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Comparative Analysis of Different Salt Stresses Effects on the Germination Characteristics of Quinoa Varieties (*Chenopodium quinoa* Willd) Cultivated in Arid Regions

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Abstract

This research was conducted under laboratory conditions at the Faculty of Natural and Life Sciences, University of chahid Hamma Lakhdar El Oued in collaboration with the Research Laboratory of Biodiversity and Valorization of Bioresources in Arid Regions (LR18ES36), Department of Life Sciences, University of Gabes. The study aimed to investigate the effects of salt stress on various quinoa (*Chenopodium quinoa*) varieties, specifically: Q101 (*Amarilla Marangani*: AM), Q102 (*Amarilla Sacca*: AS), Q103 (*Blanca de Junin*: BJ), Cancula (K), Giza 02 (G02) from Egypt, and Black (B) and Red (R) from Chile. During the germination phase, each variety was exposed to different salt solutions (NaCl, Na2CO3, KCl, CaCl2, and seawater) at varying concentrations to assess its sensitivity to salinity. Germination efficiency was measured using key indicators such as root length, stem length, overall plant length, fresh and dry weight, water content, germination rate, speed of germination, and germination vigor index. The results showed that the seven quinoa varieties exhibited varying responses to the different concentrations of seawater and sodium chloride (NaCl), indicating biological and physiological differences. Significant variation was observed among the varieties in terms of plant height, germination speed, and vigor index. However, no differences were noted in the germination rate and regularity for varieties treated with sodium carbonate (Na2CO3). For calcium chloride (CaCl2) and potassium chloride (KCl), distinct differences were found, particularly in plant height and the germination strength index, though no differences were detected in germination rate, speed, regularity, or index. These findings highlight the varying degrees of salt tolerance among quinoa varieties, which could be critical for improving quinoa cultivation in saline environments.

Keywords: salt stress, sodium chloride, Na2O3, KCl, CaCl2, seawater, quinoa, germination

Introduction:

Grain cultivation has been fundamental to human nutrition throughout history. However, the recent food crisis, driven by the rapid growth of the global population, underscores the urgent need to enhance agricultural productivity. While developed countries have successfully increased their cereal production through advanced agricultural techniques and relatively stable population growth, developing nations struggle with larger populations and limited resources, resulting in heightened demand for agricultural output. Additionally, crops worldwide face significant challenges from environmental stressors such as drought, salinity, and high temperatures, which adversely affect plant growth, vital functions, and biodiversity (FAO, 2011). In response to these challenges, scientists have identified and developed grain and semi-cereal varieties capable of thriving under harsh environmental conditions. Quinoa (*Chenopodium quinoa* Willd.), a member of the Amaranthaceae family, is one such crop. Native to the Andean regions, quinoa is renowned for its genetic diversity, exceptional nutritional profile, and remarkable adaptability to diverse environments (Lombardi et al., 2022). It exhibits high tolerance to salinity and drought, requiring minimal water and enduring relatively high temperatures (Oelke et al., 1992; Shahid et al., 2020). Certain quinoa ecotypes mature under irrigation conditions equivalent to just 50 mm of rainfall per season, and some cultivars withstand temperatures as low as -18°C during early growth stages (Martinez et al., 2009; Bazile et al., 2016; Mujica et al., 2001; Catacora & Canahua, 1992) .These traits make quinoa a valuable crop for enhancing agricultural resilience in saline and arid regions(Zafar, et al., 2024; Zurita-Silva, et al., 2014; Jacobsen et al., 2001, 2003; Koyro & Eisa, 2008; Jacobsen & Jensen, 2009; Hariadi et al., 2011). Quinoa's global prominence has surged in recent years due to its superior nutritional qualities, including high protein content with all essential amino acids and essential minerals such as phosphorus, magnesium, potassium, and iron (Navruz-Varli & Sanlier, 2016). Its chemical composition is comparable to milk, further boosting its appeal (Mungofa et al., 2022; Barghava et al., 2006; James, 2009; Munir, 2011). Consequently, quinoa cultivation has expanded to regions experiencing climate change and soil salinization, including India, Pakistan, China, Australia, the Mediterranean, and North Africa (Leonardo Hinojosa et al., 2019). Abiotic stresses like salinity and drought significantly contribute to global crop losses, reducing productivity by over 50% (Mittler, 2019). Climate change projections indicate a rise in global temperatures, exacerbating these challenges (Abdelaziz & Redouane, 2020). Quinoa’s ability to adapt to a wide range of agricultural soils, including highly saline and drought-prone areas, positions it as a key crop for sustainable agriculture in difficult environments. This study aims to evaluate the resistance of seven quinoa varieties to different types and concentrations of salinity during the germination stage. This comparative agroecological evaluation will deepen our understanding of quinoa's adaptability, informing strategies to enhance sustainable agriculture in arid and saline regions.

I- Materials and methods

1- Plant materials

Quinoa is of great importance in nutrition, and this crop is extremely important for its nutritional value. Because it was introduced to Algeria a few years ago and due to the lack of existing studies on it, it was chosen to determine the extent of its tolerance to different types of salt stress. The seeds of seven varieties of quinoa (*Chenopodium quinoa* Willd) were used in this study. These varieties were introduced to Algeria in 2014 within the framework of the quinoa crop dissemination project implemented by the Food and Agriculture Organization of the United Nations (FAO). All cultivars were obtained from Peru by the Technical Institute for the Development of Desert Agriculture (ITDAS) and included the following cultivars: Amarilla Marangani, Amarilla Sacaca, White, Kancolla; From Egypt, it was Giza 2; From Chile there were black and red varieties.

2- Used salt compounds:

- **Sodium chloride**: **(NaCl)**
- **Potassium chloride**: **(KCl)**
- **Calcium chloride: ($CaCl_2$)**
- **Sodium carbonate: (Na_2CO_3)**
- **Sea water:**

Table 01: Shows the components of sea water

Element	Ratio	Element	Ratio
Sulfur	0.091	oxygen	85.84
Calcium	0.04	hydrogen	10.82
Potassium	0.04	chloride	1.94
Brom	0.0067	sodium	1.08
Carbon	0.0028	Magnesium	0.1292

3- Method of conducting the experiment:

Implementation of the experiment: Three replicates of seven types of grains were grown in Petri dishes with filter paper for each concentration after purification. The seeds were sterilized in 2% diluted water for 5 minutes, then washed well with distilled water twice or Three times, and tested for germination on filter paper according to the methods stipulated in the international rules and annexes for seed tests. Allocate 180 petri dishes, at a rate of 30 dishes for each variety. The seed can be considered sprouted once The Appearance of the Worthy (Milimo, 2013). So that the temperatures in all the experiments varied between 21-22°C and the humidity between 35-45 atmospheres.

4- Methods for preparing solutions:

Salt solutions were prepared by dissolving the weight of the molar mass of each salt (sodium chloride - potassium chloride - calcium chloride - sodium carbonate) in a liter of distilled water, to obtain the concentration 1 mol/L of each salt, and 1 liter of sea water and distilled water were brought as needed. Then, other concentrations of each salt were prepared by diluting the previously prepared solution to a concentration of 1 mol/liter of each salt as follows:

Table 02: shows the concentration of the salts used in the experiment

Concentration of salts used	Concentration of salts used
Distilled water H2O(S0)	
(S1) Sodium chloride (NaCl) 150 mm/l	(S3) Potassium chloride (KCl) 150 mm/l
(S1) Sodium chloride (NaCl) 200 mm/l	(S3) Potassium chloride (KCl) 200 mm/l
(S1) Sodium chloride (NaCl) 250 mm/l	(S3) Potassium chloride (KCl) 250 mm/l
(S2) Sodium Bicarbonate (Na2Co3) 150mM/l	(S4) Calcium dichloride (CaCl2) 150 mm/l
(S2) Sodium Bicarbonate (Na2Co3) 200mM/l	(S4) Calcium dichloride (CaCl2) 200 mm/l
(S2) Sodium Bicarbonate (Na2Co3) 250mM/l	(S4) Calcium dichloride (CaCl2) 250 mm/l
sea water 20%(S5)	
sea water 40%(S5)	
sea water 60%(S5)	

5- Growth measurements:

During the germination experiment of seven quinoa varieties under varying salt concentrations, the following measurements were taken:

1. Germination Speed (PGS) (%)

Germination speed was calculated using the equation described by (Mahmoud et al.,2004

; Kandil et al., 2019). for each variety studied. The formula is as follows:

Germination speed (%) = (Number of sprouted seeds x 100) / (Number of days since the beginning of germination)

2. Germination Rate Index (GRG)

The germination rate index was calculated as the sum of the ratio of the number of seeds germinated per day to the number of days until the end of the germination process.

Germination rate guide It is the total sum of the:

(number of seeds sprouted per day ÷ the number of that day).

3. Germination Percentage (GP) (%)

The germination percentage was calculated based on the method of (Mahmoud et al., 2004):

Germination percentage (%) = (Number of sprouted seeds X100/ (Total number of seeds).

4. Uniformity of Germination (UG)

Uniformity of germination was determined by dividing the total number of germinated seeds by the total number of days until the completion of germination.

Total number of germinated seeds ÷ total number of days to germination.

5. Determination of Germination Quality

Germination quality was monitored from the beginning for each variety studied, recording observations on the elongation process. It was observed that all varieties exhibited a hypocotyl extension, which pushed the cotyledons upwards.

6. Post-Germination Measurements

After the completion of germination for each variety under different saline conditions, the following parameters were measured:

- Fresh weight (FWS)
- Dry weight (DWS)
- Total plant length (**LS)**
- Stem length (SLS)
- Root length (RL)
- **Weight of the water content of seedlings of the seven quinoa varieties studied according to type and salt concentration in mg (WCS)**

It is the difference between the wet weight and the dry weight of the studied samples

7. Germination Strength Indices (GIS)

- Germination Strength Index 1: **germination percentage x plant length**

- Germination Strength Index 2: **germination percentage × dry weight of the plant**

These steps aim to assess the effects of salinity on the growth and environmental response of quinoa across different varieties used in this experiment.

Statistical analysis:

We analysed the results obtained using the analysis of variance (ANOVA) test, and to estimate the differences between the samples and evaluate the degree of significance of the differences, we used the Fisher test at the significance level ($P \leq 0.05$).

In this study, we used the statistical program SPSS, version 15

II- Results analysis and discussion

1- Results and statistical analysis

i- Comparison of root length of seedlings of the seven quinoa varieties studied according to type and salt concentration

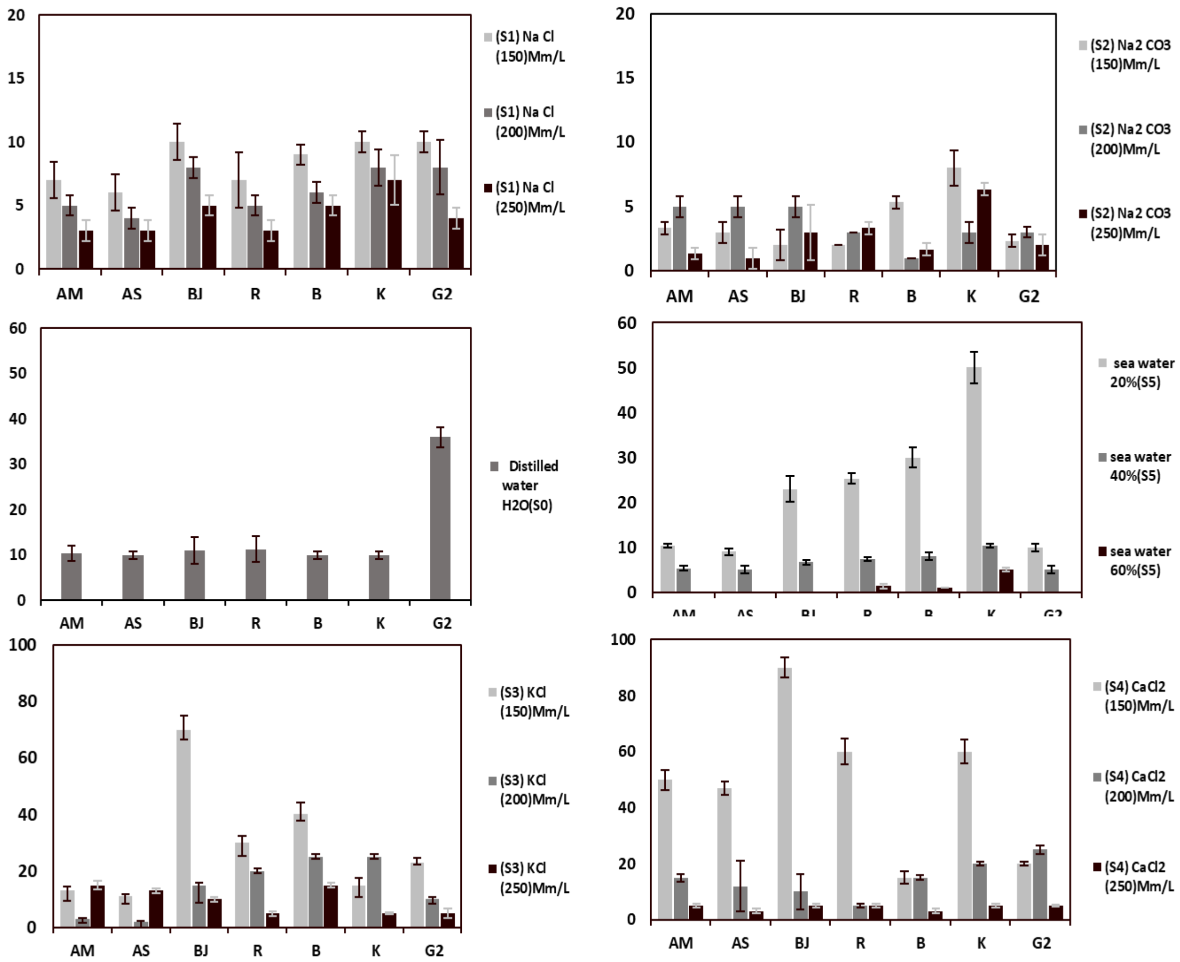

Figure No. 01 Comparison of root length of seedlings of the seven quinoa varieties studied according to type and salt concentration in mm

Comparing the root length of seedlings of the seven quinoa varieties studied according to type and salt concentration in millimeters with respect to root length, the results varied between the different salts as follows:

1- The effect of sodium chloride (NaCl):

Regarding the effect of NaCl on root length, the results showed that if the concentration exceeds 250 mm/L, the plants completely fail to germinate, and for this reason we took into account concentrations from 200 to 250 for comparison and statistical analysis. Using the statistical analysis program SPSS ver.15, we statistically analyzed these results by analysis of variance (Fisher's test), and we found that there are significant differences in the effect of salt concentrations on the growth of quinoa varieties. In other words, there are significant differences between quinoa varieties in resistance to salinity. The results also show that the response of plants to salinity differs from that to distilled water. We found that the Fisher test value was $F=43,711$, and the P-value was significantly less than 0.05 ($P \leq 0.05$). This indicates the existence of significant differences between the types, as shown in (Figure No. 01).

2- The effect of sodium carbonate (Na2 CO3):

Through statistical analysis on the effect of sodium carbonate on quinoa varieties, it was found that there are significant differences between the varieties in response to this salt. Whereas, the value of Fisher's test was $F = 54,521$ and the probability score P-value was much less than 0.05 ($P \leq 0.05$). This indicates the existence of significant differences between the types, as shown in (Figure No. 01).

3- The effect of potassium chloride (KCl):

Through statistical analysis of the effect of KCl on quinoa varieties, it was found that there are significant differences between the varieties in response to this salt, as the value of Fisher's test was $F = 87,393$ and the degree of probability P-value was much lower. From 0.05 ($P \leq 0.05$), and this indicates the presence of significant differences between the varieties, which is shown in (Figure No. 01).

4- The effect of calcium chlorine, CaCl2:

Through statistical analysis of the effect of CaCl2 on quinoa varieties, it was found that there were significant differences between the varieties in response to this salt, as the Fisher test value was $F=452,029$ and the P-value was lower. Much more than 0.05 ($P \leq 0.05$), and this indicates the presence of significant differences between the varieties. The results are summarized in (Figure No. 01).

5- The effect of sea water:

Since plants fail to grow at concentrations exceeding 80%, the statistical analyzes were limited to comparing distilled water and effective concentrations. Through statistical analysis of the effect of sea water on quinoa varieties, it was found that there are significant differences between the varieties in response. To this treatment, the value of Fisher's test was $F=195.343$ and the probability score P-value was much less than 0.05 ($P \leq 0.05$). This indicates that there are significant differences between the varieties and the results are summarized in (Figure No. 01).

ii- Results and statistical analysis with comparison to average peduncle length:

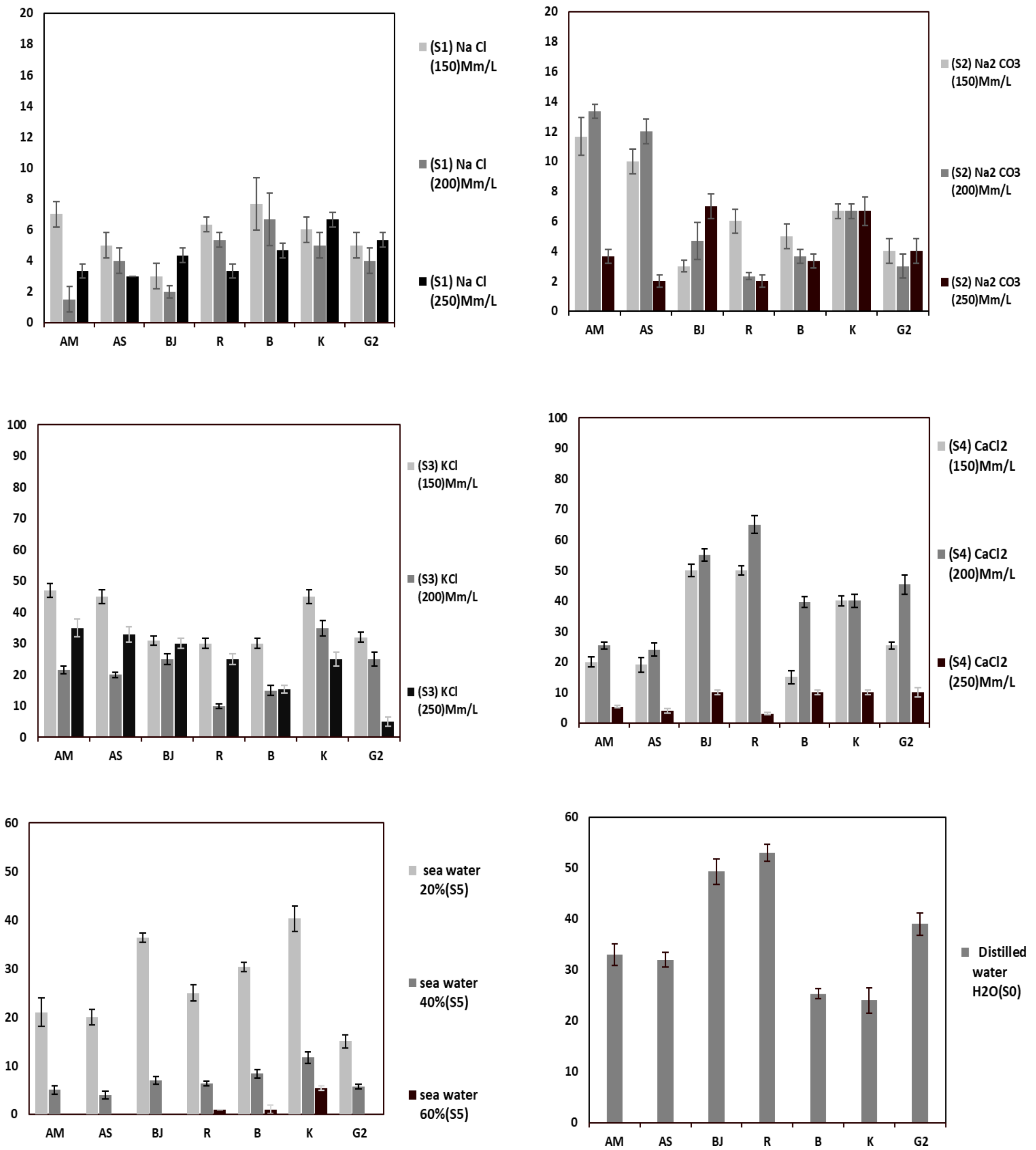

Figure No. 02 Stem length of seedlings of the seven studied quinoa varieties according to type and salt concentration in millimeters

1- The effect of sodium chloride (NaCl):

Regarding the effect of NaCl on root length, the results showed that if the concentration exceeds 250 mm/L, the plants completely fail to germinate, and for this reason we took into account concentrations from 200 to 250 for comparison and statistical analysis. Through the analysis of variance of these results, which were limited only to comparing the effects of concentrations 200, 225, and 250 with distilled water, we notice that there are significant differences in the effect of salt concentrations on the growth of quinoa varieties. In other words, there are significant differences between quinoa varieties in resistance to Salinity. The results also show that the response of plants to salinity is different from that of distilled water. We found that the value of Fisher's test was F = 279.46 and the probability score P-value was much less than 0.05 ($P \leq 0.05$) in (Figure No. 02).

2- The effect of sodium carbonate (Na2 CO3):

The results showed that there are significant differences between varieties in response to Na2 and CO3 concentrations on the growth of quinoa varieties. In other words, there are significant differences between quinoa varieties in resistance to sodium carbonate. The results also show that the response of plants to Na2 CO3 differs from that to distilled water, and we found that the value of Fisher's test was F=123,023 and the probability degree P-value is much less than 0.05 ($P \leq 0.05$). This is what explains in (Figure No. 02).

3- The effect of potassium chloride (KCl):

The results showed that there are significant differences between varieties in response to K Cl concentrations on the growth of quinoa varieties. In other words, there are significant differences between quinoa varieties in resistance to K Cl. The results also show that the response of plants to potassium chloride is different from that in water. Distilled, we found that the value of Fisher's test was F= 112,393 and the probability degree P-value was much less than 0.05 ($P \leq 0.05$) shows the results of the variance test in (Figure No. 02).

4- The effect of calcium chlorine (CaCl2):

The results showed that there are significant differences between varieties in response to CaCl2 concentrations on the growth of quinoa varieties. In other words, there are significant differences between quinoa varieties in resistance to calcium chloride. The results also show that the response of plants to CaCl2 is different from that in water. Distilled, we found that the value of Fisher's test was F = 86,029 and the probability score P-value was much less than 0.05 ($P \leq 0.05$), which is shown in (Figure No. 02).

5- The effect of sea water:

Since plants fail to grow at concentrations exceeding 60%, statistical analyses were limited to comparing distilled water and effective concentrations.

Through statistical analysis on the effect of sea water on quinoa varieties, it was found that there were significant differences between the varieties in response to this treatment, as the Fisher test value was F = 53.84 and the probability score was P-value. Significantly less than 0.05 ($P \leq 0.05$).

This indicates that there are significant differences between the varieties, which are shown in (Figure No. 02).

iii- Comparing the wet weight of seedlings of the seven quinoa varieties studied according to different salt concentrations and testing the variance to study the differences between them.

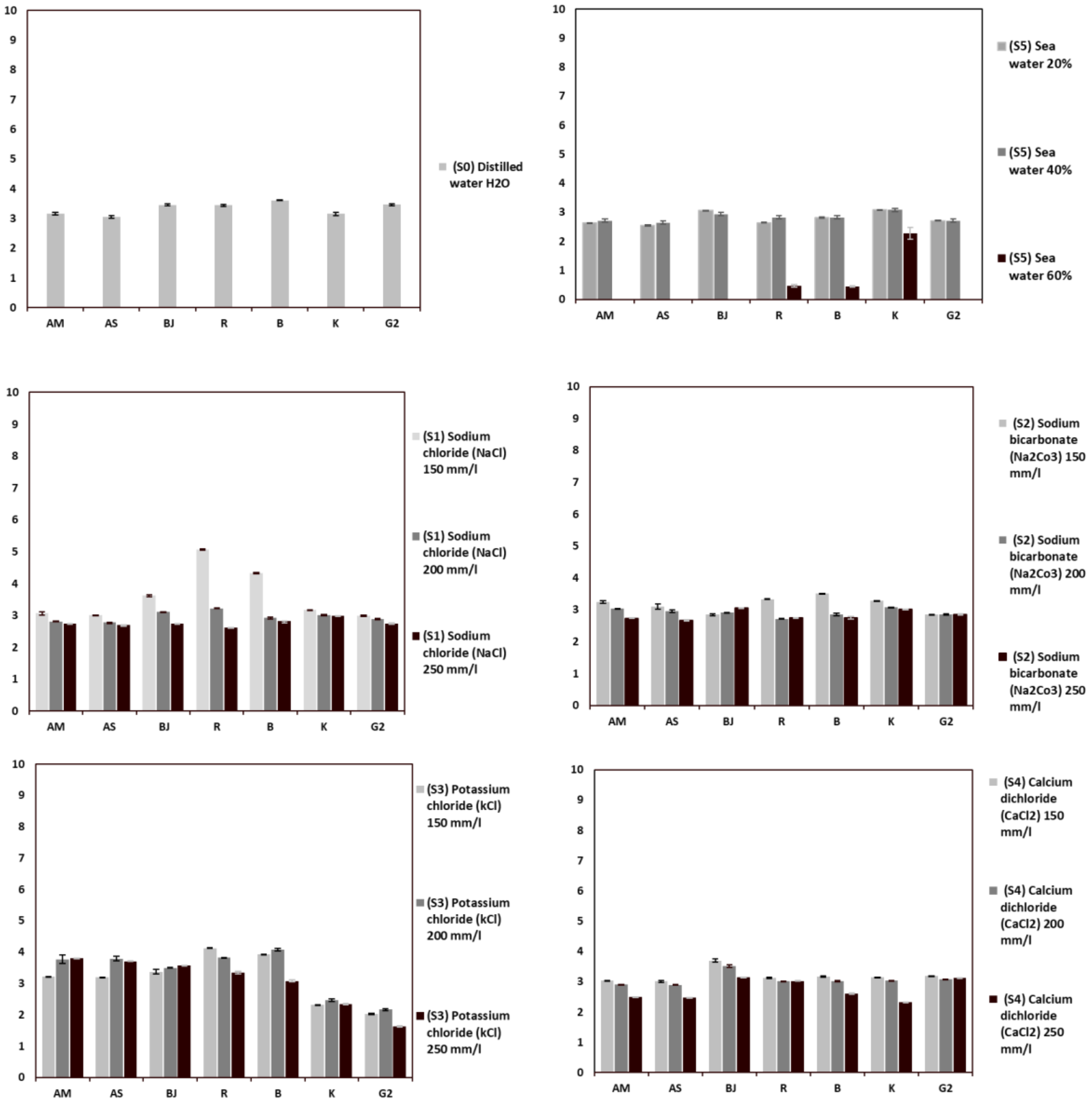

Figure No. 03 Wet weight of seedlings of the seven quinoa varieties studied according to different salt concentrations in milligrams

1- The effect of sodium chloride (NaCl):

Regarding the effect of sodium chloride on the wet weight of seedlings, the results showed that if the concentration exceeded 250 mm/L, the plants completely failed to germinate in all the varieties studied, and for this reason we took into account concentrations from 150 to 250 for comparison. And statistical analysis. Using the statistical analysis program SPSS version 15, we analyzed these results statistically by analysis of variance (Fisher's test), and found that there were significant differences in the effect of salt concentrations on the growth of quinoa varieties. In other words, there are significant differences between quinoa varieties in salt tolerance. The results also showed that the response of plants to salinity differs from the response to distilled water. We found that the value of Fisher's test was $F = 1474.353$, and the P value was significantly less than 0.05 ($P \geq 0.05$). This indicates the presence of statistically significant differences between species, as shown in (Figure No. 03).

2- The effect of sodium carbonate Na2 CO3:

Through statistical analysis on the effect of sodium carbonate on quinoa varieties, it was found that there are significant differences between the varieties in response to this salt. Whereas, the value of Fisher's test was $F = 62.184$ and the probability score P value was significantly less than 0.05 ($P \geq 0.05$). This indicates that there are statistically significant differences between the categories, as shown in (Figure No. 03).

3- Effect of potassium chloride (KCl):

Through statistical analysis of the effect of KCl on quinoa varieties, it was found that there were significant differences between the varieties in response to this salt, as the Fisher test value was $F = 1876.101$ and the P value was lower. Much more than 0.05 ($P<0.05$), and this indicates that there are significant differences between the varieties, which is shown in (Figure No. 03).

4- The effect of calcium chlorine CaCl2:

Through statistical analysis of the effect of $CaCl_2$ on quinoa varieties, it was found that there were statistically significant differences between the varieties in response to this salt, as the Fisher test value was $F=753.484$ and the probability score was P-value. Much less than 0.05 ($P<0.05$) and this indicates that there are significant differences between the varieties. The results are summarized in (Figure No. 03).

5- The effect of sea water:

Since plants fail to grow at concentrations exceeding 60%, statistical analyzes were limited to comparing distilled water and effective concentrations. Through statistical analysis of the effect of sea water on quinoa varieties, it was found that there were statistically significant differences between the varieties in response to this treatment, as the Fisher test value was $F=352.935$ and the probability score P-value was much lower. of 0.05 ($P \geq 0.05$). This indicates that there are statistically significant differences between the species, and the results are summarized in (Figure No. 03).

iv- Comparing the dry weight of seedlings of the seven studied quinoa varieties according to different salt concentrations and testing the variance to study the differences between them.

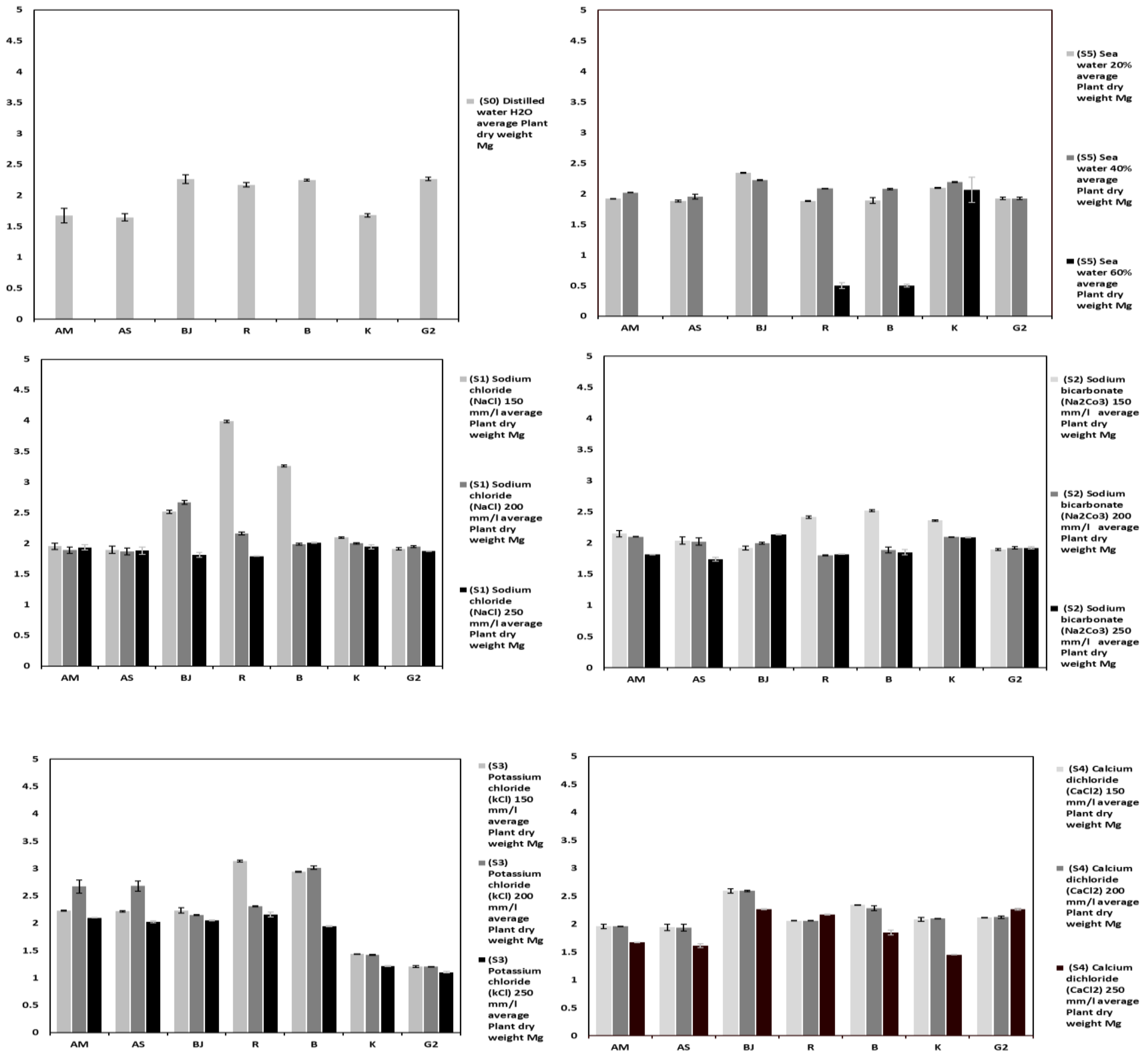

Figure No. 04 Dry weight of the seven studied quinoa cultivars by type and salt concentration in mg

1- The effect of sodium chloride (NaCl):

Regarding the effect of NaCl on the dry weight of seedlings, the results showed that if the concentration exceeds 250 mm/L, germination completely fails in all varieties, and for this reason we took into account concentrations from 150 to 250 for comparison and statistical analysis.

Through the analysis of variance of these results, which were limited only to comparing the effects of concentrations 150, 200, and 250 with distilled water, we notice that there are significant differences in the effect of salt concentrations on the growth of quinoa varieties. In other words, there are significant differences between quinoa varieties in resistance to Salinity.

The results also show that the response of plants to salinity is different from that of distilled water. We found that the value of Fisher's test was F= 964.101 and the probability degree P-value is much less than 0.05 ($P \leq 0.05$). (Figure 04) show the results of the variance test.

2- The effect of sodium carbonate Na2 CO3:

The results showed that there are significant differences between varieties in the response to Na2 CO3 concentrations on the growth of quinoa varieties. In other words, there are significant differences between quinoa varieties in resistance to sodium carbonate.

The results also show that the response of plants to Na2 CO3 differs from that to distilled water, and we found that the value of Fisher's test was F = 57.753 and the probability degree P-value is much less than 0.05 ($P \leq 0.05$ This is shown in (Figure 04)

3- The effect of potassium chloride (K Cl):

The results showed that there are significant differences between varieties in the response to K Cl concentrations on the growth of quinoa varieties. In other words, there are significant differences between quinoa varieties in resistance to K Cl.

The results also show that the response of plants to potassium chloride differs from that in Distilled water, and we found that the value of Fisher's test was F=1397.563 and the probability degree P-value was much less than 0.05 ($P \leq 0.05$) and (Figure 04) show the results of the variance test

4- The effect of calcium chlorine (CaCl2):

The results showed that there are significant differences between varieties in the response to CaCl2 concentrations on the growth of quinoa varieties. In other words, there are significant differences between quinoa varieties in resistance to calcium chloride.

The results also show that the response of plants to CaCl2 is different from that in water. Distilled, we found that the value of Fisher's test was F =215.670 and the probability score P-value is much less than 0.05 ($P \leq 0.05$), which is shown in (Figure 04).

5- The effect of sea water:

Since plants fail to grow at concentrations exceeding 60%, statistical analyzes were limited to comparing distilled water and effective concentrations.

Through statistical analysis on the effect of sea water on quinoa varieties, it was found that there were significant differences between the varieties in response to this treatment, as the value of the Fisher test was F = 128.931 and the probability score was P-value. Significantly less than 0.05

(P≤0.05). This indicates the presence of significant differences between the types, which are shown in (Figure 04)**.**

v- Comparing the water content of seedlings of the seven quinoa varieties studied according to different salt concentrations and testing the variance to study the differences between them.

1- The effect of sodium chloride (NaCl):

Regarding the effect of NaCl on the water content of seedlings, the results showed that if the concentration exceeded 250 mm/L, the plants completely failed to germinate in all the studied

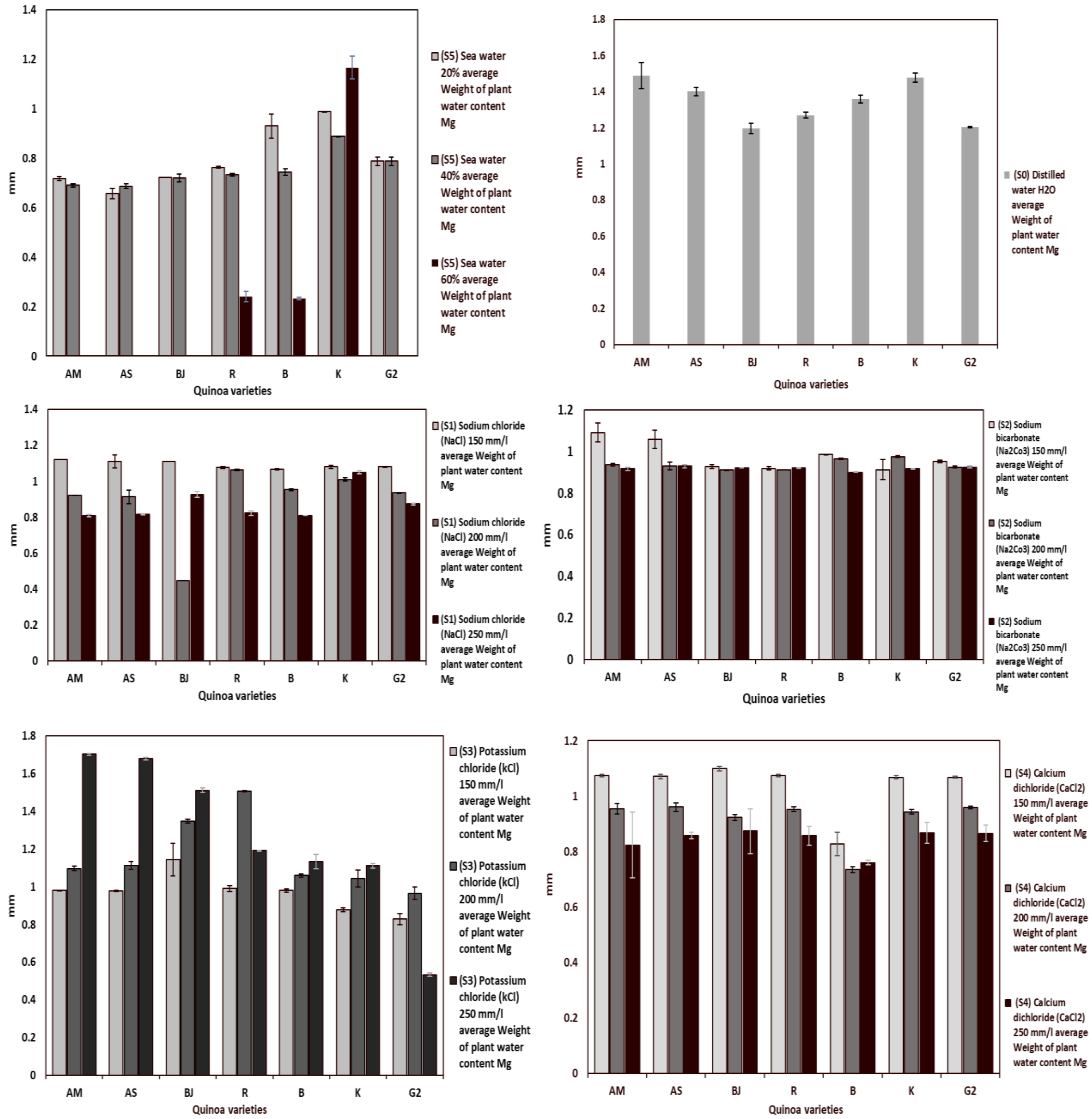

Figure No.05 weight of water content of seedlings of the seven quinoa varieties studied by type and salt concentration in mg

varieties, and for this reason we took into account concentrations from 150 to 250 for comparison. And statistical analysis...

Using the statistical analysis program SPSS ver.15, we statistically analyzed these results by analysis of variance (Fisher's test), and we found that there are significant differences in the effect of salt concentrations on the growth of quinoa varieties. In other words, there are significant differences between quinoa varieties in resistance to salinity. The results also show that the response of plants to salinity is different from that of distilled water

We found that the Fisher test value was F=43.711, and the P-value was significantly less than 0.05 ($P \leq 0.05$). This indicates the existence of significant differences between the types, as shown in (Figure 05).

2- The effect of sodium carbonate Na2 CO3:

Through statistical analysis on the effect of sodium carbonate on quinoa varieties, it was found that there are significant differences between the varieties in response to this salt.

Whereas, the value of Fisher's test was F = 54,521 and the probability score P-value was much less than 0.05 ($P \leq 0.05$). This indicates the existence of significant differences between the types, as shown in (Figure 05).

3- The effect of potassium chloride (KCl):

Through statistical analysis of the effect of KCl on quinoa varieties, it was found that there were significant differences between the varieties in response to this salt, as the Fisher test value was F = 87,393 and the P-value was lower. Much more than 0.05 ($P \leq 0.05$), and this indicates the presence of significant differences between the varieties, which is shown in (Figure 05).

4- The effect of calcium chlorine, CaCl2:

Through statistical analysis of the effect of CaCl2 on quinoa varieties, it was found that there were significant differences between the varieties in response to this salt, as the Fisher test value was F=452,029 and the probability score was P-value. Much less than 0.05 ($P \leq 0.05$), and this indicates the presence of significant differences between the varieties. The results are summarized in (Figure 05).

5- The effect of sea water:

Since plants fail to grow at concentrations exceeding 60%, the statistical analyzes were limited to comparing distilled water and effective concentrations. Through statistical analysis on the effect of sea water on quinoa varieties, it was found that there are significant differences between the varieties in Response to this treatment, as the value of Fisher's test was F=195.343 and the probability score P-value was much less than 0.05 ($P \leq 0.05$). This indicates that there are significant differences between the types and the results are summarized in (Figure 05).

vi- The results of the analysis of the studied parameters and a summary of the results of the statistical analyzes between the varieties and the concentrations of salts in the rest of the parameters.

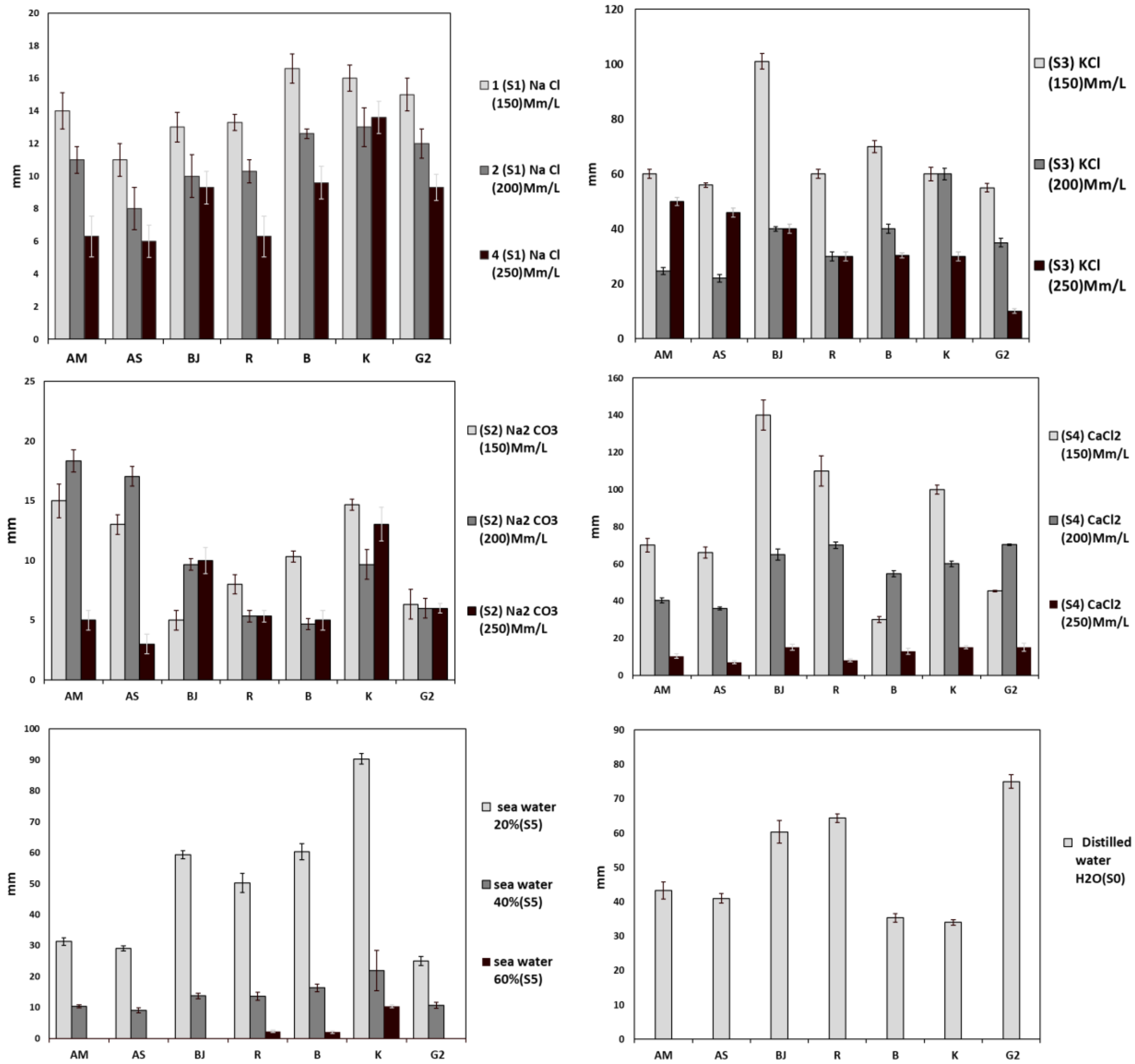

Figure No. 06 The length of seedlings of the seven quinoa varieties studied according to type and salt concentration in mm

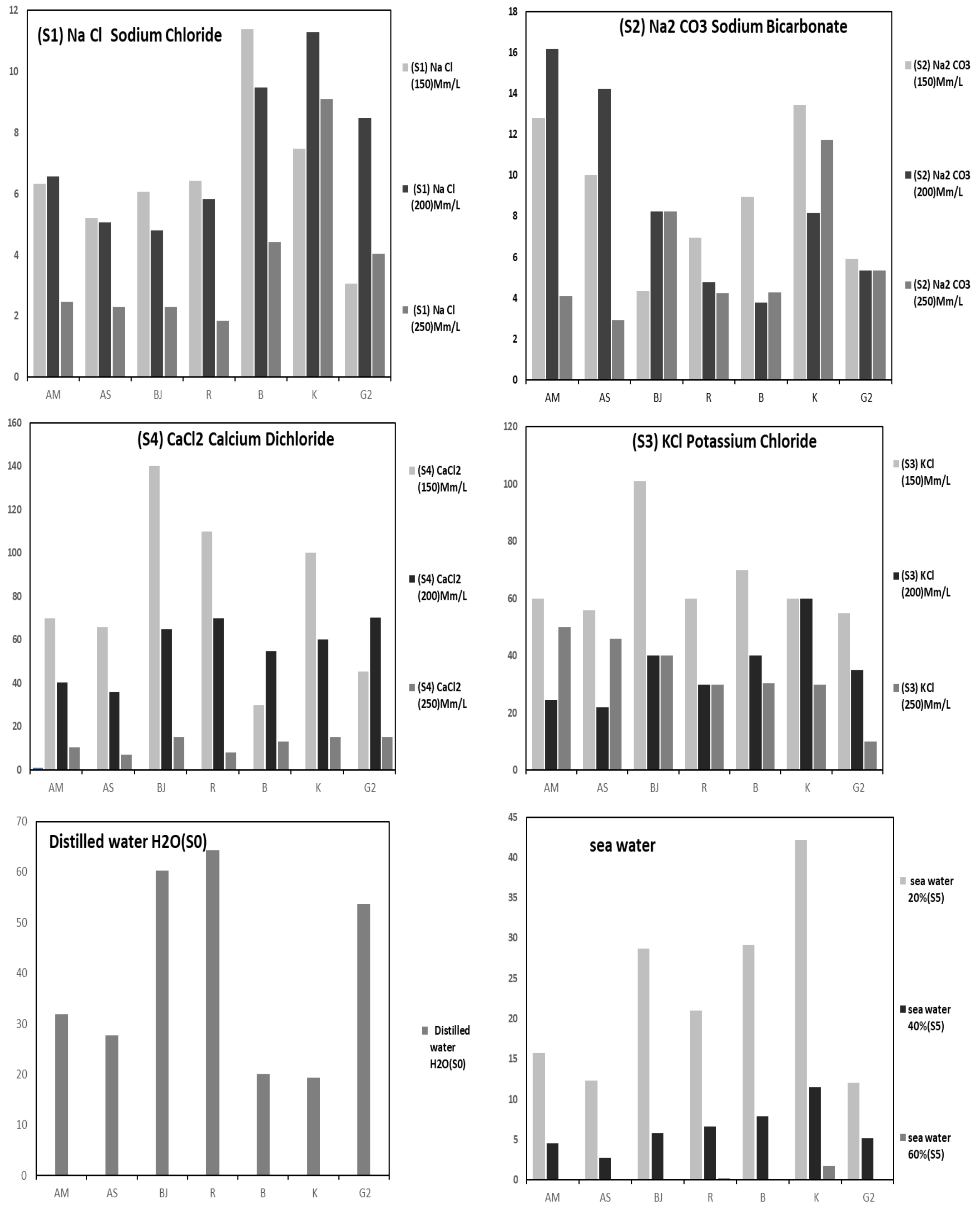

Figure No. 07 Germination strength index 1 for seedlings of the seven quinoa varieties studied according to type and salt concentration

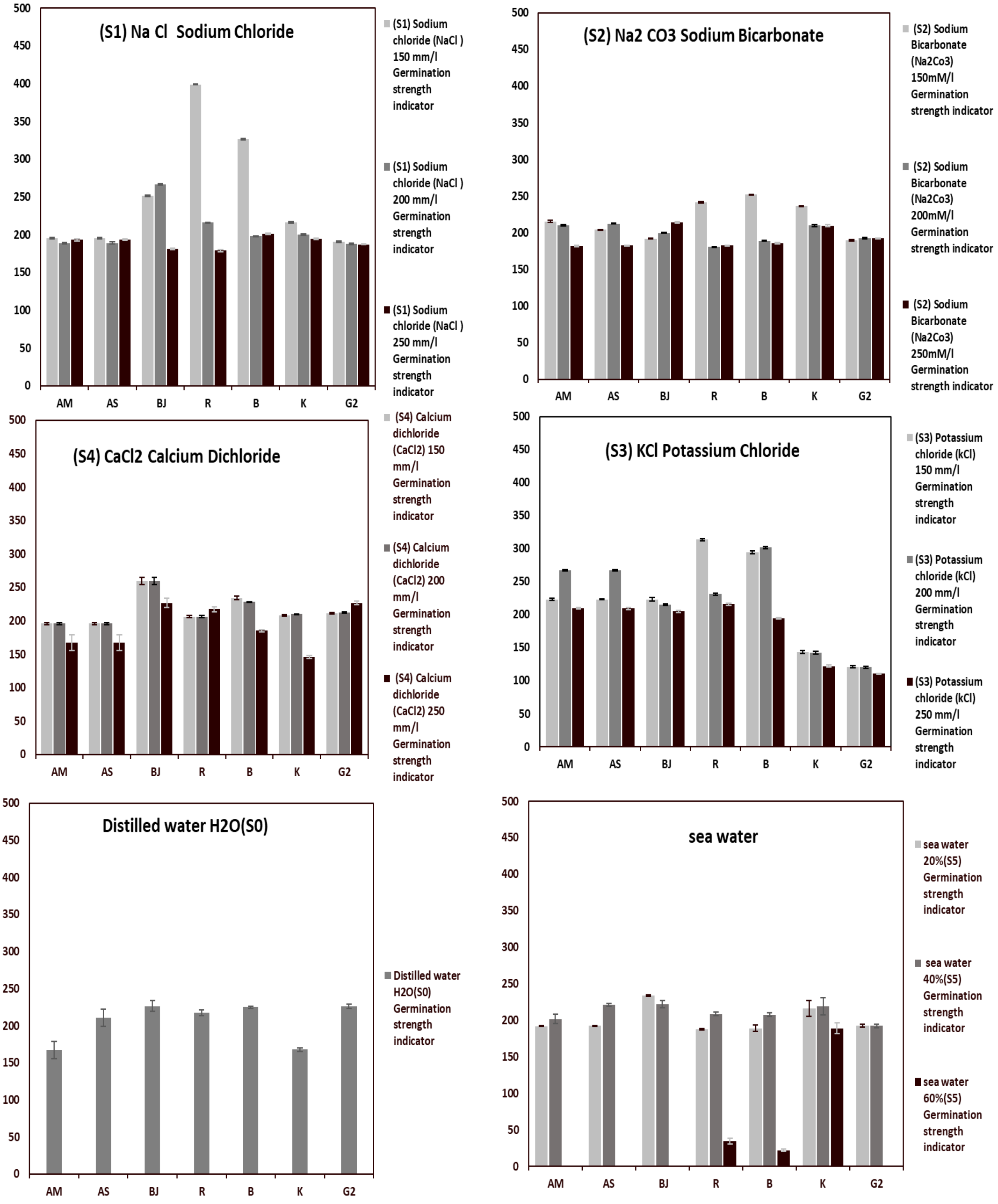

Figure No. 08 Germination strength index 2 for seedlings of the seven quinoa varieties studied according to type and salt concentration

1- The effect of sodium chloride (NaCl) on the studied parameters:

The results of the statistical analyzes are summarized (the results marked with an asterisk * mean that there are significant differences between the varieties or between the concentrations, the results shown in red mean that there are no significant differences).

The results shown in the table show that there are significant differences between the varieties, with regard to plant length, germination speed, germination vigor index 1 and 2, and germination index rate. As for the germination rate and germination uniformity, there are no significant differences.

All results are shown in (Figure 06 to 08).

2- - The effect of sodium carbonate (Na2Co3) on the studied parameters:

The results of the statistical analyzes are summarized (the results marked with an asterisk * mean that there are significant differences between the varieties or between the concentrations, and the results shown in red mean that there are no significant differences).

The results shown in the table show that there are significant differences between the varieties with regard to plant length, germination speed, germination vigor index 1 and 2, and germination index rate. As for the germination rate and germination uniformity, there are no significant differences

All results are shown in (Figure 06 to 08).

3- The effect of potassium chloride (KCl) on the studied parameters:

The results of the statistical analyzes are summarized (the results marked with an asterisk * mean that there are significant differences between the varieties or between the concentrations, the results shown in red mean that there are no significant differences).

The results show that there are significant differences in plant length, germination strength index 1, and germination strength index 2, while the remaining factors do not have significant differences.

All results are shown in (Figure 06 to 08).

4- The effect of calcium dichloride (CaCl2) on the studied parameters:

The results of the statistical analyzes are summarized (the results marked with an asterisk * mean that there are significant differences between the varieties or between the concentrations, the results shown in red mean that there are no significant differences).

The results shown in the table show that there are significant differences between the varieties with regard to plant length, germination strength index 1 and 2. As for germination rate, germination speed, germination uniformity, and germination index rate, there are no significant differences.

All results are shown in (Figure 06 to 08).

5- The effect of sea water on the studied parameters:

The results of the statistical analyzes are summarized in (the results marked with an asterisk * mean that there are significant differences between the varieties or between the concentrations, the results shown in red mean that there are no significant differences).

As can be seen in the table, all the parameters studied (plant length, germination rate, etc.) showed significant differences between the varieties. Plants respond to different degrees to changes in seawater concentration, and this means biological and physiological differences between the varieties.

The differences between varieties in response to concentrations are explained in (Figure 06 to 08).

2- discussion

I explained the results obtained from the statistical analyzes for all the different salt treatments, which gave varying percentages and degrees according to the types of salts (NaCl - Na2O3 - KCl - CaCl2 - sea water), and at different concentrations. The germination rate in quinoa seeds was inversely proportional to the salinity concentration in both seawater and sodium chloride, i.e. the higher the concentration, the lower the germination rate and speed. (Gadeh, 2013) (Causin et al., 2020) (Ruiz-Carrasco, et al., 2011) (Morales et al., 2011)

This is consistent with what was stated by (Ouji et al.; 2015) (Chiraz et al.; 2011), and according to (den Toom 2016; Patiballa et al., 2024; Slatni et al., 2024), the germination rate and speed It is high in the control (distilled water), and decreases in salt treatments as the concentration increases.

The decrease in the rate and speed of germination is due to the inability of the seeds to germinate, due to damage to the embryonic organs and the high pressure of the solution, which hinders the absorption of water, (Awaad 2023; Chavarín-Martínez, et al., 2019). It is consistent with the study conducted by (Morales et al., 2022; Brakez et al., 2014; Adolf et al., 2013)on seeds of the Puccinella nuttalliana plant, in which it was found that germination was delayed for one day at a concentration of (0.5%) of sodium chloride salt, and germination was delayed for (8) days when the seeds were placed in a concentration (2%) of sodium chloride salt solution. In general, the germination delay period depends on the type of plant seeds and the salt concentration (Panuccio, et al, 2014). on the seeds of the francoeuria crispa plant, which is one of the wild plants in the Arabian Peninsula, and is considered one of the perennial plants of the Compositae family. Its seeds did not germinate at concentrate

ons (40% and 60 % and 100%) of the seawater solution (Adolf et al., 2013 ; Muhammad Al-Asafi and Ahmed Shams Al-Din, 2014). When studying the effect of different concentrations of sodium salts on the germination of Cassia senna L. seeds, the percentage of seed germination was high

(98% - 100%) in water. Normal and low salt concentrations (0.0001 - 0.01) molar did not have a clear effect on germination. Increasing the level of salinity concentration to (0.2) molar caused germination to be inhibited and reduced. The effect was more evident for sodium chloride solution compared to other salts. (Al-Najjar et al., 2023) Regarding the effect of six levels of salinity, it was found that the germination rate gradually decreased with increasing salinity concentration, which is consistent with (Stoleru, et al., 2019) that salt stress reduces germination and growth rates in different plant species (Obaid et al., 2011).

Exposing the seeds of non-halophytic plants (Glycophytes), such as (wheat, barley, tomatoes, squash, beans, lentils, beans, castor, etc.), to a salt solution leads to a direct inhibition of germination with an increase in the concentration of salt in that solution, and the germination stage is one of the most sensitive stages to salts. Salinity delays germination for several days (Ismail, 1990).

It is consistent with a study by (Seid & Birhane, 2017). On seeds of the arak tree Salvadora persica, high salinity concentrations caused a delay in germination, even though this tree is considered resistant to salts. It is consistent with what was , confirmed by (Awasthi et al., 2016), that there is an inverse relationship between salt stress and seed germination, as he indicated that increasing salinity caused a reduction in the germination rate by treating the seeds of four types of vegetables with different salt concentrations. This was confirmed by (Iqbal et al., 2020) the germination stage is one of the most sensitive stages to salts, as salinity delays germination or fails it at levels of salt solution that directly inhibits it. This is consistent with what(Gallagher, 1985) found when he studied the effect of salinity on the germination of seeds of three types of salt-tolerant plants (purslane, cereal, and barley), that seeds can germinate at sea water levels mixed with fresh water at concentrations (19.3 and 31.8) decimens/m, and they fail to germinate at the levels of seawater mixed with fresh water at concentrations of (21.6 and 34.4) decimens/m for purslane, cereal, and barley, respectively, which indicates that increasing the salinity of seawater mixed with water reduces the levels of Germination.

It is consistent with what was mentioned by (Singh et al., 2012). that increasing the concentration of salts caused a reduction in the germination rates of tomato seeds when using three salt concentrations (4, 8, and 12) dS/m from a mixture of sodium chloride and calcium chloride salts. And sodium sulfate. It is consistent with the study conducted by (Fong et al., 2021), on the effect of salinity on the germination rates of mung bean seeds, as four concentrations were used, namely (50, 100, 150, and 200) mmol/L of chloride salt. Sodium, they found that increasing salinity concentrations caused a reduction in seed germination rates (82%, 95%, and 96% and 97%), respectively. According to (Orlovsky et al., 2016). there is a difference in resistance to salinity between plant varieties during the germination stage with sodium chloride salt solution, and in general it delays germination, and depends on the type of plant seeds and the salt concentration.

This is consistent with what (Panuccio et al; 2014; Eisa et al; 2012) found, when they studied the effect of salinity on the germination and growth of quinoa, that quinoa types differ among themselves in degrees of Tolerant to salinity

Whereas the results obtained during our experiment showed that quinoa species differ among themselves in degrees of salinity tolerance, at a concentration of 40% of seawater and 250 mmol/L of NaCl, the germination rate was 100%. In all the varieties studied, this indicates that all varieties have the ability to tolerate a high percentage of salinity. However, at a concentration of 60% of sea water, differences were found between the varieties, as the variety (quinoa Red), (black quinoa), and (Cancula: K) (brown quinoa), germination occurred at varying rates, and the highest percentage was for (Cancula: K), which is 90%, while for (black quinoa) The germination rate of (Cancula: K) was 20%, while the rest of the varieties did not germinate at all.

As for treatment with sodium carbonate solution Na2O3 at different concentrations, differences were found between the varieties in plant length and germination rate index, where the highest concentration was 200 mmol/l, and the maximum length was in the (Cancula: K) variety (brown quinoa). 13 mm, and the lowest length was in the (Giza 02: G02) variety (Egyptian quinoa) at 4.7 mm, as well as in the germination strength index 1, which was in (Cancula: K), which was the highest index (1400), and the lowest index was in the (Giza 02: G02) variety, which It is (470). As for the rest of the parameters (germination speed and germination uniformity), there are no differences.

When treated with a solution of potassium chloride (KCl) and calcium chloride (CaCl2), at different concentrations, significant apparent differences were found between the varieties in the treatments (plant length and germination vigor index1). In the (Blanca de Junin :BJ) variety ((White quinoa) The maximum plant length was (175 mm), and this was at a potassium chloride solution (KCl) concentration of 15 mmol/L, and (140 mm) calcium chloride solution (CaCl2) at a concentration of 150 mmol/L, while it decreased relatively with increasing concentration in both solutions.

As for the germination power index and coefficient with KCl solution at a concentration of 15 mmol/L, the highest germination power index was 1 in the (Blanca de Junin :BJ) variety (17500), and the lowest index was in (Giza 02: G02) (5000). As for the coefficient with CaCl2 solution at a concentration of 100 mmol/L, the (Blanca de Junin :BJ) variety had the highest index (14000), and the (Giza 02: G02) variety had the lowest index (4500).

As for the rest of the parameters (germination speed, germination percentage, germination uniformity, and germination rate index), there was homogeneity and there were no differences between the varieties. Based on statistical studies that were applied to the various treatments, it showed that there is a difference in resistance to salinity between the varieties during the germination stage, noting that all of the quinoa varieties studied are resistant to salinity.

3- Conclusion

The environmental phenomena that affect the various stages of plant growth and development, and its various physiological functions with their physical and chemical characteristics, as well as the type of plant, and among the most common of these phenomena are salts that cause the problem of salinity and their impact on the germination stage. The harmful effects resulting from saline environments have been overcome by cultivating the quinoa plant inhibits the effectiveness of salts for seed germination and growth, which leads to increasing the efficiency and vitality of the plants, so they grow under high salt conditions without causing any negative damage. Therefore, this research aims to study the effect of salt stress on different samples of the quinoa plant. (Q101 (Amarilla Marangani: AM); Q102 (Amarilla Sacca: AS); Q103 (Blanca de Junin :BJ); (Cancula: K); while the variety (Giza 02: G02) from Egypt (Black: B) and (Red: R) from Chile) in the germination stage, with each variety treated with different salt media (NaCl - Na2O3 - KCl - CaCl2 - sea water) And at several different concentrations, and determining the extent of their sensitivity to salinity during the germination period, by inferring germination efficiency (measuring germination rate - germination speed - root length and stem length), as the results obtained indicated that plants respond in different degrees to changing concentrations. Seawater, and this means that there are biological and physiological differences. It was also shown that there are fundamental differences between the varieties in the length of the plant, the speed of germination, and the indicator of the strength of germination. As for the percentage of germination and the uniformity of germination, there is no difference in the solutions treated with sodium carbonate Na2CO3 - - As for calcium chloride - CaCl2 - and potassium chloride - KCl - sodium chloride - NaCl, there are differences between the varieties, especially in the length of the plant and the germination strength index, but there are no germination rates, germination speed, germination uniformity, and germination index rate. Differences. Accordingly, in this study we used limited varieties of the quinoa plant, and therefore we believe it is necessary to conduct other studies through which a physiological study of these and other varieties of quinoa is carried out at all stages of growth, so that we can find the varieties that are most resistant to salts. It is also more resistant to some other stresses, such as heat and drought, which our region suffers from. There is also a study of its chemical composition, the nutritional value of quinoa produced in our country, the nutritional value of its leaves for humans and animals, and other topics of importance regarding this new crop.

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