important role in increase the resistance of plants to environmental stresses such as drought stress. That's why this experiment aims to investigate the impact of drought stress and foliar application Jasmonic acid on yield and some agronomic and physiologic characteristics of Quinoa cultivars.

Material and methods

This experiment was carried out in split factorial design based on randomized complete block design with three replications in Kerman agricultural research and education center (Joupar station) during 2018. The main factor was included non-stress (normal irrigation) and drought stress (based on 60% and 90% of usable soil moisture discharge) and foliar application of JA in three levels (0, 1 and 2 mg/l) and varieties (Giza1, Titicaca, Q29) as factorial arranged in sub factor. The measured traits were seed yield, inflorescence number in plant, seed 1000 weight, biological yield, plant height, harvest index, relative water content and chlorophyll index.

Results and discussion

The results showed that drought stress reduced the seed yield and some agronomic and physiologic traits of Quinoa. The application of JA, especially concentration of 2 mg/L improved these traits compared to the control treatments. The highest seed yield and biological yield were obtained from interaction of normal irrigation and 2 mg/l JA and Titicaca cultivar by 3316 and 13265 kg/ha, respectively. The lowest

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seed yield and biological yield related to interaction of drought stress and non-application of JA and Giza1 cultivar by 1682 and 7733 kg/ha, respectively. The highest plant height was achieved from the interaction of Titicaca cultivar under non-stress conditions and application of 2 mg/l JA by 142.4 cm. The highest chlorophyll leaf index (SPAD index) was observed under non stress conditions and spraying of 1 mg/l JA in Giza1 by 58.8.

Conclusions

According to the result of this research, it can be suggested that JA as a growth regulator, can increase seed yield and productivity of quinoa cultivars, especially Titicaca cultivar through the reducing the negative effect of drought stress and improving plant growth

Keywords: Deficit irrigation, Growth regulator, Harvest index, Quinoa, Seed yield

Table 1. Soil physical and chemical properties of experiment site 0-30 cm depth.

Soil texture	Sand	Clay	Silt	Ph	EC	Field Capacity	Permanent wast Point	Specific waight
	------------%-------------				$ds.m^{-1}$	-------------%---------------		$g.cm^{-3}$
Sandy Loam	69	13	18	7.7	1.98	18.8	7.6	1.41

Table 2. Analysis of variance of measured traits

S.O.V	df	Seed yield	Cluster/plant	1000- Seed weight	Biological yield
Replication	2	41672.1^{ns}	43.005^{ns}	0.05^{ns}	3849864.4**
Drought stress (D)	1	6103179.8**	56.01*	0.66 **	53093833.8**
Error	2	332557.4	5.72	0.007	2488171.4
Jasmonic acid (JA)	2	370203.2**	2.11^{ns}	1.40 **	4642977.9**
Cultivar (C)	2	245117.6*	7.53^{ns}	0.09 *	3395092.9**
JA × D	2	39147.1^{ns}	2.22^{ns}	0.10 *	3173503.7**
C × D	2	486942.9**	1.39^{ns}	0.010 ^{ns}	1127267.1^{ns}
C × JA	4	223412.6*	7.62^{ns}	0.008 ^{ns}	2265643.2**
C × JA × D	4	544173.1**	0.33 ^{ns}	0.030 ^{ns}	6650313.2**
Error	32	70140.8	1.98	0.025	655884.4
CV(%)		*10.4*	*9.1*	*5.2*	*7.4*

Table 2. Continued

S.O.V	df	plant height	Harvest index	RWC	Chlorophyll Index
Replication	2	49.83 *	1.73^{ns}	13.79 ^{ns}	0.55 ^{ns}
Drought stress (D)	1	4579.02 **	55.83**	315.81**	204.55 **
Error	2	29.01	5.95	23.99	1.207
Jasmonic acid (JA)	2	1066.66 **	6.66 *	96.11**	65.38 **
Cultivar (C)	2	1039.75 **	0.07^{ns}	0.87^{ns}	43.61 **
JA × D	2	55.97*	2.07^{ns}	9.92^{ns}	5.56 ^{ns}
C × D	2	93.86 **	3.31**	8.82^{ns}	3.63 ^{ns}
C × JA	4	198.57 **	3.79^{ns}	6.93^{ns}	10.53**
C × JA × D	4	63.15*	8.21**	11.47^{ns}	11.48 *
Error	32	18.51	1.98	15.48	4.93
CV(%)		*3.7*	*5.6*	*5*	*4.3*

**,*and ns means significant at 5% and 1% probability levels and non-significant, respectively

Table 3. Mean comparison of water stress, foliar with application of Jasmonic acid and cultivar interaction on some traits of Quinoa

Irrigation (evacuation humidity)	J.A	Cultivar	Seed yield	Biological yield	plant height	Harvest index	Chlorophyll Index
	mg.lit^{-1}		---------- kg.ha^{-1}	----------	cm	%	
D_1 (Non-stress)	0	Giza$_1$	3015^{a-d}	11835^{a-d}	109^{d-f}	25.9^{a-d}	2.7^{b-e}
		Titicaca	3225^{ab}	11629^{b-e}	132.6^{a}	25^{a-d}	52.2^{b-f}
		Q_{29}	2204^{gh}	9190^{g-i}	121^{b-d}	24.05^{b-f}	48.4^{fg}
	1	Giza$_1$	3266^{ab}	12710^{ab}	119.6^{c-f}	25.6^{a-d}	58.8^{a}
		Titicaca	3120^{a-c}	12046^{a-c}	132.6^{a}	26^{a-c}	52.7^{b-e}
		Q_{29}	$2666c^{d-g}$	10254^{e-i}	110.6^{c-f}	26.1^{a-c}	56.2^{ab}
	2	Giza$_1$	2802^{b-e}	10615^{c-g}	130.6^{ab}	26.3^{a-c}	55.2^{a-c}
		Titicaca	3316^{a}	13265^{a}	142.4^{a}	27.6^{a}	52.2^{b-e}
		Q_{29}	3140^{a-c}	12483^{ab}	124.1^{bc}	26.6^{ab}	53.5^{b-d}
D_2 (Drought stress)	0	Giza$_1$	1682^{i}	7733^{i}	87.8^{g}	21.6^{f}	50^{d-f}
		Titicaca	2375^{e-h}	9717^{gh}	107.9^{d-f}	24.6^{b-e}	48.5^{fg}
		Q_{29}	2329^{e-h}	9190^{g-i}	99.3^{fg}	24.1^{b-f}	48.4^{fg}
	1	Giza$_1$	2576^{d-g}	10895^{c-f}	109.5^{c-f}	23.6^{c-f}	50.7^{d-f}
		Titicaca	2265^{f-h}	9566^{f-h}	105.6^{ef}	23.7^{c-f}	51.4^{c-f}
		Q_{29}	2492efgh	9766^{f-h}	988^{fg}	25.5^{a-d}	51.8^{c-f}
	2	Giza$_1$	2725cdef	10481^{d-h}	107.3^{d-f}	26^{a-c}	52.4^{b-f}
		Titicaca	2061hi	9239^{gh}	125^{cd}	22.2^{ef}	48.7^{e-g}
		Q_{29}	2198gh	9000^{hi}	115.9^{c-e}	23.2^{d-f}	46.4^{g}

The same letters in each column are not significantly different. D1: Non-stress (60% evacuation humidity), D2: drought stress (90% evacuation humid)

Table 4. Correlation of measured traits

	Adjectives Pearson Correlation	1	2	3	4	5	6	7
1	**Cluster/plant**	1						
2	**Seed yield**	0.238	1					
3	**1000- Seed weight**	0.075	0.440^{**}	1				
4	**Biological yield**	0.269^{*}	0.808^{**}	0.495^{**}	1			
5	**plant height**	0.334^{*}	0.584^{**}	0.347^{*}	0.623^{**}	1		
6	**Harvest index**	0.169	0.748^{**}	0.427^{**}	0.553^{**}	0.411^{**}	1	
7	**RWC**	0.160	0.503^{**}	0.395^{**}	0.457^{**}	0.572^{**}	0.318^{*}	1
8	**Chlorophyll Index**	0.232	0.496^{**}	0.262	0.339^{*}	0.198	0.356^{**}	0.374^{**}

, correlation are significant at 1% and 5% probability levels

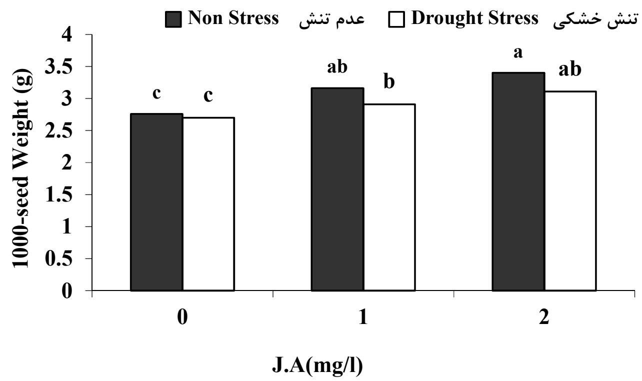

Fig. 1. Mean Comparison of Drought stress and foliar application of Jasmonic acid interaction on 1000 seed weight

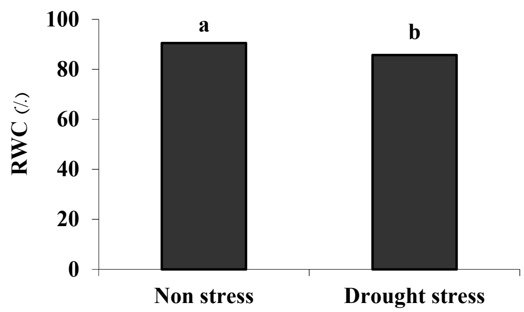

Fig. 2. Effect of drought stress on relative water conten

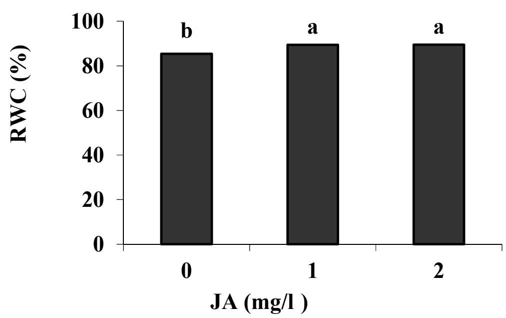

Fig. 3. Effect of foliar application of jasmonic acid on relative water content