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Original article

Investigating the combined effect of organic and chemical fertilizers on quantitative and qualitative yield of Quinoa (*Chenopodium quinoa*) under drought stress

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Extended abstract

Introduction

Modification to withstand drought stress has always faced its own bottlenecks, therefore, in the first stage, cultivating drought-resistant plants such as quinoa is the best way to prevent of reduce in crop yields. Quinoa with a scientific name (*Chenopodium quinoa*) is a dicotyledonous plant and belongs the subfamily (chenopodiaceae). There is saponin in all parts of quinoa, including leaves, flowers, fruits, seeds, and seeds coat (Bhargava and Srivastava, 2013). Also is used as an antibiotic, fungal disinfectant and in the pharmaceutical industry (Dini et al, 2001).Potassium have an important role in quality, plant tolerance to various environmental stresses, elements displacement, equilibrium, biochemical and physiological processes including photosynthesis, protein formation and opening and closing of pores and formation of vessels. The use of livestock and poultry manures is important in soil management and sustainability and improves the physical, chemical and microbial properties of the soil. The present study was conducted to investigate the effect of livestock and chemical fertilizers on the quantitative and qualitative characteristics of quinoa under drought stress.

Materials and Methods

This experiment was conducted in the form of split-split plot in a randomized complete block design with three replications.in the field of research of the Agricultural Research Institute of Zabol University In year of 2019-2020 In this experiment, drought stress was the main plot, cow manure as a sub-plot and potassium fertilizer as a sub-sub plot. The measured traits included: number of spikes, 1000-seed weight, grain yield, biological yield, harvest index, proline, carbohydrate and protein. Protein was measured by Bradford (1976). Proline was measured using the method (Bates, 1973) as follows.

Results and discussion

The results showed that the simple, double and triple effects of drought stress, cow manure and potassium fertilizer were significant different at the level of 1% probability on 1000-grain weight and grain yield. The highest 1000-grain weight and grain yield were obtained when using full irrigation treatment. The simple, double and triple effects of drought stress, cow manure and potassium fertilizer were significant different at the level of 1% probability on Carbohydrates and grain protein. Also, the

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highest amount of grain protein was obtained in the application of 20 t ha^{-1} of manure and no potassium fertilizer in the stage of grain filling and the highest amount of leaf carbohydrates in the treatment of 10 tons of manure and 200 $kg.ha^{-1}$ of potassium in the cessation stage of irrigation in the flowering stage. The results also showed that the highest of grain yield was obtained when using 10 t.ha-1 of manure and 200 $kg.ha^{-1}$ of potassium fertilizer during full irrigation.

Conclusion
The results showed that the combined application of manure cow and potassium in full irrigation conditions improved the quantitative and qualitative characteristics of quinoa. The triple effects of drought stress× manure× potassium increased grain yield, 1000-grain weight, harvest index, proline, protein and carbohydrates. The highest grain yield was obtained in the simultaneous use of cow manure and potassium fertilizer in the complete irrigation stage. In fact, the using of manure in addition to retaining moisture under conditions of severe stress increases the absorption of essential elements and plant growth, and the absorption of elements such as nitrogen, increases the growth of aerial parts of the plant and stores more nutrients in these areas for re-transfer during seeds ripen. On the other hand, due to its positive effect on maintaining moisture in the plant and increasing the duration of photosynthesis due to the continuity of leaf area in the reproductive stage, potassium consumption can provide more nutrients to more flowers and thus increase yield. It becomes a plant. Under stress conditions, the amount of carbohydrates and proteins increased, which is due to plant adaptation.

***Keywords*:** Carbohydrates, Grain yield, Proline, Protein

Table 1. Average minimum and maximum temperatures during the growing season

Tepmerature (˚C)	January	February	March	April
Average min	2.65	4.31	10.17	15.2
Average max	15.2	20.94	25.37	29.31
Rainfall (mm)	27.1	16.9	0	22.7

Table 2. Physical and chemical characteristics of soil experimental

Deapth	Soil texture	pH	EC	N	P	K	organic material
cm			$dS.m^{-1}$	%	------------ $mg.kg^{-1}$	------------	%
0-30	Sandy loam	7.80	1.32	0.05	2.58	46.14	6.05

Table 3. Analysis of variance of morphological and biochemical characteristics of *Chenopodium quinoa* under drought stress and cow Manure and potassium

S.O.V	DF	Spike no.	Grain W.t	Grain Yield	Biological yield
Repeat	**2**	0.01	0.0039	0.01	0.6344
Drought stress (S)	**2**	2.08**	0.44**	1.89**	1.27*
Maine error	**4**	0.49	0.0001	0.02	0.88
Manure (M)	**2**	0.45	0.073 **	0.43**	3.98*
(S)*(M)	**4**	0.77**	0.28**	1.33**	3.97 **
Sub-error	**12**	0.24	0.0001	0.02	0.76
K	**2**	0.19	0.112**	0.11*	0.63
(S)*(K)	**4**	0.17	0.31**	0.04	0.28
(M)*(K)	**4**	0.16	0.18**	0.32**	1.61**
(S)*(M)*(k)	**8**	0.14	0.14**	0.22**	0.58*
Sub sub-error	**36**	0.16	0.00007	0.03	0.24
CV%	-	*28.21*	*0.4*	*11.63*	*9.98*

Table 3. Continued

S.O.V	DF	Harvest index	Proline	Protein	Carbohydrat
Repeat	2	25.86	3.95	13370.63	324.57**
Drought stress (S)	2	781.65**	331.59**	407112.27**	573471.61
Maine error	4	69.96	0.61	12780.9	6489.23
Manure (M)	2	46.58	495.21**	437663.3**	874640.20**
(S)*(M)	4	167.04**	87.379**	304545.4**	243908.05**
Sub-error	12	25.08	0.32	3527.77	7582.47
K	2	19.54	82.19**	320927.52**	236802.53**
(S)*(K)	4	5.28	115.28**	166620.46**	272629.95**
(M)*(K)	4	20.98	125.66**	22892.22	302488.65**
(S)*(M)*(k)	8	82.34**	29.212**	361079.35**	541108.73**
sub-error Sub	36	21.01	0.55	9818.42	6209.5
CV%	-	*14.31*	*7.52*	*10.25*	*4.11*

Statistically significant at the probability levels of 5% and 1%, respectively.

Table 4. Comparison of averages Interaction drought stress and cow manure on spike number in *Chenopodium quinoa*

Irrigation levels	Cow manure t ha^{-1}	Spike no.
Full irrigation	**0**	13.33^{ab}
	10	15.16^{a}
	20	12.44^{abc}
Flowering Stage	**0**	9.776^{bc}
	10	8.88^{bc}
	20	15.11^{a}
Seed Filling stage	**0**	1^{c}
	10	9.778^{bc}
	20	9.77^{bc}

Means in each column followed by the similar letter are not significantly different at 5% probability level.

Table 5. Comparison of averages Interaction characteristics of under drought stress and cow manure potassium on Chenopodium quinoa

Irrigation levels	Cow manure	potassium	weight of thousand grain	grain yield	Biological yield	Harvest index
	t. ha-1	kg.ha-1	gr	t.ha-1	t.ha-1	%
Full irrigation	0	0	2.08f	2.28ab	5.14c-g	44.22a
		100	2.29c	2.11abc	5.28b-f	40.18ab
		200	1.63p	1.956be	4.88c-g	40.52ab
	10	0	2.03h	1.31hL	4.38f-h	29.73c-g
		100	1.97j	1.48g-j	4.56d-h	34.39b-e
		200	2.02h	1.64e-h	4.8c-g	34.47b-e
	20	0	3.05a	2.09a-d	4.8c-g	44.49a
		100	1.99i	1.84c-f	4.99c-g	37.1abc
		200	2.13de	2.34a	7.34a	37.3abc
Stop irrigation at the flowering stage until the seeds begin to fill	0	0	1.77m	1.1klm	4.62c-h	23.89fg
		100	2.01h	1.15j-m	3.78h	30.63c-g
		200	1.8i	0.99L-m	4.37f-h	23.04fg
	10	0	1.68o	1.51j-m	4.56d-h	33.19be
		100	2.01h	1.31h-L	5.05c-g	25.84d-g
		200	2.04g	1.75d-g	5.59bc	31.88b-f
	20	0	1.72n	1.44g-k	5.16b-f	28.03d-g
		100	2.09f	1.13hl	4.48e-h	25.37e-g
		200	1.52f-i	1.97j	4.99c-g	30.73e-f
Stopping irrigation in the stage of seed filling until the end of seed filling	0	0	2.14d	1.44g-k	4.95c-g	29.16c-g
		100	2.14d	0.88m	4.12gh	21.63g
		200	2.06g	0.958m	3.78h	25.77d-g
	10	0	2.29c	1.84c-f	5.47b-d	34.52bcd
		100	2.37b	1.62e-h	6.09b	26.84d-g
		200	2.12e	1.95b-e	5.32a-c	32.07b-f
	20	0	2.05g	1.18i-l	4.4f-h	26.97d-g
		100	1.87k	2.05a-d	5.4b-d	38.07abc
		200	1.99ij	1.67e-h	4.94c-g	33.75be

Table 5. Continued

Irrigation levels	Cow manure	potassium	Proline	Carbohydrat	Protein
	t. ha-1	kg.ha-1	mg.gr-1	mg.gr-1	mg.gr-1
Full irrigation	0	0	0.94i	1854.62ef	1285.19bcd
		100	4.8f	1975.10e	875.56hi
		200	2.5g	1792.12f	411.11l
	10	0	8.08e	2417.81ab	694.07ij
		100	7.73e	1975.10e	864.44hi
		200	12.64d	1625.45g	816.30hi
	20	0	4.6f	1605.66g	496.89kl
		100	2.35gh	1912.60ef	1160de
		200	13.11d	1570.24g	840hi
Stop irrigation at the flowering stage until the seeds begin to fill	0	0	1.7g-i	1881.70ef	858.52hi
		100	12.64d	1295.94h	862.96hi
		200	2.0g-i	1348.02h	1180.74cde
	10	0	18.14b	1378.23h	1380efg
		100	18.56b	2230.31cd	1080e-g
		200	12.64d	2502.19a	865.19hi
	20	0	19.19ab	2205.31cd	1578.52a
		100	18.14b	1524.06g	793.33hi
		200	19.89a	1910.87ef	931.85f-h
Stopping irrigation in the stage of seed filling until the end of seed filling	0	0	4.1f	2404.62ab	480.74kL
		100	15.91c	1145.24i	824.44hi
		200	1.06hi	1898.02ef	595.56jk
	10	0	4.6f	2240.73cd	1431.85ab
		100	18.14b	2137.6d	1351.11bc
		200	4.1f	2325.45bc	918.52gh
	20	0	18.14b	2161.56d	1342.22bc
		100	11.94d	2284.48bcd	1107.41def
		200	12.29d	2142.81d	1064.44e-g

Means in each column followed by the similar letter are not significantly different at 5% probability level.