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Saline Water As Supplementary Irrigation and Plant Spacing in Relation to The Productivity and Quality of Quinoa under Calcareous Soil Conditions

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QUINOA (*Chenopodium quinoa* Wild.), is a pseudo-cereal crop and it is a highly nutritious food product, being cultivated for several thousand years in South America. As well as, it has great potential in the enhancement of food for humans and animals feeding. Two field experiments were conducted during 2016/2017and 2017/2018 winter seasons in calcareous soil at the Experimental Farm of the City of Scientific Researches and Technological Applications in Borg Al-Arab, Alexandria, Egypt. These experiments were conducted to evaluate the effect of supplementary irrigation and planting distance on Quinoa (*Chenopodium quinoa* Wild.) cv. Nat oil yield, yield components, seed quality and water use efficiency using saline water in the arid land. The experiment design was a split plot in three replications. Main plots were assigned to rainfall as well as supplementary irrigation with saline (EC_e 8.3 ds/m) underground water (I_0=rainfed, I_1=one supplementary irrigation + rainfall, I_2=two supplementary irrigation + rainfall, I_3= three supplementary irrigation +rainfall),while the sub-plots were occupied by the plant distance at (15, 20, 25 cm). The results revealed that the highest mean values of most characters and seed yield recorded with the application of three supplementary irrigations + rainfall in the first season and the application of (two or three) supplementary irrigation + rainfall in the second season and sowing the quinoa at 15 cm between plants gave the highest values of characters in both growing seasons.

Keywords: Quinoa, Grain yield, Salinity, Spacing, Supplementary irrigation, Rainfall

Introduction

Due to the lack of available resources in Egypt and the increase in the food gap, thera is a trend towards new crops that could grow in arid and semi-arid lands, where the main crops cannot grow. These crops should have the tolerance to drought and salinity conditions and do not compete with major crops for available resources.Therefore, the aim is to cultivate quinoa in semi-arid lands in Borg El Arab City.

Quinoa (*Chenopodium quinoa* Willd.) is considered a highly important crop in the Andes of Peru and Bolivia more than 5000 years ago (Ruiz et al., 2014) and has attracted attention recently due to its high nutritional value and its high growth potential under extremely harsh conditions of drought and soil salinity. Regardless of the high protein content, the seeds are also rich in amino acids, vitamins, and minerals, which can meet or exceed human requirements. FAO has chosen this crop as one of the main crops to play a key role in ensuring food security in the 21st century because of its high nutritional value and strong resistance to different climatic conditions. Quinoa is a seed crop known for its broad adaptation and high nutritional value. Its center of origin is the Andean Mountains of South America near Lake Titicaca in Peru and Bolivia (Food and Agriculture Organization of the

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United Nations (FAO, 2011). The Incas considered quinoa consecrated; it is known as the (mother grain) and is a staple in the Altiplano districts of the Andes Mountains (National Research Council, 1989). In 2008, Peru and Bolivia represented 90% of worldwide quinoa creation (FAO, 2011). The significant shippers of Bolivian quinoa incorporate the United States (45%), France (16%), and The Netherlands (13%), trailed by Germany, Canada, Brazil, and the United Kingdom (FAO, 2011).

Quinoa contains the majority of the amino acids essential for human, including lysine, isoleucine, leucine, phenylalanine, tyrosine, threonine, tryptophan, valine, histidine, and methionine (Morita et al., 2001). Its protein quality is much higher than that of other grains (Vega-Gálvez et al., 2010). Lysine and amino acids in Quinoa are higher than that in wheat. Quinoa has likewise been accounted for to have more calcium (Ca), phosphorus (P), and iron (Fe) contrasted with maize grain. Water is the principle Treatments constraining crop yield in a great part of the world where precipitation is deficient to fulfill crop need. With the expanding competition for limited water assets worldwide and ever-increasing demand for agricultural commodities, the call to improve the proficiency and profitability of water use for harvest yield, to guarantee food security and address the vulnerabilities related with environmental change, has never been increasingly earnest. Countries facing the scarcity of water resources must focus their attention on the use of non-conventional water resources to partially reduce water scarcity. These resources can be obtained using many methods, such as desalination of seawater, use of groundwater with high salt content, collect rainwater and the use of water resources of marginal quality for irrigation. (Oster and Grattan, 2002 and Corwin et al., 2008).

The water-use productivity systems utilized with ordinary assets have been improved. Be that as it may, water-rare nations should depend more on the utilization of non-customary water assets to incompletely lighten water shortage. In water-rare conditions, such water assets are gotten to through the desalination of seawater and profoundly harsh groundwater, the reaping of water, and the utilization of minimal quality water assets for the water system(Qadir and Oster, 2004).

The utilization of saline and additionally sodic wastewater and groundwater for farming is relied upon to increment. Saltiness is a standout amongst the most harmful abiotic stresses that limit the advancement and profitability of yield, particularly in arid and semi-arid lands. Using salt tolerant species that can tolerate high salinity in soil and allow irrigation with saline water is one of the options proposed recently to mitigate and counteract the adverse effects of salinity in agricultural production (Munns and Tester, 2008 and Koyroet al., 2008). Quinoa possesses great adaptability to different agro-climatic conditions, and it can tolerate drought, frost, heat, salinity, poor soils among others (Jacobsen, 2003, Jacobsen et al., 2003, Mujica et al., 2004, Geerts et al., 2008 and Martínez et al., 2009). Quinoa is one of the promising candidates for sustainable agriculture in salt-affected regions. Quinoais a facultative halophyte and could be used as an alternative cash crop for land and water unsuitable for conventional crops in arid and semi-arid regions (Eisa et al., 2017). Quinoa attracted worldwide attention, during the recent time, because of its exceptional tolerance to various unfavorable environmental conditions (Choukr-Allah et al., 2016). Quinoa could grow and complete its life cycle under high salinity levels equal to those found in seawater (Koyro and Eisa, 2008 & Shabala et al., 2013 and Panuccio et al., 2014).

The objective of this study to evaluate the effect of supplementary irrigation and planting distance on quinoa yield and yield components in the arid land.

Materials and Methods

Two field experiments were conducted during 2016/2017and 2017/2018 winter seasons in calcareous soil at the Experimental Farm of the City of Scientific Researches and Technological Applications in Borg Al-Arab, Alexandria, Egypt, to study the effect of supplementary irrigation and planting distance on Quinoa (*Chenopodium quinoa* Wild.) cv. Nat oil yield, yield components, seed quality and water use efficiency using saline water in the arid land.

Physical and chemical analysis of the soil and organic matter were determinedaccording to Page et al. (1982) at the Agricultural Research Center, Ministry of Agricultural, Egypt. At the depth of 0-30 cm are shown in Table 1.

The prevailing climate in the experimental area for the two seasons was obtained from NASA https://power.larc.nasa.gov/ and Weather underground https://www.wunderground.com/ websites are shown in Table 2.

Quinoa seeds obtained from the desert research center, Egypt drilled by hand in the hill on December 7th in the two seasons, respectively.

TABLE 1. Physical and chemical properties of the experimental soil before sowing in the two seasons

Properties	2016/2017	2017/2018
Mechanical:		
Clay %	20.6	20.6
Silt %	16.3	16.3
Sand %	63.1	63.1
Texture	Sandy clay loam	Sandy clay loam
Soluble Cations & anions (meq/L) in soil paste		
PH** (1:2.5)	8.55	8.5
E.C (ds/m) in soil paste	1.08	1.15
Ca^{2+}	3	3
Mg^{2+}	0.1	0.1
Na^{+}	11	12
K^{+}	1.3	1.5
HCO_3^-	4.4	4
Cl^-	0.4	0.37
Total N%	----	----
Available Nitrogen (mg/Kg)		
NH_4^+	119	147
NO_3^-	119	119
Available potassium (mg/Kg)	420	410
Available Phosphorus (mg/Kg)	5.1	3.9
Total carbonate %	32.5	32.5
Organic matter %	0.82	0.93

TABLE 2. Average mean of monthly temperature, relative humidity, and rainfall
S.= Sun, T.=Temperature, R.= Relative, and HUM.= Humidity

Season	Month	S. Radiation	T. MAX (^{0}C)	T. MIN (^{0}C)	RAIN (mm)	R.HUM (%)
2016/2017	Dec.	11.9	20.0	12	50.1	67.5
	Jan.	12.6	20.0	11	5.7	68.4
	Feb.	15.7	27.0	13	12.9	67.4
	Mar.	20.5	28.0	17	0.3	63.5
	Apr.	24.5	36.0	19	91.1	59.6
	May	27.6	39.0	22	0.1	55.9
2017/2018	Dec.	10.8	28.0	16	8.7	70.3
	Jan.	12.5	23.0	13	41.0	69.1
	Feb.	14.7	26.0	16	11.6	65.2
	Mar.	20.3	33.0	19	1.3	55.6
	Apr.	24.4	36.0	21	5.6	54.7
	May	26.6	41.0	20	0.02	54.1

The experiment was laid out in a split plot design in three replications in the two seasons. Main plots were assigned to supplementary irrigation (Rainfall only, Rainfall + one supplementary irrigation, Rainfall + two supplementary irrigation, and Rainfall +three supplementary irrigation), while plant spacing allocated sub-plots (15, 20 and 25 cm).
Underground water was used for supplementary irrigation with EC 8.3 ds/m.

The experimental fields were fertilized with 55 kg P_2O_5/ha during seedbed preparation. It was added and well mixed with the soil before sowing, raking it in lightly at a depth of 10-15 cm. The rate of nitrogen fertilizer was 238 kg N/ha. Nitrogen fertilizer in the form of ammonium nitrate (33.5% N) was applied in two equal doses at sowing and at the first irrigation and in the treatment of rainfall the nitrogen fertilizer was added during the rainfall.

And for the second seasons because of a little amount of rainfall, the treatment of rainfall only was canceled.The supplementary irrigation was added monthly.

The plot size was 6 m^2 (2 x 3 m). Each plot included 4 rows. Each hill contained one plant after thinning.

Fresh weight, leaf: steam ratio, dry weight (g/plant), plant height (cm), biological yield (kg/ha.), seed yield (g/plant), seed yield (kg/ha.), straw yield (kg/ha.), harvest index % (HI), and1000-seed weight (g) were studied in both seasons. On the other hand, flour of seeds was taken at harvest and then NIRS method (Ozaki et al., 2007) was used to determine i.e.:protein (%), fat (%), ash (%), fiber (%), carbohydrates (%), N (%), Na (mg/100g), K(mg/100g), Ca(mg/100g), Mg(mg/100g), and Fe(mg/100g).

Data collected for the two experiments were subjected to analysis of variance according to the procedure outlined by Gomez and Gomez (1984). All statistical analysis was performed using the statistical analysis system (SAS) computer software (1999). Treatment means were compared using Fisher's least significant difference (LSD) test at P = 0.05.

Results and Discussion

Growth

Means of fresh weight (g) leaf: steam ratio and dry weight at 90 days after sowing (DAS) for the two seasons are presented in Table 3.

Supplementary irrigation effects

Supplementary irrigation with saline water had no significant effect on all the mentioned growth traits at the two seasons.

Plant spacing effects

Plant spacing exerted a significant effect on all studied growth traits at the two seasons, except for leaf: steam ratio. Plants sown at distance 15 cm significantly exceeded those planted with distance 25cm but there was no significant difference between plants sown at distance 15 cm and 20 cm for the fresh weight g/plant at the first season. On the other hand, for the second season plants sown at distance 20 cm was among those treatments having a high value compared with the other treatments.

Also, Plants sown at distance 15 cm significantly exceeded those planted with distance 25cm but there was no significant difference between plants sown at distance 15 cm and 20 cm for the dry weight accumulation g/plant at the first season. Whereas, in the second seasonthe highest value of the fresh weight and dry weight (g/plant) was obtained by sowing at distance 20 cm compared with the other treatments.These results are in agreement with those achieved by Isobeet al. (2015) who found that at a lower planting spacing and more extensive row width plots, the fresh weight and dry weight/plant was higher than that in higher planting spacing and smaller row width plots. In this manner, he presumed that quinoa variety NL-6 needs from 50 to 100 plants for each m^{-2} to get high dry weight paying little mind to plant spacing and ridge width.

Yield and yield components

The results pertaining to plant height (cm), biological yield (kg/ha), seed yield (g/plant), straw yield (kg/ha), Harvest Index (HI) and 1000 seed weight for the two seasons as influenced by supplementary irrigation and distance between plants were presented in Tables 3, 4 and 5.

Supplementary irrigation effects

Supplementary irrigation with saline water had a significant effect on all the mentioned yield traits except the harvest index.The integration among rainfall and one supplementary irrigation resulted in a significant increase in plant height compared with rainfall alone at the first season, but there was no significant difference between this treatment and the third and fourth treatments. And it had no effect on this trait in the second season. The increase in biological and seed yield obtained from the application of three supplementary irrigation in addition to the rainfall in the two seasons. Yield results in 2017 and 2018 season showed similar trends. Irrigated treatments had increased yields compared to dryland treatments. Climate condition had the main role in seed yield across seasons. In 2017 and 2018 seasons, the maximum temperatures reached 41°C. Air temperature exceeding 35°C has been shown to cause plant pollen sterility in many quinoa accessions (Hafidet al., 2005), which leads to poor seed set and low yield. In Washington State, low yields in quinoa have been reported in areas that experience high

TABLE 3. Fresh weight (g/plant), Leaf/steam ratio, dry weight (g/plant) and plant height (cm) of quinoa cv. Nat oil as affected by supplementary irrigation and plant spacing

Treatments	Fresh weight (g)		Leaf: steam ratio		Dry weight (g)		Plant height (cm)	
	Season							
	2016/2017	2017/2018	2016/2017	2017/2018	2016/2017	2017/2018	2016/2017	2017/2018
Irrigation (I)								
I0	155.7 a	-	0.166 a	-	48.9 a	-	64.8 b	-
I1	171.5 a	156.8 a	0.198 a	0.301 a	49.0 a	35.9 a	71.6 a	35.3 a
I2	183.2 a	170.5 a	0.184 a	0.276 a	55.2 a	36.1 a	68.1 ab	40.4 a
I3	205.2 a	233.6 a	0.186 a	0.291 a	56.8 a	43.8 a	69.3 ab	42.3 a
Plant spacing (cm). (S)								
15	208.8 a	172.3 b	0.181 a	0.256 a	58.5 a	37.0 b	67.8 a	40.4 a
20	166.4 ab	236.3 a	0.175 a	0.343 a	50.3 ab	48.2 a	70.9 a	37.9 a
25	161.5 b	152.3 b	0.193 a	0.270 a	48.7 b	30.6 b	66.6 a	39.8 a
Interaction								
I x S	NS	*	NS	NS	NS	*	NS	NS

I0=rainfed, I1=one irrigation, I2=two irrigation, I3= three irrigation, Means followed by the same letter are not significant at 0.05, *: significant difference at 0.05 level of probability and NS. Not significant difference at 0.05 level of probability.

heat (Peterson, 2013).Temperatures above 30°C happened at various phases of plant development every year. In 2017 most of the high temperatures happened in April. This was toward the end of the growing season after flowering and initial seed set. In 2018, the high temperatures came earlier in March. These dates coincided with flowering which can affect seed set and maturity. Irrigation may partially reduce heat stress and increase seed yield. In both years the irrigated plots had much higher yields than the non-irrigated plots. These results are in harmony with those reported by Martinez et al. (Martinez, 2009).who found higher yields in the higher irrigation treatments within each location in Chile. Also, results show that the highest values of the straw yield were obtained from the treatment of rainfall in addition two three supplementary irrigations at the two seasons. Whereas for the 1000 seed weight at the first season the increase in the 1000 seed weight obtained from the application of one supplementary irrigation in addition to the rainfall at the first season, and from the application of two supplementary irrigation in addition to the rainfall at the second season.

Effect of plant spacing

Plant spacing had a significant effect on all the mentioned yield traits, except for plant height, seed yield per plant at the two seasons, straw yield at the second season, harvest index and 1000 seed weight at the first season.

Plants sown at distance 15 cm resulted in a significant increase on all yield traits compared with the other treatments. Similar results were reported by (Erazzúet al., 2016) on quinoa. They found that rising plant planting spacing from 70.000 to 460.000 plants h-1, resulted in reducing grain yield from 5,389 to 3,049 kg ha-1, respectively. The addition of grain diameter was related to low planting spacing. Thousand seeds weight reduced as plant spacing increased and this is a possible explanation for the strength loss. This may be also attributed to the potential plant-to-plant competition on available resources, water, and nutrients as reported by (Abd El-Hamed et al., 2011). The plant populations which produced the highest seed yield (40 plants/m2 or higher) produced lower quality seed than plant populations below 40 plants/m2 (Rahman et al., 2005). On the other hand (Speharand Rocha 2009). studied the effect of increasing of densities in the range of 100,000 to 600,000 plants ha-1 on quinoa genotype 4.5, and they found that the analyses of 1000-seeds weight, biomass and grain yield were not affected by increasing plant spacing, resulting in non-significant effects. As a result of low plant spacing, a higher weight of 1000-seeds was attained in relative to high plant spacing. Such an increase in weight of 1000-seeds was associated with the increment in seed diameter. Seed size character is very important for global market demand for quinoa (Adolf et al., 2013) and (González-Teuber et al., 2018).

TABLE 4. Biological yield (kg/ha), seed yield (kg/ha) and seed yield (g/plant) of quinoa cv. Nat.Oil 1 as affected by supplementary irrigation and distance between plants.

Treatments	Biological yield (kg/ha)		Seed yield (kg/ha)		Seed yield (g/plant)	
	Season					
	2016/2017	2017/2018	2016/2017	2017/2018	2016/2017	2017/2018
Irrigation (I)						
I0	6576.1 c	-	2602.4 c	-	24.9 b	-
I1	8113.4 bc	4009.5 b	3599.9 b	828.8 b	34.7 a	8.5 a
I2	8713.5 b	5909.6 a	3656.9 b	1240.8 a	34.2 a	11.9 a
I3	10875.7 a	6122.1 a	4443.1 a	1171.1 a	42.1 a	11.1 a
Plant spacing (cm): (S)						
15	11436.9 a	5867.4 a	4648.5 a	1402.7 a	35.0 a	11.0 a
20	7763.6b	4890.4 b	3314.1 b	959.0 b	32.4 a	9.5 a
25	6508.5 b	5283.5 ab	2764.1 b	878.9 b	34.6 a	11. a
Interaction						
I x S	NS	**	NS	NS	NS	NS

I0=rainfed, I1=one irrigation, I2=two irrigation, I3= three irrigation, Means followed by the same letter are not significant at 0.05, *: significant difference at 0.05 level of probability and NS. Not significant difference at 0.05 level of probability.

TABLE 5. Straw yield (kg/ha), harvest index (HI) and 1000 seed weight (g) of quinoa cv. Nat.Oil 1 as affected by supplementary irrigation and distance between plants.

Treatments	Straw yield (kg/ha)		HI (%)		1000 seed weight (g)	
	Season					
	2016/2017	2017/2018	2016/2017	2017/2018	2016/2017	2017/2018
			Irrigation (I)			
I0	3973.6 b	-	39.8 a	-	2.7 c	-
I1	4119.4 b	3180.8 b	41.4 a	21.0 a	3.1 a	2.6 c
I2	5238.9 ab	4668.8 a	42.2 a	21.4 a	2.9 b	2.9 a
I3	6432.5 a	4951.0 a	46.6 a	18.9 a	3.0 b	2.8 b
			Plant spacing (cm): (S)			
15 cm	6561.1 a	4464.7 a	40.9 a	24.8 a	2.8 a	3.0 a
20 cm	4459.8 b	3931.4 a	44.3 a	20.1 b	2.9 a	2.7 b
25 cm	3802.5 b	4404.5 a	42.3 a	16.4 c	3.0 a	2.7 b
Interaction						
I xS	NS	**	NS	**	**	**

I0=rainfed, I1=one irrigation, I2=two irrigation, I3= three irrigation, Means followed by the same letter are not significant at 0.05, *: significant difference at 0.05 level of probability and NS. Not significant difference at 0.05 level of probability.

Seed chemicals and minerals components

The results pertaining to protein, fat, ash, fiber, carbohydrate percentages,Na(mg/100g), K(mg/100g), Ca(mg/100g), Mg(mg/100g) and Fe(mg/100g) for the two seasons as influenced by supplementary irrigation and distance between plants were presented in Tables 6-9.

Supplementary irrigation effects

Supplementary irrigation with saline water had a significant effect on all the mentioned chemicals and minerals components except protein, carbohydrate, Na, K, Ca and Fe percentages at the first season and Mg percentages at the two seasons. at the first season, there was no significant difference between the use of rainfall only or add one or three supplementary irrigations on the fat percentage, while there was no significant difference between using two or three supplementary irrigations on ash and fiber percentages. On the other hand at the second season. The integration among rainfall and two supplementary irrigations resulted in a significant increase in moisture, fat and carbohydrate percentages compared with other treatment, but there was no significant difference between this treatment and application of one supplementary irrigation on K and Ca percentages. Whereas the integration among rainfall and one supplementary irrigation had the heights values on protein, ash, fiber, Na and Fe at the second season. Maybe the smallest seed had a high concentrate of protein and other minerals. This result was in contradiction with those reported by Koyro and Eisa (2007) who showed that plant height, the number of seeds, seed yield, dry weight of seeds was significantly reduced by salinity. Except at the levels of high salinity proteins % also total Nitrogen had increased significantly in the seeds while the content of total carbohydrates (also total C) had decreased. In addition, the germination ability decreased by reducing seed size. At the high levels of salinity, the seed coat prevented the passing of Na and Cl to the seed inner. a clear tendency was found between tolerating toxic elements (Na and Cl) and elements which is ultimately necessary (Mg, Ca, K, S, and P) across the seed coat of salt-treated plants also a significant change of the allocation of elements in the embryo. The results showed that because of the highly preserved seed inner it led to a high salinity tolerant of quinoa seeds. Koyro and Eissa (2008) illustrated that quinoa is a salt resistance plant and can survive even use 100% sea water for irrigating the plants. However, the number of seeds, the growth, weight, the yield, and seed dry matter per plant gradually decreased in the presence of salinity. The proteins % (also total N) increased significantly in the seeds whereas the content of total carbohydrates (also total C) decreased uncommonly leading to a decreased C/N ratio. At the high concentrations of salinity, the passing of NaCl into the seed was blocked. There seems to be a connection between these effects, the salt-resistant of the plant and a possible pre-adjustment of the produced seed to saline conditions.

Plant spacing effects

Plant spacing had a significant effect on all the mentioned traits, except for carbohydrate, Na, K, Ca and Mg at the first season. And for Fe at the two seasons. The highest value of moisture percentage obtained from planted with distance 25 cm at the second season, furthermore The highest value of protein percentage obtained from planted with distance 20 cm at the two seasons, moreover The highest value of fat percentage obtained from planted with distance 15 or 20 cm at the first season and with distance 15 cm at the second season, As well as The highest value of ash percentage obtained from planted with distance 20 cm at the two seasons, Also The highest value of fiber percentage obtained from planted with distance 20 cm at the two seasons, and The highest value of carbohydrate percentage obtained from planted with distance 25 cm at the second season. Whereas there was no significant difference between planted with distance 15 or 20 cm on Na and Mg(mg/100g) at the second on the other hand the highest values of K and Ca(mg/100g) were obtained from planted with distance 15 cm at the second season.These results are in agreement with those obtained by Bhargava et al. (2007) they indicated that the most biological yield was acquired at 25 cm distance for15 November sowing date (18.99 tons/ha) in 2003-04, and at 20 cm dividing for 30 November sowing date in 2004-05 (13.90 tons/ha). Late sowing around 15 December gave the least yield for every one of the spacings. Carotenoid at 15 cm distance and 30 November sowing date for both 2003-04 and 2004-05 was (1.06 mg/g and 1.09 mg/g individually). In both seasons, protein content for 30 November sowing date at 15 cm spacing was (3.88 g/100 g for both years). Protein content was reduced in the plants that were developed at 25 cm spacing in all the sowing dates. The mean protein substance of the considerable number of harvests was least in 15 December sowing date for all line spacings in both years.González (2018) demonstrated that Seed yield increased by 34.7% with the increase of plant spacing from 56.000

plant ha^{-1} to 167.000 plant ha^{-1}. The increase of plant spacing essentially diminished the weight of 1000-seeds and weight of hectoliter. Protein in seeds increased at low planting spacing, though starch was decreased. There were no differences between the two planting densities on the seed content of the fiber or absolute fat. The impacts of plant spacing on the mineral substance in quinoa seeds, the calcium, and magnesium substance increased at low spacing contrasted and high planting spacing. Then, no impacts of plant spacing on phosphorus, potassium, iron and zinc content in quinoa seeds were identified. Accordingly, the present examination reasons that the plant spacing that gives higher seed yield is related to a decrease in seed quality as far as protein content. Then again, low plant spacing increased the heaviness of 1000-seeds and hectoliter, which is reflected in the seed measure.

TABLE 6. protein, fat and ash percentages of quinoa cv. Nat.Oil 1 as affected by supplementary irrigation and distance between plants

Treatments	Protein (%)		Fat (%)		Ash (%)	
	Season					
	2016/2017	2017/2018	2016/2017	2017/2018	2016/2017	2017/2018
	Irrigation (I)					
I0	15.6 a		5.7 a		2.8 b	
I1	15.9 a	18.01 a	5.5 ab	5.3 b	2.7 b	3.8 a
I2	15.8 a	16.36 b	5.5 b	5.4 a	2.8 ab	2.9 b
I3	15.7 a	16.28 b	5.5 ab	5.3 ab	2.9 a	2.9 c
Plant spacing (cm): (S)						
15 cm	15.6 b	16.7b	5.6 a	5.5 a	2.7 b	3.1 b
20 cm	16.1 a	17.4 a	5.7 a	5.2 c	2.9 a	3.5 a
25 cm	15.5 b	16.6 c	5.4 b	5.4 b	2.7 b	2.9 c
Interaction						
I xS	NS	**	**	**	**	**

I0=rainfed, I1=one irrigation, I2=two irrigation, I3= three irrigation, Means followed by the same letter are not significant at 0.05, *: significant difference at 0.05 level of probability and NS. Not significant difference at 0.05 level of probability.

TABLE 7. fiber, carbohydrate, and nitrogen percentages of quinoa cv. Nat.Oil 1 as affected by supplementary irrigation and distance between plants.

Treatments	Fiber (%)		Carbohydrate (%)		N (%)	
	Season					
	2016/2017	2017/2018	2016/2017	2017/2018	2016/2017	2017/2018
	Irrigation (I)					
I0	4.0 b	-	71.9 a	-	2.5 a	-
I1	3.8 c	5.7 a	72.1 a	67.1 b	2.5 a	2.9 a
I2	4.1 a	4.3 b	71.8 a	70.9 a	2.5 a	2.6 b
I3	4.2 a	4.0 c	71.3 a	71.5 a	2.5 a	2.6 b
Plant spacing (cm): (S)						
15 cm	3.9 b	4.5 b	71.9 a	70.2 b	2.5 b	2.7 b
20 cm	4.2 a	5.2 a	71.1 a	68.5 c	2.6 a	2.8 a
25 cm	4.0 b	4.3 c	72.3 a	70.8 a	2.5 b	2.7 c
Interaction						
I xS	**	**	NS	**	NS	**

I0=rainfed, I1=one irrigation, I2=two irrigation, I3= three irrigation, Means followed by the same letter are not significant at 0.05, *: significant difference at 0.05 level of probability and NS. Not significant difference at 0.05 **level of probability.**

TABLE 8. Na(mg/100g), K(mg/100g) and Ca(mg/100g) of quinoa cv. Nat.Oil 1 as affected by supplementary irrigation and distance between plants

Treatments	Na (mg/100g)		K (mg/100g)		Ca (mg/100g)	
	Season					
	2016/2017	2017/2018	2016/2017	2017/2018	2016/2017	2017/2018
			Irrigation (I)			
I0	85.3 a	-	807.9 a	-	130.6 a	-
I1	85.2 a	87.9 a	807.5 a	809.9 a	130.4 a	133.3 a
I2	85.5 a	85.6 b	807.5 a	808.5 ab	132.1 a	131.5 ab
I3	85.5 a	85.6 b	808.6 a	808.2 b	131.5 a	130.6 b
			Plant spacing (cm): (S)			
15 cm	85.3 a	86.7 a	807.5 a	809.4 a	130.8 a	132.6 a
20 cm	85.7 a	86.7 a	808.4 a	808.6 b	132.2 a	131.2 c
25 cm	85.2 a	85.7 b	807.9 a	808.6 b	130.4 a	131.5 b
Interaction						
I xS	NS	**	NS	NS	NS	**

I0=rainfed, I1=one irrigation, I2=two irrigation, I3= three irrigation, Means followed by the same letter are not significant at 0.05, *: significant difference at 0.05 level of probability and NS. Not significant difference at 0.05 level of probability.

TABLE 9. Seed Mgand Fe content of quinoa cv. Nat.Oil 1 as affected by supplementary irrigation and distance between plants in both seasons

Treatments	Mg (mg/100g)		Fe (mg/100g)	
	Season			
	2016/2017	2017/2018	2016/2017	2017/2018
Irrigation (I)				
I0	128.6 a	-	13.2 a	-
I1	128.4 a	129.6 a	13.2 a	14.0 a
I2	129.0 a	128.6 a	13.3 a	13.3 b
I3	128.6 a	128.7 a	13.3 a	13.2 b
Plant spacing (cm). (S)				
15	128.8 a	129.1 a	13.2 a	13.5 a
20	128.8 a	129.2 a	13.4 a	13.6 a
25	128.4 a	128.6 b	13.2 a	13.4 a
Interaction				
I xS	NS	*	NS	NS

I0=rainfed, I1=one irrigation, I2=two irrigation, I3= three irrigation, Means followed by the same letter are not significant at 0.05, *: significant difference at 0.05 level of probability and NS. Not significant difference at 0.05 level of probability

Conclusion

We can conclude that quinoa can help in the self-sufficiency of food in Egypt since the greatest threat to the survival of humanity is the ever-increasing gap between population growth and food supply. Quinoa the newly introduced food crop can be cultivated in marginal lands, since; the crop is drought, salinity tolerant and can grow in the sandy soil of arid and semiarid regions and with other most harmful abiotic adverse Treatments that affect crop production. Quinoa would provide bread and other seed products for Bedouins who inhabit deserts, where quinoa is a highly nutritious food crop, with an outstanding protein quality and a high content of a range of vitamins and essential minerals. Quinoa has enormous potential in the food industry being gluten-free and highly nutritious. It can be concluded that the application of three supplementary irrigation along with sowing at distance 15 cm could be recommended for optimum seed yield of quinoa cv. Nat oil.

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الماء الملحي كري تكميلي ومسافات الزراعة وعلاقتهم بانتاجية وجودة محصول الكينوا تحت ظروف الاراضي الجيرية.

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يعد محصول الكينوا من اهم المحاصيل التى تزرعه قبائل الإنكا في جبال الإنديز في بيرو وبوليفيا منذ أكثر من ٥٠٠٠ سنة ، حيث إستخدمه المحاربين القدماء كغذاء لهم لما له من قيمة غذائية عالية وفي لغتهم يطلقون عليه «شيسيا ماما» والتى تعنى (أم الحبوب) وبلغت من أهمية هذا المحصول وتقديسهم له انه في كل عام يبدأ الإمبراطور موسم الزراعة بغرس حبه منه بفأس من ذهب .ترجع أهمية المحصول الي إحتوائه علي نسبة عالية من البروتين مقارنة بالحبوب الأخري ، كما يوجد الحامض الأميني الليسين في بروتين الحبوب بنسبة تصل إلي ضعف المتواجد منه في بروتين القمح وتحتوي الحبوب ايضاً علي نسبة عالية من كافة المعادن الضرورية للغذاء وبخاصة الكالسيوم والحديد والتى تفوق المتواجدة في باقي الحبوب بالاضافة الى محتواها العالي من مضادات الاكسدة الفلافونيدات flavonoids وبشكل خاص نوعين منهما (Kaempferol، Quercetin) وبالتالي دورها في علاج مرض السكري هذا بالإضافة الي إحتواء الحبوب علي نسبة عالية من الفيتامينات وبنسب أعلي من الحبوب الأخري وبقيم تلبي أو تتجاوز متطلبات الإنسان.ونظراً لأهمية المحصول فقد تم إختياره من قبل منظمة الأغذية والزراعة باعتباره أحد المحاصيل الرئيسية التى ستلعب دوراً رئيسياً في ضمان الأمن الغذائي في القرن ال ٢١ بسبب قيمته الغذائية العالية ومقاومته الشديدة للظروف المناخية المعاكسة .ونظراً للقيمة الغذائية العالية لهذة الحبوب إستخدمته وكالة الفضاء الأمريكية ناسا كغذاء متوازن وكامل لرواد سفن الفضاء . لذا فقد أجريت هذة الدراسة بهدف

١- دراسة تأثير الري التكميلى بمياه ملحية علي انتاجية و جودة محصول الكينوا
٢- دراسة تأثير مسافات الزراعة علي انتاجية و جودة محصول الكينوا
٣- دراسة التداخل بين الري التكميلى ومسافات الزراعة علي انتاجية و جودة محصول الكينوا

وذلك لتحقيق الأهداف الآتية :

١. في ضوء الزيادة السكانية المتزايدة ومحدودية الموارد التي تواجهها مصر اليوم والذي يؤدي بدوره الي عدم إنتاج ما يكفي من الغذاء من حيث الكم والنوع لتلبية الاحتياجات اليومية للمواطنين ، ومن هنا ظهرت الحاجة الي محاصيل غذائية جديدة غير تقليدية للزراعة خارج نطاق الوادي والدلتا لعدم منافسة المحاصيل التقليدية وذات احتياجات مائية منخفضة وتتحمل الإجهادات البيئية المختلفة .فإذ بمحصول الكينوا يطرح نفسه بقوة كأحد محاصيل المستقبل الواعدة المكملة وليست البديلة لسد جزء من الفجوة الغذائية في مصر . حيث أن زراعة المحاصيل الحقلية تحت الظروف القاسية من بيئة قاحلة في التربة الرملية والملحية واستخدام مياه الري ذات الملوحة العالية هي واحدة من أكبر التهديدات التي تواجه الأمن الغذائي وخاصة بالنسبة للمزارعين أصحاب الحيازات الصغيرة .

٢. محصول الكينوا كمحصول غذائي تم إدخاله حديثاً يمكن أن يعالج جزء من الفجوة الغذائية ، حيث يتميز المحصول بتحمله للجفاف والملوحة وينمو في التربة الرملية في المناطق القاحلة وشبه القاحلة ومع العوامل السلبية غير الحيوية الأخري الأكثر ضرراً والتي تؤثر علي إنتاج المحاصيل .

ويعتقد ان الكينوا يمكن أن تلعب دوراً هاماً في القضاء علي الجوع وسوء التغذية والفقر وخاصة في البلدان النامية .

كما تساعد منظمة الأغذية والزراعة FAO مصر في مجال الأمن الغذائي من خلال إدخال أصناف كينوا جديدة واعدة للتقييم تحت الظروف المصرية ونقل التكنولوجيا والتدريب من خلال المشروع الإقليمي للكينوا « المعونة الفنية للتعريف بمحصول الكينوا وإنتاجها في كل من مصر ، الجزائر ، العراق ، إيران ، لبنان ، موريتانيا ، السودان واليمن»

لذا فقد أجريت تجربتان حقليتان خلال موسمي زراعة ٢٠١٧/٢٠١٦ و ٢٠١٨/٢٠١٧ في تربة جيرية الخاصة بالمزرعة التجريبية بمدينة الأبحاث العلمية والتطبيقات التكنولوجية ببرج العرب- الاسكندرية- مصر، علي التوالي . وتهدف التجربة الي دراسة تأثير الري التكميلى بمياه ملحية ومسافات الزراعة علي انتاجية و جودة محصول الكينوا.

وتتلخص أهم النتائج كما يلى:
لم يكن للري التكميلي بالماء الملحي أي تأثير معنوي علي كل صفات النمو المدروسة خلال الموسمين.

كانللكثافة النباتية تأثيرًا معنوياً كبيرًا على جميع صفات النمو المدروسة في الموسمين ، باستثناء نسبة الأوراق: السيقان. تفوقت النباتات المزروعة بمسافة ١٥ سم بشكل ملحوظ علي تلك المزروعة بمسافة ٢٥ سم ولكن لم يكن هناك فرق معنوي كبير بين النباتات المزروعة بمسافة ١٥ سم و ٢٠ سم للوزن الطازج / نبات في الموسم الأول ، من ناحية أخرى ، في الموسم الثاني اعطت النباتات المزروعة بمسافة ٢٠ سم أعلي القيم بالنسبة للوزن الطازج / نبات.وقد اثرت تفاعلات الدرجة الأولى معنوياً فقط على الوزن الطازج / نبات ووزن جاف / نبات في الموسم الثاني.

أوضحت النتائج انه كان للري التكميلي بالمياه المالحة تأثير كبير على جميع الصفات المحصول المدروسة باستثناء دليل الحصاد. أدى استخدام رية واحدة تكميلية بالإضافة الي ماء المطر إلى زيادة كبيرة في ارتفاع النبات مقارنة مع مياه الأمطار وحدها في الموسم الأول ، ولكن لم يكن هناك فروق معنوية بين هذه المعاملة والمعاملات

الثالثة والرابعة. ولم يكن له أي تأثير على هذه الصفة في الموسم الثاني. تم الحصول علي اعلي القيم في المحصول البيولوجي والبذورعند تطبيق ثلاثة ريات تكميلية بالإضافة إلى مياه الأمطار في الموسمين.

تظهر البيانات أيضًا أنه تم الحصول على أعلى قيم لمحصول القش من معاملة مياه الأمطار بالإضافة إلى اثنين أو ثلاث ريات تكميلية في الموسمين. أما بالنسبة للزيادة في وزن ١٠٠٠ بذرة في الموسم الأول ، تم الحصول عليها من تطبيق رية تكميلية واحدة بالإضافة إلى مياه الأمطار في الموسم الأول ، وتطبيق ريتين تكميليتين بالاضافة الي ماء المطر في الموسم الموسم الثاني.

كان للكثافة النباتية تأثير كبير على جميع صفات المحصول المذكورة ، باستثناء ارتفاع النبات ، محصول البذور لكل نبات في الموسمين ، محصول القش في الموسم الثاني ، دليل الحصاد ، ووزن ١٠٠٠ بذرة في الموسم الأول. أعطت النباتات المزروعة بمسافة ١٥ سم أعلي القيم مقارنة بالمعاملات الأخرى في كل صفات المحصول.

كان للري التكميلي بالمياه المالحة تأثير كبير على جميع المكونات الكيميائية والمعادن المذكورة باستثناء نسب البروتين والكربوهيدرات والصوديوم و البوتاسيوموالكالسيومو الحديد في الموسم الأول ونسب الماغنيسيوم في الموسم الثاني. في الموسم الأول ، لا يوجد فرق معنوي بين استخدام مياه الأمطار فقط أو إضافة واحد أو ثلاثة ريات تكميلية على نسبة الدهون ، في حين لم يكن هناك فرق معنوي بين استخدام اثنين أو ثلاثة ريات تكميلية على نسب الرماد والألياف. من ناحية أخرى في الموسم الثاني ، أدى التوليف بين هطول الأمطار وريتين تكميليتين إلى زيادة كبيرة في نسب الرطوبة والدهون والكربوهيدرات مقارنة مع المعاملات الأخرى ، ولكن لم يكن هناك فرق معنوي بين استخدام هذة المعاملة وتطبيق رية تكميلية واحدة علىالنسب المئوية لـK و Ca . في حين أن التوليف بين مياه الأمطار رية تكميلية واحدةاعطي اعلي قيم للبروتين ، والرماد ، والألياف ، و الصوديوم و الحديد في الموسم الثاني.

كان لكثافة النباتية تأثير معنوي على جميع الصفات المذكورة ، باستثناء الرطوبة والكربوهيدرات و والصوديوم و البوتاسيوموالكالسيوم والماغنسيوم في الموسم الأول. وللحديد في الموسمين. تم الحصول علي أعلى نسبة للبروتين من الزراعة علي مسافة ٢٠ سم في الموسمين ، علاوة على ذلك تم الحصول علي أعلى قيمة لنسبة الدهون من الزراعة علي مسافة ١٥ أو ٢٠ سم في الموسم الأول ومسافة ١٥ سم في الموسم الثاني ، وكذلك تم الحصول علي أعلى قيمة لنسبة الرماد من الزراعة علي مسافة ٢٠ سم في الموسمين ، وكذلك أعلى قيمة لنسبة الألياف التي تم الحصول عليها من الزراعة علي مسافة ٢٠ سم في الموسمين ، وأعلى قيمة نسبة الكربوهيدرات اتم الحصول عليها من الزراعة مسافة ٢٥ سم في الموسم الثاني. بينما لم يكن هناك فرق معنوي بين الزراعة علي مسافة ١٥ أو ٢٠ سم على الصوديوم و الماغنسيوم في الموسم الثاني ،و تم الحصول على أعلى قيم للبوتاسيوم والكالسيوم من الزراعة علي مسافة ١٥ سم في الموسم الثاني.