Alexandria Journal of Soil and Water Sciences (AJSWS) Volume: 7 (1)

Evaluating the Role of Some Soaking Materials in Enhancing the Growth Characteristics and Nutrient Contents of Quinoa Crop Grown Under Saline Soil Conditions

Wafaa H.Mohamed[1],Hanan.I.Gad[1], and Mostafa M. Wqeda[1]

1-Soil and Agri. Chemistry Dept. Faculty of Agriculture (Saba-basha) Alexandria University.

DOI: 10.21608/AJSWS.2023.183147.1007

Article Information

Received: December 20th 2022

Revised: December 25th 2022

Accepted: January 8th 2023

Published: January13st 2023

ABSTRACT: Quinoa is a halophytic species emerging as a potential new crop in many regions of the world because of the nutritional composition of its seeds. A field experiment was conducted on Chenopodium quinoa Willd. in a private farm in Hosh Issa in Beheira Governorate, Egypt during the growing season that started from 24/11/2018 to 2/4/2019, to evaluate the effect of pre-soaking the seeds in different concentrations of three solutions (Hydrogen peroxide, Salicylic acid, and Potassium Chloride) on the growth and production of quinoa cultivated under saline soil conditions. A significant increase in morphological parameters of quinoa seeds was observed as a result of pre-soaking quinoa seeds in hydrogen peroxide, salicylic acid, and potassium chloride. The highest values for both fresh weight (197.00g/branch) and dry weight (34.57 g/branch) were obtained by soaking in salicylic acid at a concentration. Concerning the biochemical analysis of plants, the maximum value of chlorophyll content resulted from soaking the seeds in salicylic acid at a concentration of 10-2 mol/L followed by potassium chloride and hydrogen peroxide without significant difference between them. While the highest proline content was achieved by soaking the seeds in salicylic acid at a concentration of 10-2 mol/L, followed by potassium chloride at a concentration of 0.54 mol/L, then in hydrogen peroxide 4 x 10-5 mol/L. The data also showed that the highest value of grain yield was obtained from soaking quinoa seeds in salicylic acid and potassium chloride at a concentration of (10-2 mol/L and 0.54mol/L, respectively) without significant difference between them. Generally, soaking quinoa seeds in different concentrations of soaking solutions resulted in a significant increase in grain yield compared to the control. Potassium chloride solution has a higher effect on increasing N, P, K, and Na contents. The salicylic acid solution followed the KCl solution in increasing the quinoa nutrient content. The less effect was for the Hydrogen Peroxide solution.

Keywords: Soil salinity, quinoa, Hydrogen peroxide, Salicylic acid, Potassium Chloride.

INTRODUCTION

Soil salinity is one of the main problems affecting agriculture and crop production in many regions of the world, especially in the dry and semi-arid regions, as salts accumulate in the root zone of the plant and then affect its growth and production, the direct effect of salinity on the plant is the osmotic pressure, which leads to a deficit in water absorption and influences the nutritional balance in the soil. Hu and Schmidtler (2005) have indicated that salinity can affect the mineral nutrition of plants differently. Salinity may cause deficiencies or nutrient imbalances due to competing more Na and Cl ions with nutrients such as K+, Ca2 +, and NO3-. To better understand the role of the contribution of nutrients in plant resistance to salinity, improved fertilizer management practices are required in arid and semi-arid areas and areas suffering from high salinity (Hu et al., 2017). There is a critical need to minimize the effects of salt stress on plant growth and crop yield. A possible approach is introducing species that are tolerant to high soil salinity and ensuring an acceptable yield, one of these tolerant species is Quinoa (Chenopodium quinoa Willd.).Quinoa is a seed crop, native to the Andes. It was the traditional Cultivated seed crop for Andean. It was for more than 7000 years (Jacobsen, 2011), and quickly gained interest all over the world (Bhargava et al.,2006). Quinoa is well adapted to grow under unfavorable soil and climate conditions (Hariadi et al., 2011). Quinoa is a new salt-tolerant crop in many parts of the world due to the nutritional composition of its seeds. Another approach that can be taken to reduce the effects of soil salinity is to carry out a process of acclimating the seeds by soaking them before planting (Kumai et al., 2007).

High, rapid and homogeneous germination leads to a good field establishment, but the salt stress hinders this as it is one of the most important physiological stresses that affect seed germination and seedling growth, which in turn affects the subsequent growth stages as a result of the accumulation of dissolved salts to a degree that exceeds their natural rates in the soil, which leads to Inhibiting germination as a result of the negative effect of water absorption from the roots and the entry of some ions in quantities that do not match the cell's needs, thus affecting the vital processes and this problem can be overcome through breeding programs or genetic engineering, but it is not so easy because of the complex nature of the salinity tolerance This trait is governed by multiple genes, so the use of other methods that shorten the time, effort and cost, such as stimulating the seeds through the process of pre-soaking the seeds in some solutions such as hydrogen peroxide, salicylic acid and potassium chloride, which can be one of the alternative solutions to reduce the effect of salt stress. Plant hormones play an important role in seed germination, including salicylic acid, which is one of the most important of these hormones, which leads to an increase in the speed of germination(Torres - Garcia et al.,2009). Salicylic acid is used to increase the tolerance of plants against abiotic and biotic stresses (Chen, et al., 2007).

Therefore, this study was designed to evaluate the effect of soaking quinoa seeds in different concentrations of hydrogen peroxide, salicylic acid, and potassium chloride for possible salt stress relief on quinoa plants.

MATERIALS AND METHODS

A field experiment was conducted on wild quinoa (Chenopodium quinoa) on a private farm in HoshIssa in Beheira Governorate, Egypt during the growing season that started from24/11/2018 to 2/4/2019 to evaluate the effect of soaking the seeds in three solutions (hydrogen peroxide, salicylic acid, and potassium chloride) on the growth and production of quinoa cultivated under saline soil conditions.

Quinoa (Chenopodium quinoa wild) seeds were obtained from the Agricultural Research Center, Giza, Egypt. The experiment was conducted in a complete randomized design (CRD) with 12 treatments and three replications to study the effect of soaking quinoa seeds in different concentrations of (hydrogen peroxide, salicylic acid, and potassium chloride) on the properties of quinoa plant (Chenopodium quinoa wild).

Quinoa seeds were sown on The 24th of November 2018 at the rate of 3 kg/ fed in rows 3.5 meters long, and 20 cm apart. The experimental unit area was 7 m2 (3.5 m in length and 2 m in width).

For priming treatments, seeds of quinoa (Chenopodium quinoa wild) were soaked for 8 hours at room temperature (25±2 C) in respective solutions of each treatment as follows:

Hydrogen peroxide (HP) [(0(control), 2x10-5,4x10-5 and 6 x10-5 mol/L).

Salicylic acid (SA) [0 (control), 10-6, 10-4 and 10-2 mol/L)

Potassium chloride (KCl) [0(control), 0.13 ,0.27 and 0.54 mol/L)

Seeds of control treatments were soaked for 8 hours at room temperature (25±2 C) in distilled water.

The experimental field was prepared by plowing the soil twice, then the recommended dose of phosphorous (36 kg P2O5/ fed) as Calcium super phosphate (15.5% P2O5), and potassium (50 kg /fed) as potassium sulfate (48% K2O) were added to the soil, While nitrogen was added in two doses in the form of urea (46% nitrogen) at a rate of 75 kg nitrogen / feddan. It was added in two doses, the first dose during the hoeing process and the second dose at the beginning of flowering Quinoa seeds, which were previously soaked for 8 hours in the above mentioned soaking solutions, were sown in the field.

To identify some properties of experimental soil, surface soil samples (0-30 cm depth) were collected before planting to identify some of the physical and chemical properties of the experimental site. The air-dried soil samples were crushed and passed through a 2 mm sieve. The physical and chemical properties of the soil were estimated according to the methods described by Jackson (1973). The obtained results are shown in Table (1).

Soil analysis:

Particle size distribution was estimated using the pipette method as described by Black (1965). Soil pH was measured in a 1:2.5 soil solution according to Jackson (1973). EC is commonly used for indicating the total ionized concentration of solutions and soluble cations and anions were added to the Jackson (1973). CaCO3 content was determined by the colorimetric method, by measuring the CO2 volume evolved from the reaction of hydrochloric acid with soil carbonates, then the total carbonates were calculated as calcium carbonate percentage. SAR, the value was calculated according to Richards (1954).

Table (1). Some physical and chemical characteristics of the experimental soil

Soil properties	Values
Particle size distribution (%)	
Clay	23.1
Sand	69.9
Silt	7.0
Textural class	**Sandy clay loam**
pH (1:2.5 soil suspension)	8.3
EC (dS/m) (saturated soil-water Paste)	8.8
SAR	20.38
Soluble cations (saturated soil-water Paste) (meq/l)	
K+	8.7
Ca2+	14.0
Mg2+	12.0
Na+	73.4
Soluble anions (saturated soil-water Paste) (meq/l)	
HCO3¯	6.0
CO3 -	0.0
Cl -	70.0
SO4=	24.6
Calcium carbonate (%)	10
Organic matter (%)	0.7
Available phosphorus (mg/kg)	9.00
Available nitrogen (mg/kg)	27.44
Available potassium (mg/kg)	84.8

Plant analysis and recorded data:

Five guarded plants from each plot were taken at 105 days after sowing for measuring the following parameters:

Fresh and dry weights (g/branch).

Chlorophyll content (mg/g FW) was determined according to Moran (1982).

Proline content (mg/g FW) was determined according to the method described by Vartanian et al. (1992).

Grain yield (ton/fed).

The nutrient contents of leaves were determined by the digestion of dry leaves with H2SO4+H2O2 (Lowther, 1980).

Statistical analysis

The obtained results were statistically analyzed, and ANOVA and LSD values were calculated to test the differences between the studied treatments according to Steel and Torrie (1980).

RESULTS AND DISCUSSION

The field experiment was conducted to study the effect of soaking quinoa seeds in hydrogen peroxide (HP) with four concentrations [0 (control), $2x10^{-5}$, $4x10^{-5}$, and $6x^{-5}$ mol/L], salicylic acid (SA with four concentrations [0 (control), 10^{-6}, 10^{-4} and 10^{-2} mol/L] and potassium chloride with four concentrations [0(control), 0.13,0.27 and 0.54 mol/L) on the fresh and dry weight of quinoa plants, plant biochemical analysis, the yield of quinoa crop grown under salt affected soil conditions.

I. Fresh and dry weights of quinoa

I.1. Effect of various soaking solutions:

One of the objectives of this study is to know the effect of soaking in hydrogen peroxide, salicylic acid, and potassium chloride and its concentrations on the fresh weight (g/branch) and dry weight of quinoa under soil salinity, the fresh and dry weight data (g/branch) were recorded in Table 2.

The results showed that all the different soaking treatments caused a significant increase in fresh and dry weight (g/branch) compared to the control. On the other hand, by comparing soaking the seeds in hydrogen peroxide, salicylic acid, and potassium chloride, we found that there was a non-significant increase in fresh weight (g/branch) as a result of soaking In these solutions, noting that the highest value of the fresh weight resulted from soaking in salicylic acid (135.37 g/branch). Gunes *et al*. (2007) demonstrated that exogenously applied SA increased plant growth significantly both in saline and non-saline conditions and this may be related to its inhibiting effect on Cl^- and Na^+ and improving the uptake of N, Mg, Fe, Mn, and Cu and/or due to its effect on lipid peroxidation, measured in terms of malondialdehyde (MDA) content and membrane permeability

From the data in Table (2), fresh weight (g/ branch) increased according to its susceptibility to different seed soaking solutions compared to the control. The rates of increase in fresh weight (g/

branch)with hydrogen peroxide (HP), salicylic acid (SA), and potassium chloride (KCl) solutions compared to control were (42.25, 61.23, and 45.62 %), respectively.

These facts may be due to that salicylic acid is involved in many biological processes within the plant, especially energy processes and increases the plant's ability to resist the harmful effect caused by the high salinity of soil and irrigation water. Also, the increase of fresh weight by salicylic acid returns to the role of salicylic acid in increasing absorption of water and nutrients and the reflection of that positive role in increasing the efficiency of representation carbon dioxide. And this result is consistent with the findings of Forouzandeh *et al.* (2019).

Table (2) shows the dry weight (g/ branch) and its response to different soaking materials. The results showed that all different soaking treatments caused an increase in dry weight (g/ branch) compared to the control.

The lower values of dry weight (11.96 g/ branch) in the case of non-soaked seeds are due to the depressing effect of salinity on plant growth due to the increase in the osmotic capacity of the soil resulting in a decrease in the availability of water for the plant. These results were in line with those mentioned by Hussain *et. al.* (2018)

Soaking the seeds in hydrogen peroxide caused a non-significant increase in dry weight (g/ branch) while soaking the seeds in salicylic acid and potassium chloride solutions caused a significant increase in the dry weight (g/ branch) compared to the control. The rate of increase in dry weight (g/ branch) with hydrogen peroxide (HP), salicylic acid (SA), and potassium chloride (KCl) solutions compared to control were (99.67, 120, and 114.54 %), respectively.

Soaking the seeds in hydrogen peroxide caused an increase in fresh weight (g/ branch) Zhang *et al.*,(2001) showed that the exogenous addition of H_2O_2 under water stress significantly increased the content of IAA and GA3. It also works to preserve the water content of the plant, through the contribution of hydrogen peroxide to stimulate rapid changes in the cytoplasm pH and the vacuole in the guard cells of the plant. Finally, it leads to controlling the opening and closing of the stomata, reducing the transpiration process, and then retaining the water content of the plant.

This increase is attributed to the role of salicylic acid in increasing the dry weight of plants, as salicylic acid increases the uptake of carbon dioxide, water, nutrients and the accumulation of dry matter.

The results in (Table 2) showed that soaking in potassium chloride Significantly affected the weight characteristic in increasing the vegetative dry and fresh weight, which resulted in the treated plants. The reason is attributed to the role of potassium, which stimulates the growth of the vegetative system by stimulating large numbers of protein synthesis enzymes, and oxidation and reduction enzymes. This result is similar to what was obtained by Al-Shahwani *et al*. (2007).

I.2. Effect of different concentrations of soaking solutions:

Table (2) displays the fresh weight (g/branch) as affected by the different concentrations of the soaking solutions. Among the treatments, the data showed that different concentrations of the soaking solutions caused a highly significant increase in fresh weight (g/branch) compared to the Control treatment.

In Table 2, fresh weight (g/branch) as a result of pre-soaking quinoa seeds in different concentrations of hydrogen peroxide (HP) is presented in Table 2. The treatment (4 $x10^{-5}$mol/L) gave the highest fresh weight (144.87 g/plant) while treating the seeds with hydrogen peroxide (2 $x10^{-5}$ and 6 x 10^{-5} mol/L) led to a decrease in fresh weight compared to the treatment (4 $x10^{5}$ mol/L).

Fresh weight values (g/branch) as a result of pre-soaking quinoa seeds in concentrations of salicylic acid (SA) are presented in Table 2. The fresh weight increased as a result of soaking the Quinoa seeds in the three concentrations of salicylic acid compared to the control. Treatment (10^{-2} mol/L) had the highest fresh weight (197.00 g/branch) followed by lower concentrations of salicylic acid (SA) (10^{-6} mol/L) and 10^{-4} mol/L)

This increase in fresh weight is attributed to the vegetative growth-encouraging effects of this plant hormone, which is in agreement with several studies showing that exogenous supplementation with salicylic acid may also enhance growth as a limitation on inhibitory abiotic growth induced by abiotic stress conditions (Shakirov, et al., 2003) in many agricultural crop stresses (El-Tayeb, 2005), in addition to increased levels of Phyto hormones such as auxins and cytokinins. As a result of acid treatment, salicylic acid has been found in some plants, which encourages growth (Sakhabutdinova *et al*, 2003).

Data regarding the effect of pre-soaking seeds in potassium chloride Solution and its concentrations on fresh weight (g/branch) are shown in Table 2. The results indicated that fresh weight (g/branch) increased with increasing KCl concentration compared to the control. The fresh weight (g/branch) increased with increasing KCl concentration from 13.51 to 27.03 to 54.05 mol/L. Maximum fresh weight (g/branch was recorded with 0.54 mol/L KCl (164.2 g/branch), followed by (124.2 g/branch) in 0.27 mol/L KCl, respectively. The lowest fresh weight (g/branch) (117.9 g/branch) was observed at 0.13 mol/L KCl, respectively, without significant difference between the three treatments. The results are in agreement with those of Yari et al. (2010)

Among the treatments, the data showed that different concentrations of the soaking solutions caused a highly significant increase in dry weight (g/branch) compared to the control.

Dry weight (g/ branch) as influenced by pre-soaking seeds in hydrogen peroxide (HP) are presented in Table 2. The maximum dry weight (30.8 g/branch) was recorded with soaking in (4 x 10^{-5} mol/L). on the other hand, treatment of seeds with hydrogen peroxide at a concentration of (2 x10^{-5} and 6 x 10^{-5} mol/L) caused a decrease in this parameter without significant difference (Table 2).

Dry weight (g/ branch) as influenced by pre-soaking seeds In different Salicylic acid (SA) concentrations is presented in Table (2). It was observed from the data that, the dry weight of the plant was increased progressively with increased Salicylic acid from (10^{-6} to10^{-4} and 10^{-2} mol/L), respectively. SA concentration of 10^{-2} mol/L recorded the maximum dry weight (34.57g/branch) compared with other concentrations of salicylic acid and without significant difference. This could be due to the positive effect of SA in activating enzyme systems in the seed and facilitating metabolite transport to the seedling and then increasing dry weight. Also, reduces ionic toxicity and improves the balance of nutrient metabolism and transport. These results are in agreement with Kaydan et al (2006) who reported that SA stimulates hormones to make chlorophyll more active to produce more plastids which leads to an increase in seedling dry weight and the seedling vigor Index.

It was observed from the data table (2) that the dry weight of the quinoa plant was decreased progressively with increasing KCl levels. The maximum dry weight was recorded for 0.13 mol/L KCl (34.40 g), followed by (30,87, and 26.07 g/ branch) in 0.27 and 0.54 mol/L KCl, respectively. Without significant differences between concentrations. The decrease in dry weight was also reported by other researchers (Basra *et al.,* 2005; Argentel *et al.,* 2006; Saboora *et al.,* 2006. They reported that treatment levels had a significant effect on shoot dry weight.

II. chlorophyll and proline contents of the quinoa plant

II.1. Effect of various soaking solutions

The effect of soaking quinoa seeds in hydrogen peroxide, salicylic acid, and potassium chloride and its concentrations on chlorophyll and Proline content under soil salinity are recorded in Table 2. Means of Chlorophyll content as affected by different soaking solutions are presented in Table (2). Among the treatments, the data showed that soaking quinoa seeds in solutions of hydrogen peroxide (HP), salicylic acid (SA) and potassium chloride (Kcl) caused a significant increase in Chlorophyll content compared to the control treatment. The increase in Chlorophyll content over control for hydrogen peroxide (HP), salicylic acid (SA), and potassium chloride (Kcl) were (31.72, 37.16, and 31.92 %), respectively.

Table (2) showed that chlorophyll content was affected by different soaking solutions. Among the treatments, the data showed that soaking solutions caused a highly significant increase in chlorophyll content compared to the control (9.93 mg/g). The results also showed that the largest increase in chlorophyll content resulted from salicylic acid treatment (13.62 mg/g) followed by potassium chloride (13.10 mg/g) and hydrogen peroxide(13.08 mg/g) without a significant difference between them.

Salicylic acid protects plants against many types of environmental stress, including salt stress. It also plays an important role in regulating ion absorption, hormonal balance, and stomata movement, in addition to its role in accelerating the formation of chlorophyll pigments, accelerating the process of photosynthesis, and increasing the activity of some important enzymes, which are positively reflected in the course of physiological operations in the plant.

Salicylic acid also works in improving the growth characteristics of plants exposed to salt stress through its role in stimulating the photosynthesis process by preserving the enzymes involved in this process and the permeability of the plasma membranes and the increase of building optical pigments. According to Jabbarzaden *et al*. (2009) who showed that., the important role of this compound may also be due to increasing the products of photosynthesis, so there is an excess of ready-made sugars to promote the growth of the flower group.

This effect on chlorophyll is due to the effect of encouraging growth. The reason for the increase in the chlorophyll content in the leaves may be that soaking the quinoa seeds in salicylic acid indicates the acid’s role in stimulating a large number of enzymes, including the enzymes responsible for building the chlorophyll molecule, and stimulating the formation of proteins, which reduces the decomposition of chlorophyll and thus increases the total chlorophyll content or the stimulation of enzymes responsible for the process of cell division, elongation, and growth, which leads to an increase in the phenotypic characteristics of the plant, including the height of the plant, which is the main place for the pigment chlorophyll or the reason for this cell division, the effect of salicylic acid on chlorophyll, which was positively reflected in its increase in the leaves of the plant or to the effect of increasing the absorption of the necessary nutrients in the synthesis of chlorophyll, and its effect on maintaining chlorophyll from disintegration. These results are in agreement with these of Kaydan et al. (2006), who reported that the SA stimulates hormones to make chlorophyll more active to produce more plastids which leads to an increase in seedling dry weight and the seedling vigor Index.

Effective proline accumulates in higher osmotically stressed plants by stimulating its synthesis and stopping the process of its destruction (Delauney and Verma,1993) (Khalid *et al.*.,2009) showed that, the concentration of proline rises with the increase in salinity concentrations. (Parida and Das, 2005 and Djerroudi et al.,2010) their study on two types of Atripelex after a week of saline stress found that the difference in proline accumulation depends on the amount of salinity in the medium.

Table (2) displays the Proline content as affected by the different soaking solutions (hydrogen peroxide, salicylic acid (SA), and potassium chloride (KCl). Among all treatments, the data showed that different soaking solutions caused a highly significant increase in Proline content at 70 and 105 days compared to the control.

The proline and other free amino acids in plants increase with water stress but the presence of vitamins or)salicylic acid during water stress lowered this effect.

The main effect in table 2 showed that the largest increase in Proline content of quinoa plants resulted from hydrogen peroxide (89.01 and 23.38 ug g^{-1}) (followed by potassium chloride (83.25 and 22.23 ug g^{-1}) and salicylic acid treatment (82.50 and 19.12 ug g^{-1}) at 70 and 105 days after sowing, respectively.

The percent increase in Proline content over control treatment for hydrogen peroxide (HP), salicylic acid (SA), and potassium chloride (KCl) were (8.39, 15.44%),15.09, 30.87%) and (14.32,19.60 %) at 70 and 105 days after sowing, respectively. Soaking quinoa seeds in hydrogen peroxide achieved a significant difference in the concentration of proline compared to the control. Several studies have indicated that hydrogen peroxide treatment greatly improved the levels of non-enzymatic antioxidants such as proline under different stress conditions (Bohnert and Jensen, 1996).

Salicylic acid is considered an anti-oxidant because it has a high ability to scavenge free radicals (ROS) due to the presence of high electron exchange, as this compound is characterized by acidity that gives it a strong characteristic of the presence of an OH group in the site Ortho, and this site electrons are pushed, and then the acidity is increased to increase the OH in the site ortho, which leads to an increase in the effective electron exchange to include the area of the OH, the ring, and the carboxylic group) i.e. electron exchange is directed towards the OH group attached to the ring (which gives it an anti-oxidant because it has a high ability to sweep electrons inside the ring, as studies indicate the role of chains in the effectiveness of antioxidant enzymes (Almagro *et al*.,2009).

Soaking with potassium chloride achieved a significant difference in the concentration of proline compared to the control. The reason may be due to the role of potassium in increasing the proportion of protein formed in the plant and its catalytic role in the production of growth regulators (cytokines), which delays aging and then delays the breakdown of proteins in the plant.

II.2. Effect of different concentrations of soaking solution

Table (3) displays Chlorophyll content as affected by the different concentrations of the soaking solutions. Among the treatments, the data showed that different concentrations of the soaking solutions caused a highly significant increase in Chlorophyll content compared to the control (9.93 mg/g). the decrease in the chlorophyll content of the leaves with the increase in salt stress in the plant Could be due to the increase in salinity leading to the transfer and accumulation of some mineral elements in the leaves and a deficiency of others such as iron, due to its entry into the composition of the chloroplasts responsible for the production of proteins, and the low content of the leaves of chlorophyll can be attributed to the fact that the ammonium anions that accumulate in the leaves may break down chlorophyll by crushing the plastids in the blade of the leaves of plants growing in a medium of high salinity

Chlorophyll content as a result of pre-soaking quinoa seeds in different concentrations of hydrogen peroxide (HP) is presented in Table 2.

The increase in concentrations from (0 to 4 x10^{-5} mol/L) caused increased Chlorophyll content. The treatment (4 x10^{-5} mol/L) was characterized by the highest Chlorophyll content (14.93 mg/g). On the other hand, treating seeds with hydrogen peroxide at a concentration of (6 x10^{-5} mol/L) reduced this parameter without a significant difference compared to other concentrations of hydrogen peroxide.

Chlorophyll content as a result of pre-soaking quinoa seeds in concentrations of salicylic acid (SA) is presented in Table 2. The Chlorophyll content increased with the increase in concentrations from ((10^{-6} mol/L to 10^{-2} mol/L). Treatment (10^{-2} mol/L) had the highest chlorophyll content (17.07 mg/g).

The reason for the increased content of chlorophyll in the leaves may be due to soaking the seeds of the crop before planting with salicylic acid, which indicates the role of the acid in stimulating a large number of enzymes, including the enzymes responsible for building the chlorophyll molecule, and stimulating the formation of proteins, which reduces the breakdown of chlorophyll and thus increases Either the total chlorophyll content or the stimulation of enzymes responsible for the process of division, cell elongation and growth, or the reason for this is the positive effect of salicylic acid in increasing it to the leaves of the plant and thus increasing the absorption of the nutrients necessary in the synthesis of chlorophyll. These results are consistent with Kaydan et al (2006), who reported That SA stimulates hormones to make chlorophyll more active to produce more plastids.

The chlorophyll content as affected by seed soaking in Kcl concentrations is presented in Table 2. The results showed that an increase in potassium chloride concentrations from (0.13 to 0.54 mol/L) was followed by a continuous increase in chlorophyll content compared to the control. The treatment (0.54 mol/L) was characterized by the highest content of chlorophyll (15.93 mg/g).

Salinity inhibits the activity of cells in food transportation in various parts of the plant (Kumar et al., 2020). The presence of salt stress can minimize the synthesis of chlorophyll pigments and photosynthesis experiences a rate of pressure and other important processes involved in it (Desoky *et al*., 2020).

Potassium plays an essential role in plant photosynthesis and metabolism. It also has an important role in the breakdown of carbohydrates, which provides energy for plant growth. Potassium also increases drought resistance in plants and helps reduce water loss in plants. The lowest content of chlorophyll was recorded in the leaves of the control treatment.

Salinity is one of the most important abiotic factors that limit crop productivity. The most important process affected by plants growing under saline conditions is photosynthesis. The decrease in photosynthesis under salinity is attributed to stomata closure resulting in reduced intracellular CO concentration but is also due to non-stomal factors. Stepien and Klobus, 2006 indicated that salt affects photosynthetic enzymes and chlorophyll. The content of chlorophyll is one of the main factors affecting the ability of photosynthesis. Decreased or no change in plant chlorophyll content under salinity stress was observed in different plant species. (Nageswara *et al*., 2001) indicated that the ability of plant tissues to photosynthesize is due to the content of chlorophyll in leaves.

Table (2) displays proline content as affected by the different concentrations of the soaking solutions. Among the treatments, the data showed that different concentrations of the soaking solutions caused a highly significant increase in proline content compared to the control.

Data on the effect of pre-soaking seeds in hydrogen peroxide (HP) concentrations on the proline content of quinoa plants are presented in Table 2.

The results showed that an increase in hydrogen peroxide (HP) concentrations from (2 to 4 and 6) were followed by a continuous increase in proline contents of quinoa plants at 70 and 105 days after sowing compared to the control.

The maximum proline content was recorded by 4×10^{-5} and 6×10^{-5} mol/L (HP)(88.28 and 23.98ug g^{-1} $_{f.w.}$) at 70 and 105 days after sowing, respectively.

Proline has vital roles in osmotic adjustment (Hasegawa et al. 2000), stabilization, and protection of enzymes, proteins, and membranes (Ashraf and Foolad,(2007) from damaging effects of drought-osmotic stresses. Also, reduces the oxidation of lipid membranes (Demiral and Türkan, 2004).

For treatments of seed soaking in different concentrations of Salicylic acid (SA), data on proline content (at 70 and 105 days after sowing are presented in Table 2. As for the effect of salicylic acid, it led to a significant increase of the amino acid proline, as it reached the high concentration of treatment with salicylic acid at a concentration of 10^{-2} and 10^{-4} mol/L, which amounted to 109.27 and 31.32 ug $g^{-1}{}_{f.w}$) at 70 and 105 days after sowing, respectively compared to the control treatment. Ahmad *et al.* (2018) elucidated that the SA treatment enhanced the antioxidant enzyme activity as well as the proline levels in salt-stressed Vicia faba L.

The proline contents at 70 and 105 days after sowing of KCl concentrations are presented in Table 2. The results showed that an increase in potassium chloride concentrations from (0.13 to 0.54 mol/L) was followed by a continuous increase in proline contents compared to the control. The treatment (0.54 mol/L) was characterized by the highest content of proline at 70 and 105 days after sowing, respectively. The minimum proline contents were recorded with 0.13 mol/L (83.87 and 25.41ug g^{-1} $_{f.w.}$). In the treatment with KCl at the concentration of 0.13 mol/L, it led to a significant reduction of the amino acid proline, as it reached the lowest concentration.

III. Grain yield (ton/fed.)

III.1. **Effect of various soaking solutions**

Table (2) shows another objective of this study, which is to study the effect of pre-soaking quinoa seeds in hydrogen peroxide, salicylic acid, and potassium chloride solutions on the yield of quinoa grains grown under soil salinity conditions.

Among all the treatments, the data showed that different soaking solutions caused a highly significant increase in the yield of quinoa grains compared to the control.

The yield of quinoa grains obtained from the control treatment was, (0.24 tons/fed.). In, the decrease in grain yield was more pronounced, which indicates that the high salinity of soil has a depressive effect on grain yield.

By comparing the main effect of the three solutions with each other, the results showed that the lowest significant grain yield was observed with the treatment of seeds with a hydrogen peroxide solution. The grain yield of quinoa plants treated with hydrogen peroxide is 1.10 tons/fed.). This was followed by potassium chloride treatment (1.53 tons /fed.), while the salicylic acid treatment gave the highest increase in grain yield (1.77 tons /fed.) without a significant difference between salicylic acid and potassium chloride. Golubkina et al., (2018) showed that the exogenous application of plant growth regulators is receiving worldwide attention. These plant growth regulators can be used in many different ways for increasing crop yields. When they are used as priming agents, they accelerate the early crop growth processes especially the germination of the seeds. These results were consistent with the ones of Gashti*et al.(*2012), in which Potassium helped increase the yield and yield components of peanuts.

Potassium increases the yield and quality of agricultural products and enhances the ability of plants to resist diseases, insect attacks, cold stresses, drought, and other adverse conditions. It aids in the development of a strong and healthy root system and increases the efficiency of absorption and utilization of N and other nutrients. Potassium has been described as a “quality element”, ensuring the optimum quality of agricultural products (Ujwala, 2011).

This yield increase is due to the role of salicylic acid in increasing the dry weight of plants, as salicylic acid increases the absorption of carbon dioxide and the accumulation of dry matter and increases the absorption of water and nutrients and the reflection of that positive role in increasing the efficiency of carbon dioxide metabolism. The resulting compounds such as sugars, amino acids, and proteins are increased and transferred to the fruits, which leads to an increase in the weight of the seeds.

III.2. Effect of different concentrations of soaking solution

Table (2) presents the yield of quinoa grains resulting from soaking quinoa seeds before planting in different concentrations of the soaking solutions. Among the treatments, the data showed that different concentrations of the soaking solutions resulted in a highly significant increase in grain yield compared to the control treatment l.

Our data indicate that soaking seeds in 4 $x10^{-5}$ mol/L H_2O_2 solution before germination in saline conditions resulted in the maximum increase in grain weight 1.43 t/fed), which may be due to the acclimatization process to salt stress. Although acclimatization is a complex phenomenon, our results indicated that while salt stress can be detrimental to plants emerging from seeds pre-treated with water, previous application of mild oxidative stress in seeds can lead to reduced adverse effects of salinity on plant growth.

On the other hand, immersing the seeds in (2 $x10^{-5}$mol/L H_2O_2) resulted in the increase in grain weight to (1.40 tons/fed.). On the other hand, the use of 6 $x10^{5}$ mol/L H_2O_2 was less effective in increasing grain weight compared to the other two treatments (1.33 tons/fed).

Our data suggest that soaking seeds in 4 $x10^{-5}$ mol/L H_2O_2 solution before germination in salinity conditions led to a salt stress acclimation process.

Sarath G, et al.,(2007) showed that the uptake of O_2 and H_2O was significantly increased in the H_2O_2-soaked seeds of Pseudotsugamenziesii compared to the control, indicating an improved conversion rate of reserve lipids to carbohydrates, thus increasing the synthesis of cellular components.

The grain yield of quinoa as a result of soaking quinoa seeds in different concentrations of salicylic acid (SA) is shown in Table (2). The results indicated that the grain yield increased with increasing the concentrations of salicylic acid from (10^{-6} to 10^{-2} mol/L.), where soaking in the concentration (10^{-2} mol/L) recorded the highest grain yield (3.05 tons/fed.).

Table (2) shows the yield of quinoa grains as affected by soaking the seeds in different concentrations of KCl. The results showed that increasing the potassium chloride concentration from (0.13 to 0.54mol/L) led to a continuous increase in grain yield compared to the control. The soaking treatment with a concentration of (0.54 mol/L) of potassium chloride was characterized by producing the highest yield of quinoa grains (2.53 tons / fed.).

Table (2). Effect of pre-soaking quinoa seeds in different concentrations of Hydrogen peroxide, Salicylic acid, and Potassium Chloride on the growth and grain yield of quinoa

Treatments	Conc.	Fresh weight (g)	Dry weight (g)	Chlorophyll mg/g FW	Proline at 70 days mg/g	Proline at 105 days mg/g	Grain yield ton/fed
Hydrogen peroxide (HP)	Control	85.30	13.0	10.13	70.12	10.43	0.24
	$2x10^{-5}$ mol/L	123.57	25.57	13.17	84.97	18.22	1.40
	$4 x10^{-5}$ mol/L	144.87	30.80	14.93	88.28	23.84	1.43
	$6 x10^{-5}$ mol/L	123.63	26.17	14.10	86.62	23.98	1.33
Salicylic acid (SA)	Control	83.70	11.57	9.93	70.10	10.43	0.24
	10^{-6} mol/L	136.70	28.80	13.37	84.57	26.68	1.03
	10^{-4} mol/L	189.70	30.93	14.10	92.1	31.32	2.42
	10^{-2} mol/L	197.00	34.57	17.07	109.27	25.10	3.05
Potassium chloride (KCl)	Control	82.87	11.30	9.73	70.00	10.34	0.24
	0.13 mol/L	117.90	34.40	11.43	83.87	25.41	1.25
	0.27 mol/L	124.20	30.87	15.30	85.19	25.49	2.09
	0.54 mol/L	164.23	26.07	15.93	93.92	27.66	2.53
The main effect of solution type							
Hydrogen peroxide (HP)		119.43	23.88	13.08	82.50	19.12	1.10
Salicylic acid (SA)		135.37	26.47	13.62	89.01	23.38	1.77
Potassium chloride (KCl)		122.27	25.66	13.10	83.25	22.23	1.53
$LSD_{0.05}$		58.33	12.57	1.63	9.97	5.57	0.34
The main effect of concentration							
0		83.96	11.96	9.93	70.07	10.40	0.24
1		126.06	29.59	12.66	84.47	23.44	1.34
2		152.92	30.86	14.78	88.52	26.88	1.98
3		161.62	28.94	15.70	96.60	25.58	2.31
$LSD_{0.05}$		40.62	10.08	1.89	11.51	6.43	0.39
Solution type		n.s	n.s	n.s	**	**	**
Concentration		**	**	**	***	***	***
Solution X Concentration		n.s	n.s	n.s	n.s	n.s	*

IV. Leaf nutrient contents

IV.1. Effect of various soaking solutions

The results in Table (3) show the effect of various soaking solutions i.e. hydrogen peroxide, salicylic acid, and potassium chloride on the leaf nutrient contents of quinoa plants. The results indicated that soaking solutions significantly affected the leaf nutrient contents of quinoa plants compared to the control treatment. Potassium chloride solution has a higher effect on increasing N, P, K, and Na contents. The nutrient contents were 1.85, 0.5, 1.14, and 4.18% for N, P, K, and Na, respectively. The increases over the control treatment were 5.65, 57.58, 20.00, and 16.43%, respectively. The salicylic acid solution followed the KCl solution in increasing the quinoa nutrient content with increments of 4.52, 51.52, 10.53, and 12.40%, respectively. The less effect was for the Hydrogen Peroxide solution.

Phosphorus showed the greatest increase upon soaking, This increase could be due to more translocation of nutrients due to the activity of hormones at seed imbibition. The increase in sodium content in quinoa was likely the result of the increased osmotic pressure allowing more sodium to move into quinoa seed through passive diffusion (Narsih and Harijono, 2012).

IV.2. Effect of different concentrations of soaking solution

The results in Table(3) show the effects of different concentrations of soaking solution on nutrient contents of quinoa leaves such as N, P, K, and Na. Increasing the concentration of soaking solutions significantly increases the nutrient contents. No soaking of quinoa seeds led to the low concentration of N, P, and K but has a high concentration of Na. The highest concentration of soaking solutions resulted in increasing the nutrient contents by 46.0, 21.39, and 9.71% for N, P, and K, respectively over the control treatment. The Na content was decreased by 37.23% as a result of increasing the concentrations of the soaking solutions as compared to the control treatment.

Table(3). Effect of pre-soaking quinoa seeds in different concentrations of Hydrogen peroxide, Salicylic acid, and Potassium Chloride on leaf nutrients content

Treatments		N	P	K	Na
Solutions	Conc.	%			
Hydrogen peroxide (HP)	0	1.40	0.27	0.91	4.32
	$2.0x10^{-5}$ mol/L	1.69	0.30	0.96	3.83
	$4.0x10^{-5}$ mol/L	1.82	0.37	0.97	3.30
	$6.0 x10^{-5}$ mol/L	2.08	0.38	0.98	2.90
Salicylic acid (SA)	0	1.60	0.49	1.01	4.73
	10^{-6} mol/L	1.70	0.51	1.05	4.70
	10^{-4} mol/L	1.90	0.52	1.07	3.80
	10^{-2} mol/L	2.29	0.56	1.07	2.90
Potassium chloride (KCl)	0	1.50	0.41	1.07	4.83
	0.13 mol/L	1.80	0.55	1.13	4.54
	0.27 mol/L	1.98	0.53	1.15	4.40
	0.54 mol/L	2.12	0.52	1.20	2.90
Soaking solutions					
Hydrogen peroxide (HP)		1.77 b	o.33 b	0.95 b	3.59 a
Salicylic acid (SA)		1.85 a	0.50 a	1.05 ab	4.03 b
Potassium chloride (KCl)		1.87 a	0.52 a	1.14 a	4.18 a
$LSD_{0.05}$		0. 07	0.46	0.18	0.31
Concentrations					
0		1.50 d	o.41 b	1.04 a	4.62 a
1		1.73 c	0.47 a	1.08 a	4.37 a
2		1.90 b	0.49 a	1.13 a	3.83 b
3		2.19 a	0.51 a	1.14 a	2.90 c
$LSD_{0.05}$		0.08	0.45	0.19	0.36
Solutions		***	**	*	***
Concentration		*	***	ns	***
Solution x Concentration		ns	ns	ns	ns

Soaking with salicylic acid stimulated the seeds to germinate under stress conditions, and this is attributed to the role of Salicylic acid improves the germination and growth of plant cells and its positive effect on the metabolic and physiological processes that take place in plant cells, such as building carbohydrates, proteins, and sugars, as the addition of salicylic acid leads to an increase in the period and several cell divisions and their expansion and elongation (Hayat and Ahmad, 2007). Growth of plants exposed to stress conditions through its role in stimulating the process of photosynthesis by preserving the enzymes involved in this process and the permeability of plasma membranes and increasing photosynthetic pigment (Singh and Usha, 2003).

This significant increase in quinoa growth can be attributed to the role of salicylic acid in regulating many functional activities, including flowering induction, regulating ion absorption, hormonal balance, and influencing stomata work(Barker and Pilbeam, 2007).

Soaking quinoa seeds with salicylic acid improved the performance of the seed under stress conditions, and this is attributed to the role of salicylic acid in stimulating the growth of the root system, improving the efficiency of water and nutrients absorption, and increasing the efficiency of photosynthesis, especially in conditions of salt stress (Singh, and Usha, 2003). The results indicated that soaking the quinoa seeds with salicylic acid increased the protein and energy compounds as a result of increasing N and P content. This fact can be explained by the fact that salicylic acid promotes cell replication in the root, thus leading to increased root growth and nutrient absorption.

It may be concluded that the seeds soaked with plant growth regulators (such as salicylic acid) are beneficial for the stages of growth and productivity of some crops, which is known as the strategy of preventing the harmful effect of environmental stresses (Bahrani and Pourreza, 2012).

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الملخص العربي

تقييم دور بعض مواد النقع في تعزيز صفات النمو لمحصول ومحتوى العناصر للكينوا النامية تحت ظروف الاراض الملحية

وفاء حسن محمد[1] , حنان اسماعيل جاد[1] , مصطفي محمد وقيدة[2]

1-قسم الاراضي والكيمياء الزراعية كلية الزراعة – سابا باشا – جامعة الاسكندرية

2-طالب دراسات عليا

الكينوا من الأنواع الملحية والتي ظهرت كمحصول جديد في العديد من مناطق العالم بسبب التركيب الغذائي لبذورها ، وقد أجريت تجربة حقلية على الكينوا البرية (*Chenopodium*) في مزرعة خاصة في حوش عيسى بمحافظة البحيرة ، مصر خلال موسم النمو الذي بدأ من 2018/11/24 إلى 2019/4/2 لتقييم تأثير النقع المسبق للبذور في تركيزات مختلفة من بعض المحاليل (بيروكسيد الهيدروجين وحمض الساليسيليك وكلوريد البوتاسيوم) على نمو وإنتاج الكينوا المنزرعة تحت ظروف التربة المالحة. لوحظ زيادة معنوية في المتغيرات المورفولوجية لبذور الكينوا نتيجة النقع المسبق لبذور الكينوا ببيروكسيد الهيدروجين وحمض الساليسيليك وكلوريد البوتاسيوم. تم الحصول على أعلى قيمة لكل من الوزن الرطب والوزن الجاف مع النقع بحمض الساليسيليك (197.00 و 34.57 جم / فرع) بتركيز 10-2 مول/ لتر على التوالي). اما فيما يتعلق بتحليل النباتات البيوكيميائية ، نتجت القيمة القصوى لمحتوى الكلوروفيل من نقع البذور في حمض الساليسيليك بتركيز 10-2 مول/ لتر متبوعًا بكلوريد البوتاسيوم نقع البذور في بدون فرق معنوي بينهما. بينما تم تحقيق اعلى محتوى من البرولين عن طريق نقع البذور في حمض الساليسيليك بتركيز 10-2 فورمال متبوعًا بكلوريد البوتاسيوم بتركيز 54,05 مول/ لتر ثم نقع البذور في بيروكسيد الهيدروجين4x510مول/لتر مع وجود فرق معنوي بينهم . أدى النقع في التركيزات المختلفة لمحاليل النقع إلى زيادة معنوية عالية في محصول الحبوب مقارنةً بالكونترول. وأن أعلى قيمة لمحصول الحبوب تم الحصول عليها من النقع بحمض الساليسيليك وكلوريد البوتاسيوم بتركيز 10-2 مول/ لتر و 54,05 مول/ لتر يليهم نقع البذور في محلول بيروكسيد الهيدروجين بتركيز4 x510 مول/ لتر. احدث نقع بذور الكينوا في محاليل البوتاسيوم كلوريد اعلى تأثير في زيادة المحتوى من عناصر *N P, K, and Na* ، تبعه النقع في حامض السلسليك بينما كان اقل تأثير بالنقع في محلول الهيدروجين بيروكسيد.