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 Willd.), 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 2016/2017 and 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 Willd.) 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 (ECₑ 8.3 ds/m) underground water (I₀=rainfed, I₁=one supplementary irrigation + rainfall, I₂=two supplementary irrigation + rainfall, I₃=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, there 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...
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 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 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-custodial 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 (Oster and Grattan, 2002 and Corwin et al., 2008).

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 abiatic 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 Koyro et 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. Quinoa is 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 determined according 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

<table>
<thead>
<tr>
<th>Properties</th>
<th>2016/2017</th>
<th>2017/2018</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mechanical:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clay %</td>
<td>20.6</td>
<td>20.6</td>
</tr>
<tr>
<td>Silt %</td>
<td>16.3</td>
<td>16.3</td>
</tr>
<tr>
<td>Sand %</td>
<td>63.1</td>
<td>63.1</td>
</tr>
<tr>
<td>Texture</td>
<td>Sandy clay loam</td>
<td>Sandy clay loam</td>
</tr>
<tr>
<td><strong>Soluble Cations &amp; anions (meq/L) in soil paste</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PH** (1:2.5)</td>
<td>8.55</td>
<td>8.5</td>
</tr>
<tr>
<td>E.C (ds/m) in soil paste</td>
<td>1.08</td>
<td>1.15</td>
</tr>
<tr>
<td>Ca²⁺</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Mg²⁺</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td>Na⁺</td>
<td>11</td>
<td>12</td>
</tr>
<tr>
<td>K⁺</td>
<td>1.3</td>
<td>1.5</td>
</tr>
<tr>
<td>HCO₃⁻</td>
<td>4.4</td>
<td>4</td>
</tr>
<tr>
<td>Cl⁻</td>
<td>0.4</td>
<td>0.37</td>
</tr>
<tr>
<td><strong>Total N%</strong></td>
<td>----</td>
<td>----</td>
</tr>
<tr>
<td><strong>Available Nitrogen (mg/Kg)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NH₄⁺</td>
<td>119</td>
<td>147</td>
</tr>
<tr>
<td>NO₃⁻</td>
<td>119</td>
<td>119</td>
</tr>
<tr>
<td><strong>Available potassium (mg/Kg)</strong></td>
<td>420</td>
<td>410</td>
</tr>
<tr>
<td><strong>Available Phosphorus (mg/Kg)</strong></td>
<td>5.1</td>
<td>3.9</td>
</tr>
<tr>
<td><strong>Total carbonate %</strong></td>
<td>32.5</td>
<td>32.5</td>
</tr>
<tr>
<td><strong>Organic matter %</strong></td>
<td>0.82</td>
<td>0.93</td>
</tr>
</tbody>
</table>

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.

TABLE 2. Average mean of monthly temperature, relative humidity, and rainfall

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

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\(_2\)O\(_5\)/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), and 1000-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 25 cm 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 25 cm 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 season, the 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

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 (Erazzu et 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.

### 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

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Fresh weight (g)</th>
<th>Leaf/steam ratio</th>
<th>Dry weight (g)</th>
<th>Plant height (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Irrigation (I)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I0=rainfed</td>
<td>155.7 a</td>
<td>-</td>
<td>0.166 a</td>
<td>48.9 a</td>
</tr>
<tr>
<td>I1=one irrigation</td>
<td>171.5 a</td>
<td>156.8 a</td>
<td>0.198 a</td>
<td>49.0 a</td>
</tr>
<tr>
<td>I2=two irrigation</td>
<td>183.2 a</td>
<td>170.5 a</td>
<td>0.184 a</td>
<td>55.2 a</td>
</tr>
<tr>
<td>I3=three irrigation</td>
<td>205.2 a</td>
<td>233.6 a</td>
<td>0.186 a</td>
<td>56.8 a</td>
</tr>
<tr>
<td>Plant spacing (cm). (S)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>208.8 a</td>
<td>172.3 b</td>
<td>0.181 a</td>
<td>58.5 a</td>
</tr>
<tr>
<td>20</td>
<td>166.4 ab</td>
<td>236.3 a</td>
<td>0.175 a</td>
<td>50.3 ab</td>
</tr>
<tr>
<td>25</td>
<td>161.5 b</td>
<td>152.3 b</td>
<td>0.193 a</td>
<td>48.7 b</td>
</tr>
<tr>
<td>Interaction</td>
<td>I x S</td>
<td>NS</td>
<td>*</td>
<td>NS</td>
</tr>
</tbody>
</table>

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.
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 (Spehar and 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.**

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Biological yield (kg/ha)</th>
<th>Seed yield (kg/ha)</th>
<th>Seed yield (g/plant)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Season</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Irrigation (I)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I0=rainfed</td>
<td>6576.1 c</td>
<td>-</td>
<td>2602.4 c</td>
</tr>
<tr>
<td>I1=one irrigation</td>
<td>8113.4 bc</td>
<td>4009.5 b</td>
<td>3599.9 b</td>
</tr>
<tr>
<td>I2=two irrigation</td>
<td>8713.5 b</td>
<td>5909.6 a</td>
<td>3656.9 b</td>
</tr>
<tr>
<td>I3=three irrigation</td>
<td>10875.7 a</td>
<td>6122.1 a</td>
<td>4443.1 a</td>
</tr>
<tr>
<td>Plant spacing (cm): (S)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15 cm</td>
<td>11436.9 a</td>
<td>5867.4 a</td>
<td>4648.5 a</td>
</tr>
<tr>
<td>20 cm</td>
<td>7763.6 b</td>
<td>4890.4 b</td>
<td>3314.1 b</td>
</tr>
<tr>
<td>25 cm</td>
<td>6508.5 b</td>
<td>5283.5 ab</td>
<td>2764.1 b</td>
</tr>
<tr>
<td>Interaction</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I x S</td>
<td>NS</td>
<td>**</td>
<td>NS</td>
</tr>
</tbody>
</table>

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.**

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Straw yield (kg/ha)</th>
<th>HI (%)</th>
<th>1000 seed weight (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Season</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Irrigation (I)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I0=rainfed</td>
<td>3973.6 b</td>
<td>-</td>
<td>39.8 a</td>
</tr>
<tr>
<td>I1=one irrigation</td>
<td>4119.4 b</td>
<td>3180.8 b</td>
<td>41.4 a</td>
</tr>
<tr>
<td>I2=two irrigation</td>
<td>5238.9 ab</td>
<td>4668.8 a</td>
<td>42.2 a</td>
</tr>
<tr>
<td>I3=three irrigation</td>
<td>6432.5 a</td>
<td>4951.0 a</td>
<td>46.6 a</td>
</tr>
<tr>
<td>Plant spacing (cm): (S)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15 cm</td>
<td>6561.1 a</td>
<td>4464.7 a</td>
<td>40.9 a</td>
</tr>
<tr>
<td>20 cm</td>
<td>4459.8 b</td>
<td>3931.4 a</td>
<td>44.3 a</td>
</tr>
<tr>
<td>25 cm</td>
<td>3802.5 b</td>
<td>4404.5 a</td>
<td>42.3 a</td>
</tr>
<tr>
<td>Interaction</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I x S</td>
<td>NS</td>
<td>**</td>
<td>NS</td>
</tr>
</tbody>
</table>

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 for 15 November sowing date (18.99 tons/ha) in 2003-04, and at 20 cm which 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 at 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 planting 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 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

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Protein (%)</th>
<th>Fat (%)</th>
<th>Ash (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Irrigation (I)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I0</td>
<td>15.6 a</td>
<td>5.7 a</td>
<td>2.8 b</td>
</tr>
<tr>
<td>I1</td>
<td>15.9 a</td>
<td>5.5 ab</td>
<td>5.3 b</td>
</tr>
<tr>
<td>I2</td>
<td>15.8 a</td>
<td>5.5 b</td>
<td>5.4 a</td>
</tr>
<tr>
<td>I3</td>
<td>15.7 a</td>
<td>5.5 ab</td>
<td>5.3 ab</td>
</tr>
<tr>
<td>Plant spacing (cm): (S)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15 cm</td>
<td>15.6 b</td>
<td>16.7 b</td>
<td>5.6 a</td>
</tr>
<tr>
<td>20 cm</td>
<td>16.1 a</td>
<td>17.4 a</td>
<td>5.7 a</td>
</tr>
<tr>
<td>25 cm</td>
<td>15.5 b</td>
<td>16.6 c</td>
<td>5.4 b</td>
</tr>
<tr>
<td>Interaction</td>
<td>NS</td>
<td>**</td>
<td>**</td>
</tr>
</tbody>
</table>

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.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Fiber (%)</th>
<th>Carbohydrate (%)</th>
<th>N (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Irrigation (I)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I0</td>
<td>4.0 b</td>
<td></td>
<td>71.9 a</td>
</tr>
<tr>
<td>I1</td>
<td>3.8 c</td>
<td>5.7 a</td>
<td>72.1 a</td>
</tr>
<tr>
<td>I2</td>
<td>4.1 a</td>
<td>4.3 b</td>
<td>71.8 a</td>
</tr>
<tr>
<td>I3</td>
<td>4.2 a</td>
<td>4.0 c</td>
<td>71.3 a</td>
</tr>
<tr>
<td>Plant spacing (cm): (S)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15 cm</td>
<td>3.9 b</td>
<td>4.5 b</td>
<td>71.9 a</td>
</tr>
<tr>
<td>20 cm</td>
<td>4.2 a</td>
<td>5.2 a</td>
<td>71.1 a</td>
</tr>
<tr>
<td>25 cm</td>
<td>4.0 b</td>
<td>4.3 c</td>
<td>72.3 a</td>
</tr>
<tr>
<td>Interaction</td>
<td>**</td>
<td>**</td>
<td>NS</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Season</th>
<th>Irrigation (I)</th>
<th>Plant spacing (cm): (S)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I0</td>
<td>85.3 a</td>
<td>-</td>
<td>807.9 a</td>
</tr>
<tr>
<td>I1</td>
<td>85.2 a</td>
<td>87.9 a</td>
<td>807.5 a</td>
</tr>
<tr>
<td>I2</td>
<td>85.5 a</td>
<td>85.6 b</td>
<td>807.5 a</td>
</tr>
<tr>
<td>I3</td>
<td>85.5 a</td>
<td>85.6 b</td>
<td>808.6 a</td>
</tr>
</tbody>
</table>

| I x S      | 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 Mg and Fe content of quinoa cv. Nat.Oil 1 as affected by supplementary irrigation and distance between plants in both seasons

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Mg (mg/100g)</th>
<th>Season</th>
<th>Fe (mg/100g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Irrigation (I)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I0</td>
<td>128.6 a</td>
<td>-</td>
<td>13.2 a</td>
</tr>
<tr>
<td>I1</td>
<td>128.4 a</td>
<td>129.6 a</td>
<td>13.2 a</td>
</tr>
<tr>
<td>I2</td>
<td>129.0 a</td>
<td>128.6 a</td>
<td>13.3 a</td>
</tr>
<tr>
<td>I3</td>
<td>128.6 a</td>
<td>128.7 a</td>
<td>13.3 a</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Plant spacing (cm): (S)</th>
</tr>
</thead>
<tbody>
<tr>
<td>15 cm</td>
</tr>
<tr>
<td>20 cm</td>
</tr>
<tr>
<td>25 cm</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Interaction</th>
<th>Mg</th>
<th>NS</th>
<th>*</th>
<th>NS</th>
</tr>
</thead>
</table>

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.

References


INFLUENCE OF FEED WITHDRAWAL PERIOD ON GROWTH PERFORMANCE...

Alimento del Presente y Futuro, Puno, Peru: FAO; CIP; UNA.


بعد محصول الكينوا من أهم المحاصيل التي تزدهر ظهورًا في مصر. يوجد في بوروندي منذ أكثر من 500 سنة حيث استخدمها المحاربين القدماء كغذاء لهم لما له من قيمة غذائية عالية ويشير أيضاً إلى أنه يحتوي على نسبة عالية من البروتين ومتواجدة في بروتين الحبوب بنسبة تصل إلى ضعف المتواجدة من بروتين القمح. كما يوجد في حالات الوزن الذئبي الفائق. وهو أيضاً يحتوي على نسبة عالية من الكالسيوم واليود والكوبن والأسيتامين في بروتين الكينوا. ولهذا مدى أهمية هذا المحصول في كل عام يتم استخدامه كغذاء متوازن وكامل لرواد سفن الفضاء. لذا فقد أجريت هذه الدراسة بهدف:

1. دراسة تأثير الري التكميلي بمياه ملحية ومسافات الزراعة على انتاجية و جودة محصول الكينوا.
2. دراسة تأثير مسافات الزراعة على انتاجية و جودة محصول الكينوا.
3. دراسة التداخل بين الري التكميلي ومسافات الزراعة على انتاجية و جودة محصول الكينوا.

وتلك الأهداف الآتية:

1. في ضوء الزيادة السكانية المتزايدة وحدودية الموارد التي تواجهها مصر اليوم، ويثر إلى تأثير الري التكميلي بمياه ملحية ومسافات الزراعة على انتاجية و جودة محصول الكينوا.
2. محصول الكينوا كمحصول غذائي تم إدخاله خلال العقود الأخيرة يمكن أن يعالج جزء من الفجوة الغذائية في مصر والتي تأتي من خلال النقصات في القمح. يمكن أن يلعب الكينوا دوراً هاماً في القضاء على الجوع وسوء التغذية والفقر وخاصة في البلدان النامية.
3. أظهرت النتائج أنه كان للري التكميلي بالمياه المالحة تأثير كبير على جميع الصفات المدروسة، ولكن لم يكن له أي تأثير على دليل الحصاد. أدى استخدام الري التكميلي بكثافة النباتية لخفض التعرض للظروف المناخية المفيدة للزراعة، وزيادة ضرورة التحكم في التربة وضمان التربة الرطبة والانتاجية، وزيادة المنتجات الغذائية، وزيادة رخصة تغذية ورياح الطقس، وزيادة الفئات الغذائية في مصر.

وتتناقص أم لنتنقي بحث في محصول الكينوا.

INFLUENCE OF FEED WITHDRAWAL PERIOD ON GROWTH PERFORMANCE ...