EFFECT OF IRRIGATION RATES AND ORGANIC FERTILIZATION ON GROWTH, YIELD AND ACTIVE CONSTITUENTS OF QUINOA (*CHENOPODIUM QUINOA* WILLD) PLANT

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Abstract

The current study was conducted at the experimental Farm of South Tahrir in Al-Behira governorate, Horticulture Research Station, Horticulture Research Institute (HRI), during the two successive seasons of 2016/2017 and 2017/2018. The main target of this work was to identifying the effective rate of applied irrigation at 3 rates of (400, 500 and 600 m^3/fed.) combined with organic compost fertilizers at levels (0, 5, 7.5 and 10 m^3/fed.) on growth yield and chemical composition of quinoa (*Chenopodium quinoa* Willd) plant. The obtained data showed that, application of irrigation at moderate rates (500m^3) +10m^3compost/fed./season) to quinoa plant recorded the maximum values of plant height, number of branches/plant, dry weight of herb/plant (g), seed weight /plant (g), seed index، protein, carbohydrates, N, P and K contents in both seasons. While, minimum values were obtained by irrigation rates 400m^3/fed./seasons + 5m^3compost /fed. Irrigation rate (400m^3 + 10m^3compost/fed./season) resulted in the highest values of saponins and phenols. While, the lowest values were obtained by irrigation rates 600m^3/fed.+5m^3compost/fed.

Key Words: irrigation**,** Organic compost**,** Quinoa, Saponin, Phenols.

INTRODUCTION

Quinoa (*Chenopodium quinoa* Willd) belongs to the Amaranthaceae family and cultivated in South America. Quinoa grains are characterized by its high protein (15 %) content with abundance of essential amino acids, and a wide range of vitamins, minerals phenols and saponins. Quinoa is a promising worldwide plant for human consumption. Saponins in quinoa are basically glycosidic triterpenoids with glucose. Quinoa contains from 2 to 10% fat. Quinoa and soya oils exhibit similar fatty acid compositions; thus, quinoa is a rich source of essential fatty acids such as linolenic (18:2n-6: 52%) and linolenic (18:3n-6: 40%) Vega-Gálvez *et al.*, (2010).

The number of studies on irrigation and fertilization requirements of quinoa is still quite limited. In this connection. Razzaghi *et al.,* (2012) showed that, quinoa is able to tolerate drought and can grow with only 200 mm of rainfall. Whereas, Abdelaziz *et al.*, (2013) noticed that, the highest grain yield (66.3 g $plant^{-1}$) has been

recorded when quinoa was subjected to full irrigation and received 10 t ha^{-1} of compost. However, the lowest yields were obtained by receiving 50% of full irrigation without organic matter supply. Lavini *et al*., (2014) reported that, the lowest values of water conductivity resulted in higher dry weight of herb, seed weight, plant height and total saponin content, and a small decrease in free phenolic compounds in quinoa seeds. Abdullah *et al.,* (2017) indicated that, the increase in water reduced the agronomic traits such as harvest index, number of seeds and yield of quinoa. Also it showed that the pH values in soils were not significantly affected by irrigation, while Ec significantly affected. Branka *et al*., (2017) revealed that, lower and higher irrigation levels from $I_{0.5}$ decreased the protein N, P, K, Mg, Mn, Cu, Zn and B concentrations of soybean (*Glycine max* L). Saleh *et al.,* (2018) revealed that, excessive water volume can also reduce the growth rate of green bean plants. Moreover, too much water in the soil is detrimental to plant growth, due to oxygen deprivation in the plant's roots.

Concerning, the effect of organic fertilization, Dimitrios *et al.,* (2012) indicated that, the highest saponin content and yield were found in quinoa plants treated with cow manure and compost treatments, while the lowest saponin content was found under control treatment (0.30-0.35%). In addition, Hirich *et al.,* (2014) indicated that, organic amendment of 10 t/ ha and 5 t/ ha significantly increased seed yield by 18 % under stress conditions and by 13 % under full irrigation for quinoa, also reported that organic (cow and manure) and inorganic N fertilization had a positive effect on plant height, number of branches/plant and crude protein compared with the control. In regard, Sakr *et al*., (2014) stated that, all organic fertilization treatments, significantly enhanced the vegetative growth characteristics of roselle (plant height, number of branches/ plant, leaf area, root length, fresh and dry weights of leaves and roots/plant, fresh weight of fruits, seed yield, seed oil percentage and seed oil yield/plant), and chemical composition of leaves (total chlorophylls, carotenoids, total carbohydrates contents as well as N, P and K%) compared to the control. Kyeong *et al*., (2018) showed that, growth of *Codonopsis lanceolata* showed superior tendency in the treatment of mixed organic matter, the major saponin of *C. lanceolata*, could be identified as foetidissimoside A, lancemaside A, lancemaside B, and lancemaside D.

The purpose of this investigation was to determine the effect of irrigation rates and organic fertilization on growth, yield and its chemical constituents of quinoa under sandy soil conditions and provide information on improving quinoa crop production in arid and semi-arid Mediterranean region, which is influenced by multiple abiotic stresses.

MATERILAS AND METHODS

The present study was carried out at the Experimental Farm of South Tahrir, Al-Behira governorate, Horticulture Research Station, Horticulture Research Institute (HRI), Agriculture Research Center, (ARC), during the two successive seasons of 2016/ 2017 and 2017/2018.

The experiment consisted of 12 treatment combinations with three levels each of irrigation rates (400, 500 and 600 m^3/fed.) and organic fertilization (Control (0), 5, 7.5 and 10 m^3 / fed.). The experiment was laid out in split plot design with three replications. The main plot was irrigation rates and the sub-plot was the organic fertilization. The compost fertilizer was obtained from Faculty of Agriculture, Cairo University. Rock phosphate (20 % P_2O_5) was added during of soil preparation at the rate of 100 kg/fed. mixed with compost. Control received all the proper agricultural procedures for quinoa production according to recommended dose (ammonium sulphate150 Kg/fed., calcium super phosphate 150 Kg/fed. and potassium sulfate 50 Kg/fed.).

The experimental unit area was 6.00 m^2 every unit contained 3 dripper lines. Every experimental unit contained 30 plants (about 23000 plant/ feddan) dripper lines with 3 m length each and 60 cm distance between each dripper lines. The drippers (with discharge of 2 liters / hour) were spaced at 30 cm on the irrigation lines. Seeds of quinoa were obtained from a private company at Cairo.

Quinoa (*Chenopodium quinoa* Willd) plant was sown on 30th and 31th October in the first and second seasons, respectively at spacing of (60 x 30 cm) during both seasons on one side of the row. After sowing, all seeds were irrigated 30 minutes every day until established, then were irrigated every one week for 30, 35 and 40 min. (±5min.) for three irrigation rates (400, 500 and 600 m^3/fed./season in the two seasons, respectively). Plants were harvested in March 19 and 18 in the first and second seasons, respectively.

The experiment consists of 12 treatments of irrigation rates and organic compost as follows:

1- Irrigation at 400 m^3/fed. with recommended dose of NPK (Control).
2- Irrigation at 400 m^3/fed. with 5m^3/fed. compost.
3- Irrigation at 400 m^3/fed. with 7.5m^3/fed. compost.
4- Irrigation at 400 m^3/fed. with 10 m^3/fed. compost.
5- Irrigation at 500 m^3/fed. with recommended dose of NPK.
6- Irrigation at 500 m^3/fed. with 5 m^3/fed. compost.
7- Irrigation at 500 m^3/fed. with7. 5 m^3/fed. compost.
8- Irrigation at 500 m^3/fed. with 10 m^3/fed. compost.
9- Irrigation at 600 m^3/fed. with recommended dose of NPK .
10- Irrigation at 600 m^3/fed. with 5 m^3/fed. compost.

11- Irrigation at 600 m^3/fed. with 7.5 m^3/fed. compost.

12- Irrigation at 600 m^3/fed. with 10 m^3/fed. compost.

Physical and chemical analysis of soil, compost and irrigation water were done at Soils, Water and Environment Research Institute Lab. (A.R.C.) according to the methods of Donald, (1996) as shown in Tables (1, 2and 3).

Table 1. Some physical and chemical properties of the experimental soil.

Soil characteristics		Value	Soil characteristics		Value
Particle size distribution			Bulk density	($Mg\ m^{-3}$)	1.65
Coarse sand	%	14.6	Hydraulic conductivity	($cm\ h^{-1}$)	34.3
Fine sand	%	74.1	$CaCO_3$	($g.kg^{-1}$)	1.86
Silt	%	6.1	Organic matter	($g.kg^{-1}$)	0.21
Clay	%	5.2	EC	(dSm^{-1})	2.24
Soil texture		Sand	pH (1:2.5 soil water suspension)		7.9

Table 2. Chemical analysis of well water.

EC (dSm^{-1})	Cations ($meq.L^{-1}$)				Anion ($meq.L^{-1}$)			pH	**RSC** ($meq.L^{-1}$)	**Adj. SAR.**
	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	HCO_3^{-}	CL^{-}	SO_4^{2-}			
2.04	4.52	3.72	8.4	1.57	2.07	7.5	8.64	7.53	-	8.07

Table 3. Chemical characteristics of compost used.

Characteristics		Value	Characteristics		Value
pH (1:10 soil water extract)		7.06	Total Nitrogen	($g.kg^{-1}$)	1.56
EC	(dSm^{-1})	5.10	C\N ratio		14.3
Moisture content	($g.kg^{-1}$)	16.1	Total P	($g.kg^{-1}$)	1.88
Organic matter	($g.kg^{-1}$	46.5	Total K	($g.kg^{-1}$)	3.05
Organic Carbon	($g.kg^{-1}$)	27.0	Density	(Mgm^{-1})	0.54

The recorded data included:

Plant height (cm), number of branches/plant, dry weight of plant (gm.) seed yield/plant (gm), and seed index (1000 seed weight).

Plant chemical composition at the end of each season:

Chemical analysis of seeds was performed at harvest time on mature seeds obtained from treated plants of *Chenopodium quinoa* Willd.), for the determination of protein and nitrogen using Micro Kjeldahl method as described by Jackson *et al.*, (2001), phosphorus (P %) was determined according to Olsen and Sommers (1982) while, Potassium % determined using flame photometerically method outlined by Dewis and Freitas (1970). total carbohydrates (% DW) using the method described by Evenhuis and DeWaard (1980), total phenols and saponins content determined as described by Nickel *et al.*, (2016). Seeds for saponins extraction (30 g) were thoroughly grounded and then extracted with water at 60°C for 3 h. The ratio of water to seeds was 15 to 1 (by weight). The extract was centrifuged and the supernatant filtered (pore size 0.45 lm).

The layout of this experiment was designed as split-plot design with 3 replicates as described by Gomez and Gomez (1984).This statistical analysis was done

by using the computer program M-STATE software version (4) using the L.S.D. test at 5 %.

RESULTS AND DISCUSSION

Effect of irrigation rates and organic fertilization and their interaction on growth characteristics:

1-Plant height and number of branches/plant:

Data in Tables (4 and 5) indicated that, in both seasons the highest plant height and number of branches/plant were obtained from plants irrigated with the moderate rate 500 m^3/fed./season (83.68 and 82.26 cm) for plant height and (17.97and 19.28 branches/plant) for number of branches/plant in the first and second seasons, respectively), followed by plants irrigated with the abundant rate of 600 m^3/fed /fed./season (giving values of 77.63 and 79.85 cm) and (15.21 and 17.34 branches/plant) for plant height and number of branches/plant in the two seasons, respectively), whereas the lowest values (73.70 and 74.82 cm) and (14.35 and 16.19 branches/plant) in the two seasons, respectively) were obtained from plants irrigated at the lowest rate (400 m^3/fed /fed./season). In both seasons, the differences between three irrigation rates were significant. However it may be concluded the irrigation water applied increases the availability of nutrients that can uptake with moderate rate which helps plants to vertical growth compared with other irrigation .The effect of irrigation rates on plant height and number of branches/plant are similar to that detected by Lavini *et al*., (2014) on quinoa.

Table 4. Effect of irrigation rates and organic fertilization on plant height (cm) of quinoa (*Chenopodium quinoa* Willd.) in the first and second seasons of 2016/2017 and 2017/2018.

Fertilization treatments	Plant height (cm)							
	Irrigation rates m^3/fed./season							
	First season 2016/2017				Second season 2017/2018			
	400 m^3/fed	500 m^3/fed	600 m^3/fed	Means	400 m^3/fed	500 m^3/fed	600 m^3/fed	Means
NPK (control)	72.02	82.00	75.00	76.34	76.05	81.20	78.21	78.49
5 m^3/fed. compost	72.00	80.00	74.00	75.33	73.21	78.21	78.65	76.69
7.5 m^3/fed. compost	74.01	85.00	77.02	78.68	74.11	83.20	80.20	79.17
10 m^3/fed. compost	76.77	87.70	84.50	82.99	75.91	86.41	82.35	81.56
Means	73.70	83.68	77.63	---	74.82	82.26	79.85	---
LSD: at 5%								
Irrigation rate (I)	0.76				1.94			
Fertilization (F)	1.37				1.31			
(I x F)	2.38				2.27			

Table 5. Effect of irrigation rates and organic fertilization on number of branches/ plant of quinoa (*Chenopodium quinoa* Willd.) in the first and second seasons of 2016/2017 and 2017/2018.

Fertilization treatments	Number of branches/ plant							
	Irrigation rates m^3/fed./season							
	First season 2016/2017				Second season 2017/2018			
	400 m^3/fed	500 m^3/fed	600 m^3/fed	Means	400 m^3/fed	500 m^3/fed	600 m^3/fed	Means
NPK (control)	13.22	16.54	14.25	14.67	14.11	17.25	15.54	15.63
5 m^3/fed. compost	11.41	14.63	13.25	13.10	14.00	14.36	15.36	14.57
7.5 m^3/fed. compost	15.50	18.25	15.62	16.46	17.21	20.36	18.01	18.53
10 m^3/fed. compost	17.26	22.45	17.70	19.14	19.45	25.14	20.44	21.68
Means	14.35	17.97	15.21	---	16.19	19.28	17.34	---
LSD: at 5%								
Irrigation rate (I)	2.46				2.78			
Fertilization (F)	1.78				2.00			
(I x F)	3.08				3.46			

Regarding the effect of fertilization treatments on plant height and number of branches/plant, the data in Tables (4 and 5) showed that, the organic fertilization treatments had a significant effect on the plant height and number of branches/plant. Among the different fertilization treatments, the applications of 10m^3 compost/fed. significantly gave the highest values (82.99 and 81.56 cm) and (19.14 and 21.68/plant) for plant height and number of branches/plant in the two seasons, respectively) compared with the recommended dose of NPK fertilization (76.34 and 78.49 cm) and (14.67 and 15.63/plant) in the two seasons, respectively). The least effective treatments which gave (75.33 and 76.69 cm) and (13.10 and 14.57/plant) was 5m^3 compost in the 1st and 2nd seasons, respectively. . Similar increases in the growth parameters as a result of organic and recommended dose of NPK fertilization treatments were reported by Hirich *et al.,* (2014) on quinoa plant.

Data illustrated in Tables (4 and 5) also indicated a significant effects for the interaction between irrigation rates and fertilization treatments. In both seasons, the best results of the plant height and number of branches/plant (87.70 and 86.41cm) and (22.45 and 25.14 branch/plant) in the first and second seasons, respectively) were obtained with irrigation amount of 500 m^3/fed combined with 10m^3 compost compared with NPK treatment combined with400 m^3/fed which gave the lowest values (72.02 and 76.05 cm) and (13.22 and 14.11 branches/plant) in the two season, respectively. However it may be concluded that, the irrigation water applied increases the availability of nutrients that can uptake with moderate rate (500m^3/fed./season) which helps plants to vertical growth compared with other irrigation 400 and 600 m^3/fed./season.

2-Dry weight of herb:

It is clear from the results recorded in the two seasons (Table 6) that significant differences occurred between dry weight of herb (g) produced by plants irrigated at different rates. In general, moderate irrigation at 500 m^3/fed resulted the highest dry weight of herb (35.64 and 39.56 g/plant) in first and second seasons,

respectively), followed by plants irrigated with 600 m^3/fed (28.29 and 31.45 g/plant in the two seasons respectively). On the other hand, the lowest rate (400 m^3/fed) gave the lowest values (25.91 and 29.40 g/plant) in the two seasons, respectively. This trend was similar to that reported by Lavini *et al.*, (2014) on quinoa plants.

Also, quinoa plants responded favorably to the organic fertilization treatments. Plants received 7.50 and 10m^3 compost significantly increased dry weight of herb compared to the NPK (27.92 and 31.26 g/plant) in the first and second seasons, respectively). The application of organic fertilization to the sandy soil has been a successful practice for improving the physical and chemical conditions as well as its productivity. These results are in agreement with Hirich *et al.*, (2014) on quinoa plants.

The interaction between the effects of irrigation rates and fertilization treatments was significant in both seasons. As results of this interaction, the highest values recorded in the two seasons (42.50 and 46.72g/plant in first and second seasons, respectively) were obtained when irrigation at 500 m^3/fed was combined with fertilization using 10 m^3 compost/fed.

This reduction in the production of dry weight/plant of quinoa *(Chenopodium quinoa* Willd) plants irrigated at the lowest rate may be related to the effect on vegetative growth that was observed with irrigation with amount of 400m^3/fed./season. As previously mentioned, irrigation at the rate of 400m^3/fed./season gave the lowest values for the different vegetative growth parameters that were recorded (plant height and number of branches/plant).

Table 6. Effect of irrigation rates and organic fertilization on dry weight of plant (g) of quinoa seeds (*Chenopodium quinoa* Willd.) in the first and second seasons of 2016/2017 and 2017/2018.

Fertilization treatments	Dry weight of plant (g)							
	Irrigation rates m^3/fed./season							
	First season 2016/2017				Second season 2017/2018			
	400 m^3/fed	500 m^3/fed	600 m^3/fed	Means	400 m^3/fed	500 m^3/fed	600 m^3/fed	Means
NPK (control)	24.50	32.65	26.61	27.92	28.65	35.89	29.24	31.26
5 m^3/fed. compost	24..05	30.71	25.00	26.59	27.41	34.81	29.00	30.41
7.5 m^3/fed. compost	26.31	36.68	27.66	30.22	29.63	40.82	30.88	33.78
10 m^3/fed. compost	28.78	42.50	33.87	35.05	31.89	46.72	36.69	38.43
Means	25.91	35.64	28.29	---	29.40	39.56	31.45	---
LSD: at 5%								
Irrigation rate (I)	0.10				0.85			
Fertilization (F)	0.46				0.90			
(I x F)	0.80				1.56			

3- Seed weight/plant:

The results in (Table 7 and Figure 1) indicated that the effect of irrigation rates (400, 500 and 600 m^3/fed) and different fertilization treatments on seed weight/plant (g) was significant. Maximum seed weight/plant (49.74 and 50.16 g/plant) was obtained from plants irrigated with 500 m^3/fed. in the first and second seasons, respectively. These results agreed with that of Abdelaziz *et al.*, (2013) on quinoa plants and Saleh *et al.,* (2018) green bean.

Furthermore, the results presented in Table (7) revealed that, seed weight/plant were steady significantly influenced by application of organic fertilization treatments compared with NPK plants. The highest values (51.82 and 53.01 g/plant) were obtained from plants supplied with 10 m^3 compost/fed in both seasons, respectively. These finding are in agreement with Sakr *et al*., (2014) on roselle plants.

Concerning to the effect of different combinations between irrigation rates and different levels of fertilization treatments on seed weight/plant of quinoa plants. The data in both seasons, showed that application of 500 m^3/fed irrigation water and 10 m^3 compost/fed was the most effective treatment on increasing seed weight/plant (54.65 and 57.61 g/plant)as compared with all treatments in the two seasons. Whereas irrigation at 400 m^3/fed combined with NPK (control) gave the lowest seed weight /plant (40.01 and 39.01 g/plant) in both seasons, respectively.

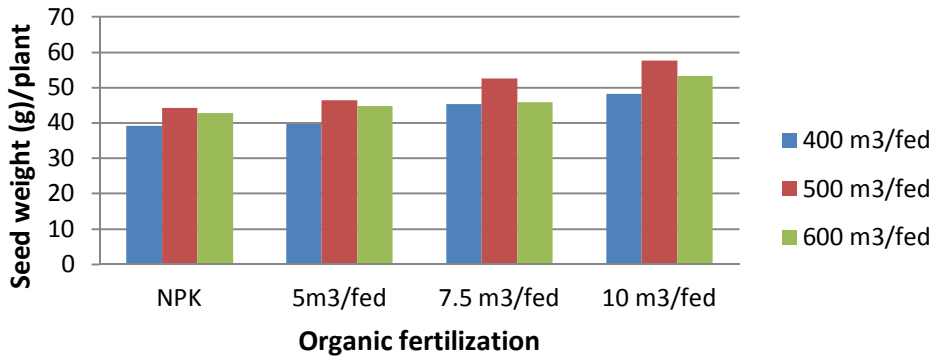
Table 7. Effect of irrigation rates and organic fertilization on seed weight/plant (g) of quinoa seeds (*Chenopodium quinoa* Willd.) in the first and second seasons of 2016/2017 and 2017/2018.

Fertilization treatments	Seed weight/plant (g)							
	Irrigation rates m^3/fed./season							
	First season 2016/2017				Second season 2017/2018			
	400 m^3/fed	500 m^3/fed	600 m^3/fed	Means	400 m^3/fed	500 m^3/fed	600 m^3/fed	Means
NPK (control)	40.01	45.21	43.89	43.04	39.01	44.20	42.63	41.95
5 m^3/fed. compost	40.98	47.45	43.43	43.95	39.65	46.31	44.74	43.57
7.5 m^3/fed. compost	44.11	51.66	46.78	47.52	45.20	52.51	45.81	47.84
10 m^3/fed. compost	46.33	54.65	48.79	51.82	48.20	57.61	53.21	53.01
Means	42.86	49.74	45.72	---	43.02	50.16	46.60	---
LSD: at 5%								
Irrigation rate (I)	0.95				1.06			
Fertilization (F)	0.81				0.91			
(I x F)	1.14				1.54			

The organic fertilizer influenced significantly the growth parameter. This might be due to the improvement in soil physical condition for the plant growth along with

increased availability of N, P and K at the early stage of crop growth. Nitrogen, phosphorus and potassium contained in organic fertilizer have great effects in plant growth and development. Plants need high concentration of these primary nutrients as any deficiency of these essential nutrients will prevent good plant growth. Thus, sufficient nitrogen, phosphorus and potassium supplied by organic fertilizer help in producing taller plant Khandaker and Rohani (2017).

Fig.(1): Effect of irrigation rates and organic fertilization on seed weight /plant (g)of qoinoa in the second season2017/2018.



4- Seed index:

Regarding the effect of irrigation rates and fertilization treatments on seed index of quinoa plants, the data in Table (8) indicated that, different irrigation rates increased the seed index. The highest values (3.59 and 3.49 g/1000 seeds) were obtained from plants received 500 m^3/fed. in the two seasons, respectively. While the lowest values (3.13 and 3.14 g/1000 seeds) were obtained from plants received the lowest irrigation level (400m^3/fed.) in both seasons, respectively.

Table 8. Effect of irrigation rates and organic fertilization on seed Index (g) of quinoa seeds (*Chenopodium quinoa* Willd.) in the first and second seasons of 2016/2017 and 2017/2018.

Fertilization treatments	Seed Index (g)							
	Irrigation rates m^3/fed./season							
	First season 2016/2017				Second season 2017/2018			
	400 m^3/fed	500 m^3/fed	600 m^3/fed	Means	400 m^3/fed	500 m^3/fed	600 m^3/fed	Means
NPK (control)	2.91	3.31	3.00	3.07	2.93	3.30	3.01	3.08
5 m^3/fed. Compost	3.00	3.50	3.05	3.18	3.01	3.41	3.22	3.21
7.5 m^3/fed. Compost	3.25	3.65	3.29	3.40	3.26	3.52	3.46	3.41
10 m^3/fed. Compost	3.36	3.88	3.56	3.60	3.35	3.71	3.69	3.85
Means	3.13	3.59	3.23	---	3.14	3.49	3.35	---
LSD: at 5%								
Irrigation rate (I)	0.03				0.04			
Fertilization (F)	0.07				0.04			
(I x F)	0.12				0.07			

On the other hand, for the effect of organic fertilizer on seed index, it was clear that the application of 10 m^3 followed by 7.5 m^3 compost/fed. being the superior in producing the highest seed index with significant differences in both seasons compared to all fertilization treatments.

The interaction between the effects of irrigation rates and fertilization treatments resulted in considerable differences between the values obtained with the different combination treatments. The highest values (3.88 and 3.71 g/1000 seeds) were obtained from plants irrigated with 500 m^3/fed. and supplied with10 m^3 compost/fed. in both seasons, respectively. These results were in accordance with those obtained by Abdelaziz *et al*., (2013) on quinoa plants and Safaei *et al*., (2014) on black cumin.

II- Effect of irrigation rates and organic fertilization and their interaction on chemical composition:

1- Saponins and phenols:

It is clear from the results in Tables (9 and10) and Figures (2 and 3) that, a significant reduction in the saponins and phenols content in both seasons were recorded with increasing irrigation from 400 to 600 m^3/fed. Furthermore, 400m^3/fed gave the highest values (0.87 and 0.80 %) and (1.57 and 1.59 %) for saponins and phenols % in the first and second seasons, respectively in comparison with all irrigation rates. The results of the present investigations are in close agreement with the findings of Lavini *et al*., (2014) in quinoa seeds.

Table 9. Effect of irrigation rates and organic fertilization on saponin contents of quinoa seeds (*Chenopodium quinoa* Willd.) in the first and second seasons of 2016/2017 and 2017/2018.

Fertilization treatments	Saponins content (%) of quinoa seeds							
	Irrigation rates m^3/fed./season							
	First season 2016/2017				Second season 2017/2018			
	400 m^3/fed	500 m^3/fed	600 m^3/fed	Means	400 m^3/fed	500 m^3/fed	600 m^3/fed	Means
NPK (control)	0.65	0.54	0.48	0.56	0.63	0.55	0.46	0.55
5 m^3/fed. Compost	0.67	0.54	0.51	0.57	0.65	0.54	0.48	0.56
7.5 m^3/fed. Compost	0.85	0.61	0.54	0.67	0.76	0.60	0.56	0.64
10 m^3/fed. Compost	1.29	0.64	0.59	0.84	1.16	0.65	0.64	0.82
Means	0.87	0.58	0.53	---	0.80	0.59	0.54	---
LSD: at 5%								
Irrigation rate (I)	0.01				0.03			
Fertilization (F)	0.01				0.03			
(I x F)	0.03				0.05			

In this regard, it is clear from these data that raising organic fertilizers from 5 to 10m^3/fed. steadily increased the recorded values of saponins and phenols content compared to control (NPK). The highest values (0.84 and 0.82 %) and (1.64 and 1.61 %) were obtained from plants supplied with 10m^3/fed. for saponins and phenols content in the two seasons, respectively. These results are in harmony with the findings of Dimitrios *et al.,* (2012) on quinoa plants. Also, it is noticed that, the effect of different combinations of irrigation rates and different compost treatments on the saponins and phenols content of quinoa plants are significant. The data in both seasons showed that application of 400m^3/fed combined with 10m^3/fed compost was the most effective treatment on increasing saponins and phenols content as compared with all treatments in the two seasons.

Fig. (2): Effect of irrigation rates and organic fertilization on saponin contents of quinoa seeds in the second season 2017/2018.

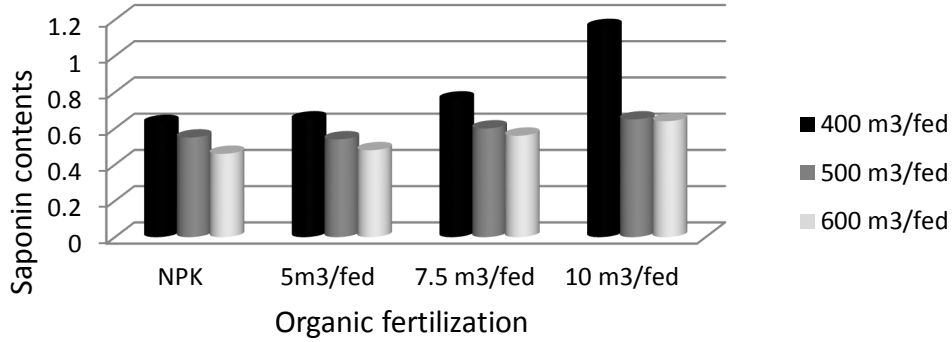
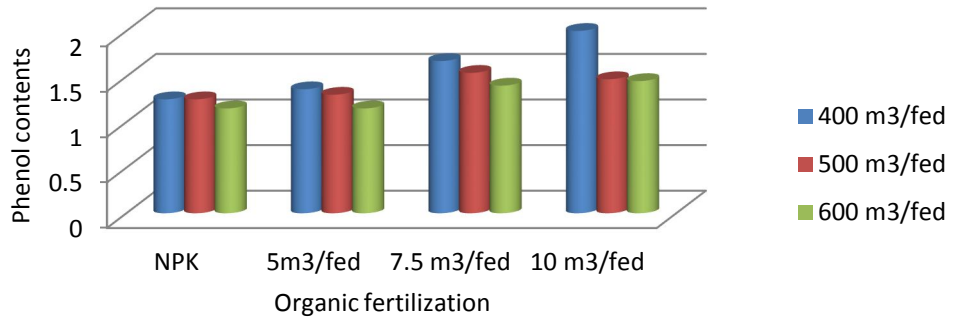


Table 10. Effect of irrigation rates and organic fertilization on phenols contents of quinoa seeds (*Chenopodium quinoa* Willd.) in the first and second seasons of 2016/2017 and 2017/2018.

Fertilization treatments	Phenols contents of quinoa seeds							
	Irrigation rates m^3/fed./season							
	First season 2016/2017				Second season 2017/2018			
	400 m^3/fed	500 m^3/fed	600 m^3/fed	Means	400 m^3/fed	500 m^3/fed	600 m^3/fed	Means
NPK (control)	1.25	1.25	1.15	1.22	1.29	1.26	1.10	1.22
5 m^3/fed. compost	1.36	1.30	1.15	1.27	1.37	1.26	1.11	1.25
7.5 m^3/fed. compost	1.67	1.54	1.40	1.54	1.70	1.40	1.25	1.45
10 m^3/fed. compost	2.00	1.47	1.45	1.64	1.97	1.49	1.36	1.61
Means	1.57	1.39	1.29	---	1.59	1.35	1.21	---
LSD: at 5%								
Irrigation rate (I)		0.07				0.02		
Fertilization (F)		0.03				0.02		
(I x F)		0.05				0.05		

Fig. (3): Effect of irrigation rates and organic fertilization on phenol contents of quinoa seeds in the second season 2017/2018.



2- *Proteins and total carbohydrates content:*

The results in Table (11) showed the effect of irrigation rates (400, 500 and 600 m^3/fed) and organic fertilization treatments on the protein and total carbohydrates contents (%) in quinoa seeds. In general, irrigation rates caused a significant effect on the protein and total carbohydrates. The highest percentages (14.94 and 72.01 %) from protein and carbohydrate contents, respectively in the second season were obtained from seeds of plants irrigated at the moderate rate (500m^3/fed), followed by those irrigated with 600 and 400m^3/fed, respectively. These results are in agreement with Branka *et al.,* (2017) of soybean (*Glycine max* L) and Saker *et al.,* (2014) on roselle plants.

Table 11. Effect of irrigation rates and organic fertilization on protein and carbohydrates contents of quinoa seeds (*Chenopodium quinoa* Willd.) in the second season of 2017/2018.

Fertilization treatments	Protein and carbohydrates contents of quinoa seeds							
	Irrigation rates m^3/fed./season							
	Protein %				Carbohydrates %			
	400 m^3/fed	500 m^3/fed	600 m^3/fed	Means	400 m^3/fed	500 m^3/fed	600 m^3/fed	Means
NPK (control)	12.19	13.44	12.31	12.65	67.01	70.00	68.11	68.37
5 m^3/fed. Compost	11.88	12.50	12.06	12.15	65.49	70.91	68.95	68.45
7.5 m^3/fed. Compost	12.81	15.06	13.81	13.89	67.88	72.84	70.80	70.51
10 m^3/fed. Compost	13.13	18.75	15.75	15.88	69.74	74.29	71.99	72.01
Means	12.50	14.94	13.48	---	67.53	72.01	69.96	---
LSD: at 5%								
Irrigation rate (I)		0.90				1.76		
Fertilization (F)		0.85				1.69		
(I x F)		1.80				2.41		

On the other hand, quinoa (*Chenopodium quinoa* Willd) plants responded to the organic fertilization treatments. In the second season, the highest values (15.88 and 72.01 %) from protein and carbohydrates in the second season, respectively) were obtained from plants fertilized with 10m^3 compost compared with NPK fertilizers (12.65 and 68.37 %) in the second seasons, respectively, followed by supplied plants with 7.5 m^3, whereas 5m^3 compost /fed was the least effective fertilization treatment, giving 12.15 and 68.45 % in the second season, respectively. These results agreed with those Hirich *et al.,* (2014) on quinoa.

Regarding the effect of the interaction between irrigation rates and different compost fertilization treatments on the protein and carbohydrates contents in Table (11), the data resulted in the second season showed that, the highest values (18.75 and 74.29 %) for protein and carbohydrates content in the second season, respectively) were obtained from plants irrigated with 500m^3/fed and supplied with the highest fertilization level (10 m^3/fed.).

N, P and K percentages:

It is clear from the results in Table (12) that, significant increases in the N, P and K contents were recorded with different irrigation rates (400,500 and 600m^3/fed). Moreover, 500m^{3}fed gave the highest percentages (2.39, 0.37 and 0.71 %) for N, P and K contents in the second season, respectively. Based on our experimental data, the percentages of N, P and K were decreased by decreasing the irrigation level from 500 to 400m^3/fed. These results are in harmony with the findings of Branka *et al*., (2017) on soybean plants.

As for the effect of different compost treatments, data in Table (12) clear that, in general, raising the rate of compost gave considerable increases in the N, P and K contents. The highest values of these elements were accumulated in plants supplied with the highest compost rate 10 m^3/fed. These results are in close agreement with the findings of Sakr *et al*., (2014)

It was also observed that, the interaction between irrigation rates and compost fertilization treatments on N,P and K contents gave the highest percentages (3.00, 0.54 and 0.92 %) were obtained from plants supplied by 500m^3/fed. with 10m^3/compost fed.

Table 12. Effect of irrigation rates and organic fertilization on nitrogen (N), phosphorus (P) and potassium (K) contents (%) of quinoa seeds (*Chenopodium quinoa* Willd.) in the second season 2016/2017.

Fertilization treatments	Nitrogen (N) %				Phosphorus (P) %				Potassium (K) %			
	Irrigation rates (m^3/fed.)				Irrigation rates (m^3/fed.)				Irrigation rates (m^3/fed.)			
	400 m^3/fed	500 m^3/fed	600 m^3/fed	Mean	400 m^3/fed	500 m^3/fed	600 m^3/fed	Means	400 m^3/fed	500 m^3/fed	600 m^3/fed	Means
NPK (control)	1.95	2.15	1.97	2.02	0.21	0.26	0.21	0.23	0.45	0.55	0.47	0.49
5 m^3/fed. compost	1.90	2.00	1.93	1.94	0.21	0.30	0.25	0.25	0.45	0.62	0.55	0.54
7.5 m^3/fed. compost	2.05	2.41	2.21	2.22	0.23	0.36	0.31	0.30	0.50	0.75	0.55	0.60
10 m^3/fed. compost	2.10	3.00	2.52	2.54	0.28	0.54	0.48	0.43	0.54	0.92	0.80	0.75
Mean	2.00	2.39	2.16	---	0.23	0.37	0.31	---	0.49	0.71	0.59	---
LSD: at 5%												
Irrigation rate (I)	0.14				0.01				0.03			
Fertilization (F)	0.13				0.02				0.04			
(I x F)	0.17				0.03				0.05			

CONCLUSION

Based on the aforementioned discussion, it could be concluded that the application of irrigation at moderate rates (500 m^3 irrigation water + 10m^3compost/fed./season) to quinoa plants recorded the maximum values on growth parameters as well as protein, carbohydrates, N, P and K contents in both seasons, while (400m^3 irrigation water + 10m^3compost/fed./season) resulted in the highest values of saponins and phenols. Despite the increase in saponins when using the rate of 400 m^3 /fed., but it have several benefits such as; increase the resistance of natural plant against pests and insects and used in pharmaceutical industries.

On the other hand, utilization of organic fertilizers had positive effects on growth parameter and chemical composition. In general, it seems that supplied of quinoa with 500 m^3 irrigation water + 10 m^3/fed./season compost is a good practice for achieving high growth and yield.

Due to the high nutritional value of quinoa grains, it can be used as an alternative to wheat, which requires double the consumption of quinoa from irrigation water especially in the water shortage conditions we suffer from it now.

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تأثير معدلات الرى والتسميد العضوى على النمو والمحصول والمواد الفعالة على نبات الكينوا

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أجريت الدراسة الحالية في المزرعة البحثية لمحطة بحوث البساتين بقرية علي مبارك جنوب التحرير بمحافظة البحيرة التابعة لمعهد بحوث البساتين – مركز البحوث الزراعية- مصر.

أجريت هذه الدراسة لدراسة تأثير الري على بمعدلات (400 و 500 و 600 م ^{3} / فدان/الموسم) بالتفاعل مع سماد الكمبوست العضوي عند مستويات (0 و5، 7.5 و 10 م ^{3} / فدان) وذلك علي نبات الكينوا (*Chenopodium quinoa* Willd) خلال الموسمين المتعاقبين 2017/2016 و2018/2017 .

أظهرت نتائج الدراسة أن تطبيق معدل الري المعتدل 500م ^{3} / فدان / موسم) مع أضافة 10 م^3 كمبوست على نبات الكينوا سجل أعلى قيم لارتفاع النبات وعدد الفروع / النبات والوزن الجاف للعشب (جم)، وزن البذور / نبات (جم)، ووزن 1000 بذرة وكذلك محتوي البذور من المواد البروتينية و الكربوهيدرات وكذلك النتروجين والفسفور والبوتاسيوم خلال الموسمين بينما أقل القيم تم الحصول عليها من الري بمعدل 400 م^3/ فدان مع 5 م^3 كمبوست / فدان. إضافة الي ذلك الري بمعدل 400م^3 / فدان بالتفاعل مع 10م^3 كمبوست أعطي أعلي القيم من مركبات الصابونينات والفينولات بينما أقل القيم تم الحصول عليها من الري بمعدل 600 م^3 /فدان مع 5 م^3 كمبوست /فدان.