An-Najah National Univesity

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Influence of Salicylic Acid (SA) and Brassionosteroid (BRs) on Pepper (C*apsicum annuum*) Under Salinity Stress

By

Mahmoud Hasan Mahmoud Droubi

Supervisors

Dr. Heba Al-Fares

Dr. Munqez Shtaya

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Effect of salicylic Acid and Brassinosteroid on the Performance of Sweet Pepper Plant (C*apsicum annuum*) under Different salinity Levels

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Mahmoud Hasan Mahmoud Droubi

This Thesis was Defended Successfully on 14/2/2021 and approved by:

Defense Committee Members	**signature**
1. Dr. Heba Al-Fares / Supervisor	....
2. Dr Munqez Shtaya / Co-Supervisor	....
3. Dr. Abdullah AL-Omari / External Examiner	....
4. Dr. Hassan Abu Qaoud / Internal Examiner	....

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الاقرار

أنا الموقع أدناه، مقدّم الرسالة التي تحمل العنوان:

Effect of salicylic Acid and Brassinosteroid on the Performance of Sweet Pepper Plant (C*apsicum annuum*) under Different salinity Levels

أقر بأن ما اشتملت عليه هذه الأطروحة إنما هو نتاج جهدي الخاص، باستثناء ما تمت الاشارة إليه حيثما ورد. وأن هذه الرسالة كاملة، أو اي جزء منها لم يقدم من قبل لنيل اي درجة او لقب علمي او بحثي لدى أي مؤسسة تعليمية أو بحثية أخرى.

Declaration

The work provided in this thesis, unless otherwise referenced, is the researcher's own work, and has not been submitted elsewhere for any other degree or qualification.

Student's Name: **اسم الطالب:** محمود حسن محمود درويش

Signature: **التوقيع:**

Date: **التاريخ:** 2021 / 2 / ١٧

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Abstract

The present investigation was carried out to evaluate the effect of different concentrations of salicylic acid and brassionosteroid (detailed chemical name such as mentioned in the methodology) on pepper plant under different salinity level. Pots experiments were conducted on (Formula) pepper plant under different salinity level (0, 50, 150 mM) NaCL. Combination of different levels of both salicylic acid (0, 0.05, 0.5 mM and brassionosterol (0, 0.05, 0.5 mM) were used. The treatments were all the combinations of the three factors. The plants were irrigated with the growth regulators (0.05, 0.5 mM). The yield was significantly reduces under salinity treatment alone, other parameters including; fruit weight, fruit number, shoot height and width , branch number were also reduced., increased sodium and chloride percentage in leaves.

Application of brassinosteroid and salicylic acid mitigates the effect of sodium chloride stress and improved both growth and yield of pepper seedling.

The application of BR and SA increased fruit number, fruit weight stem height, stem girth, chlorophyll content, above ground fresh weight, above ground dry weight, root fresh weight and root dry weight.

Brassinosteroid treatment increased fruit weight by 10% , 25% , 50%at 0 , 50 , 150 mM NaCl respectively compared to control treatment (without BR), SA treatment increased the fruit weight by 48% , 31% , 56% in comparison to control (without SA) at 0, 50, 150 mM NaCl, respectively.

Both BR and SA application reduced the effect of salinity on chlorophyll content. BR treatment increased chlorophyll content by 6_12%, SA application increased chlorophyll content by 6_14%, however, and when both were applied chlorophyll content was increased 30-60% at the different level of salinity.

The study revealed that the application of brassionosteroid and salicylic acid reduced the effect of salinity on the yield and growth of pepper plant.

Chapter One

Introduction

1.1 Introduction

Salinity and drought are the major abiotic stress that reduces plant growth and crop productivity worldwide. Abiotic stress resulting from excessive salinity or water deficit led to reduction in photosynthesis, transpiration and other processes associated with plant growth, development and crop productivity. Symptoms salinity stress includes visible injuries to leaves, induces stomata closure, and leaf rolling. Water stress causes a faster decline in the chlorophyll and protein content, osmotic adjustment altering both the structure and function of membranes. (Shannon, 1997 and Tiwari et al., 2010).

Climate of Palestine is considered arid and semi-arid, suffering from continuous shortage in water supply for domestic, industrial and agricultural purposes. The scarcity of water and the deterioration of its quality is a major driving force for land degradation and reduction in crop production in Palestine. The Jordan Valley is a fertile productive region, described as the food basket of Palestine. Groundwater originating from the Quaternary Aquifer System forms the main water resource in the Jordan Valley. However, the quality of this groundwater is threatened mainly by the high chloride concentration.

Pepper (*Capsicum annuum* L.) is an important vegetable cultivated in the Jordan Valley. Sweet peppers used in salads, cooked dishes and have high nutritional values as it contain high level of vitamin A and vitamin C. The large furrowed fruits are technically berries and can be green, red, yellow, or orange. Peppers are best known in pharmaceutical industry because of its capsaicin contents, which is used as a pain relieving medication. Pepper plants are considered moderately sensitive, sensitive or highly susceptible to salt stress (Aktas et al., 2006; Lee, 2006), and it is grown under protected greenhouse conditions in temperate regions and in the open field under warm Mediterranean climates. Seed germination and early seedling growth are considered as the most sensitive stages to salinity stress in most crops (Ashraf and Foolad, 2005). Germination and emergence of pepper seeds is also slow and non-uniform under normal as well as stress conditions (Demir and Okcu, 2004). Soil salinity, if not properly managed, can become a limiting factor for pepper stand establishment causing decrease in germination rate and germination percentage of pepper seeds. Moreover, pepper yield is reduced by 14% for every increase in unit of salinity above its threshold (Rhoades *et al.*, 1992).

Many plant hormone induce growth and alleviate salinity stress such as strigolactones, salicylic acid (SA) and brassinosteroids (BRs). Salicylic acid (SA) is considered as a hormone-like substance, which plays an important role in photosynthetic rate, stomatal conductance and transpiration (Khan et al., 2003 and Arfan et al., 2007), increasing antioxidative protection (Xu et al., 2008), and inhibiting Na^+ and

Cl^- accumulation (Gunes et al., 2007). Several lines of evidence demonstrate the alleviating role of SA during salinity (Shakirova et al., 2003) and drought (Singh and Usha, 2003). Exogenous application of SA can ameliorate salinity stress in many plant species (Horváth et al., 2007; Ashraf et al., 2010; Hayat et al., 2010). Brassinosteroids, has revealed that they elicit a wide spectrum of morphological and physiological responses in plants including stem elongation, pollen tube growth, leaf bending and epinasty, root inhibition, induction of ethylene biosynthesis, proton pump activation, xylem differentiation and the regulation of gene expression (Li and Chory 1999, Mussig et al. 2002, Sasse 2003). In addition to stimulating growth, they are effective in reducing abiotic stresses such as moisture, drought, low and high temperature, salinity, and heavy metal (Clouse and Sasse 1998, Rao et al. 2002, Anuradha and Rao 2003; Ozdemir et al. 2004, Ali et al. 2007, Hayat et al. 2007, Hasan et al. 2008) induced inhibitory effects (Rao et al. 2002).

Under salinity stress endogenous level of SA increased along with the increase in the activity of salicylic acid biosynthetic enzyme in rice seedling (Sawada et al., 2006). Jayakannan et al. (2013) have recently shown that SA improves salinity tolerance in Arabidopsis by restoring membrane potential and preventing salt-induced K^+ loss via a guard cell outward rectifying K(+) (GORK) channel. Arabidopsis seedling pretreated with SA showed up regulation of H^+-ATPase activity, thereby improving K^+ retention during salt stress; SA pretreatment did not prevent accumulation of Na^+ in roots but somehow helped to reduce the concentration of accumulated Na^+ in the shoot (Jayakannan et al., 2013). The application of SA also promoted salinity tolerance in barley, as manifested by increases in the content of chlorophyll and carotenoid and maintaining membrane integrity, which associated with more K^+ and soluble sugar accumulation in the root under saline condition (El-Tayeb, 2005). Nazar et al. (2011) have demonstrated that SA alleviates the reduction in photosynthesis under salt stress by enhancing nitrogen and sulfur assimilation and antioxidant metabolism differentially in mung bean cultivars. The negative effects of salinity may also be mitigated by BR (El-Mashad and Mohamed, 2011; Ashraf et al., 2010; Krishna, 2003; Anuradha and Seeta Ram Rao, 2001). Application of BR enhanced the activity of antioxidant enzymes (SOD, POX, APX, and GPX) and the accumulation of nonenzymatic antioxidant compounds (tocopherol, ascorbate, and reduced glutathione) (El-Mashad and Mohamed, 2011). Both BRs and SA are ubiquitous in the plant kingdom, affecting plant growth and development in many different ways, and are known to improve plant stress tolerance. Ashraf et al. (2010) have reviewed and discussed the current knowledge and possible applications of BRs and SA that could be used to mitigate the harmful effects of salt stress in plants. They have also discussed the roles of exogenous applications of BRs and SA in the regulation of various biochemical and physiological processes leading to improved salt tolerance in plants.

1.2. Objectives of the study

The objective of this study is to study the effect of applying different levels of both Salicylic acid (SA) and Brassinosteroids (BRs) on pepper growth under saline condition.

Chapter Two

Literature Review

2.1. Effect of salinity stress on plant

Pepper is considered sensitive (Ayers and westcot, 1985; Cornillon and Palloix, 1995) or moderately-sensitive to salt stress (Meiri and Shalhevet, 1973; Ayers and Westoct, 1985; Rhoades et al., 1992). Almost 20% of cultivated area of the world and half of the worlds irrigated lands are stressed by the salinity (Chinnusamy et al., 2005). High salt content in the soil affect the soil porosity and decrease soil water potential (Hopkins 1995), and affects the physiology of plants, both at the cellular as well as whole plant levels (Murphy et al. 2003). In addition, Salinity cause ionic imbalance in the cell due to accumulation of Na and Cl ions (Hasegawa et al. 2000) and the excess amount of sodium ions in the cell cause enzyme inhibition such as those of nitrogen metabolism (Soussi et al. 1998), nitrate reductase (Shafea 2003) and rubisco and PEP carboxylase (Soussi et al. 1999) and metabolic dysfunction (Booth and Beardall 1991) such as degradation of photosynthesis pigments (Abdullah and Ahmad 1990, Soussi et al. 1999). Generally Salt stress inhibits plant growth for two reasons: first by an osmotic or water-deficit effect of salinity and second by a salt-specific or ion-excess effect of NaCl. Moreover, plants subject to salinity stress conditions produce cytotoxic activated oxygen that can seriously disrupt normal metabolism, through oxidative damage of lipids, proteins, and nucleic acids (abbaspour, 2012).

The problems experienced by higher plants owing to salt stress result from osmotic stress and ionic stress resulting from high concentrations of toxic ions exceeding the threshold to which most plants are adapted. Ahmad et al., (2017) also reported reduced growth, decrease in pigment content and uptake of essential elements in Pisum sativum under NaCl stress. Reduction in pigment synthesis and alteration in nutrition assimilation under salt stress directly affects photosynthetic efficiency, plant-water status, enzyme activities and synthesis of proteins and carbohydrates and the stability of cell membranes (Alamgir et al., 2008; Türkan & Demiral, 2009; Alzahrani et al., 2019).

Photosynthesis process is highly affected by salinity, Sudhir and Murphy (2004) reported the salt stress cause damage to the photosynthesis machinery at multiple levels, such as pigments, stomatal functioning and gaseous exchange, structure and function of thylakoid membrane, electron transport and enzymes. Sothe decrease in photosynthesis under saline condition is one of the most important factor responsible for reduced plant growth and productivity because the ability of plant to produce biomass and yield with higher salinity levels is connected to a marked inhibition of photosynthesis (ChartzoulakisandKlapaki 2000, Bethke and Drew 1992). Chartzoulakis and Klapaki (2000) demonstrated a partial closure of stomata which cause a reduction in photosynthesis at higher salinity levels. Salt stress can disturb growth and photosynthetic processes by causing changes in the accumulation of Na, Cl, and nutrients, and disturbance in water and osmotic potential. Moreover, salinity stress decrease photosynthetic pigment, K and P contents, while increasing proline, soluble sugars, ascorbic acid, Na and Cl contents in canola plant (Saker et al ., 2012b).

Desingh and Kanagaraj, (2007) conclude that photosynthetic rate and activity of RuBP carboxylase and sucrose phosphate synthase decreased with increasing salinity level.Bethke and Drew, (1992) reported that high salinity levels lead to 85% inhibited photosynthesis.

Salinity affects growth and chemical contents and has been shown to limit pepper yield (Paridam and Das, 2005). Several study showed that salinity decreases pepper yield (Chartzoulakis and Klapaki, 2000; Navarro et al., 2002) affecting primarily the total fruit yield (above 10 mM NaCl), then the average fresh fruit weight (>25 mMNaCl) and, finally, the number of fruits per plant (>50 mM NaCl) (Chartzoulakis and Klapaki, 2000). Salinity reduces total yield by a fruit size reduction (Chartzoulakis and Klapaki, 2000; Navarro et al., 2002) or by a decrease in both the number and size of fruits (Meiri and shalhevet, 1973; Gomez et al., 1996). However, irrigation with an EC of 4.4 ds/m which caused 46% and 25% reduction in plant dry weight (leaves plus stem) and marketable yield, respectively, may still be considered economically acceptable in certain Mediterranean areas (Barbieri, 1995)

Seed germination and early seedling growth are considered are the most sensitive stages to salinity stress (Ashraf and Foolad, 2005). Salinity may cause significant reductions in the rate and final percentages of germination, which in turn may lead to uneven stand establishment and reduce crop yields (Fooled et al., 1999).Several authors have shown that salinity caused a decrease in both germination rate and germination percentage of pepper (Chartzoulakis and Klapaki, 2000)

2.2. Role of salicylic acid on the plant

Salicylic acid is one of phenol derivatives which previously isolated from willow bark (John Buchner, 1928) and it is classified under the group of plant hormones and is assigned divers regulatory roles in plant growth and increase plant tolerance to salt stress (Hayat and Ahmad, 2007 ; Amin et al, 2009 ; Shahba et al, 2010).

Salicylic acid (SA) is a signaling or messenger molecule in plant tolerance against various biotic and a biotic stresses (Horvath et al., 2007). Studies have showed that SA has different effects on stress adaptation and damage development of plants that depend on plant species, concentration, method and time of SA application (Metwally et al., 2003).

The Exogenous application of SA affect some physiological process in the plant; ethylene synthesis, interfering with membrane depolarization, stimulating photosynthetic machinery, wound response in soybean plant (Leslie and Romani, 1988; Zhao et al., 1995), Rajasekaran and blake (1999) shown that plant growth regulators like salicylic acid protect photosynthesis and enhance the growth of jack pine seedlings under drought. The application of salicylic acid increase yield and number of pods in mung bean plant (Singh and Kaur, 1980).

Gutierrez et al. (1998) reported an increase in growth of shoots and roots of soybean plants in response to salicylic acid treatment. Dhaliwal et al. (1997) and zhou et al. (1999) also showed that SA increases the leaf area in sugarcane plants. SA also plays an important role in regulation of some physiological processes in plants such as effects on growth and development, ion uptake and transport and membrane permeability (Simaei et al., 2012)

Some earlier reports display that exogenous SA can ameliorate the impairing effects of drought stress in different species (Arfan et al., 2007), Several studies have shown that the effects of cytotoxicity induced by salt stress can be ameliorated by exogenous application of SA (Simaei et al., 2012). SA has ability to decrease membrane deterioration and inhibited Na accumulation and increase K, Ca and Mg content of stressed plants (Ben Ahmad et al, 2009). Gomez et al. (1993) observed an improvement in plant biomass and yield of wheat genotypes under water stress with SA application.

2.3. Role of brassionosteroids in the plant

Brassinosteroids (BRs) are a new type of phytohormones with significant growth promoting influence (Clouse and Sasse 1998; Rao et al.2002; Tanaka et al 2005; Xia et al 2009a). Brassinosteroids are considered as plant hormones with pleiotropic effects as they influence wide array of developmental processes such as growth, seed germination, rhizogensis, flowering, senescence, abscission and maturation (Sasse 1999).

BRs improve the resistance of plants against environmental stresses such as water stress, salinity stress, low temperature stress and high temperature (Rao et al. 2002).

BRs were reported to increase resistance to salinity stress in many plants, including pepper (*Capsicum annuum* L.)(Abbas et al. 2013). Ashraf et al., 2010 demonstrated that BRs affect plant growth and development in many different ways and improve plant stress tolerance.

The potential application of BRs in agriculture and horticulture are dependent not only on their ability to enhance crop yield, but also to up-regulate other physiological processes (Clouse and Sasse, 1998). Kauschmann et al. (1996) reported that BRs are also essential for proper plant development and play an important role in controlling cell elongation. Shoot dry biomass and seed yield of brassica juncea were considerably increased by the exogenous application of brassinosteroids (Hayat et al., 2000) and more seed production was observed in groundnut with exogenous 24-epibrassinolide (Vardhini and Rao, 1998)

BRs affect many physiological process such as cell expansion, cell division, xylem differentiation, proton pump activity, ethylene biosynthesis, and photosynthesis (*Xia et al., 2009*). BRs play role in regulating a wide range of processes, including source/sink relationship, seed germination, photosynthesis, flowerring, and responses to abiotic and biotic stresses *(Deng et al. 2007*).

Anuradha and Rao (2001) observed an increase in salinity tolerance in rice at germination and seedling stage when brassinosteroids were applied exogenously under saline condtions. And also Swamy and Rao (2009) showed that exogenous application of 24-EBL increased the rate of photosynthesis and that growth promotion was associated with increased chlorophyll content in geranium *(Pelargonium graveolens*).

BRs are reported to modify the membrane structure and stability under stress conditions (*Hamada, 1986*).BRs have also been known to improve water relations increasing relative water content, water use efficiency, gs, and thus the transpiration rate in stressed plants (*Ali et al., 2005; Hayat et al., 2010*)

Baiguz (2000a) found that BRs increased DNA, RNA and protein contents of *Chlorella vulgaris* as the number of cells increased in the medium.

Fujioka and Sakurai (1997) indicate that 24-epiBL promote elongation of inner tissues via enhancing microtubules and cellulose biosynthesis and thus changing mechanical characteristics of the cell wall. However BRs have been reported to increase photosynthesis by increasing Rubisco activation state (Yu et al., 2004), carboxylation efficiency and also have an ability to regenerate RuBP, under stress (Ogweno et al., 2008). Previous reports shown that BRs modified antioxidant enzyme activities under salinity (Ali et al., 2007), moreover Kolomeichuk, et al (2020) indicate that Exogenously applied BRs increased chlorophyll content, CO_2 assimilation and quantum yield of photosystem II, ribulose-1,5-bisphosphate carboxylase/oxygenase (Rubisco) activity moreover BRs increased the expression of *Rubisco large subunit* (*rbcL*) and *Rubisco small subunit* (*rbcS*) genes, the level of endogenous hormones, and the total amino acid content (Derevyanchuk et al.,2017)

Chapter Three

Materials and Methods

3.1. Plant material and experiment site

The experiment was carried out in a greenhouse, at An- Najah National University/ Faculty of Agriculture and Vet. Med. in Tulkarm located in the North of West Bank (Palestine) using sweet pepper plant.

3.2. Preparing and sowing

Seedlings of pepper plant cultivar (formula) were grown in plastic pot (10 L) (one seedling per pot) filled with sand and peatmoss (1:1, v/v). Seedling were kept in greenhouse under natural light conditions at 7 Feb 2018. One month after transplanting, the effect of salinity, BRs and SA was investigated by applying three salinity levels (0, 50, 150 mM NaCl) and three level of BRs and SA (0, 0.05, and 0.5 mM).

3.3. BR and SA preparation

To prepare a foliar spray of 24-epibrassinolide ($C_{28}H_{48}O_6$, molecular weight = 480; Sigma) the stock was initially dissolved in 1 ml ethanol and concentrations of (0, 0.05, and 0.5 mM) were made up with distilled water containing 0.02% Tween 20 (polyoxyethylenesorbitan monolaurate; Sigma Chemicals, U.K.) as a surfactant. Similarly, salicylic acid (2 hydroxybenzoic acid,2^-(HO) C6H4CO2H, molecular weight = 138.12; Sigma) was initially dissolved in 1 ml ethanol and concentrations of (0, 0.05, and 0.5 mM) were made up with distilled water containing 0.02% Tween 20 (polyoxyethylenesorbitan monolaurate; Sigma Chemicals, U.K).

3.4. Treatment with NaCl

After 30 day of planting, different concentration of NaCl (0, 50 and 150 mM NaCl) were used as irrigation source. Pots were irrigated manually when needed depending on moisture content of the soil. Three levels for both Brassionosteroid and Salslic acid (0 , 0.05 , 0.5) and three levels of NaCl (0 , 50 ,150) were used after 40 day from planting, the levels of all factors were arranged as full factorial treatments in a Completely Randomized Design (CRD) with three replicates for each treatments, therefore, a total of 27 treatment were used in this experiment.

3.5. Growth parameter

Growth parameter were taken for the plants between September 1st and September 10th, the measurement of each pots were taken as the following:

3.5.1 Vegetative growth at maturity including:

Plant height: from the soil surface to the tip of plants.

Number of the branches: The total number of horizontal stem extension per plant.

Leaf area: Total leaf area in mm^2 per plant was measured using Area Meter AM350 manufactured by ADC bioscientific Ltd (Figure 1).

Figure 1: Leaf area meter.

Leaf number: The total number per plant

Main stem diameter: Three reading per plant was measured using caliper.

Fresh weights of above ground biomass, and root biomass: Total above ground and root biomass per plant was weighed directly at the end of the growing season.

Dry weights of above ground biomass, and root biomass: Total above ground and root biomass per plant was weighed after oven dried at 70 C◦ for 48 h.

3.5.2 Yield and yield components

Fruit number: Total number of fruit per plant was counted.

Fruit weight: Total number of fruit per plant was weighed.

3.5.3 Chlorophyll contents

The chlorophyll readings and leaf greenness of the pepper plants were taken using chlorophyll meter (Figure 3) (chlorophyll meter SPAD-502 Plus, Konica Minolta sensing, Inc., Japan)

Figure 2: Chlorophyll Meter SPAD-502Plus, Konica Minolta Sensing, Inc., Japan.

3.6. Nutrient element content

Leaf samples from the plants under different treatments were taken, the samples were oven dried at (temp 580 C◦). All nutrient analysis were conducted at the laboratory of scientific research center at An-Najah National University, Nablus, Palestine. Methodology of Motsara, M.R. guide to laboratory establishment for plant nutrient analysis (Food and Agriculture Organization of the United Nations, 2008) were used.

The followings were measured

Dry ashing :from each sample , 2 gm were taken using sensitive balance and placed in crucible and heated at 580 C◦ for three hours in high temperature laboratory oven(carbolite LHT 6/30, UK) (Figure 4) for destroy organic matter and the ash dissolved in 250 ml distilled water to get solution for analysis .

Figure 3: High temperature laboratory oven (carbolite LHT 6/30, UK)

3.6.1 Nitrogen content

Digestion: 0.5 gm from each sample was put in the pipe, (0.04 gm of $CuSo_4$ and 15 gm of Na_2So_4) as catalyst, add 20 ml H_2So_4 for digestion, the pipet heated at the turbotherm (Gerhardt, Germany) for 15 minutes at 80 C◦, 15 minutes at 90 C◦, 90 minutes at 100 C◦ at the end of this steps the sample digest and become clear solution.

Distillation: 25 ml of boric acid was taken and added to the solution for catch ammonia gas that result from the process. The solution was then put on the distillation unit vapodest (Gerhardt, Germany) (Figure 5), then 70 ml of NaOH and 30 ml of H_2O was added to about 4 minutes, the boric acid color change from purple to green, these indicate that ammonia gas was available.

Titration: the solution was titration with 0.095 mM HCL, solution color was change from green to purple, the volume of acid require was recording and we used it in the equation.

% of N = ((Volume of acid used – Volume of blank) * Normality of acid * 1.4007)/ weight of sample (gm)

Figure 4: Distillation unit vapodest (Gerhardt, Gerhardt, Germany)

3.6.2 Sodium, Calcium and potassium content

For sodium: 100 ml form each sample are filtrated without digestion.

For calcium and potassium: 50 ml from each sample (solution) was filtrated, and 1 ml of HNO3 added to be digestion and heated on the hot plate, after digestion sample was completed to 100 ml with distilled water.

Sodium and potassium were estimated photometrically by sherwood flame photometer 410 (Figure 6).

Figure 5: Flamephotometer (Sherwood, UK)

3.6.3 Chloride content

Chloride content in the leaf sample was estimation using the volumetric method (A.O.A.C official method 937.09).

M mole of CL = m mole of $AgNo_3$ – m mole of NH_4SCN

= (V. OF $AgNo_3$ XNormality _ V. OF NH_4SCN X Normality)

Cl (ppm) = M mole of CLX M.W of CL Xdilution value

3.6.4 Phosphorus content

Phosphorus content were measured using Spectrophotometric vanadium phosphomolybdate method (Motsara, M. R., & Roy, R. N., 2008). 25 ml from each sample (solution) was taken, 1 spoon of $K_2S_2O_8$ added, 2 ml of H_2SO_4 for digestion and total solution was heated in the hood to become clear, after digestion the solution was completed to 50 ml with distilled water, 2 to 3 drop of naphthalene and NaOH was added to change the color, then 10 ml of vanadomolybdate reagents added, and kept for 15 minutes. To calculate the P content the following equation was used:

P content (μg) in 1 gm of sample = C * df

C = concentration of P (μg/ml) as read from the standard curve

df = dilution factor , which is 100 * 10 = 1000

Figure 6: Spectrophotometer

Statistical analysis

All collected data were analyzed using SAS software, ANOVA tests were conducted for the different variables for both the main and the interaction effect followed by mean separation using Duncan's Multiple Range Test at 5% probability level.

Chapter Four

Results

4.1 The effect of salicylic acid and brassinosteroid on fruit number of pepper under different salinity levels.

The result showed that salinity has high significant negative effect on the fruit number of pepper ($P<0.0001$) Table 1, when salinity level increase the fruit number decrease (table 2).

In addition Salicylic acid treatment has significant effect on the fruit number ($P<0.0073$) based on the mean separation the highest fruit number was 21.8 at 0.05 SA compared 16.5 with no SA (table 5). But the combination of SA and salinity was not significantly different.

Number of fruits was affected in plant treated with BR and SA , the analysis of variance reveled that BR and SA combination has highly significant influence on fruit number of pepper ($P<0.0019$) for example, the highest fruit number was 24.5 at zero BR and 0.05 SA compared to 8 at control. In addition mean separation showed response to Brassinosteroid under salinity treatment had significant effect on fruit number of pepper plant, fruit number increased from 20.6 (with no BR treatment) to 25.7 (with 0.05BR treatment)under moderate salt stress (50 mM NaCl) although BR treatment at 0.5 concentration was not significant (table 3_8).

Table 1: The analysis of variance for the effect of Salinity, BR and SA on number of fruit for pepper plant

Type 3 Tests of Fixed Effects				
Effect	**Num DF**	**Den DF**	**F Value**	**Pr > F**
Salinity	2	54	150.02	<.0001
BR	2	54	2.64	0.0802
Salinity*BR	4	54	3.19	0.0200
SA	2	54	5.40	0.0073
Salinity*SA	4	54	1.02	0.4042
BR*SA	4	54	4.91	0.0019
Salinity*BR*SA	8	54	1.95	0.0704

R= Replicate, Salinity = (50, 150) mMNaCL, BR = Brassinosteroid, SA = salicylic acid

Table 2: The effect of applying different levels of NaCl on fruit number of pepper plant (formula)

Salinity (Mm NaCl	**Average number of fruit /plant**
0	34.0741 a
50	22.1481 b
150	3.4444 c

Means followed by the same letter(s) are not significantly differ at 5% P value.

Table 3: The effect of applying different levels of BR on fruit number of pepper plant (formula)

BR	**Average number of fruit /plant**
0	17.6296 a
0.05	20.4074 a
0.5	21.6296 a

Means followed by the same letter(s) are not significantly differ at 5% P value

Table 4: The effect of applying different levels of NaCl and BR on fruit number of pepper plant (formula)

Salinity	BR	Average number of fruit /plant	Letter Group
0	0	29.5556 bc	BC
0	0.05	32.2222 ab	AB
0	0.5	40.4444 a	A
50	0	20.6667 c	C
50	0.05	25.7778 bc	BC
50	0.5	20.0000 c	C
150	0	2.6667 d	D
150	0.05	3.2222 d	D
150	0.5	4.4444 d	D

Means followed by the same letter(s) are not significantly differ at 5% P value

Table 5: The effect of applying different levels of SA on fruit number of pepper plant (formula)

SA	Average number of fruit /plant	Letter Group
0	16.5185	B
0.05	21.8148	A
0.5	21.3333	A

Means followed by the same letter(s) are not significantly differ at 5% P value

Table 6: The effect of applying different levels of NaCl and SA on fruit number of pepper plant (formula)

Salinity	SA	Average number of fruit /plant	Letter Group
0	0	28.5556	AB
0	0.05	37.8889	A
0	0.5	35.7778	A
50	0	18.3333	C
50	0.05	24.1111	BC
50	0.5	24.0000	BC
150	0	2.6667	D
150	0.05	3.4444	D
150	0.5	4.2222	D

Means followed by the same letter(s) are not significantly differ at 5% P value

Table 7: The effect of applying different levels of BR and SA on fruit number of pepper plant (formula)

BR	SA	Average number of fruit /plant	Letter Group
0	0	8.6667	B
0	0.05	24.5556	A
0	0.5	19.6667	A
0.05	0	21.2222	A
0.05	0.05	20.0000	A
0.05	0.5	20.0000	A
0.5	0	19.6667	A
0.5	0.05	20.8889	A
0.5	0.5	24.3333	A

Means followed by the same letter(s) are not significantly differ at 5% P value

Table 8: The effect of applying different levels of NaCl, BR and SA on fruit number of pepper plant (formula)

Salinity	BR	SA	Average number of fruit /plant	Letter Group
0	0	0	17.3333	CDEF
0	0	0.05	35.6667	ABC
0	0	0.5	35.6667	ABC
0	0.05	0	32.0000	ABC
0	0.05	0.05	34.0000	ABC
0	0.05	0.5	30.6667	ABC
0	0.5	0	36.3333	ABC
0	0.5	0.05	44.0000	A
0	0.5	0.5	41.0000	AB
50	0	0	7.3333	DEF
50	0	0.05	34.6667	ABC
50	0	0.5	20.0000	CDEF
50	0.05	0	28.6667	ABC
50	0.05	0.05	21.6667	BCDEF
50	0.05	0.5	27.0000	ABCD
50	0.5	0	19.0000	CDEF
50	0.5	0.05	16.0000	CDEF
50	0.5	0.5	25.0000	ABCDE
150	0	0	1.3333	F
150	0	0.05	3.3333	F
150	0	0.5	3.3333	F
150	0.05	0	3.0000	F
150	0.05	0.05	4.3333	EF
150	0.05	0.5	2.3333	F
150	0.5	0	3.6667	F
150	0.5	0.05	2.6667	F
150	0.5	0.5	7.0000	DEF

Means followed by the same letter(s) are not significantly differ at 5% P value

4.2 The effect of salicylic acid and brassinosteroid on fruit weight of pepper under different salinity levels.

The analysis of variance of fruit weight revealed that salinity had a highly significant negative effect on this parameter. BR and SA had also significant effect on the fruit weight of pepper plant ($P<0.0010$ and $P<0.0006$) respectively (table 9). Mean separation revealed BR treatment increase fruit weight of plant and also for SA treatment.

High significant interaction was observed for salinity*BR and salinity*SA ($P<0.0002$, $P<0.0001$) respectively (table 9), according to the mean separation the interaction (salinity*SA) and (salinity*BR) reduce effect of salinity at different level.

In general SA treatment with or without salinity has highly significant effect as it increase the fruit weight , for example the fruit weight was 501 g at 0.5 SA under salinity level 50 mM NaCL was higher than 382 g (without SA) at the same salinity levels (table 10). There was no significant interaction between BR and SA on fruit weight of pepper ($P<0.1050$ and $P<0.6850$) (table 9)

Table 9: The analysis of variance for the effect of Salinity BR, SA on fruit weight for pepper plant

Type 3 Tests of Fixed Effects				
Effect	**Num DF**	**Den DF**	**F Value**	**Pr > F**
Salinity	2	54	480.39	<.0001
BR	2	54	7.94	0.0010
Salinity*BR	4	54	6.76	0.0002
SA	2	54	8.60	0.0006
Salinity*SA	4	54	7.09	0.0001
BR*SA	4	54	2.02	0.1050
Salinity*BR*SA	8	54	0.71	0.6850

R= Replicate, Salinity = (50, 150) mMNaCL, BR = Brassinosteroid, SA = salicylic acid

Table 10: The effect of applying different levels of NaCl and SA on fruit weight of pepper plant (formula)

Salinity	SA	Average weight of fruit /plant	Letter Group
0	0	1686.01	B
0	0.05	2497.09	A
0	0.5	2166.16	A
50	0	382.83	CD
50	0.05	407.79	CD
50	0.5	501.24	C
150	0	51.2000	D
150	0.05	61.7889	D
150	0.5	80.0000	D

Means followed by the same letter(s) are not significantly differ at 5% P value

Table 11: The effect of applying different levels of NaCl and BR on fruit weight of pepper plant (formula)

Salinity	BR	Average weight of fruit /plant	Letter Group
0	0	1801.44	B
0	0.05	1985.77	B
0	0.5	2562.04	A
50	0	387.70	CD
50	0.05	486.37	C
50	0.5	417.80	CD
150	0	42.7556	D
150	0.05	64.2000	D
150	0.5	86.0333	D

Means followed by the same letter(s) are not significantly differ at 5% P value

4.3 The effect of salicylic acid and brassinosteroidand on branches number of pepper under different salinity levels

The statistical analysis showed that salinity has high significant negative effect on the branches number of pepper plant with P value 0.0001. The branches number was significantly influenced by all treatment except SA (alone) treatment (table 12).

Based on the mean separation, salinity reduce branches number from 17.8 without salinity to 10.5 and 9.1 with 50 mM and 150 mM NaCL. Similar trends was observed using BR, so BR reduce branches number from 13.4 without BR to 11.9 and 12.2 with 0.05 and 0.5 BR, respectively. (Table 13 and 14)

The combination of both growth regulator has significant influence on the branches number when the salinity was zero or 50 mM NaCL, in contrast the highest negative effect was observed when the salinity was 150 mM NaCL. (Table 15 and 16)

In general the combination between SA and BR and salinity has positive effect on the branches number when the salinity was zero or 50 mM NaCL, but the negative effect was observed when the salinity was 150 mM NaCL, for example the highest value of branches number was 20 at 0.5 BR and 0.05 SA with zero salinity level compared to 15.6 without SA and BR at the same level of salinity, in contrast the highest value of branches number was 22 at zero BR and SA with 150 mM NaCL compared to 6.6 at 0.05 BR and 0.05 SA at the same level of salinity. (Table 17)

Table 12: The analysis of variance for the effect of BR, SA and combination on branches number for pepper plant

Type 3 Tests of Fixed Effects				
Effect	**Num DF**	**Den DF**	**F Value**	**Pr > F**
Salinity	2	54	211.01	<.0001
BR	2	54	5.73	0.0056
Salinity*BR	4	54	10.68	<.0001
SA	2	54	0.03	0.9697
Salinity*SA	4	54	24.08	<.0001
BR*SA	4	54	5.56	0.0008
Salinity*BR*SA	8	54	9.72	<.0001

R= Replicate, Salinity = (50, 150) mMNaCL, BR = Brassinosteroid, SA = salicylic acid

Table 13: The effect of applying different levels of NaCl on branches number of pepper plant (formula)

Salinity	Average number of branches /plant	Letter Group
0	17.8889	A
50	10.5556	B
150	9.1852	C

Means followed by the same letter(s) are not significantly differ at 5% P value

Table 14: The effect of applying different levels of BR on branches number of pepper plant (formula)

BR	Average number of branches /plant	Letter Group
0	13.4074	A
0.05	11.9259	B
0.5	12.2963	B

Means followed by the same letter(s) are not significantly differ at 5% P value

Table 15: The effect of applying different levels of NaCl and BR on branches number of pepper plant (formula)

Salinity	BR	Average number of branches /plant	Letter Group
0	0	17.7778	A
0	0.05	17.7778	A
0	0.5	18.1111	A
50	0	10.0000	BC
50	0.05	10.8889	B
50	0.5	10.7778	B
150	0	12.4444	B
150	0.05	7.1111	D
150	0.5	8.0000	CD

Means followed by the same letter(s) are not significantly differ at 5% P value

Table 16: The effect of applying different levels of NaCl and SA on branches number of pepper plant (formula)

Salinity	SA	Average number of branches /plant	Letter Group
0	0	15.4444	B
0	0.05	19.4444	A
0	0.5	18.7778	A
50	0	9.5556	DE
50	0.05	10.3333	CD
50	0.5	11.7778	CD
150	0	12.6667	C
150	0.05	7.6667	E
150	0.5	7.2222	E

Means followed by the same letter(s) are not significantly differ at 5% P value

Table 17: The effect of applying different levels of NaCl, SA and BR on branches number of pepper plant (formula)

Salinity	BR	SA	Average number of branches /plant	Letter Group
0	0	0	15.6667	BC
0	0	0.05	19.0000	AB
0	0	0.5	18.6667	AB
0	0.05	0	15.0000	BCD
0	0.05	0.05	19.3333	AB
0	0.05	0.5	19.0000	AB
0	0.5	0	15.6667	BC
0	0.5	0.05	20.0000	AB
0	0.5	0.5	18.6667	AB
50	0	0	7.6667	EF
50	0	0.05	11.6667	CDEF
50	0	0.5	10.6667	CDEF
50	0.05	0	10.6667	CDEF
50	0.05	0.05	9.6667	EF
50	0.05	0.5	12.3333	CDE
50	0.5	0	10.3333	DEF
50	0.5	0.05	9.6667	EF
50	0.5	0.5	12.3333	CDE
150	0	0	22.0000	A
150	0	0.05	7.6667	EF
150	0	0.5	7.6667	EF
150	0.05	0	7.6667	EF
150	0.05	0.05	6.6667	F
150	0.05	0.5	7.0000	F
150	0.5	0	8.3333	EF
150	0.5	0.05	8.6667	EF
150	0.5	0.5	7.0000	F

Means followed by the same letter(s) are not significantly differ at 5% P value

4.4 The effect of salicylic acid and brassinosteroid on leaf number of pepper under different salinity levels

Based on the statistical analysis no significant difference was observed on leaf number of pepper when plant treated with SA and BR. In contrast, salinity has high significant effect on the leaf number ($P<0.001$) (table 18). For example, the highest leaf number was 486 with no salinity compared to 187 with 50mM NaCL (table 19).

The result showed that the leaf number of pepper plant not affected by adding growth regulator under different salinity level (table 20 and 21).

Table 18: The analysis of variance for the effect of BR, SA and combination on leaf number for pepper plant.

Type 3 Tests of Fixed Effects				
Effect	**Num DF**	**Den DF**	**F Value**	**Pr > F**
Salinity	2	54	169.93	<.0001
BR	2	54	0.38	0.6841
Salinity*BR	4	54	1.01	0.4081
SA	2	54	0.62	0.5417
Salinity*SA	4	54	0.58	0.6767
BR*SA	4	54	0.52	0.7237
Salinity*BR*SA	8	54	0.79	0.6151

R= Replicate, Salinity = (50, 150) mMNaCL, BR = Brassinosteroid, SA = salicylic acid.

Table 19: The effect of applying different levels of NaCl on leaf number of pepper plant (formula)

Salinity	Average number of leaves /plant	Letter Group
0	486.81	A
50	187.41	B
150	76.2222	C

Means followed by the same letter(s) are not significantly differ at 5% P value

Table 20: The effect of applying different levels of NaCl and BR on leaf number of pepper plant (formula)

Salinity	BR	Average number of leaves /plant	Letter Group
0	0	486.33	A
0	0.05	448.78	A
0	0.5	525.33	A
50	0	166.78	BC
50	0.05	208.78	B
50	0.5	186.67	BC
150	0	80.3333	BC
150	0.05	75.0000	C
150	0.5	73.3333	C

Means followed by the same letter(s) are not significantly differ at 5% P value

Table 21: The effect of applying different levels of NaCl and SA on leaf number of pepper plant (formula)

Salinity	SA	Average number of leaves /plant	Letter Group
0	0	475.78	A
0	0.05	510.89	A
0	0.5	473.78	A
50	0	164.56	BC
50	0.05	209.56	B
50	0.5	188.11	BC
150	0	66.8889	C
150	0.05	60.5556	C
150	0.5	101.22	BC

Means followed by the same letter(s) are not significantly differ at 5% P value

4.5 The effect of salicylic acid and brassinosteroid on stem width of pepper under different salinity levels

The analysis of variance indicate that salinity was high significant effect on stem width (P<0.0001), salicylic acid treatment and brassinosteroids treatment also has significant effect on stem width with P value 0.0233 and 0.0154, respectively (table 22). Based on the mean separation we observed increasing in the value when BR value increase, generally, the highest stem width was 1.5 at 0.5 BR compared to 1.35 without BR, same thing for SA treatment, the highest stem width was 1.51 at 0.05 SA compared to 1.37 without SA (table 23 and 24).The interaction between BR and SA, BR and salinity, SA and salinity, BR and SA and salinity was not significant (table 22).

Table 22: The analysis of variance for the effect of BR, SA and combination on stem width for pepper plant.

Type 3 Tests of Fixed Effects				
Effect	**Num DF**	**Den DF**	**F Value**	**Pr > F**
Salinity	2	54	123.32	<.0001
BR	2	54	4.51	0.0154
Salinity*BR	4	54	0.58	0.6781
SA	2	54	4.03	0.0233
Salinity*SA	4	54	0.30	0.8751
BR*SA	4	54	0.32	0.8611
Salinity*BR*SA	8	54	0.72	0.6757

R= Replicate, Salinity = (50, 150) mMNaCL, BR = Brassinosteroid, SA = salicylic acid

Table 23: The effect of applying different levels of BR on stem width of pepper plant (formula)

BR	Average stem width /plant	Letter Group
0	1.3556	B
0.05	1.4519	AB
0.5	1.5074	A

Means followed by the same letter(s) are not significantly differ at 5% P value

Table 24: The effect of applying different levels of SA on stem width of pepper plant (formula)

SA	Average stem width /plant	Letter Group
0	1.3704	B
0.05	1.5148	A
0.5	1.4296	AB

Means followed by the same letter(s) are not significantly differ at 5% P value

4.6 The effect of salicylic acid and brassinosteroid on stem height of pepper under different salinity levels

The analysis of variance reveled that stem height of pepper plant were significantly affected by SA, SA*salinity, BR*salinity and SA*BR combination. Although Salinity also affected on stem height of pepper plant (table 25)

The plant treated with 0.05 or 0.5 SA revealed higher height compared with plant treated with zero SA (58.1 and 57.5 (at 0.05 , 0.5 SA) and 51.4 at zero) respectively (table 26).

The results revealed that when salinity increase the plant height decrease however the SA ameliorate the effect of salinity where the stem height was 48.7 cm at 50 NaCL with 0.5 SA higher than 44.7 cm at the same level of salinity without SA. The interaction between SA and BR indicate higher height at 0.5 SA and 0.5 BR 67.2 cm compared to 47.3 cm at zero SA and BR (table 27 and 28). Based on the mean separation BR treatment and the combination salinity*SA*BR was not significant (P<0.1951, P<0.0599) respectively (table 25).

Table 25: The analysis of variance for the effect of BR, SA and combination on stem height for pepper plant

Type 3 Tests of Fixed Effects				
Effect	**Num DF**	**Den DF**	**F Value**	**Pr > F**
Salinity	2	54	492.10	<.0001
BR	2	54	1.68	0.1951
Salinity*BR	4	54	2.77	0.0362
SA	2	54	8.53	0.0006
Salinity*SA	4	54	4.14	0.0054
BR*SA	4	54	12.26	<.0001
Salinity*BR*SA	8	54	2.03	0.0599

R= Replicate, Salinity = (50, 150) mMNaCL, BR = Brassinosteroid, SA = salicylic acid

Table 26: The effect of applying different levels of SA on stem height of pepper plant (formula)

SA	Average stem height /plant	Letter Group
0	51.4074	B
0.05	58.1111	A
0.5	57.5556	A

Means followed by the same letter(s) are not significantly differ at 5% P value

Table 27: The effect of applying different levels of NaCl and SA on stem height of pepper plant (formula)

Salinity	SA	Average stem height /plant	Letter Group
0	0	78.2222	B
0	0.05	95.0000	A
0	0.5	88.4444	A
50	0	44.7778	CD
50	0.05	48.0000	C
50	0.5	48.7778	C
150	0	31.2222	E
150	0.05	31.3333	E
150	0.5	35.4444	DE

Means followed by the same letter(s) are not significantly differ at 5% P value

Table 28: The effect of applying different levels of BR and SA on stem height of pepper plant (formula)

BR	SA	Average stem height /plant	Letter Group
0	0	47.3333	D
0	0.05	62.3333	AB
0	0.5	56.4444	BCD
0.05	0	53.4444	BCD
0.05	0.05	60.2222	ABC
0.05	0.5	49.0000	D
0.5	0	53.4444	BCD
0.5	0.05	51.7778	CD
0.5	0.5	67.2222	A

Means followed by the same letter(s) are not significantly differ at 5% P value.

4.7 The effect of salicylic acid and brassinosteroid on chlorophyll content of pepper under different salinity levels

The statistical analysis show high significant negative effect for salinity treatment on the chlorophyll content ($P<0.0001$) (table 29).The chlorophyll content was 61.9 without salinity, and it not affected by 50 mM NaCL 59.3, in contrast it affected highly with 150 mM NaCL43.3 (table 30)

In addition, BR treatment has a significant effect on chlorophyll content on the pepper plant (P<0.0025), BR increase chlorophyll content from 51.7 (without BR) to 56.6 and 56.3 with BR at 0.05, 0.5 respectively (table 31).

A significant combination was observed between (salinity*SA) and (BR*SA) and (salinity*BR*SA), but the combination between BR and SA was highly significant than other (P<0.0001) (table 29).

based on the mean separation, the combination between SA and BR showed increase in the chlorophyll content when using both concentration of the hormones compared with control plant , precisely the highest chlorophyll content was 59.6 at 0.05 BR and 0.05 SA compared to 42 without hormones (Table 35).

The result showed high significant effect when plant treated with BR and SA combination under saline condition (P<0.0019), according to the mean separation the chlorophyll content was lowest when the concentration of two hormone was zero, for example the chlorophyll content was 35.3 at (0.0 SA_0.0BR) under 150mMNaCL but the highest value under same salinity level was 55.1 at (0.05 SA_0.05BR). (Table 36).

Table 29: The analysis of variance for the effect of BR, SA and combination on chlorophyll content for pepper plant

Type 3 Tests of Fixed Effects				
Effect	**Num DF**	**Den DF**	**F Value**	**Pr > F**
Salinity	2	54	90.03	<.0001
BR	2	54	6.69	0.0025
Salinity*BR	4	54	0.46	0.7616
SA	2	54	2.29	0.1111
Salinity*SA	4	54	2.87	0.0314
BR*SA	4	54	13.65	<.0001
Salinity*BR*SA	8	54	3.64	0.0019

R= Replicate, Salinity = (50, 150) mMNaCL, BR = Brassinosteroid, SA = salicylic acid

Table 30: The effect of applying different levels of NaCl on chlorophyll content of pepper plant (formula)

Salinity	Average chlorophyll content /plant	Letter Group
0	61.9889	A
50	59.3111	A
150	43.3926	B

Means followed by the same letter(s) are not significantly differ at 5% P value

Table 31: The effect of applying different levels of BR on chlorophyll content of pepper plant (formula)

BR	Average chlorophyll content /plant	Letter Group
0	51.7370	B
0.05	56.6000	A
0.5	56.3556	A

Means followed by the same letter(s) are not significantly differ at 5% P value

Table 32: The effect of applying different levels of NaCl and BR on chlorophyll content of pepper plant (formula)

Salinity	BR	Average chlorophyll content /plant	Letter Group
0	0	59.5778	AB
0	0.05	63.7000	A
0	0.5	62.6889	AB
50	0	54.5444	B
50	0.05	61.6333	AB
50	0.5	61.7556	AB
150	0	41.0889	C
150	0.05	44.4667	C
150	0.5	44.6222	C

Means followed by the same letter(s) are not significantly differ at 5% P value

Table 33: The effect of applying different levels of SA on chlorophyll content of pepper plant (formula)

SA	Average chlorophyll content /plant	Letter Group
0	53.1519	A
0.05	56.3037	A
0.5	55.2370	A

Means followed by the same letter(s) are not significantly differ at 5% P value

Table 34: The effect of applying different levels of NaCl and SA on chlorophyll content of pepper plant (formula)

Salinity	SA	Average chlorophyll content /plant	Letter Group
0	0	59.9667	AB
0	0.05	62.0444	AB
0	0.5	63.9556	A
50	0	54.5333	B
50	0.05	62.3222	AB
50	0.5	61.0778	AB
150	0	44.9556	C
150	0.05	44.5444	C
150	0.5	40.6778	C

Means followed by the same letter(s) are not significantly differ at 5% P value

Table 35: The effect of applying different levels of BR and SA on chlorophyll content of pepper plant (formula)

BR	SA	Average chlorophyll content /plant	Letter Group
0	0	42.0667	B
0	0.05	54.4778	A
0	0.5	58.6667	A
0.05	0	58.8000	A
0.05	0.05	59.6889	A
0.05	0.5	51.3111	A
0.5	0	58.5889	A
0.5	0.05	54.7444	A
0.5	0.5	55.7333	A

Means followed by the same letter(s) are not significantly differ at 5% P value

Table 36: The effect of applying different levels of NaCl, BR and SA on chlorophyll content of pepper plant (formula).

Salinity	BR	SA	Average chlorophyll content /plant	Letter Group
0	0	0	52.1000	ABCDEF
0	0	0.05	59.0667	ABCD
0	0	0.5	67.5667	A
0	0.05	0	66.1000	A
0	0.05	0.05	62.7333	ABC
0	0.05	0.5	62.2667	ABC
0	0.5	0	61.7000	ABC
0	0.5	0.05	64.3333	AB
0	0.5	0.5	62.0333	ABC
50	0	0	38.8000	EFG
50	0	0.05	64.8667	AB
50	0	0.5	59.9667	ABC
50	0.05	0	63.6000	ABC
50	0.05	0.05	61.2000	ABC
50	0.05	0.5	60.1000	ABC
50	0.5	0	61.2000	ABC
50	0.5	0.05	60.9000	ABC
50	0.5	0.5	63.1667	ABC
150	0	0	35.3000	FG
150	0	0.05	39.5000	EFG
150	0	0.5	48.4667	BCDEFG
150	0.05	0	46.7000	CDEFG
150	0.05	0.05	55.1333	ABCDE
150	0.05	0.5	31.5667	G
150	0.5	0	52.8667	ABCDE
150	0.5	0.05	39.0000	EFG
150	0.5	0.5	42.0000	DEFG

Means followed by the same letter(s) are not significantly differ at 5% P value

4.8 The effect of salicylic acid and brassinosteroid and on aboveground fresh weight of pepper under different salinity levels

The analysis of variance revealed that the aboveground fresh weight were significantly affected by salinity, the aboveground fresh weight decrease in the plant with salinity compared to the plant without salinity. Mean separation revealed that aboveground fresh weight was 628 g without salinity, in contrast it was 251 g with 50mMNaCL (table 38), However, the combination BR*salinity and BR*SA*salinity has a significant effect on the aboveground fresh weight with P value 0.0192 and 0.0484, respectively (table 37). Based on the mean separation when treating the plant with BR under saline condition, it showed the highest value of aboveground fresh weight was 750 g at 0.5 BR with zero salinity compared to 592 gwith zero BR at the same salinity level (table 39).

The interaction between BR, SA and salinity indicate that the two hormone decrease the negative effect of moderate salinity 50 mM NaCL, for example the highest value of aboveground weight was 350 g at (0.5 BR and 0.5 SA) at 50 mM NaCL compared to 95 g without SA and BR at the same level of salinity (table 40).

Table 37: Analysis of variance for the effect of BR, SA and combination on aboveground fresh weight for pepper plant

Type 3 Tests of Fixed Effects				
Effect	**Num DF**	**Den DF**	**F Value**	**Pr > F**
Salinity	2	54	121.86	<.0001
BR	2	54	1.95	0.1522
Salinity*BR	4	54	3.22	0.0192
SA	2	54	0.30	0.7392
Salinity*SA	4	54	1.29	0.2846
BR*SA	4	54	1.24	0.3048
Saliity*BR*SA	8	54	2.13	0.0484

R= Replicate, Salinity = (50, 150) mMNaCL, BR = Brassinosteroid, SA = salicylic acid

Table 38: The effect of applying different levels of NaCl on aboveground fresh weight of pepper plant (formula)

Salinity	Average aboveground fresh weight /plant	Letter Group
0	628.19	A
50	251.44	B
150	128.72	C

Means followed by the same letter(s) are not significantly differ at 5% P value

Table 39: The effect of applying different levels of NaCl, BR on aboveground fresh weight of pepper plant (formula)

Salinity	BR	Average aboveground fresh weight /plant	Letter Group
0	0	592.04	AB
0	0.05	542.33	B
0	0.5	750.19	A
50	0	217.99	C
50	0.05	275.04	C
50	0.5	261.30	C
150	0	170.72	C
150	0.05	108.94	C
150	0.5	106.49	C

Means followed by the same letter(s) are not significantly differ at 5% P value

Table 40: The effect of applying different levels of NaCl, BR and SA on aboveground fresh weight of pepper plant (formula)

Salinity	BR	SA	Average aboveground fresh weight /plant	Letter Group
0	0	0	460.70	ABCDEF
0	0	0.05	671.03	ABC
0	0	0.5	644.40	ABCD
0	0.05	0	541.97	ABCDE
0	0.05	0.05	654.10	ABCD
0	0.05	0.5	430.93	ABCDEF
0	0.5	0	764.00	A
0	0.5	0.05	749.73	A
0	0.5	0.5	736.83	AB
50	0	0	95.8667	F
50	0	0.05	346.07	CDEF
50	0	0.5	212.03	EF
50	0.05	0	321.97	CDEF
50	0.05	0.05	300.20	CDEF
50	0.05	0.5	202.97	EF
50	0.5	0	267.73	DEF
50	0.5	0.05	165.97	EF
50	0.5	0.5	350.20	BCDEF
150	0	0	299.33	CDEF
150	0	0.05	82.1667	F
150	0	0.5	130.67	F
150	0.05	0	89.3000	F
150	0.05	0.05	82.2000	F
150	0.05	0.5	155.33	EF
150	0.5	0	79.9000	F
150	0.5	0.05	100.07	F
150	0.5	0.5	139.50	F

Means followed by the same letter(s) are not significantly differ at 5% P value

4.9 The effect of salicylic acid and brassinosteroid on root fresh weight of pepper under different salinity levels

The analysis of variance revealed salinity has high significant negative effect on the root fresh weight with P value 0.0001.In addition SA treatment was also significant on the root fresh weight with P value 0.0230 (table 41). The mean separation show that root fresh weight was increased from 33.8 g without SA to 37.2 and 47.9 g with 0.05 and 0.5 SA, respectively (table 42).

A significant impact of the combination between BR, SA and salinity was also observed ($P<0.0150$).

Based on the mean separation when the salinity was zero and at 50 mM NaCL the two hormone was significantly influenced the root fresh weight, for example the highest value of root fresh weight was 65.8 g at (0.5 SA and 0.5 BR) and 50 mM NaCL salinity compared to 10 g without SA and BR at the same salinity level. (Table 43). In contrast the effect of both hormones at 150 mM NaCL was not significant.

Table 41: The analysis of variance for the effect of BR, SA and combination on root fresh weight for pepper plant

Type 3 Tests of Fixed Effects				
Effect	**Num DF**	**Den DF**	**F Value**	**Pr > F**
Salinity	2	54	37.71	<.0001
BR	2	54	0.72	0.4894
Salinity*BR	4	54	0.45	0.7683
SA	2	54	4.05	0.0230
Salinity*SA	4	54	0.55	0.6968
BR*SA	4	54	1.46	0.2261
Salinity*BR*SA	8	54	2.67	0.0150

R= Replicate, Salinity = (50, 150) mMNaCL, BR = Brassinosteroid, SA = salicylic acid

Table 42: The effect of applying different levels of SA on root fresh weight of pepper plant (formula)

SA	Average root fresh weight /plant	Letter Group
0	33.8111	B
0.05	37.2111	AB
0.5	47.9148	A

Means followed by the same letter(s) are not significantly differ at 5% P value

Table 43: The effect of applying different levels of NaCl, BR and SA on root fresh weight of pepper plant (formula)

Salinity	BR	SA	Average root fresh weight /plant	Letter Group
0	0	0	33.6000	ABCD
0	0	0.05	53.7667	ABCD
0	0	0.5	93.6667	A
0	0.05	0	70.3000	ABCD
0	0.05	0.05	56.9333	ABCD
0	0.05	0.5	58.3667	ABCD
0	0.5	0	67.1667	ABCD
0	0.5	0.05	73.0000	ABC
0	0.5	0.5	76.6000	AB
50	0	0	10.0333	D
50	0	0.05	47.3000	ABCD
50	0	0.5	30.4333	BCD
50	0.05	0	29.5667	BCD
50	0.05	0.05	38.1667	ABCD
50	0.05	0.5	25.8333	BCD
50	0.5	0	29.2667	BCD
50	0.5	0.05	15.4667	CD
50	0.5	0.5	65.8667	ABCD
150	0	0	33.6667	ABCD
150	0	0.05	12.8667	CD
150	0	0.5	28.1000	BCD
150	0.05	0	13.0667	CD
150	0.05	0.05	18.9333	BCD
150	0.05	0.5	26.8333	BCD
150	0.5	0	17.6333	BCD
150	0.5	0.05	18.4667	BCD
150	0.5	0.5	25.5333	BCD

Means followed by the same letter(s) are not significantly differ at 5% P value

4.10 The effect of salicylic acid and brassinosteroid on aboveground dry weight of pepper under different salinity levels

Statistical analysis revealed that salinity has negative effect on aboveground dry weight of pepper (P<0.0001), in contrast BR, SA and other treatment was not significant (table 10).

Based on the mean separation the value of aboveground dry weight decreases when the salinity increase, so the highest value was 109 without salinity compared to 35.6 and 18.5 with 50 mM and 150 mMNaCL respectively (table 45)

Table 44: The analysis of variance for the effect of salinity BR, SA and combination on aboveground dry weight for pepper plant.

Type 3 Tests of Fixed Effects				
Effect	**Num DF**	**Den DF**	**F Value**	**Pr > F**
Salinity	2	54	82.49	<.0001
BR	2	54	0.80	0.4530
Salinity*BR	4	54	1.93	0.1185
SA	2	54	0.25	0.7834
Salinity*SA	4	54	0.88	0.4834
BR*SA	4	54	0.77	0.5515
Salinity*BR*SA	8	54	1.49	0.1842

R= Replicate, Salinity = (50, 150) mMNaCL, BR = Brassinosteroid, SA = salicylic acid.

Table 45: The effect of applying different levels of NaCl on aboveground dry weight of pepper plant (formula)

Salinity	Average aboveground dry weight /plant	Letter Group
0	109.09	A
50	35.6185	B
150	18.5519	B

Means followed by the same letter(s) are not significantly differ at 5% P value

Table 46: The effect of applying different levels of NaCl, BR and SA on aboveground dry weight of pepper plant (formula)

Salinity	BR	SA	Average aboveground dry weight /plant	Letter Group
0	0	0	72.5000	ABCDEF
0	0	0.05	110.60	ABCD
0	0	0.5	112.83	ABCD
0	0.05	0	99.1000	ABCDE
0	0.05	0.05	123.10	ABC
0	0.05	0.5	73.9667	ABCDEF
0	0.5	0	138.30	A
0	0.5	0.05	130.33	AB
0	0.5	0.5	121.10	ABC
50	0	0	11.8333	EF
550	0	0.05	49.7000	BCDEF
50	0	0.5	31.7000	DEF
50	0.05	0	47.8000	BCDEF
50	0.05	0.05	46.0000	BCDEF
50	0.05	0.5	28.1667	DEF
50	0.5	0	37.1333	CDEF
50	0.5	0.05	20.5333	EF
50	0.5	0.5	47.7000	BCDEF
150	0	0	51.8333	ABCDEF
150	0	0.05	11.5333	EF
150	0	0.5	15.4000	EF
150	0.05	0	11.2333	F
150	0.05	0.05	11.5333	EF
150	0.05	0.5	21.5000	EF
150	0.5	0	13.0667	EF
150	0.5	0.05	12.7667	EF
150	0.5	0.5	18.1000	EF

Means followed by the same letter(s) are not significantly differ at 5% P value

4.11The effect of salicylic acid and brassinosteroid and combination on root dry weight of pepper under different salinity levels

The analysis of variance revealed high significant differences in root dry weight ($P \leq 0.0392$) for the interaction between BR, SA and salinity. However, root dry weight was not affected when treated with BR, SA, BR*salinity, SA*salinity and BR*SA, but in general the root dry weight decrease sharply and significantly affected under saline condition ($P<0.0001$). (Table 47)

According to our analysis salinity reduce the root dry weight significantly from12.4 g without salinity to 4.9 g and 3 g at 50 mM and 150 mM NaCL respectively.

Furthermore, positive significant differences was observed between SA, BR, and salinity (BR*SA*salinity) when the level of salinity was zero and 50 mM NaCL, in contrast, when the level of salinity was 150 mM NaCL a significantly negative differences was observed. For example, at 50 mM NaCL the highest value of root dry weight was 10 g at 0.5 BR, 0.5 SA compared to 1.4 g without SA and BR at the same level of salinity, while the highest value of root dry weight at 150 mM NaCL was 6.6 without SA and BR compared to other value (see list of appendix, table 48_54).

Table 47: The analysis of variance for the effect of BR, SA and combination on root dry weight for pepper plant.

Type 3 Tests of Fixed Effects				
Effect	**Num DF**	**Den DF**	**F Value**	**Pr > F**
Salinity	2	54	44.12	<.0001
BR	2	54	0.53	0.5933
Salinity*BR	4	54	0.74	0.5703
SA	2	54	2.55	0.0877
Salinity*SA	4	54	0.62	0.6480
BR*SA	4	54	1.27	0.2946
Salinity*BR*SA	8	54	2.23	0.0392

R= Replicate, Salinity = (50, 150) mMNaCL, BR = Brassinosteroid, SA = salicylic acid

Table 48 : The effect of applying different levels of NaCl on root dry weight of pepper plant (formula)

Salinity	Average root dry weight /plant	Letter Group
0	12.4296	A
50	4.9148	B
150	3.0815	B

Means followed by the same letter(s) are not significantly differ at 5% P value

Table 49: The effect of applying different levels of BR on root dry weight of pepper plant (formula)

BR	Average root dry weight /plant	Letter Group
0	6.4741	A
0.05	6.5185	A
0.5	7.4333	A

Means followed by the same letter(s) are not significantly differ at 5% P value

Table 50: The effect of applying different levels of NaCl and BR on root dry weight of pepper plant (formula)

Salinity	BR	Average root dry weight /plant	Letter Group
0	0	11.2111	AB
0	0.05	11.9333	A
0	0.5	14.1444	A
50	0	4.2556	C
50	0.05	4.9222	C
50	0.5	5.5667	BC
150	0	3.9556	C
150	0.05	2.7000	C
150	0.5	2.5889	C

Means followed by the same letter(s) are not significantly differ at 5% P value

Table 51: The effect of applying different levels of SA on root dry weight of pepper plant (formula)

SA	Average root dry weight /plant	Letter Group
0	6.0667	A
0.05	6.1778	A
0.5	8.1815	A

Means followed by the same letter(s) are not significantly differ at 5% P value

Table 52: The effect of applying different levels of NaCl and SA on root dry weight of pepper plant (formula)

Salinity	SA	Average root dry weight /plant	Letter Group
0	0	11.3333	AB
0	0.05	11.2667	AB
0	0.5	14.6889	A
50	0	3.4667	C
50	0.05	4.9111	C
50	0.5	6.3667	BC
150	0	3.4000	C
150	0.05	2.3556	C
150	0.5	3.4889	C

Means followed by the same letter(s) are not significantly differ at 5% P value

Table 53: The effect of applying different levels of BR and SA on root dry weight of pepper plant (formula)

BR	SA	Average root dry weight /plant	Letter Group
0	0	4.6333	A
0	0.05	6.2111	A
0	0.5	8.5778	A
0.05	0	6.9889	A
0.05	0.05	6.4111	A
0.05	0.5	6.1556	A
0.5	0	6.5778	A
0.5	0.05	5.9111	A
0.5	0.5	9.8111	A

Means followed by the same letter(s) are not significantly differ at 5% P value

Table 54: The effect of applying different levels of NaCl, BR and SA on root dry weight of pepper plant (formula)

Salinity	BR	SA	Average root dry weight /plant	Letter Group
0	0	0	5.8000	ABCD
0	0	0.05	10.0667	ABCD
0	0	0.5	17.7667	A
0	0.05	0	14.7000	ABC
0	0.05	0.05	10.8667	ABCD
0	0.05	0.5	10.2333	ABCD
0	0.5	0	13.5000	ABCD
0	0.5	0.05	12.8667	ABCD
0	0.5	0.5	16.0667	AB
50	0	0	1.4333	D
50	0	0.05	6.7333	ABCD
50	0	0.5	4.6000	BCD
50	0.05	0	4.7000	BCD
50	0.05	0.05	5.5667	ABCD
50	0.05	0.5	4.5000	BCD
50	0.5	0	4.2667	BCD
50	0.5	0.05	2.4333	CD
50	0.5	0.5	10.0000	ABCD
150	0	0	6.6667	ABCD
150	0	0.05	1.8333	D
150	0	0.5	3.3667	CD
150	0.05	0	1.5667	D
150	0.05	0.05	2.8000	CD
150	0.05	0.5	3.7333	CD
150	0.5	0	1.9667	D
150	0.5	0.05	2.4333	CD
150	0.5	0.5	3.3667	CD

Means followed by the same letter(s) are not significantly differ at 5% P value

4.12 The effect of salicylic acid and brassinosteroid and on the leaf area of pepper plant under different salinity levels

No significant differences were observed on the leaf area when plant treated with BR, SA, BR*SA, BR*salinity, SA*salinity and SA*BR*salinity. However, the salinity has high negative significant effect on the leaf area with P value 0.0001 (table 55)

Mean separation indicates that salinity reducing leaf area of plant from 0.7825 m^2 (zero level of salinity) to 0.2352 m^2 at 50 mM NaCL and to 0.1128 m^2 at 150 mM NaCL. (table 56)

Table 55: The analysis of variance for the effect of salinity BR, SA on leaf area of pepper plant.

Type 3 Tests of Fixed Effects				
Effect	**Num DF**	**Den DF**	**F Value**	**Pr > F**
R	2	52	2.22	0.1193
Salinity	2	52	170.33	<.0001
BR	2	52	2.72	0.0750
Salinity*BR	4	52	1.26	0.2993
SA	2	52	2.22	0.1190
Salinity*SA	4	52	0.69	0.5995
BR*SA	4	52	1.89	0.1266
Salinity*BR*SA	8	52	1.35	0.2421

R= Replicate, Salinity = (50, 150) mMNaCL, BR = Brassinosteroid, SA = salicylic acid

Table 56: The effect of applying different levels of NaCl on leaf area of pepper plant (formula)

Salinity	Average leaf area /plant	Letter Group
0	0.7825	A
50	0.2352	B
150	0.1128	C

Means followed by the same letter(s) are not significantly differ at 5% P value

Table 57: The effect of applying different levels of NaCl, BR and SA on leaf area of pepper plant (formula)

Salinity	BR	SA	Average leaf area /plant	Letter Group
0	0	0	0.7467	AB
0	0	0.05	0.6933	ABC
0	0	0.5	0.7567	AB
0	0.05	0	0.7667	AB
0	0.05	0.05	0.9000	A
0	0.05	0.5	0.4900	ABCD
0	0.5	0	0.8067	AB
0	0.5	0.05	0.9897	A
0	0.5	0.5	0.8927	A
50	0	0	0.08333	DE
50	0	0.05	0.2800	CDE
50	0	0.5	0.2033	DE
50	0.05	0	0.3600	BCDE
50	0.05	0.05	0.2433	DE
50	0.05	0.5	0.1800	DE
50	0.5	0	0.2700	CDE
50	0.5	0.05	0.2000	DE
50	0.5	0.5	0.2967	CDE
150	0	0	0.01667	E
150	0	0.05	0.1520	DE
150	0	0.5	0.1000	DE
150	0.05	0	0.1253	DE
150	0.05	0.05	0.1423	DE
150	0.05	0.5	0.1033	DE
150	0.5	0	0.06867	DE
150	0.5	0.05	0.2100	DE
150	0.5	0.5	0.09667	DE

Means followed by the same letter(s) are not significantly differ at 5% P value

4.13. The effect of salicylic acid and brassinosteroid on Nitrogen content in pepper leaves under different salinity levels

The analysis of variance for Nitrogen percentage in leaf revealed that no significant difference was observed for all the variable; Brassinosteroid, salicylic acid, BR*SA, BR*salinity, and SA*salinity. However, the concentration of SA (0.05) and SA (0.5) revealed higher nitrogen percentage (4.7%) and (4.3%) respectively compared to (4%) without SA (figure 3). In contrast 0.05 BR and 0.5 BR revealed lower nitrogen percentage (3.9) and (4.3) respectively compared to 4.8 without BR (figure 2).The effect of salinity on Nitrogen percentage was significant, it seems that salinity reduce nitrogen percentage at 50 and 150 mM (figure 1).

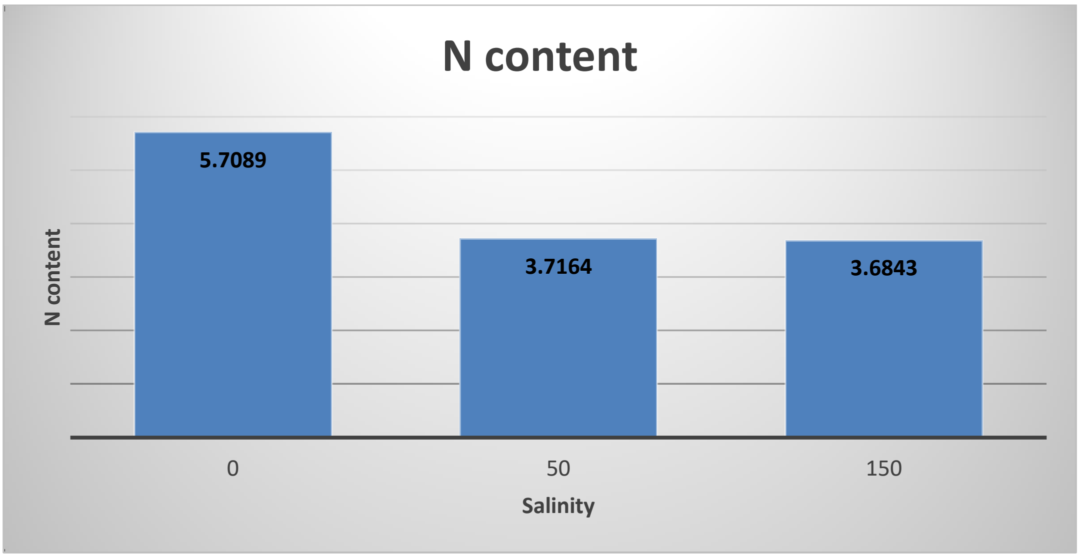

Figure 1: Effect of the salinity on nitrogen content of pepper plant (control, 50, 150 mM).

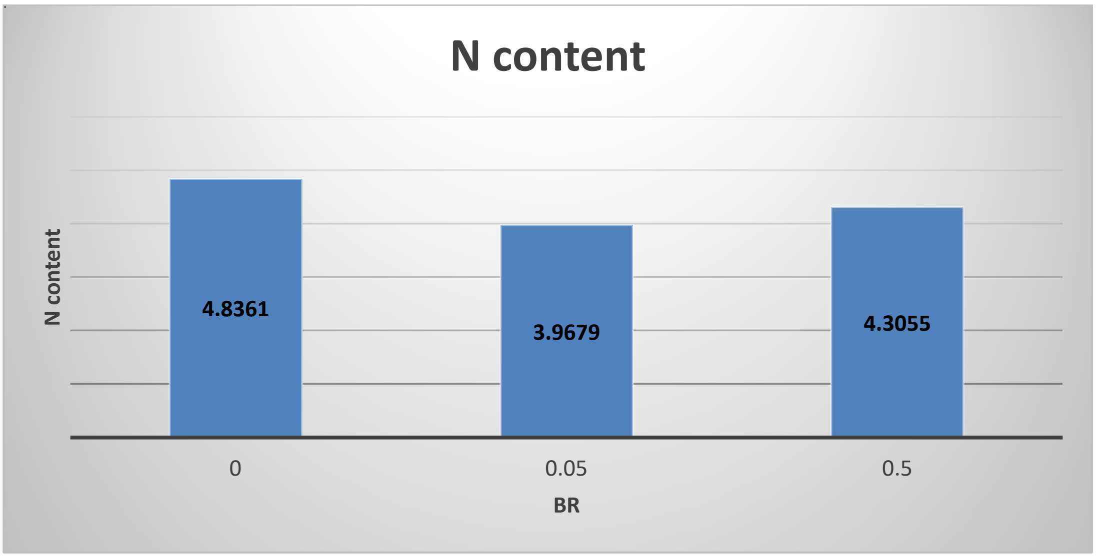

Figure 2: Effect of the Brassionosteroid on nitrogen content of pepper plant (control, 0.05, 0.5 mM).

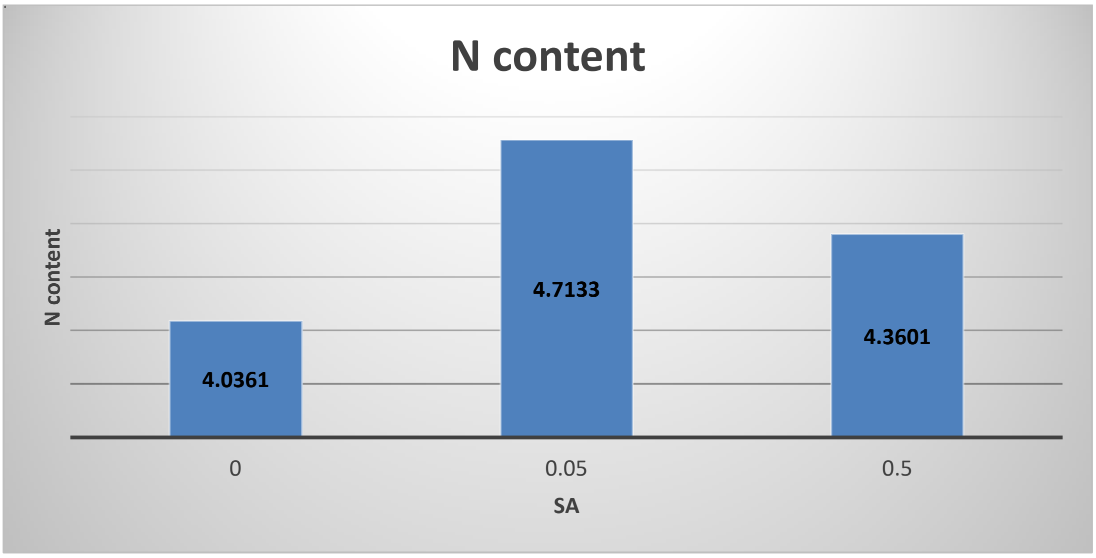

Figure 3: Effect of the salicylic acid on nitrogen content of pepper plant (control, 0.05, 0.5 mM)

4.14. The effect of salicylic acid and brassinosteroid on phosphorus content in pepper leaves under different salinity levels

Statistical analysis revealed that the effect of salinity on phosphorus percentage was variable but notsignificant, it seems that salinity increasephosphoruspercentage at 50 and 150 mMslightly, based on the mean separation(50 mM) salinity accumulate significantlyhigher amount of phosphorus (6.55 %) compared to zero salinity (2.94 %) and 150 mM salinity (4.41) (figure 4). Inaddition the analysis of leaves revealed decreasing in phosphorus content when treated with (0.05) BR (3.86 %) compared to plants withoutBR (5.21 %), SA treatment reduce phosphorus content from 4.8 (control) to 4.1 at 0.05 mM(figure 5 and 6), however the effect of SA and BR showed no differences at 0.5 mM in comparison without hormone addition, even in the combination between salinity and SA/BR at 50 mM salinity levels, the plants treated with SA or BR at 0.5 mM showed higher P content compared to plants with zero SA or BR (see appendix).

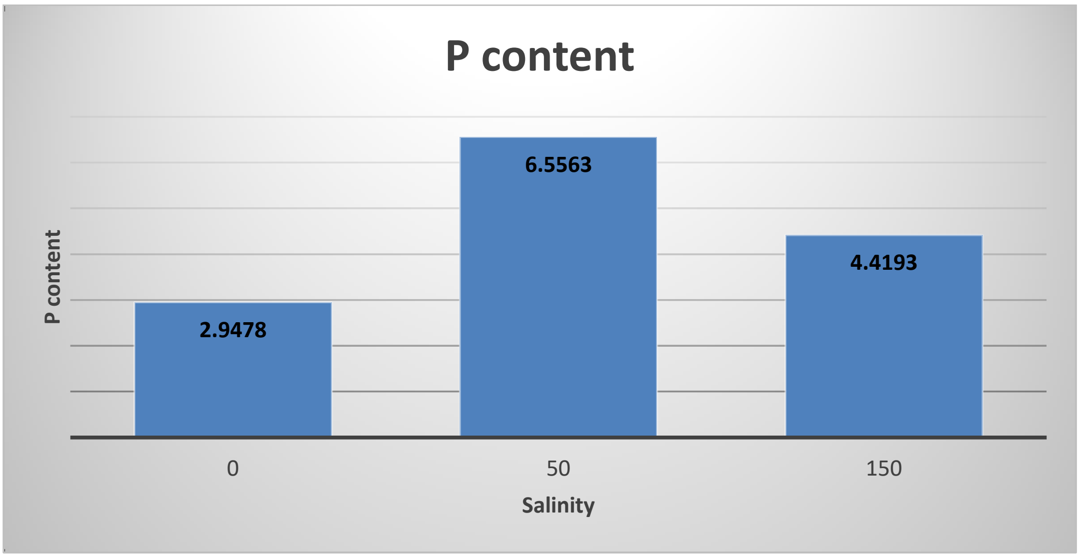

Figure 4: Effect of the salinity on phosphorus content of pepper plant (control, 50, 150 mM).

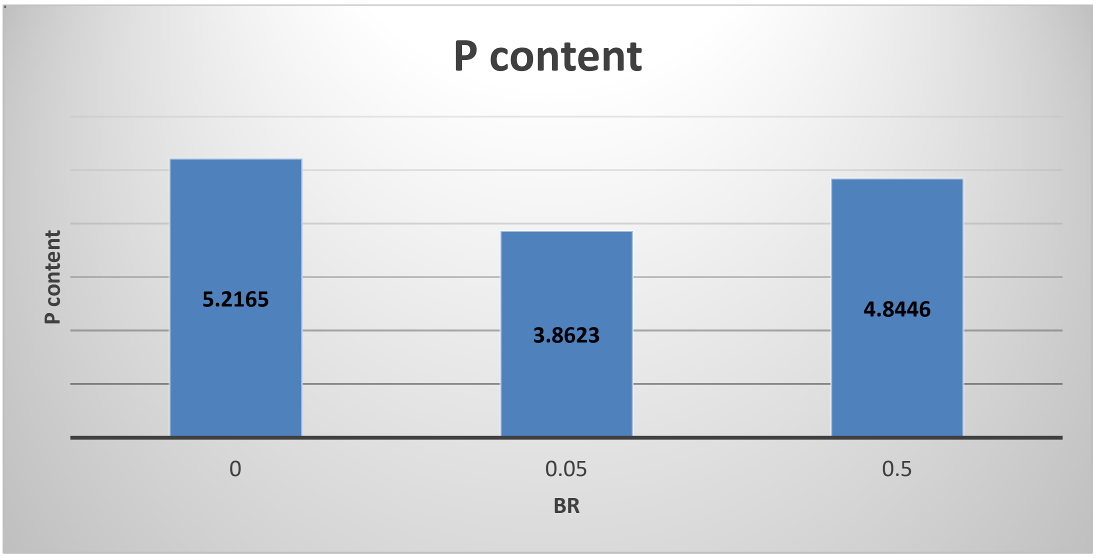

Figure 5: Effect of the Brassionosteroid on phosphorus content of pepper plant (control, 0.05, 0.5 mM).

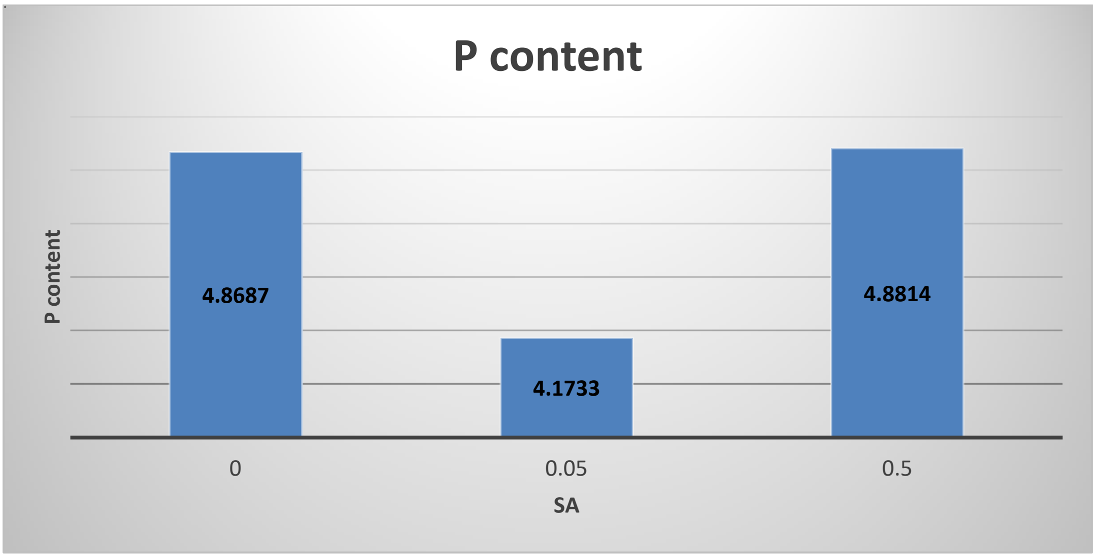

Figure 6: Effect of the salicylic acid on phosphorus content of pepper plant (control, 0.05, 0.5mM).

4.15. The effect of salicylic acid and brassinosteroid on potassium content in pepper leaves under different salinity levels

The analysis of variance revealed that salinity has high significant negative effect on the potassium content in the leaf of pepper plant with P value 0.007. Mean separation indicate the salinity reduce K content from 3.83 % at zero to 2.6 and 2.7% at 50 and 150 mMNaCL respectively (figure 7). In contrast the hormonal treatment was not significant, but based on the mean separation we observed some differences between variable in the combination between salinity and BR/SA, for example , 150 mMNaCL reduce K content from 3.6 % (control) to 2.2% , but in the presence of 0.05 BR with 150mMNaCL the value of K content increase to 3.7% (figure 8) and the same for SA , at 0.05mmM of SA potassium content K increase from 2.5% (zero SA) to 3% at 150 mMNaCL (figure 9).

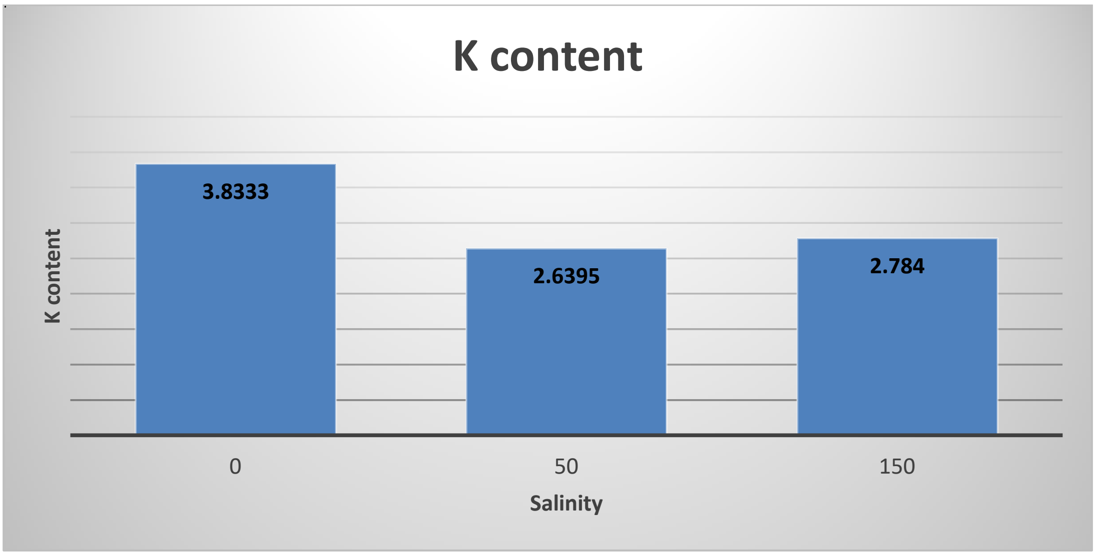

Figure 7: Effect of the salinity on potassium content of pepper plant (control, 50, 150 mM).

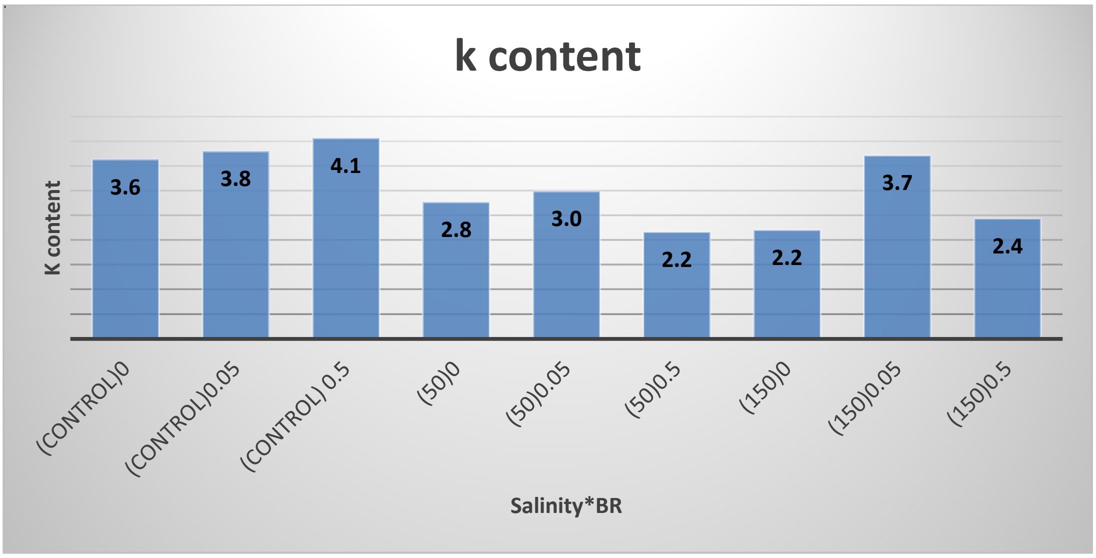

Figure 8: Effect of the interaction between Brassionosteroid and salinity on potassium content of pepper plant: salinity (control, 50, 150 mM), BR (control, 0.05, 0.5mM).

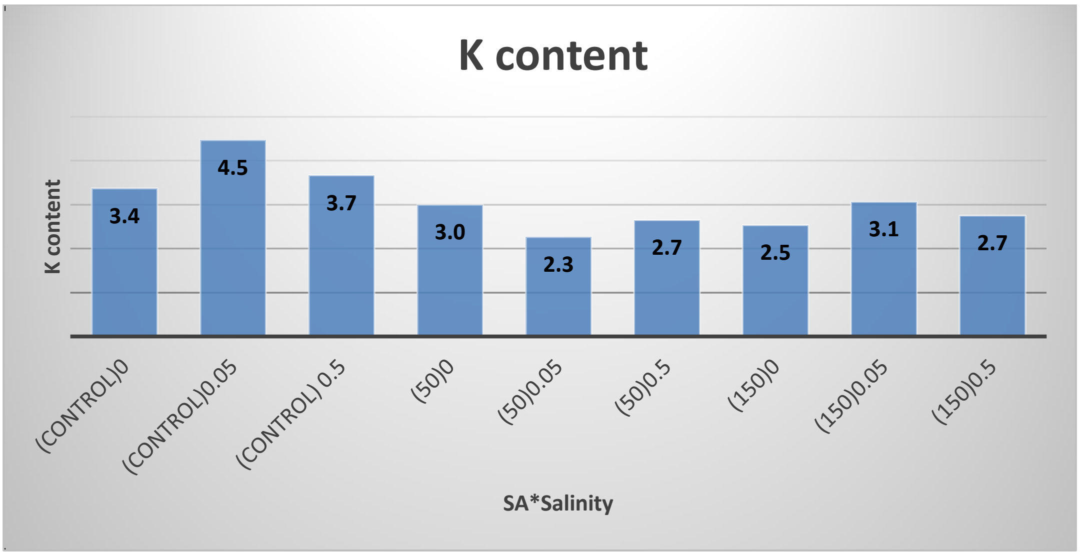

Figure 9: Effect of the interaction between Salicylic acid andsalinity on potassium content of pepper plant: salinity (control, 50, 150 mM), SA (control, 0.05, 0.5mM)

4.16. The effect of salicylic acid and brassinosteroid on sodium content in pepper leaves under different salinity levels

Sodium content highly accumulated in the leaf of plant that treated with salinity compared with non-treated plant, Na content increased from 0.166% without salinity to 4 and 3.8% with 50 and 150 mM NaCL Respectively (figure 10). Brassionosteroid and salicylic acid treatment was not significant on the sodium content , but based on the mean separation the brassinosteroid has little affected at 0.05 mM , BR decrease Na content from 2.94% (zero BR) to 2.25% at 0.05 mM BR (figure 11). Even at 50 and 150 mM salinity levels the plants with 0.05BRtreatment showed less Na content compared to plants with zero and 0.5 mM BR, for example at 50 mM NaCL plant treated with 0.05 BR has lowest sodium content 3.35 % compared to 4.33 and 4.31 % at zero and 150 mM NaCL respectively (figure 12).

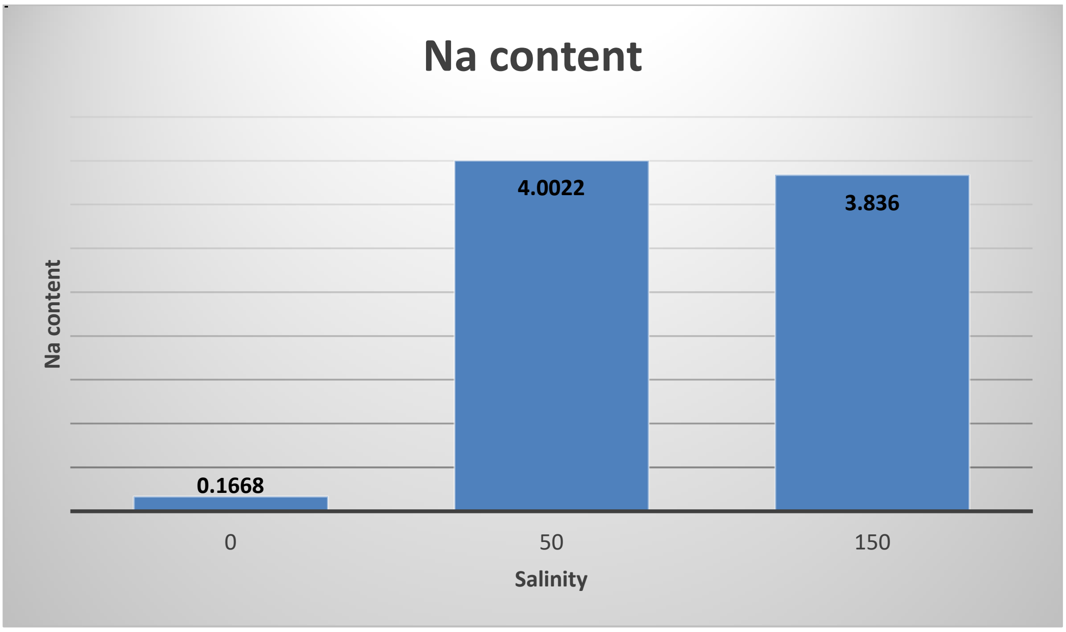

Figure 10: Effect of the salinity on sodium content of pepper plant (control, 50, 150 mM).

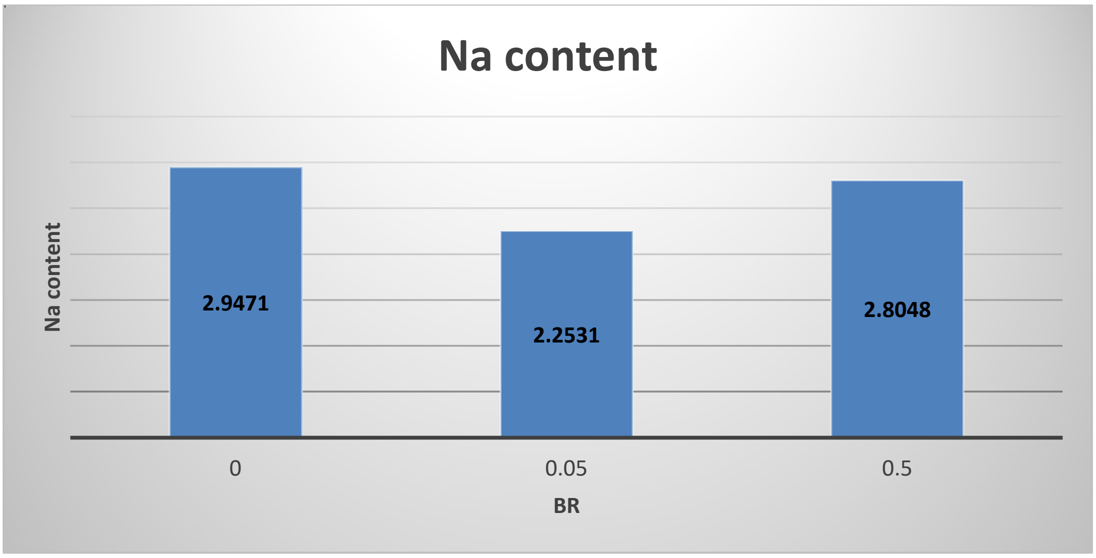

Figure 11: Effect of the Brassionosteroid on sodium content of pepper plant (control, 0.05, 0.5 mM).

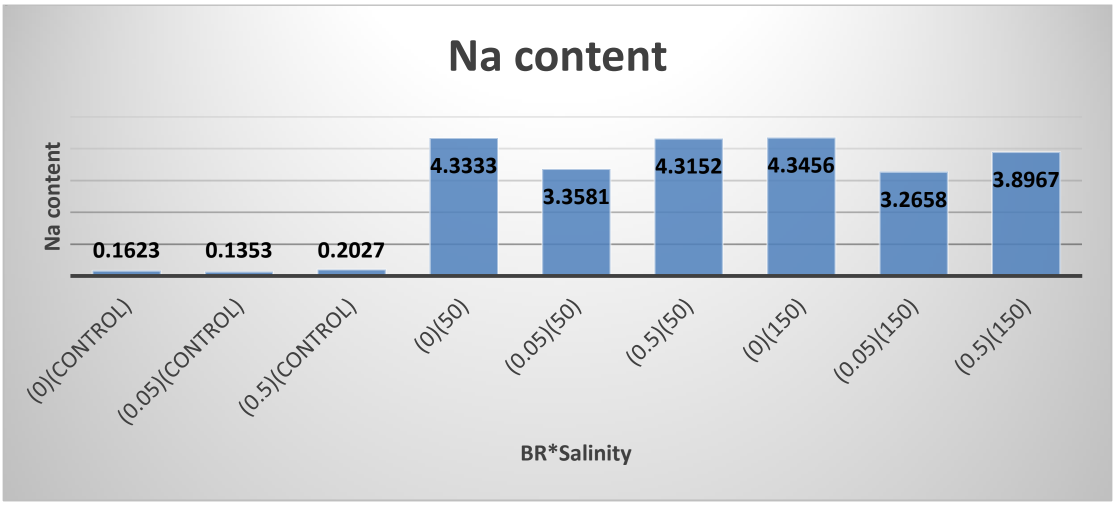

Figure 12: Effect of the interaction between Brassionosteroid and salinity on sodium content of pepper plant: salinity (control, 50, 150 mM), BR (control, 0.05, 0.5mM).

4.17. The effect of salicylic acid and brassinosteroid on chloride content in pepper leaves under different salinity levels

The analysis of variance revealed that salinity has high significant effect on the chloride content in the leaf. Based on the mean separation CL content increase from 1.08% without salinity to 4.53 and 4.58% with 50 and 150 mM NaCL respectively (figure 13).

Based on the analysis of variance chloride accumulation was lower (2.9 %) at 0.05 BR compared to 3.9 and 3.3 % at zero and 0.5 mM BR respectively. Mean separation show that SA treatment has negative effect on CL content by increasing the value when it increase (figure 14 and 15).

The combination between SA and salinity revealed that SA increase Na content in the plant, in contrast BR treatment reduce the effect of salinity as the level of chloride content decrease. For example at 150 mM chloride content in plant was 5.33 % at zero BR compared to 4.36 and 4.06 % at

0.05 and 0.5 BR at the same level of salinity respectively (see appendix figure).

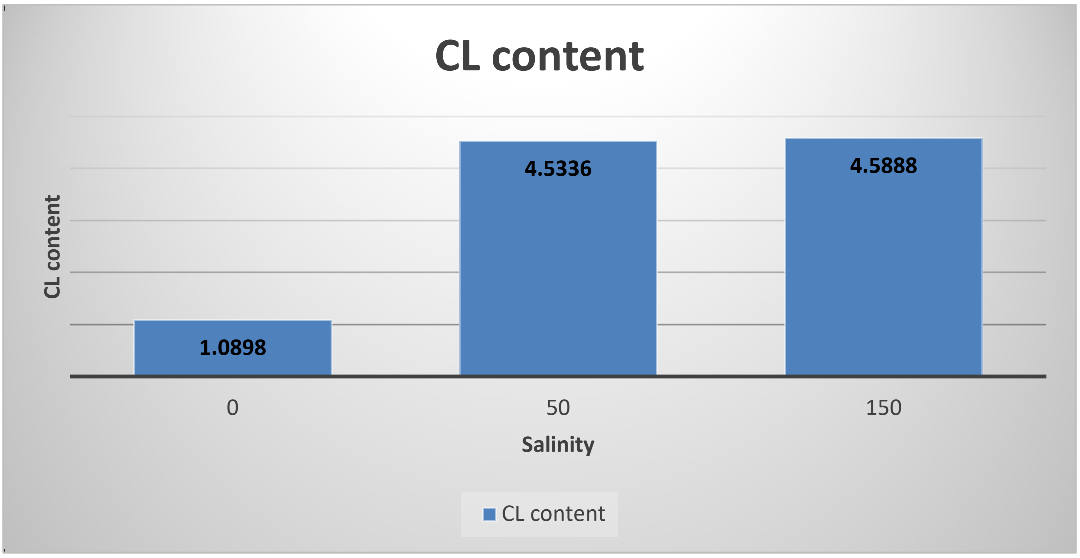

Figure 13: Effect of the salinity on chloride content of pepper plant (control, 50, 150 mM).

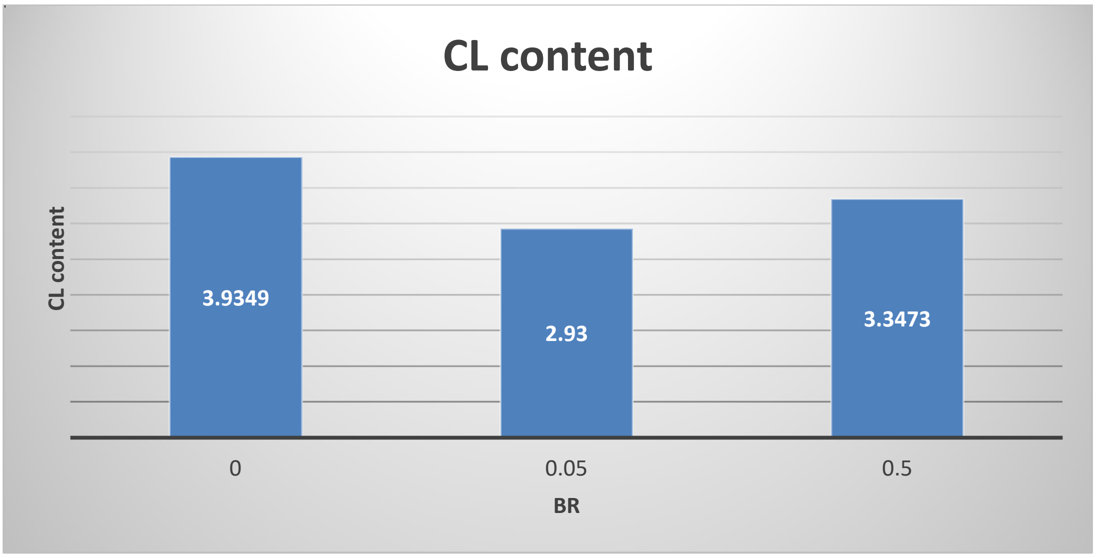

Figure 14: Effect of the Brassionosteroid on chloride content of pepper plant (control, 0.05, 0.5 mM).

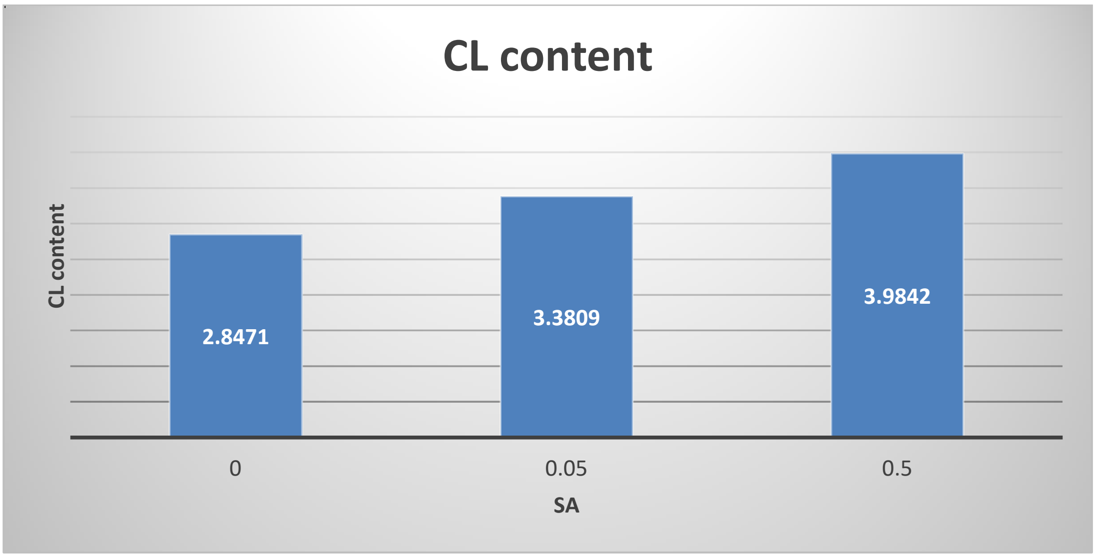

Figure 15: Effect of the salicylic acid on chloride content of pepper plant (control, 0.05, 0.5 mM).

4.18. The effect of salicylic acid and brassinosteroid on calcium content in pepper leaves under different salinity levels

Calcium accumulation in leaves of pepper plant was significantly affected by salinity. The presented data graphically illustration indicated that salinity reduce Calcium content and ranged 1.95 % in control plant to 0.84 and 0.86 % at 50 and 150 mM respectively (figure 16). Generally, with Brassionosteroid treatment, calcium content is significantly increased 1.33 and 1.23 at 0.05 and 0.5 mM respectively compared to non-treated plant 1.09 % (figure 17). In addition the mean separation revealed that salinity and BR interaction have significant difference on calcium content when the salinity levels was zero and 50 mM , for example at 50 mM calcium content increase from 0.54 % (zero BR) to 1.21 % (0.05 BR) and 0.75 % (0.5 BR)(figure 18). In contrast SA treatment alone or combination with salinity has negative effect by decreasing value of calcium content at all salinity levels (see appendix).

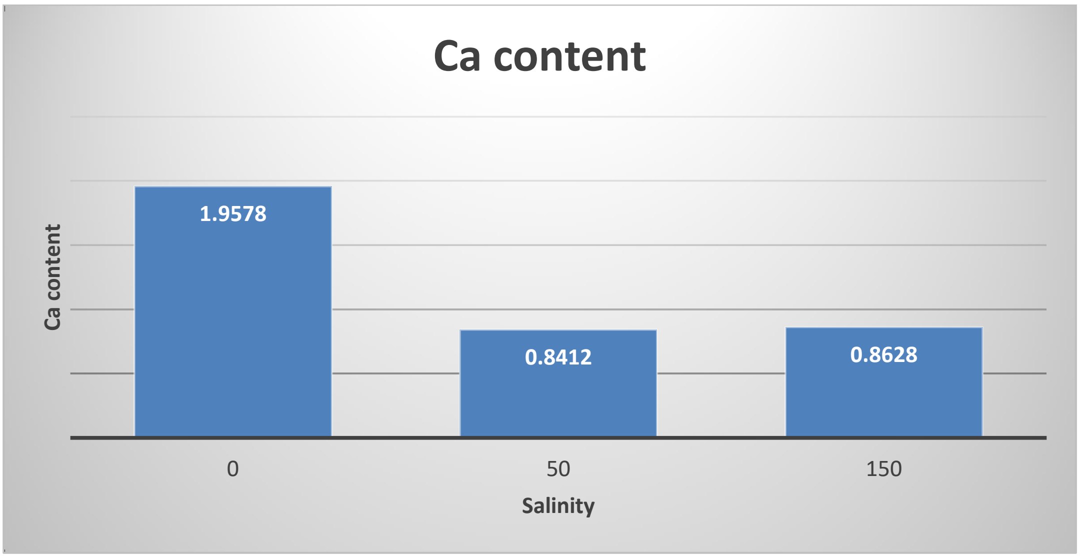

Figure 16: Effect of the salinity on calcium content of pepper plant (control, 50, 150 mM).

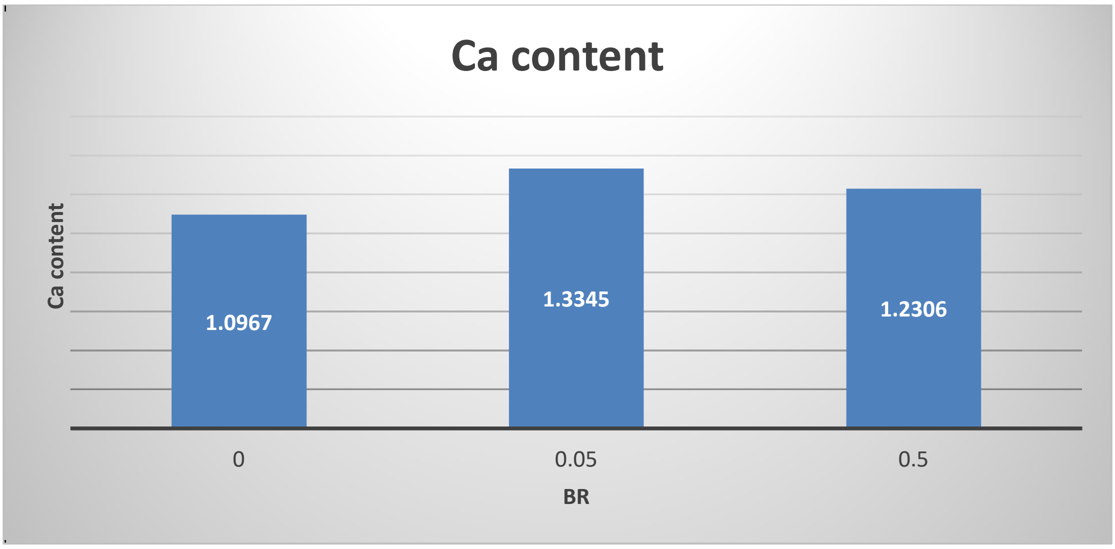

Figure 17: Effect of the Brassionosteroid on calcium content of pepper plant (control, 0.05, 0.5 mM).

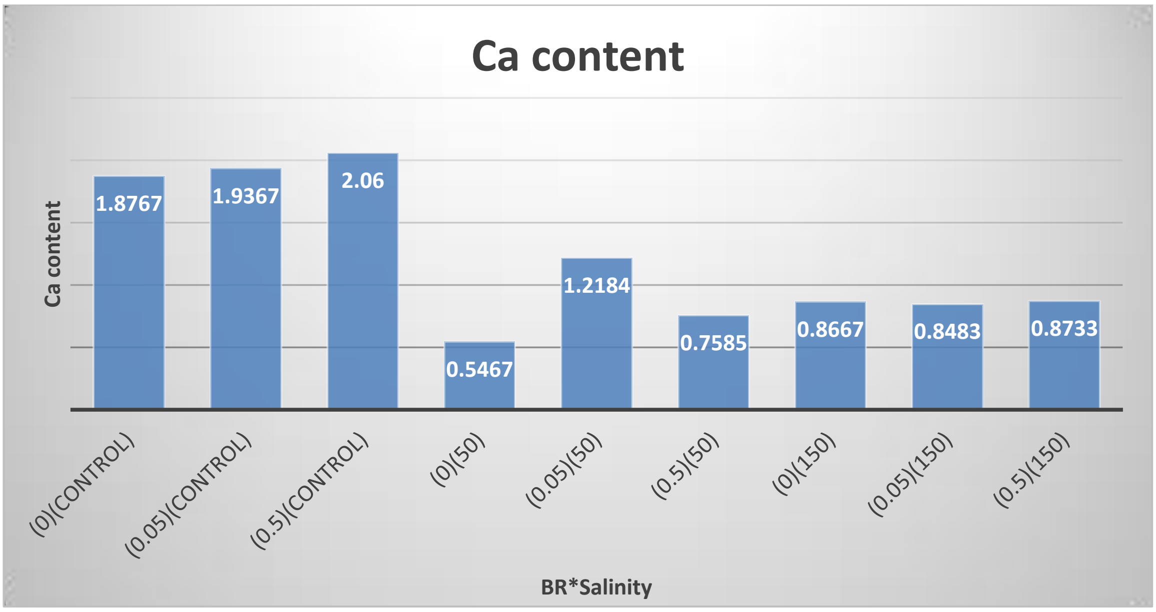

Figure 18: Effect of the interaction between Brassionosteroidandsalinity on calcium content of pepper plant: salinity (control, 50, 150 mM), BR (control, 0.05, 0.5 mM).

Chapter 5

Discussion

5.1 The effect of salicylic acid and Brassinosteroid on yield and yield component

Salinity is one of the limiting factors in agriculture production, especially in arid and semiarid regions due to high evaporation and low precipitation rates, salinity reduces growth and yield of crops through osmotic stress and toxic ions (Fozouni et al, 2015)This study has shown the effect of salicylic acid and brassinosteroids on performance of plant under different salinity levels .

Pepper is an important agricultural crop, not only because it economic important, but also because nutritional value (Martinez et al., 2015). Sweet pepper fruit (Capsicum Annum L) are an excellent source of bioactive product but the content is related with the plant response to stressful conditions.

The analysis of yield components in this study revealed higher response for fruit number, fruit weight, plant height, stem width, shoot fresh weight, root fresh weight, shoot dry weight, root dry weight and chlorophyll content.

The majority of cultivated species are susceptible to excessive concentration of dissolved ions (e.g., >30 mM or > 3 ds/m) in the rhizosphere (Ondrasek et al. 2009).For example the yield of crop such as potato, corn and onion reduced by 50% when the soil EC is increased to 5 ds/m (Horneck et al. 2007).

High salt concentrations are toxic to seedling growth, vegetative growth, flowering and fruit set, and ultimately diminisheconomic yield and quality of product (Arora et al., 2008). This study has shown the effect of salicylic acid and brassionosterid on the performance of pepper plant. Pepper is an important, widespread agricultural crop in the Mediterranean area, grown commercially in semi-arid regions where salinity is a potential problem and farmers are forced to use saline water, this being the major yield-limiting factor for crops and the cause of damage to soil physicochemical properties (Biswas, 1993; Flowers, 1999).

Salinity reduce the yield and yield component in pepper plant, however the salicylic acid and brassionosteroid treatment ameliorate the effect of salinity. This could be attributed to the effect of SA on the osmotic regulation and high P solubilizing and mineralizing ability from P-sources, production of growth promoting substances such as auxin (Aditya et al., 2009; Akhtar andSiddiqui, 2009), while BR has revealed that they elicit a wide spectrum of morphological and physiological responses in plants including stem elongation, pollen tube growth, leaf bending and epinasty, root inhibition, induction of ethylene biosynthesis, proton pump activation, xylem differentiation and the regulation of gene expression (Li and Chory 1999, Mussig et al. 2002, Sasse 2003).

BR and SA treatment significantly reduce the effect of salinity as it revealed increase in the number of fruit in pepper plant that treated with SA and BR. The positive effect on number of fruit could be due to SA and BR increased crop yield through changing plant metabolism and increase in photosynthesis products which constitute an improved supply from source to sinks, leading to increase yield.

Sweet pepper plant in relation to fruit weight under salinity condition revealed decrease in weight as salinity level increase. However BR treatment and SA treatment reduce the effect of salinity and increase the fruit weight of pepper plant. The positive effect on the fruit weight of pepper plant could be due to SA and BR induced cell division and enlargement and increasing height of plant and chlorophyll content on leaves thus increase photosynthesis and increase material that synthesis in the plant such as carbohydrates and proteins.

The comparison of the mean with tukey _ Kramer revealed that when the treatment was with BR, the fruit weight increase by 10% , 25% , 50% in comparison to control at 0 , 50 , 150 mM NaCl respectively, but when SA treatment the fruit weight increase by 48% , 31% , 56% in comparison to control at 0 , 50 , 150 mM NaCl .

In the our result the height of plant reduced by salinity, Hamada (1995) in his study on maize,.Misra et al (1997) with their study on rice seedling, Dantus et al (2005) in their study on cowpea and finally by Memon et al (2010) in their study on Brassica Campestris L . Were they indicated that under high concentration of sodium chloride plant heights decrease.

Salicylic acid treatment and brassinosteroids treatment reduce the effect of salinity on the height of plant, the positive effect on the height of plant could be due to SA play role in the preserving auxin and cytokinin in the plant tissue that play important role on cell division and elongation, and the BRs regulate both cell elongation and cell division and are essential for morphogenesis in darkness.

Pepper plant in related to chlorophyll content under saline condition revealed that decrease in chlorophyll content as salinity increase. However BR treatment and SA treatment reduce the effect of salinity on chlorophyll content. This is due to SA have an important role in porphyrins synthesis that enter to building chlorophyll pigment molecule and increase protein and amino acid synthesis that's leads to increase plastids division and increase chlorophyll pigments. SA also has positive effect on increasing activity of biological process and increase chlorophyll pigments in leaves (Kaydan et al ,. 2007) (Amanullah et al ,. 2010).Also BRs (interaction with SA) reduce the effect of salinity on chlorophyll content due to BRs has important role in improvement of photosynthetic rate and increase number of chloroplast in leaves. These result agree with some earlier results in which BRs improve photosynthesis rate mustard (Hayat et al., 2003). Dubey (2005) suggested that the BRs induced improvement in photosynthetic rate which related with increase chlorophyll content.

Swamy and Rao (2009) show that exogenous application of BR increase the rate of photosynthesis and that growth promotion was associated with increased chlorophyll content in geranium plant.

BR and SA combination was effective in increasing level of pigment in leaf of pepper plant under salt stress, high level of these pigment might be explained by the fact that BR and SA had a protective effect on leaves structure and preventing nucleus and chloroplast degradation.

The growth parameter (fresh and dry mass root part and shoot part) decreased progressively with the rise of salinity levels. Compared with control , these result are agree with those of Ghoulam et al. (2002) who show that salinity caused a marked reduction in growth parameter of sugar beet plant.

Our result show that the combination between BR and SA was more significantly affected on the root and shoot fresh and dry weight compared to SA treatment or BR treatment alone. The plant treated with NaCl and subsequently treated with SA and BR show higher shoot fresh weight, root fresh weight, shoot dry weight and root dry weight compared to other treatment, this indicates that salicylic acid and brassinosteroid application on pepper plant exhibited an increase in salt tolerance. This data showed that SA and BR treatment in low concentration could effectively improve the growth of sweet pepper plant under salinity stress.

But the earlier result show that when the plant treated with salicylic acid only result increase shoot and root fresh weight and dry weight, Baninasab,.(2010) report that SA stimulate shoot and root growth under stress in cucumber, El_tayeb ,.(2005) found that application of SA increased the dry weight of the barley seedling under stressed condition. Karkmaz et al, 2007 also reported that SA increased fresh weight and dry weight of shoots and roots under stress condition in muskmelon plants. Gutierrez_coronado et al. (1998) also report a similar increase in the growth of shoots and roots of soybean plant in response to salicylic acid

5.2 Effect of salicylic acid and brassinosteroids on chemical composition under salinity stress

The toxic effect of salinity includes many aspects. Absorption of excessive amount of sodium and calcium effects many metabolic processes within the plant. High concentration of salt in the soil causes osmotic stress, which reduces water absorption from the soil. High concentration of sodium and calcium in the soil solution may disorder nutrient ions activates, causing plant to be susceptible to osmotic and specific ion injury as well as to nutritional disorders that result in reduce yield and quality (Grattan and Grieve , 1999) . Ion toxicity and osmotic stress cause an imbalance in the metabolism and oxidative stress. The toxic effect of salinity includes plant death or decrease in its production rate. Mineral content of the leaves except Na and CL decreased under salinity condition, salinity dominated by Na and CL ions decreased the concentration of essential macro and micro elements in several vegetables crops (Grattan and Grieve, 1999; Yildirim et al., 2006). Under salinity conditions, the plant absorbs a large amount of sodium at the expense of potassium and calcium. The sodium content in the leaves increases as the salinity level increases. High accumulation of sodium in the plant can be one of the main causes of lower growth. The leaf content of calcium decreases and increases in the soil by high salinity, could be due to competition between cation, and thus nutritional imbalance occurs.

In the present study sodium and chloride concentration in the leaves increase with the increased salinity level, however treatment of salicylic acid and brassinosteroids reduce the Na and CL uptake of plant and increase uptake of N, P, K and Ca compared with control treatment under salt stress, so BR reduce Na by 24% under salinity level or keep it constant, and SA keep Na concentration constant at zero and 50 mM NaCL but no effect at 150 mM NaCL. Brassionosteroid also reduce chloride concentration at different salinity level but the salicylic acid has no effect on chloride content. Melek E et al (2012) suggest that foliar treatment of BR inhibited Na and CL accumulation but stimulated N, P, K, Mg, Fe, Mn and other element uptake under salt stress.

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Conclusion

Pepper plant is highly affected by the salinity in soil or in the irrigation water, application of hormones like salicylic acid and brassionosteroid revealed positive effect on the stressed plant to reduce the negative effect of salinity .

Salicylic acid and brassionosterid has significant effect in limiting salinity stress in growth parameters (fruit number, fruit weight, branches number, stem height, stem width, chlorophyll content etc)

The hormones improved nutrient minerals uptake (N, P, K, and Ca) compared to non-treated plant with hormones the accumulation of Na and Cl slightly reduced.

In general, salicylic acid and brassionosteroid have a positive effect in reducing soil salinity especially at 50 mM NaCL.

Recommendations

- Using salicylic acid in saline soil is recommended at 0.05 Mm on level of salinity not more than 50 Mm NaCl
- Using brassionosteroid in saline soil is recommended at 0.5 Mm on level of salinity not more than 50 Mm NaCl
- The combination between SA and BR is recommended at 0.5 _0.5 Mm on level of salinity not more than 50 Mm NaCl

References

- Abbaspour H. 2012. **Effects of salt stress on lipid peroxidation,** antioxidative enzymes and proline accumulation in pistachio

- Abbas, S.; Latif, H.H.; Elsherbiny, E.A. ***Effect of 24-epibrassinolide on the physiological and genetic changes on two varieties of pepper under salt stress conditions***. **Pak. J. Bot**. **2013**, *45*, 1273–1284.

- Ahmad, P., M.A. Ahanger, M.N. Alyemeni, L. Wijaya, D. Egamberdieva, R. Bhardwaj and M. Ashraf. 2017. ***Zinc application mitigates the adverse effects of NaCl stress on mustard [Brassica juncea (L.) Czern & Coss] through modulating compatible organic solutes, antioxidant enzymes, and flavonoid content***. **J. Plant Interact**. 12(1): 429-437.

- Alamgir, A.N.M., M. Musa and M.Y. Ali. 2008. ***Some aspects of mechanisms of nacl stress tolerance in the seedlings of four rice genotypes.*** **Bang. J. Bot**., 36(2): 181-184.

- Alzahrani, S.M., I.A. Alaraidh, H. Migdadi, S. Alghamdi, M.A. ***Khan and P. Ahmad. 2019. Physiological, Biochemical and antioxidant properties of two genotypes of Vicia faba grown under salinity stress.*** **Pak. J. Bot**., 51(3): 786-798.

- AYERS R., WESTCOT W., 1985. **Water quality for agriculture. Irrigation and Drainage**. No. 29. FAO. Rome.

- Amin B; Mahleghah G.; Mahmood H.R.M.; and Hossein M., 2009. ***Evaluation of interaction effect of drought stress with ascorbate and salicylic acid on some of physiological and biochemical parameters in okra (Hibiscus esculentus L.).*** **Research Journal of Biological Sciences**., 4(4): 380-387.

- Ashraf, M. and M.R. Foolad. 2005. **Pre-sowing seed treatment – A shotgun approach to improve germination, growth and crop yield under saline and non-saline conditions**. Advances in Agronomy 88: 223271.

- Ali, M.B., E.J. Hahn, and K.Y. Paek. 2005. **Effect of temperature on the oxidative stress defence system, lipid peroxidation and lipoxygenase system in Phalaenopsis.** Plant Physiol. Biochem. 43: 213–223.

- Ashraf, M., N.A. Akram, R.N. Arteca, and M.R. Foolad. 2010. **The physiological, biochemical and molecular roles of brassinosteroids and salicylic acid in plant processes and salt tolerance**. Crit. Rev. Plant Sci. 29:162–190.

- Abdullah Z, Ahmed R (1990). ***Effect of pre and post kinetin treatment on salt tolerance of different potato cultivars growing on saline soils***. **J. Agron**. Crop Sci.165, 94-102.

- Anuradha, S. and S. S. R. Rao. 2001. **Effect of brassinosteroids on salinity stress induced inhibition of seed germination and seedling growth of rice (Oryza sativa L.).** Plant Growth Regul. 33: 151–153.

- BARBIERI G., 1995. **Rasterize on edelle risorseid riche e strategie di irrigazione.** AttiAccademie Dei Georgofili. Ser VII Vol XLII, 589-600. [In Italian].

- Ben Ahmed; Hela; Abidi; Farouk; Manaa; Arafet; Mimouni; Zid H. **And Ezzeddine, 2009. Salicylic acid induced changes on some physiological parameters in tomato grown under salinity**. The Proceedings of the International Plant Nutrition Colloquium Xvi.

- Bethke P.C. & Drew M.C., 1992. **Stomatal and nonstomatal components to inhibition of photosynthesis in leaves of Capsicum annuum during progressive exposure to NaCl salinity**. Plant Physiology., 99: 219–226.

- Bethke, P.C. and M.C. Drew. 1992. **Stomatal and non-stomatal components to inhibition of photosynthesis in leaves of Capsicum annuum during progressive exposure to NaCl salinity**. Plant Physiol. 99: 219-226.

- Bajguz A. 2000a. **Effect of brassinosteroids on nucleic acids and protein content in cultured cells of Chlorella vulgaris**. Plant Physiol. Biochem. 38(3): 209–215.

- Booth WA, Beardall J (1991). **Effect of salinity on inorganic carbon utilization and carbonic anhydrase activity in the halotolerant algae Dunaliellasalina) Chlorophyta).** Phycologia 30, 220-225.

- CHARTZOULAKIS K., KLAPAKI G., 2000. **Response of two greenhouse pepper hybrids to NaCl salinity during different growth stages.** Sci Hort 86, 247-260. doi: 10.1016/S0304-4238(00)00151-5.

- CORNILLON P., PALLOIX A., 1995. **Influence de la salinité et de la température du substrat sur la corissance et la nutrition du piment**. Fruits 50, 469-471. [In French].

- Chinnusamy, V., A. Jagendorf and J. Zhu. 2005. **Understanding and improving salt tolerance in plants**. Crop Science 45: 437-448.

- Chartzoulakis K, Klapaki G. 2000. **Response of two greenhouse pepper hybrids to NaCl salinity during different growth stages**, Scientia Horticulturae, 86: 247-2600.

- Chartzoulakis, K. and G. Klapaki. 2000. **Response of two greenhouse pepper hybrids to NaCl salinity during different growth stages**. Scientia Horticulturae, 86: 247-260.

- Clouse, S. D. and J. M. Sasse. 1998. **Brassinosteroids: essential regulators of plant growth and development**. Annu. Rev. Plant Physiol. Plant Mol. Biol., 49: 427-451.

- Dhaliwal. RK, Malik. CP, Gosal. SS, Dhaliwal. LS, 1997, **Studies on hardening of micropropagated sugarcane (Saccharaumofficinarum L.) plantlet.** II. Leaf parameters and biochemical estimation. Ann. Biol.13: 15-20.

- Dhaliwal, R.K., C.P. Malik, S.S. Gosal and L.S. Dhaliwal, 1997. **Studies on hardening of micropropagated sugarcane (Saccharum officinarum L.) plantlet**. II. Leaf parameters and biochemical estimations. Ann. Biol. Ludhiana, 13: 15–20.

- Foolad, M.R., J.R. Hyman and G.Y. Lin. 1999. **Relationships between cold-and salt-tolerance during seed germination in tomato: analysis of response and correlated response to selection**. Plant Breeding, 118: 49-52.

- Fujioka S. and Sakurai A. 1997. **Brassinosteroids**. Nat. Prod. Rep. 14: 1–10.

- Gutierrez–Coronado, M.A., C. Trejo–Lopez and A. Larqué–Saavedra, 1998. **Effects of salicylic acid on the growth of roots and shoots in soybean**. Plant Physiol. Biochem., 36: 653–65.

- Gomez L., Blanca L. and Antonio C.S. 1993. **Evidence of the beneficent action of the acetyl salicylic acid on wheat genotypes yield under restricted irrigation**. In: Proc. scientific meeting on Forestry, Livestock and Agriculture Mexico., p. 112.

- Hajer AS, Malibari AA, Al-Zahrani HS, Almaghrabi OA. 2006. ***Responses of three tomato cultivars to sea water salinity 1. Effect of salinity on the seedling growth.*** **African Journal of Biotechnology**, 5 (10): 855-861.

- Horvath E, Szalai G, Janda T. 2007. ***Induction of Abiotic Stress Tolerance by Salicylic Acid Signaling***. **Journal of Plant Growth Regulation,** 26(3): 290- 300.

- Hayat S. and Ahmad A., 2007. **Salicylic Acid: A Plant Hormone**, Published By Springer, Xv, P. 401.

- Hasegawa PM, Bressan RA, Zhu JK, Bohnert HJ (2000). **Plant cellular and molecular response to high salinity**. Ann. Rev. Plant Physiol. Plant Mol. Biol. 51,463-499.

- Hayat S, Ahmad A (2007). **Salicylic acid: A plant hormone**. Springer, Dordrecht, the Netherlands.

- Hopkins WJ (1995). **Introduction to Plant Physiology**, Kluwer Academic Publisher, Dordrecht, the Netherlands.

- Hamada, K.1986.Brassinolideincropproduction, p. 90–196. In: Maegregor, P. (Ed.). **Plant growth regulators in agriculture**. Food Fertilization Technology Central Asia Pacific Region, Taiwan.

- Hayat, S., S.A. Hasan, M.Yusufa, Q. Hayat, and A. Ahmad. 2010. **Effect of 28-homobrassinolide on photosynthesis, fluorescence and antioxidant system in the presence or absence of salinity and temperature in Vigna radiata**. Environ. Exp. Bot. 69:105–112.

- Hayat, S., A. Ahmad, M. Mobin, A. Hussain and Q. Faridduddin. 2000. **Photosynthetic rate, growth and yield of mustard plants sprayed with 28-homobrassinolide**. Photosynthetica, 38: 469-471.

- Janeczko, A.; Oklešťková, J.; Pociecha, E.; Kościelniak, J.; Mirek, M. **Physiological effects and transport of 24-epibrassinolide in heat-stressed barley**. *Acta Physiol. Plant.* **2010**, *33*, 1249–1259.

- Kauschmann, A., A. Jessop, C. Koncz, M. Szekeres, L. Willmitzer and T. Altmann. 1996. ***Genetic evidence for an essential role of brassinosteroids in plant development***. **Plant J**., 9: 701-713.

- Kolomeichuk, L.V.; Efimova, M.V.; Zlobin, I.E.; Kreslavski, V.D.; Ol'ga, K.M.; Kovtun, I.S.; Khripach, V.A.; Kuznetsov, V.V.; Allakhverdiev, S.I. **24-Epibrassinolide alleviates the toxic effects of NaCl on photosynthetic processes in potato plants**. Photosynth. Res. **2020**, 146, 151–163.

- Lee SKD. 2006. **Hot pepper response to interactive effects of salinity and boron.** Plant Soil Environment, 52: 227-233.

- Leslie, C.A. and R.J. Romani, 1988. **Inhibition of ethylene biosynthesis by salicylic acid**. Plant Physiol., 88: 833–7.

- Metwally A, Finkemeier I, Georgi M, Dietz KJ. 2003. **Salicylic Acid Alleviates the Cadmium Toxicity in barley Seedlings**. Plant Physiology, 132(1): 272-281.

- MEIRI A., SHALHEVET J., 1973. **Pepper plant response to irrigation water quality and timing of leaching.** Physical aspects of soil water and salts in ecosystems. Ecol Stud 4, 421-429.

- Murphy KST, Durako MJ (2003). **Physiological effects of short-term salinity changes on Ruppia maritime**. Aquat. Bot. 75, 293-309.

- NAVARRO J.M., GARRIDO C., CARVAJAL M., MARTÍNEZ V., 2002. ***Yield and fruit quality of pepper plants under sulphate and chloride salinity***. **J Hortic Sci Biotechnol** 77, 52-57.

- Paridam AK, Das AB. 2005. **Salt tolerance and salinity effects on plants: a review**. Ecotoxicology and Environmental Safety, 60: 324-349.

- Plants. Journal of Medicinal Plants Research, 6: 526-529. Arfan M, Athar HR, Ashraf M. 2007. ***Does Exogenous Application of Salicylic Acid through the Rooting Me-dium Modulate Growth and Photosynthetic Capacity in Two Differently Adapted Spring Wheat Cultivars under Salt Stress?*** **Journal of Plant Physiology**, 164 (6): 685-694.

- Rao, S.S.R., Vardhini, B.V., Sujatha, E. and Anuradha, S. (2002). **Brassinosteroids-A new class of phytohormones.** Curr. Sci. 82: 1239-1245.

- RHOADES J.D., KANDIAH A., MASHALI A.M., 1992. **The use of saline waters for crop production**. FAO Irrig Drain, Paper 48.

- Rajasekaran L.R. and Blake T.J. 1999. ***New plant growth regulators protect photosynthesis and enhance growth under drought of jack pine seedlings.*** **J. Plant Growth Reg**. 18: 175–181.

- Soussi M, Lluch C, Ocana A (1999). **Comparative study of nitrogen fixation and carbon metabolism in two chickpea** (Cicer arietinum L.) cultivars under salt stress. J. Exp. Bot. 50, 1701-1708.

- Soussi M, Ocana A, Lluch C (1998). ***Effects of salt stress on growth, photosynthesis and nitrogen fixation in chick-pea (Cicer arietinum L.).*** **J. Exp.Bot**. 49, 1329-1337..

- Sudhir P, Murthy SDS (2004). **Effects of salt stress on basic process of photosynthesis**. Photosynthetica 42, 481-486.

- Simaei M, Khavari-Nejad RA, Bernard F. 2012. ***Exogenous application of salicylic acid and nitric oxide on the ionic contents and enzymatic activities in nacl-stressed soybean plants.*** **American Journal of Plant Sciences**, 3: 1495-1503.

- Shahba; Zahra; Amin B.; Mehdi Y., 2010. ***The salicylic acid effect on the tomato (Lycopersicumesculentum Mill.) germination, growth and photosynthetic pigment under salinity stress (NaCl).*** **Journal of Stress Physiology &Biochemistry**., 6(3):4-16.

- Saker, M.T., N.M. El-Sarkassy and M. P. Fuller (2012b). **Osmoregulators proline and glycine betaine contract salinity stress**. Agron. Sustain. Dev., 32:747-754.

- Singh, G. and M. Kaur, 1980. ***Effect of growth regulators on padding and yield of mung bean (Vigna radiata L.)*** Wilczek. **Indian J. Plant Physiol**., 23: 366–70.

- Sasse, J.M. (1999). **Physiological actions of brassinosteroids.** In: A. Sakurai, T. Yokota and S.D. Clouse (eds.), Brassinosteroids– Steroidal Plant Hormones, pp. 137-161. Springer, Tokyo.

- Türkan, I. and T. Demiral. 2009. **Recent developments in understanding salinity tolerance.** Environ. & Exp. Bot., 67(1): 2-9.

- Vardhini, B. V. and S. S. R. Rao. 1998. **Effect of brassinosteroids on growth, metabolic content and yield of Arachis hypogaea.** Phytochemistry, 48: 927-930.

- Xia, X.J., Y.J. Wang, Y.H. Zhou, Y. Tao, W.H. Mao, K. Shi, T. Asami, Z. Chen, and J.Q. Yu. 2009. **Reactive oxygen species are involved in brassinosteroid-induced stress tolerance in cucumber**. Plant Physiol. 150:801–814.

- Zhao, H.J., X.W. Lin, H.Z. Shi, and S.M. Chang, 1995. **The regulating effects of phenolic compounds on the physiological characteristics and yield of soybeans**. Acta Agron. Sin. 21: 351–5.

- Zhou, X.M., A.F. Mackeuzie, C.A. Madramootoo and D.L.J. **Smith, 1999. Effects of some injected plant growth regulators, with or without sucrose, on grain production, biomass and photosynthetic activity of field–grown corn plants**. Agro. Crop Sci., 183: 103–10.

- M. Szekeres, K. Nemeth, Z. Konczkalman, J. Mathur, A. Kauschmann, T. Altmann, G.P. Redei, F. Nagy, J. Schell, C. Koncz Brass in osteroids rescue the deficiency of CYP90, a cytochrome P450, **controlling cell elongation and de-etiolation in *Arabidopsis*Cell**, 85 (1996), pp. 171-182

- T. Noguchi, S. Fujioka, S. Takatsuto, A. Sakurai, S. Yoshida, J. Li, J. **C horyArabidopsis *det2* is defective in the conversion of (24R)-24-methylcholest-4-En-3-one to (24R)-24-methyl-5alpha-cholestan-3-one in brassinosteroidbiosynthesisPlant Physiol**., 120 (1999), pp. 833-840

- C. Yamamuro, Y. Ihara, X. Wu, T. Noguchi, S. Fujioka, S. Takatsuto, M. Ashikari, H. Kitano, M. MatsuokaLoss of function of a **rice *brassinosteroidinsensitive1* homolog prevents internode elongation and bending of the lamina jointPlant Cell**, 12 (2000), pp. 1591-1606

- S. Tanabe, M. Ashikari, S. Fujioka, S. Takatsuto, S. Yoshida, M. Yano, A. Yoshimura, H. Kitano, M. Matsuoka, Y. Fujisawa, H. Kato, Y. **Iwas akiA novel cytochrome P450 is implicated in brassinosteroid biosynthesis via the characterization of a rice dwarf mutant**, *dwarf11*, with reduced seed lengthPlant Cell, 17 (2005), pp. 776-790

- Dubey, R.S. 2005. **Photosynthesis in plants under stressful conditions**, p. 717–718. In: Pessarakli, M. (Ed.). Handbook photosynthesis. 2nd Ed. CRC Press, New York, NY.

- Fariduddin, Q., A. Ahmad, and S. Hayat. 2003. **Photosynthetic response of vigna radiata to presowing seed treatment with 28-homobrassinolide**. Photosynthetica 41:307–310.

- Hayat, S., A. Ahmad, M. Mobin, A. Hussain, and Q. Faridduddin. 2000. **Photosynthetic rate, growth and yield of mustard plants sprayed with 28-homobrassinolide**. Photosynthetica 38: 469–471.

- Swamy, K.N. and S.S.R. Rao. 2009. ***Effect of 24Epibrassinolide on growth, photosynthesis and essential oil content of Pelargonium graveolens (L.)***. Herit. Russian **J. Plant Physiol**. 56:616–620.

- Ghoulam C, Foursy A, Farer K (2002). **Effect of salt stress on growth, inorganic ions and proline accumulation in relation to osmotic adjustment in five sugar beetcultivars**. Environ. Exp. Bot. 47, 39-50.

- Parida, A., A.B. Das and B. Mittra, 2004. **Effects of salt on growth, ion accumulation, photosynthesis and leaf anatomy of the mangrove Bruguiera parviflora.** Tree Struct. Funct. 18: 167- 174.
- El-Tayeb, M.A., "***Response of barley grains to the interactive effect of salinity and salicylic acid***", **J Plant Growth Regul**, 45. 215-224. 2005.
- Baninasab, B., **"Induction of drought tolerance by salicylic acid in**
- The seedlings of cucumber (Cucumis sativus L.)", J of Hort Sci &
- Biotech, 85. 191-196.2010.
- Korkmaz, A., Uzunlu, M. and Demirkiran, A.R., "Treatment with
- Acetyl salicylic acid protects muskmelon seedlings against drought
- Stress", Acta Physiol Planta, 29, 503-507.2007.
- Gutierrez–Coronado, M. A., Trejo-Lopez, C. and Larque Saavedra, A. (1998), "**Effects of salicylic acid on growth of roots and shoots in soybean",** Plant Physio. Biochem, Vol. 36 pp.653-665.
- Grattan, S.R. and C.M. Grieve. 1999. **Salinity– mineral nutrient relations in horticultural crops**. Sci. Hort. 78:127–157.
- Melek E, Ertan Y, and Atilla D A ¨rk. 2012. **University, Faculty of Agriculture, Department of Horticulture**, 25240 Erzurum, Turkey.

Appendix

Table 58: The effect of applying different levels of NaCl on fruit weight of pepper plant (formula)

Salinity	Average fruit weight/plant	Letter Group
0	2116.42	A
50	430.62	B
150	64.3296	C

Means followed by the same letter(s) are not significantly differ at 5% P value

Table 59: The effect of applying different levels of BR on fruit weight of pepper plant (formula)

BR	Average fruit weight/plant	Letter Group
0	743.97	B
0.05	845.44	B
0.5	1021.96	A

Means followed by the same letter(s) are not significantly differ at 5% P value

Table 60: The effect of applying different levels of SA on fruit weight of pepper plant (formula)

SA	Average fruit weight/plant	Letter Group
0	706.68	B
0.05	988.89	A
0.5	915.80	A

Means followed by the same letter(s) are not significantly differ at 5% P value

Table 61: The effect of applying different levels of BR and SA on fruit weight of pepper plant (formula)

BR	SA	Average fruit weight/plant	Letter Group
0	0	437.64	B
0	0.05	984.11	A
0	0.5	810.14	AB
0.05	0	800.88	AB
0.05	0.05	884.29	A
0.05	0.5	851.17	A
0.5	0	881.52	A
0.5	0.05	1098.27	A
0.5	0.5	1086.09	A

Means followed by the same letter(s) are not significantly differ at 5% P value

Table 62: The effect of applying different levels of NaCl, BR and SA on fruit weight of pepper plant (formula)

Salinity	BR	SA	Average fruit weight/plant	Letter Group
0	0	0	1088.27	CD
0	0	0.05	2337.30	AB
0	0	0.5	1978.77	B
0	0.05	0	1783.57	BC
0	0.05	0.05	2227.70	AB
0	0.05	0.5	1946.03	B
0	0.5	0	2186.20	AB
0	0.5	0.05	2926.27	A
0	0.5	0.5	2573.67	AB
50	0	0	196.57	E
50	0	0.05	560.60	DE
50	0	0.5	405.93	DE
50	0.05	0	561.43	DE
50	0.05	0.05	350.83	DE
50	0.05	0.5	546.83	DE
50	0.5	0	390.50	DE
50	0.5	0.05	311.93	DE
50	0.5	0.5	550.97	DE
150	0	0	28.1000	E
150	0	0.05	54.4333	E
150	0	0.5	45.7333	E
150	0.05	0	57.6333	E
150	0.05	0.05	74.3333	E
150	0.05	0.5	60.6333	E
150	0.5	0	67.8667	E
150	0.5	0.05	56.6000	E
150	0.5	0.5	133.63	E

Means followed by the same letter(s) are not significantly differ at 5% P value

Table 63: The effect of applying different levels of SA on branches number of pepper plant (formula)

SA	Average branches number/plant	Letter Group
0	12.5556	A
0.05	12.4815	A
0.5	12.5926	A

Means followed by the same letter(s) are not significantly differ at 5% P value

Table 64: The effect of applying different levels of BR and SA on branches number of pepper plant (formula)

BR	SA	Average branches number/plant	Letter Group
0	0	15.1111	A
0	0.05	12.7778	AB
0	0.5	12.3333	B
0.05	0	11.1111	B
0.05	0.05	11.8889	B
0.05	0.5	12.7778	AB
0.5	0	11.4444	B
0.5	0.05	12.7778	AB
0.5	0.5	12.6667	AB

Means followed by the same letter(s) are not significantly differ at 5% P value

Table 65: The effect of applying different levels of NaCl, BR and SA on branches number of pepper plant (formula)

Salinity	BR	SA	Average branches number/plant	Letter Group
0	0	0	15.6667	BC
0	0	0.05	19.0000	AB
0	0	0.5	18.6667	AB
0	0.05	0	15.0000	BCD
0	0.05	0.05	19.3333	AB
0	0.05	0.5	19.0000	AB
0	0.5	0	15.6667	BC
0	0.5	0.05	20.0000	AB
0	0.5	0.5	18.6667	AB
50	0	0	7.6667	EF
50	0	0.05	11.6667	CDEF
50	0	0.5	10.6667	CDEF
50	0.05	0	10.6667	CDEF
50	0.05	0.05	9.6667	EF
50	0.05	0.5	12.3333	CDE
50	0.5	0	10.3333	DEF
50	0.5	0.05	9.6667	EF
50	0.5	0.5	12.3333	CDE
150	0	0	22.0000	A
150	0	0.05	7.6667	EF
150	0	0.5	7.6667	EF
150	0.05	0	7.6667	EF
150	0.05	0.05	6.6667	F
150	0.05	0.5	7.0000	F
150	0.5	0	8.3333	EF
150	0.5	0.05	8.6667	EF
150	0.5	0.5	7.0000	F

Means followed by the same letter(s) are not significantly differ at 5% P value

Table 66: The effect of applying different levels of BR on leaf number of pepper plant (formula)

BR	Average number of leaves/plant	Letter Group
0	244.48	A
0.05	244.19	A
0.5	261.78	A

Means followed by the same letter(s) are not significantly differ at 5% P value

Table 67: The effect of applying different levels of SA on leaf number of pepper plant (formula)

SA	Average number of leaves/plant	Letter Group
0	235.74	A
0.05	260.33	A
0.5	254.37	A

Means followed by the same letter(s) are not significantly differ at 5% P value

Table 68: The effect of applying different levels of BR and SA on leaf number of pepper plant (formula)

BR	SA	Average number of leaves/plant	Letter Group
0	0	214.89	A
0	0.05	274.78	A
0	0.5	243.78	A
0.05	0	245.67	A
0.05	0.05	250.78	A
0.05	0.5	236.11	A
0.5	0	246.67	A
0.5	0.05	255.44	A
0.5	0.5	283.22	A

Means followed by the same letter(s) are not significantly differ at 5% P value

Table 69: The effect of applying different levels of NaCl, BR and SA on leaf number of pepper plant (formula)

Salinity	BR	SA	Average number of leaves/plant	Letter Group
0	0	0	481.33	ABC
0	0	0.05	512.67	AB
0	0	0.5	465.00	ABC
0	0.05	0	434.67	ABCDE
0	0.05	0.05	474.67	ABC
0	0.05	0.5	437.00	ABCD
0	0.5	0	511.33	AB
0	0.5	0.05	545.33	A
0	0.5	0.5	519.33	AB
50	0	0	82.0000	F
50	0	0.05	254.00	BCDEF
50	0	0.5	164.33	F
50	0.05	0	230.33	CDEF
50	0.05	0.05	230.67	CDEF
50	0.05	0.5	165.33	EF
50	0.5	0	181.33	DEF
50	0.5	0.05	144.00	F
50	0.5	0.5	234.67	CDEF
150	0	0	81.3333	F
150	0	0.05	57.6667	F
150	0	0.5	102.00	F
150	0.05	0	72.0000	F
150	0.05	0.05	47.0000	F
150	0.05	0.5	106.00	F
150	0.5	0	47.3333	F
150	0.5	0.05	77.0000	F
150	0.5	0.5	95.6667	F

Means followed by the same letter(s) are not significantly differ at 5% P value

Table 70: The effect of applying different levels of NaCl on stem width of pepper plant (formula)

Salinity	Average number of leaves/plant	Letter Group
0	1.8667	A
50	1.3778	B
150	1.0704	C

Means followed by the same letter(s) are not significantly differ at 5% P value

Table 71: The effect of applying different levels of NaCl and BR on stem width of pepper plant (formula)

Salinity	BR	Average stem width/plant	Letter Group
0	0	1.7444	A
0	0.05	1.8889	A
0	0.5	1.9667	A
50	0	1.2778	BC
50	0.05	1.4222	B
50	0.5	1.4333	B
150	0	1.0444	C
150	0.05	1.0444	C
150	0.5	1.1222	C

Means followed by the same letter(s) are not significantly differ at 5% P value

Table 72: The effect of applying different levels of NaCl and SA on stem width of pepper plant (formula)

Salinity	SA	Average stem widht/plant	Letter Group
0	0	1.8000	A
0	0.05	1.9667	A
0	0.5	1.8333	A
50	0	1.3222	BC
50	0.05	1.4111	B
50	0.5	1.4000	B
150	0	0.9889	D
150	0.05	1.1667	BCD
150	0.5	1.0556	CD

Means followed by the same letter(s) are not significantly differ at 5% P value

Table 73: The effect of applying different levels BR and SA on stem width of pepper plant (formula)

BR	SA	Average stem widht/plant	Letter Group
0	0	1.2556	B
0	0.05	1.4556	AB
0	0.5	1.3556	AB
0.05	0	1.3778	AB
0.05	0.05	1.5111	AB
0.05	0.5	1.4667	AB
0.5	0	1.4778	AB
0.5	0.05	1.5778	A
0.5	0.5	1.4667	AB

Means followed by the same letter(s) are not significantly differ at 5% P value

Table 74: The effect of applying different levels of NaCl, BR and SA on stem width of pepper plant (formula)

Salinity	BR	SA	Average stem widht/plant	Letter Group
0	0	0	1.6333	ABCDE
0	0	0.05	1.9000	AB
0	0	0.5	1.7000	ABCD
0	0.05	0	1.8333	ABC
0	0.05	0.05	1.9333	AB
0	0.05	0.5	1.9000	AB
0	0.5	0	1.9333	AB
0	0.5	0.05	2.0667	A
0	0.5	0.5	1.9000	AB
50	0	0	1.1333	DEF
50	0	0.05	1.4333	BCDEF
50	0	0.5	1.2667	CDEF
50	0.05	0	1.4000	BCDEF
50	0.05	0.05	1.4000	BCDEF
50	0.05	0.5	1.4667	BCDEF
50	0.5	0	1.4333	BCDEF
50	0.5	0.05	1.4000	BCDEF
50	0.5	0.5	1.4667	BCDEF
150	0	0	1.0000	F
150	0	0.05	1.0333	F
150	0	0.5	1.1000	EF
150	0.05	0	0.9000	F
150	0.05	0.05	1.2000	DEF
150	0.05	0.5	1.0333	F
150	0.5	0	1.0667	EF
150	0.5	0.05	1.2667	CDEF
150	0.5	0.5	1.0333	F

Means followed by the same letter(s) are not significantly differ at 5% P value

Table 75: The effect of applying different levels of NaCl on stem height of pepper plant (formula)

Salinity	Average stem height/plant	Letter Group
0	87.2222	A
50	47.1852	B
150	32.6667	C

Means followed by the same letter(s) are not significantly differ at 5% P value

Table 76: The effect of applying different levels of BR on stem height of pepper plant (formula)

BR	Average stem height/plant	Letter Group
0	55.3704	A
0.05	54.2222	A
0.5	57.4815	A

Means followed by the same letter(s) are not significantly differ at 5% P value

Table 77: The effect of applying different levels of NaCl and BR on stem height of pepper plant (formula)

Salinity	BR	Average stem height/plant	Letter Group
0	0	88.7778	A
0	0.05	81.4444	A
0	0.5	91.4444	A
50	0	45.7778	B
50	0.05	49.6667	B
50	0.5	46.1111	B
150	0	31.5556	C
150	0.05	31.5556	C
150	0.5	34.8889	C

Means followed by the same letter(s) are not significantly differ at 5% P value

Table 78: The effect of applying different levels of NaCl, BR and SA on stem height of pepper plant (formula)

Salinity	BR	SA	Average stem height/plant	Letter Group
0	0	0	75.6667	BCD
0	0	0.05	101.67	A
0	0	0.5	89.0000	AB
0	0.05	0	78.0000	BC
0	0.05	0.05	91.3333	AB
0	0.05	0.5	75.0000	BCD
0	0.5	0	81.0000	AB
0	0.5	0.05	92.0000	AB
0	0.5	0.5	101.33	A
50	0	0	35.6667	FGHI
50	0	0.05	56.6667	DEF
50	0	0.5	45.0000	EFGHI
50	0.05	0	51.6667	EFGH
50	0.05	0.05	54.6667	DEFG
50	0.05	0.5	42.6667	EFGHI
50	0.5	0	47.0000	EFGHI
50	0.5	0.05	32.6667	HI
50	0.5	0.5	58.6667	CDE
150	0	0	30.6667	HI
150	0	0.05	28.6667	I
150	0	0.5	35.3333	GHI
150	0.05	0	30.6667	HI
150	0.05	0.05	34.6667	GHI
150	0.05	0.5	29.3333	I
150	0.5	0	32.3333	HI
150	0.5	0.05	30.6667	HI
150	0.5	0.5	41.6667	EFGHI

Means followed by the same letter(s) are not significantly differ at 5% P value

Table 79: The effect of applying different levels of BR on aboveground fresh weight of pepper plant (formula)

BR	Average aboveground fresh weight /plant	Letter Group
0	326.92	A
0.05	308.77	A
0.5	372.66	A

Means followed by the same letter(s) are not significantly differ at 5% P value

Table 80: The effect of applying different levels of SA on aboveground fresh weight of pepper plant (formula))

SA	Average aboveground fresh weight /plant	Letter Group
0	324.53	A
0.05	350.17	A
0.5	333.65	A

Means followed by the same letter(s) are not significantly differ at 5% P value

Table 81: The effect of applying different levels of NaCl and SA on aboveground fresh weight of pepper plant (formula)

Salinity	SA	Average aboveground fresh weight /plant	Letter Group
0	0	588.89	A
0	0.05	691.62	A
0	0.5	604.06	A
50	0	228.52	B
50	0.05	270.74	B
50	0.5	255.07	B
150	0	156.18	B
150	0.05	88.1444	B
150	0.5	141.83	B

Means followed by the same letter(s) are not significantly differ at 5% P value.

Table 82: The effect of applying different levels of BR and SA on aboveground fresh weight of pepper plant (formula)

BR	SA	Average aboveground fresh weight /plant	Letter Group
0	0	285.30	A
0	0.05	366.42	A
0	0.5	329.03	A
0.05	0	317.74	A
0.05	0.05	345.50	A
0.05	0.5	263.08	A
0.5	0	370.54	A
0.5	0.05	338.59	A
0.5	0.5	408.84	A

Means followed by the same letter(s) are not significantly differ at 5% P value

Table 83: The effect of applying different levels of NaCl on root fresh weight of pepper plant (formula)

Salinity	Average root fresh weight /plant	Letter Group
0	64.8222	A
50	32.4370	B
150	21.6778	B

Means followed by the same letter(s) are not significantly differ at 5% P value

Table 84: The effect of applying different levels of BR on root fresh weight of pepper plant (formula)

BR	Average root fresh weight /plant	Letter Group
0	38.1593	A
0.05	37.5556	A
0.5	43.2222	A

Means followed by the same letter(s) are not significantly differ at 5% P value

Table 85: The effect of applying different levels of NaCl BR on root fresh weight of pepper plant (formula)

Salinity	BR	Average root fresh weight /plant	Letter Group
0	0	60.3444	AB
0	0.05	61.8667	AB
0	0.5	72.2556	A
50	0	29.2556	C
50	0.05	31.1889	C
50	0.5	36.8667	BC
150	0	24.8778	C
150	0.05	19.6111	C
150	0.5	20.5444	C

Means followed by the same letter(s) are not significantly differ at 5% P value

Table 86: The effect of applying different levels of NaCl and SA on root fresh weight of pepper plant (formula)

Salinity	SA	Average root fresh weight /plant	Letter Group
0	0	57.0222	AB
0	0.05	61.2333	AB
0	0.5	76.2111	A
50	0	22.9556	C
50	0.05	33.6444	BC
50	0.5	40.7111	BC
150	0	21.4556	C
150	0.05	16.7556	C
150	0.5	26.8222	C

Means followed by the same letter(s) are not significantly differ at 5% P value

Table 87: The effect of applying different levels of BR and SA on root fresh weight of pepper plant (formula)

BR	SA	Average root fresh weight /plant	Letter Group
0	0	25.7667	B
0	0.05	37.9778	AB
0	0.5	50.7333	AB
0.05	0	37.6444	AB
0.05	0.05	38.0111	AB
0.05	0.5	37.0111	AB
0.5	0	38.0222	AB
0.5	0.05	35.6444	AB
0.5	0.5	56.0000	A

Means followed by the same letter(s) are not significantly differ at 5% P value

Table 88: The effect of applying different levels of BR on aboveground dry weight of pepper plant (formula)

BR	Average aboveground dry weight /plant	Letter Group
0	51.9926	A
0.05	51.3778	A
0.5	59.8926	A

Means followed by the same letter(s) are not significantly differ at 5% P value

Table 89: The effect of applying different levels of NaCl and BR on aboveground dry weight of pepper plant (formula)

Salinity	BR	Average aboveground dry weight /plant	Letter Group
0	0	98.6444	A
0	0.05	98.7222	A
0	0.5	129.91	A
50	0	31.0778	B
50	0.05	40.6556	B
50	0.5	35.1222	B
150	0	26.2556	B
150	0.05	14.7556	B
150	0.5	14.6444	B

Means followed by the same letter(s) are not significantly differ at 5% P value

Table 90: The effect of applying different levels of SA on aboveground dry weight of pepper plant (formula)

SA	Average aboveground dry weight /plant	Letter Group
0	53.6444	A
0.05	57.3444	A
0.5	52.2741	A

Means followed by the same letter(s) are not significantly differ at 5% P value

Table 91: The effect of applying different levels of NaCl and SA on aboveground dry weight of pepper plant (formula)

Salinity	SA	Average aboveground dry weight /plant	Letter Group
0	0	103.30	A
0	0.05	121.34	A
0	0.5	102.63	A
50	0	32.2556	B
50	0.05	38.7444	B
50	0.5	35.8556	B
150	0	25.3778	B
150	0.05	11.9444	B
150	0.5	18.3333	B

Means followed by the same letter(s) are not significantly differ at 5% P value

Table 92: The effect of applying different levels of BR and SA on aboveground dry weight of pepper plant (formula)

BR	SA	Average aboveground dry weight /plant	Letter Group
0	0	45.3889	A
0	0.05	57.2778	A
0	0.5	53.3111	A
0.05	0	52.7111	A
0.05	0.05	60.2111	A
0.05	0.5	41.2111	A
0.5	0	62.8333	A
0.5	0.05	54.5444	A
0.5	0.5	62.3000	A

Means followed by the same letter(s) are not significantly differ at 5% P value

Table 93: The effect of applying different levels of BR on leaf area of pepper plant (formula)

BR	Average leaf area /plant	Letter Group
0	0.3369	A
0.05	0.3679	A
0.5	0.4257	A

Means followed by the same letter(s) are not significantly differ at 5% P value

Table 94: The effect of applying different levels of NaCl and BR on leaf area of pepper plant (formula)

Salinity	BR	Average leaf area /plant	Letter Group
0	0	0.7322	A
0	0.05	0.7189	A
0	0.5	0.8963	A
50	0	0.1889	B
50	0.05	0.2611	B
50	0.5	0.2556	B
150	0	0.08956	B
150	0.05	0.1237	B
150	0.5	0.1251	B

Means followed by the same letter(s) are not significantly differ at 5% P value

Table 95: The effect of applying different levels of SA on leaf area of pepper plant (formula)

SA	Average leaf area /plant	Letter Group
0	0.3604	A
0.05	0.4234	A
0.5	0.3466	A

Means followed by the same letter(s) are not significantly differ at 5% P value

Table 96: The effect of applying different levels of NaCl and SA on leaf area of pepper plant (formula)

Salinity	SA	Average leaf area /plant	Letter Group
0	0	0.7733	A
0	0.05	0.8610	A
0	0.5	0.7131	A
50	0	0.2378	B
50	0.05	0.2411	B
50	0.5	0.2267	B
150	0	0.07022	B
150	0.05	0.1681	B
150	0.5	0.1000	B

Means followed by the same letter(s) are not significantly differ at 5% P value

Table 97: The effect of applying different levels of BR and SA on leaf area of pepper plant (formula)

BR	SA	Average leaf area /plant	Letter Group
0	0	0.2822	A
0	0.05	0.3751	A
0	0.5	0.3533	A
0.05	0	0.4173	A
0.05	0.05	0.4286	A
0.05	0.5	0.2578	A
0.5	0	0.3818	A
0.5	0.05	0.4666	A

Means followed by the same letter(s) are not significantly differ at 5% P value

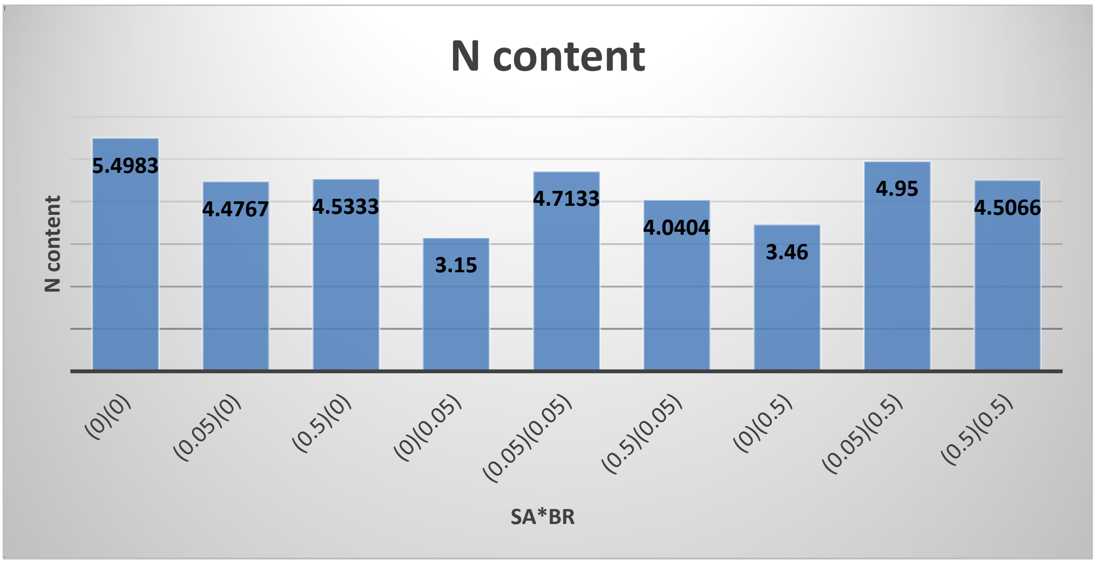

Figure 19: Effect of the interaction between Brassionosteroid and salicylic acid on nitrogen content of pepper plant: SA (0, 0.05, 0.5 mM) , BR (control, 0.05, 0.5 mM)

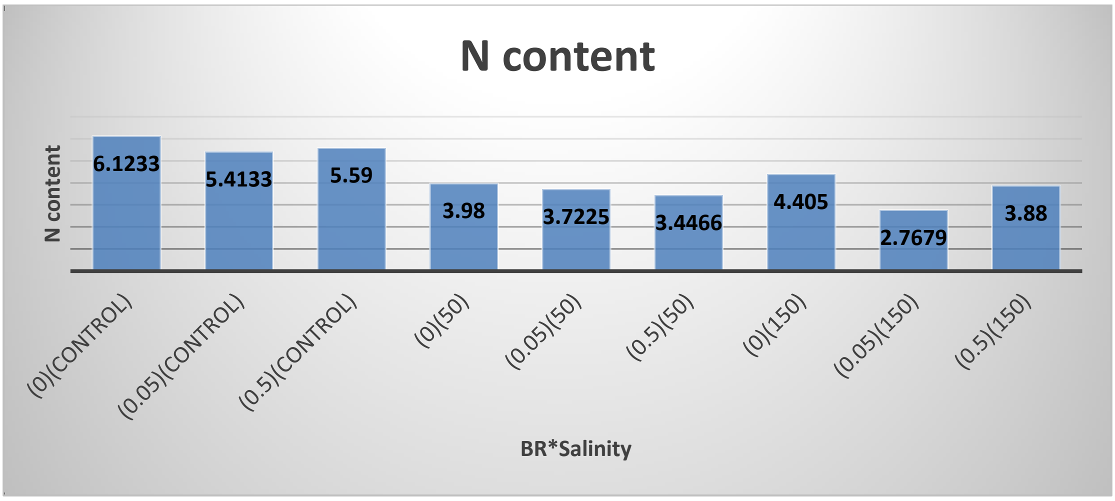

Figure 19: Effect of the interaction between Brassionosteroid and salinity on nitrogin content of pepper plant: salinity (control, 50, 150 mM) , BR (control, 0.05, 0.5 mM)

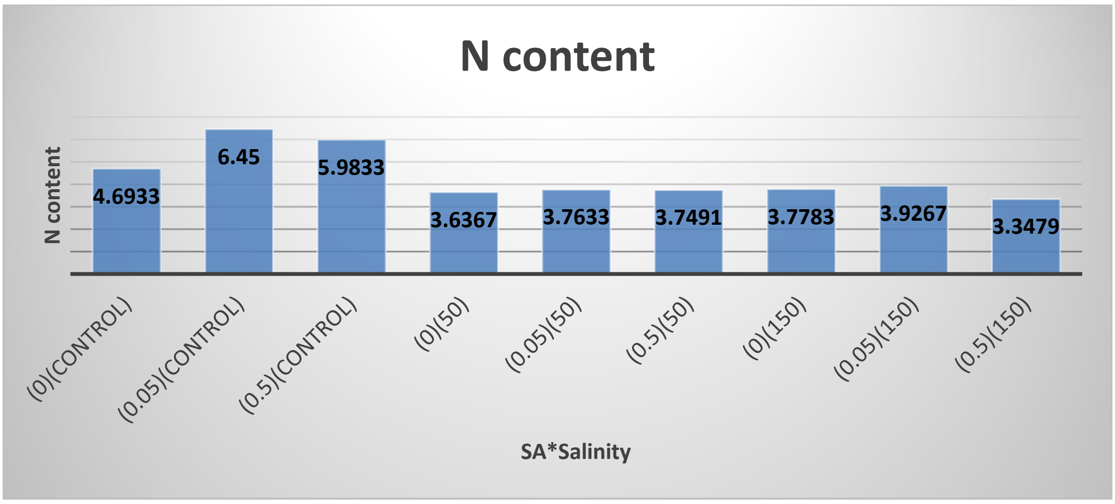

Figure 20: Effect of the interaction between salicylic acid and salinity on nitrogen content of pepper plant: salinity (control, 50, 150 mM) , SA (control, 0.05, 0.5 mM)

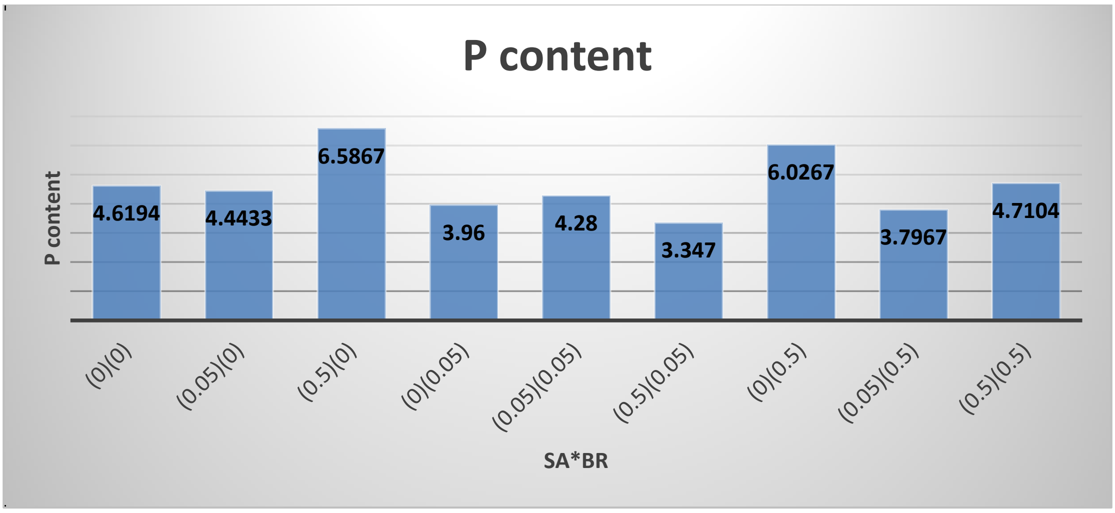

Figure 21: Effect of the interaction between Brassionosteroid and salicylic acid on phosphorus content of pepper plant: SA (0, 0.05, 0.5 mM) , BR (control, 0.05, 0.5 mM)

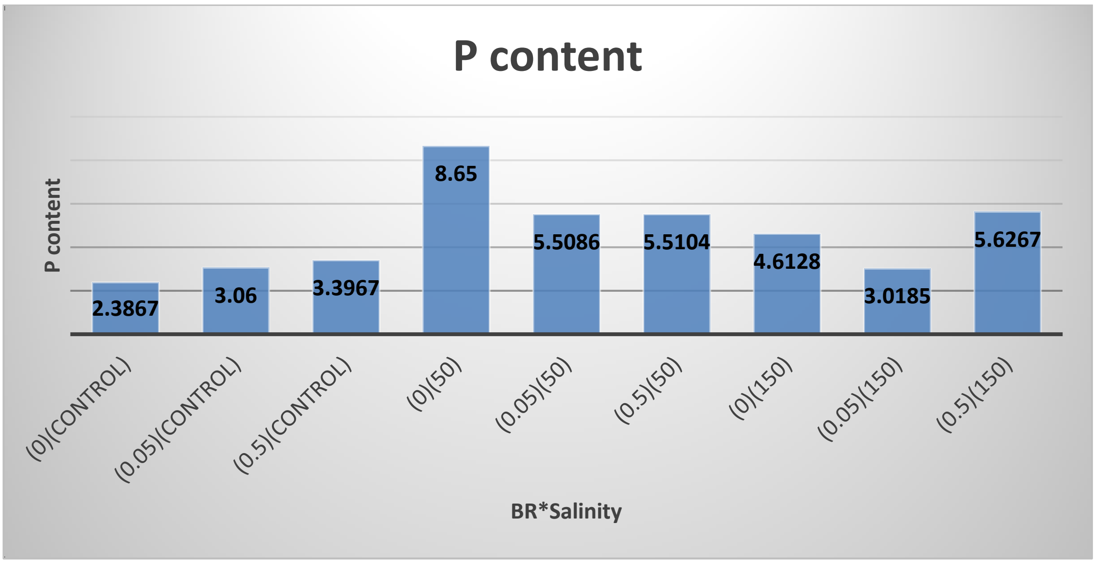

Figure 22: Effect of the interaction between Brassionosteroid and salinity on phosphorus content of pepper plant: salinity (control, 50, 150 mM) , BR (control, 0.05, 0.5 mM)

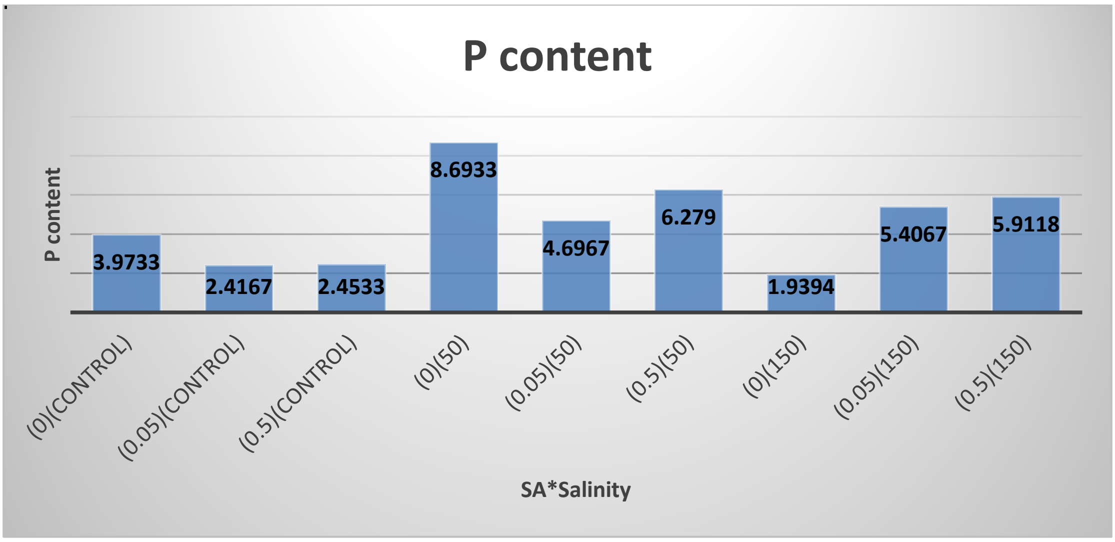

Figure 23: Effect of the interaction between salicylic acid and salinity on phosphorus content of pepper plant: salinity (control, 50, 150 mM) , SA (control, 0.05, 0.5 mM)

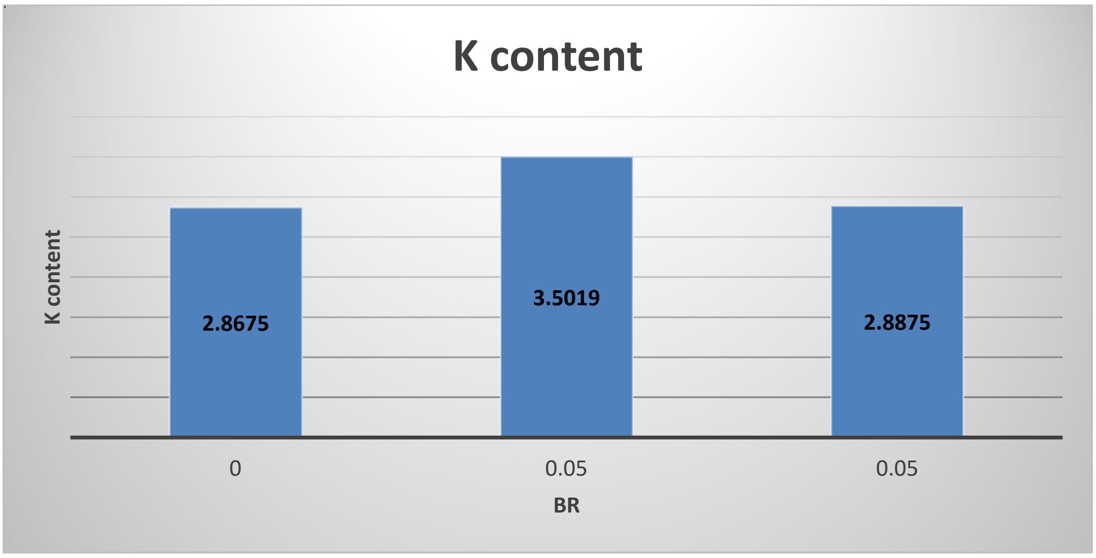

Figure 24: Effect of theBrassionosteroidon potassium content of pepper plant: BR (control, 0.05, 0.5 mM)

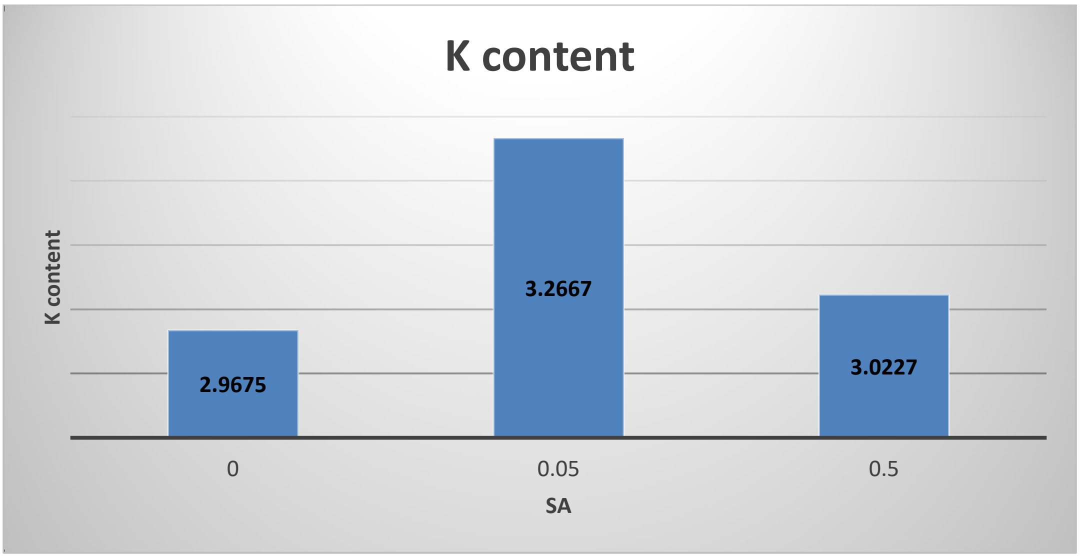

Figure 25: Effect of the salicylic acid on potassium content of pepper plant: SA (0, 0.05, 0.5 mM)

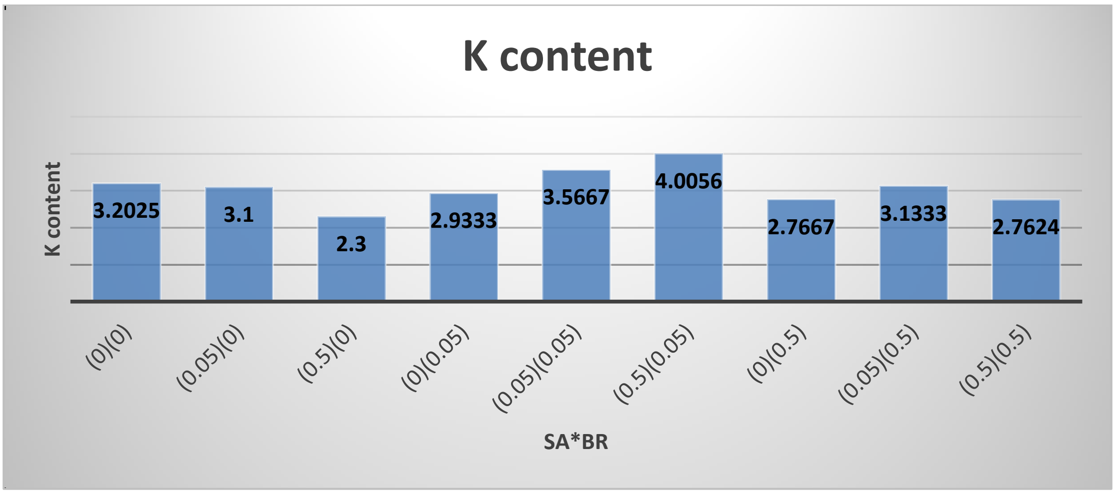

Figure 26: Effect of the interaction between Brassionosteroid and salicylic acid on potassium content of pepper plant: SA (0, 0.05, 0.5 mM) , BR (control, 0.05, 0.5 mM)

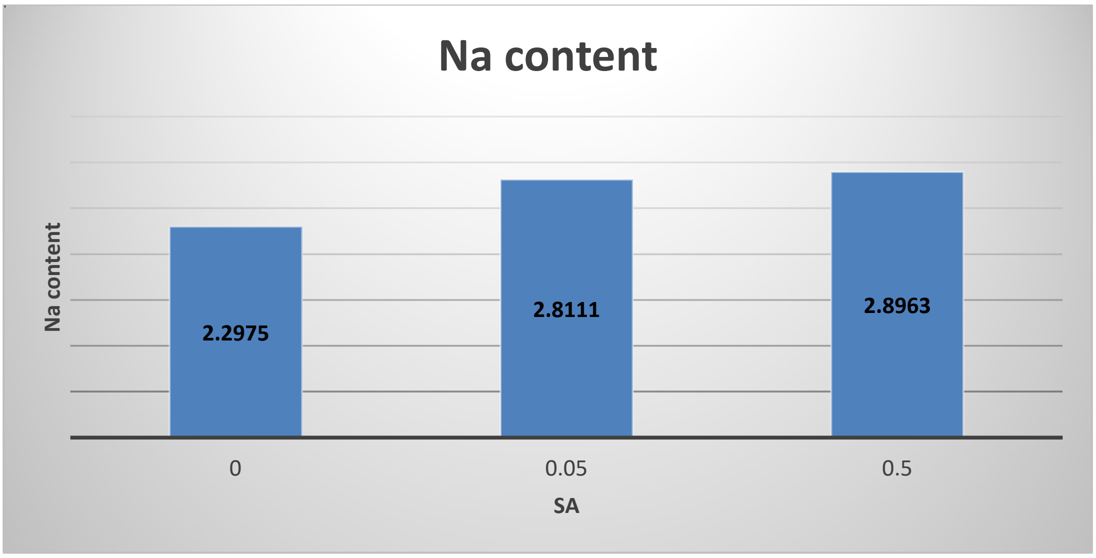

Figure 27: Effect of the salicylic acid on sodium content of pepper plant: SA (control, 0.05, 0.5 mM)

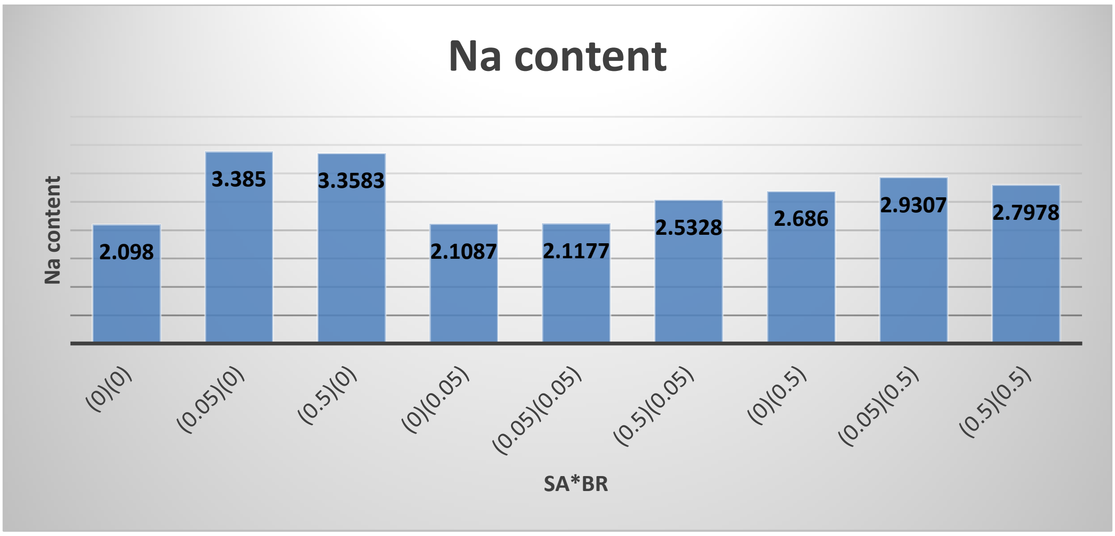

Figure 28: Effect of the interaction between Brassionosteroid and salicylic acid on sodium content of pepper plant: SA (0, 0.05, 0.5 mM) , BR (control, 0.05, 0.5 mM)

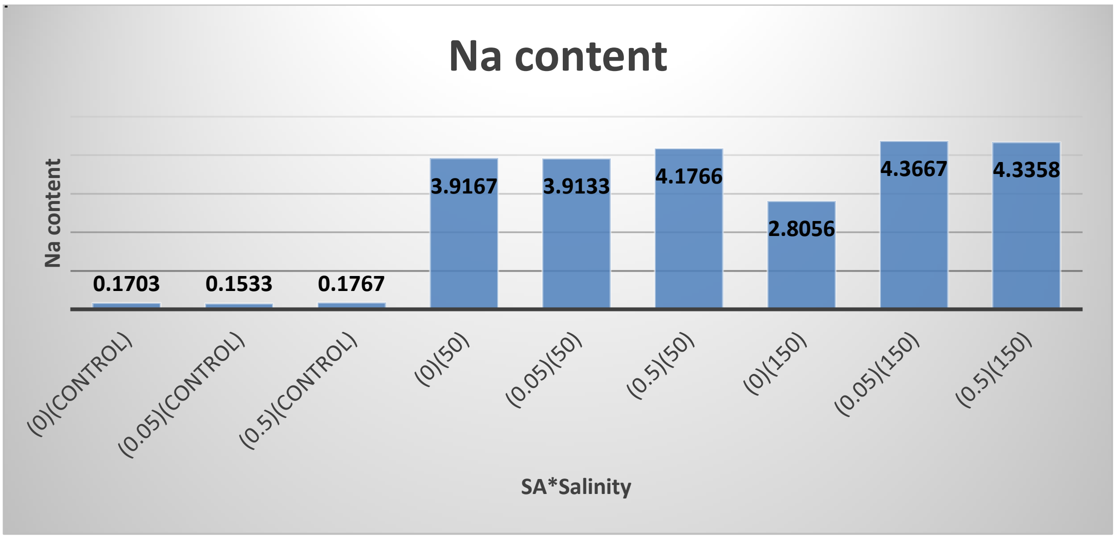

Figure 29: Effect of the interaction between salicylic acid and salinity on sodium content of pepper plant: salinity (control, 50, 150 mM) , SA (control, 0.05, 0.5 mM)

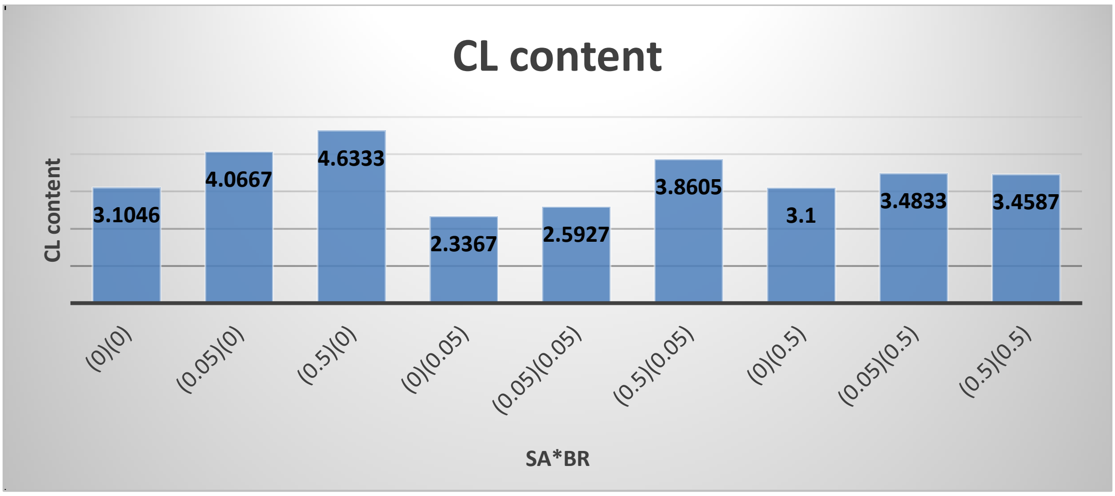

Figure 30: Effect of the interaction between Brassionosteroid and salicylic acid on chloride content of pepper plant: SA (0, 0.05, 0.5 mM), BR (control, 0.05, 0.5 mM)

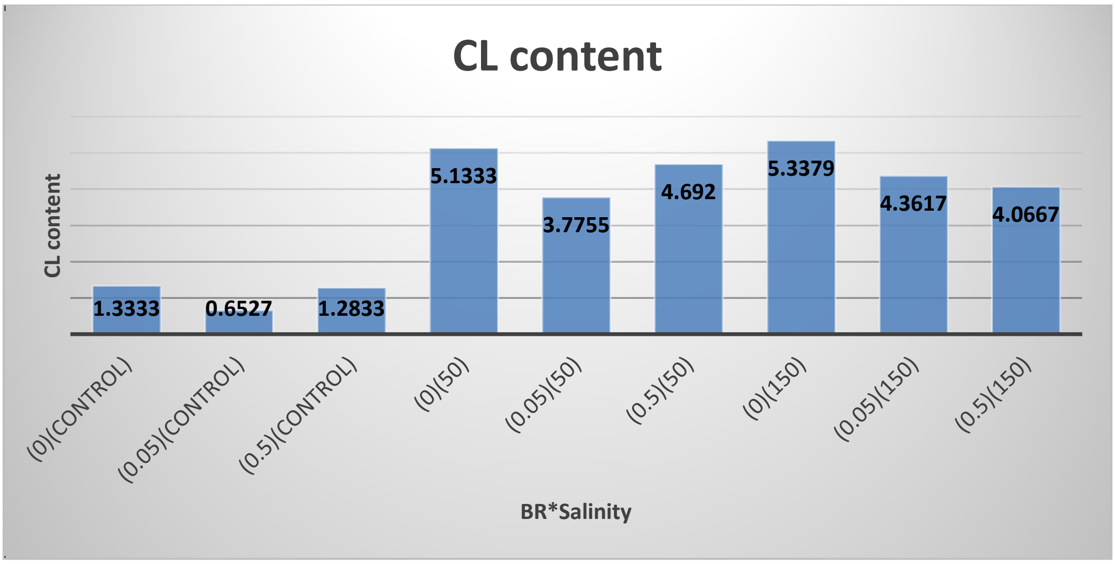

Figure 31: Effect of the interaction between Brassionosteroid and salinity on chloride content of pepper plant: salinity (control, 50, 150 mM) , BR (control, 0.05, 0.5 mM)

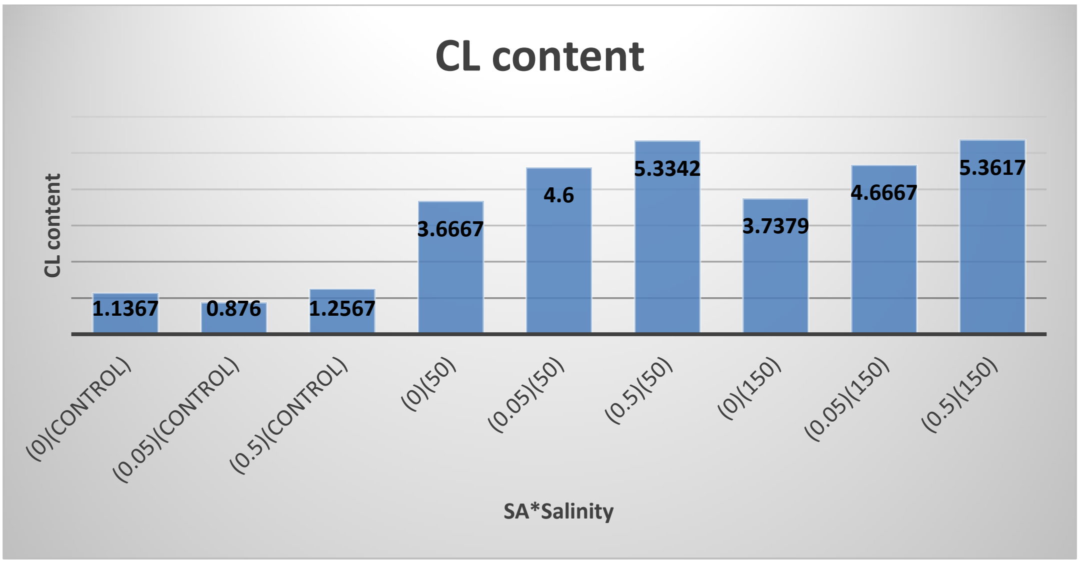

Figure 32: Effect of the interaction between salicylic acid and salinity on chloride content of pepper plant: salinity (control, 50, 150 mM) , SA (control, 0.05, 0.5 mM)

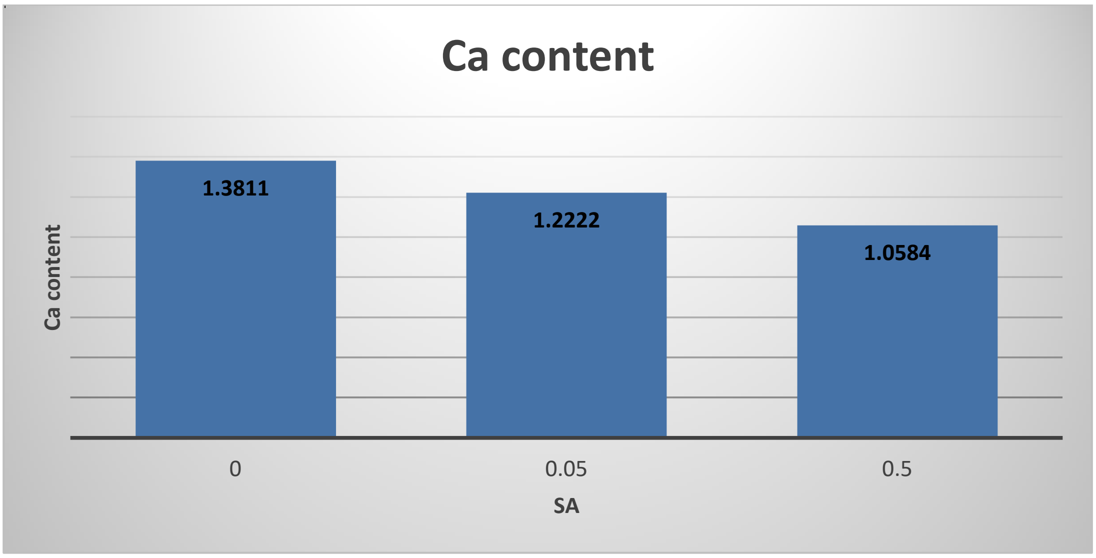

Figure 33: Effect of the salicylic acid on calcium content of pepper plant: SA (control, 0.05, 0.5 mM)

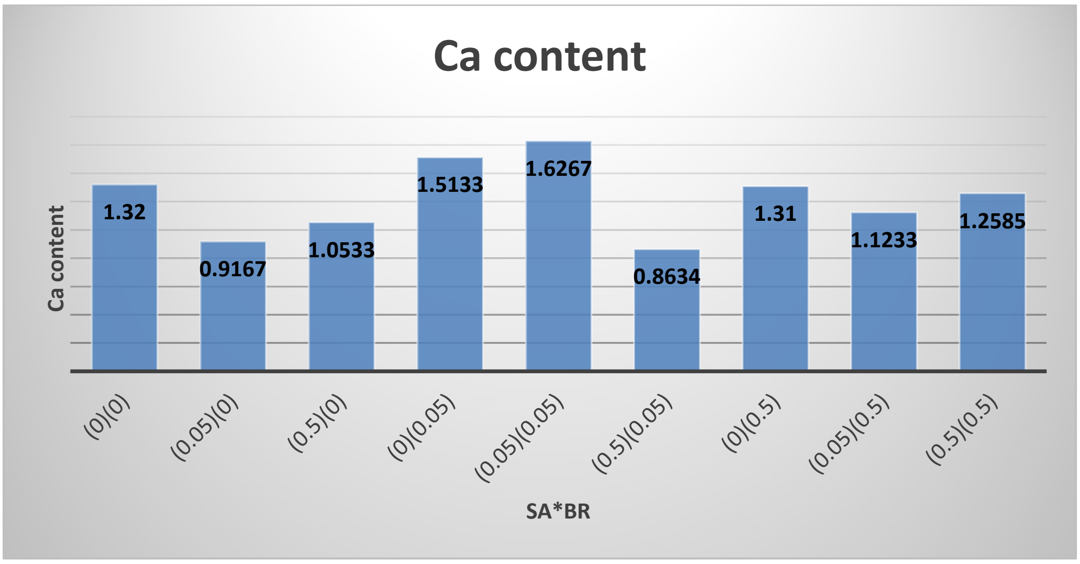

Figure 34: Effect of the interaction between Brassionosteroid and salicylic acid on calcium content of pepper plant: SA (0, 0.05, 0.5 mM) , BR (control, 0.05, 0.5 mM)

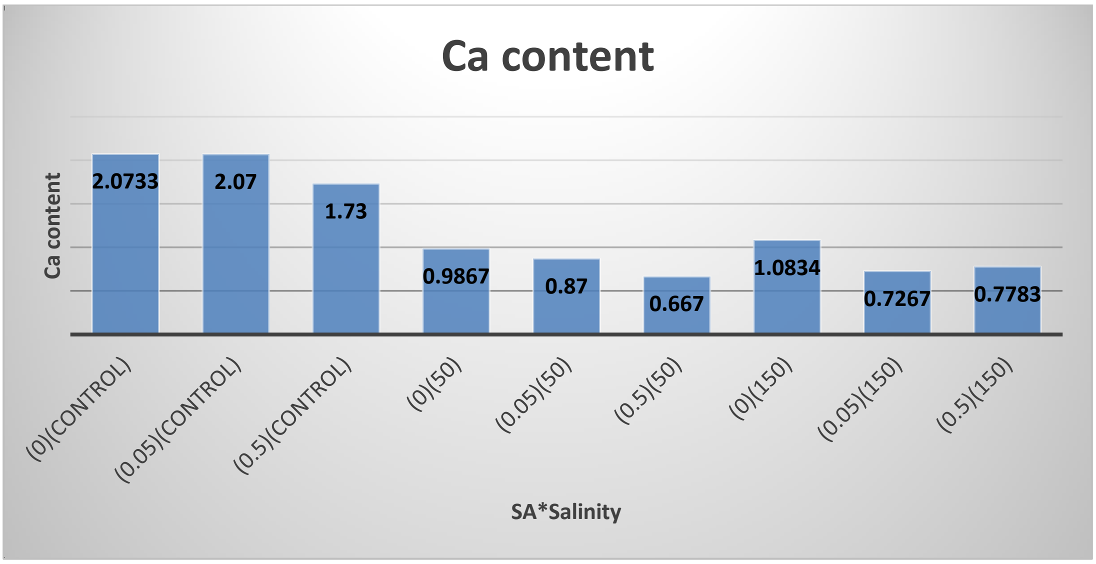

Figure 35: Effect of the interaction between salicylic acid and salinity on calcium content of pepper plant: salinity (control, 50, 150 mM) ,SA (control, 0.05, 0.5 mM)

جامعة النجاح الوطنية

كلية الدراسات العليا

تأثير حمض الساليسيليك والبراسينوسترويد على أداء نبات الفلفل الحلو تحت مستويات مختلفة من الملوحة

إعداد

محمود حسن محمود دروبي

إشراف

د. هبة الفارس

د. منقذ شتية

قدمت هذه الأطروحة استكمالاً لمتطلبات الحصول على درجة الماجستير في الإنتاج النباتي، بكلية الدراسات العليا، في جامعة النجاح الوطنية، نابلس– فلسطين.

2021

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الملخص

تم اجراء هذا البحث لتقييم تأثير التراكيز المختلفة من حمض السالسيليك والبراسيون ستروويد على نبات الفلفل تحت مستويات ملوحة مختلفة، أجريت التجارب على صنف واحد من نبات الفلفل تحت مستويات ملوحة مختلفة (0، 50، 150 ملي مولار) كلوريد الصوديوم. سقيت الاواني بتراكيز مختلفة من الحمض السالسيليك(0، 0.05، 0.5 ملي مولار) والبراسينوستيرويد (0، 0.05، 0.5 ملي مولار) وقد تم معاملتها بتراكيز مختلفة من الملوحة. تسبب الاجهاد الملحي في الاواني التي لم تحتوي حمض الساليسيلك والبراسينوستيرويد في انخفاض في المحصول ومعامل النمو (وزن الثمرة، عدد الثمار، ارتفاع وعرض الساق، عدد التفرعات وغيرها)، بينما زادت نسبة الصوديوم والكلور في الاوراق.

اضافة البراسينوستيرويد وحمض الساليسيليك يخفف من تأثير إجهاد كلوريد الصوديوم ويحسن النمو والإنتاجية في هذه الدراسة. أدى اضافة BR وSA إلى زيادة عدد الثمار، ارتفاع الساق، وزن الثمرة، عرض الساق، محتوى الكلوروفيل، الوزن الطازج فوق سطح الأرض، الوزن الجاف فوق الأرض ، الوزن الطازج للجذر والوزن الجاف للجذر.

أدت المعالجة بالبراسينوستيرويد إلى زيادة وزن الثمار بنسبة 10٪، 25٪، 50٪ عند 0، 50، 150 ملي مول كلوريد الصوديوم على التوالي مقارنة بغير المعالجة (بدون BR)، وأدت

المعالجة بحمض السالسيليك الى زيادة وزن الثمار بنسبة 48٪، 31٪، 56٪ بالمقارنة مع الغير معالجة (بدون SA) عند 0، 50، 150 ملي كلوريد الصوديوم.

المعاملة بحمض الساليسيليك والبراسينوسترويدات قللت من تأثير الملوحة على ارتفاع النبات، ويمكن أن يكون التأثير الإيجابي على ارتفاع النبات بسبب دور SA في الحفاظ على الأوكسين والسيتوسينين في الأنسجة النباتية التي تلعب دورًا مهمًا في انقسام الخلايا والاستطالة، وكذلك تنظم ال BRs استطالة الخلية وانقسام الخلايا وهي ضرورية للتشكل في الظلام.

بالإضافة إلى ذلك، أدت معالجة النبات بحمض السالسيليك والبراسينوستيرويد إلى تقليل تأثير الملوحة على محتوى الكلوروفيل. ويرجع ذلك إلى أن SA لها دور مهم في تخليق البورفيرينات التي تدخل في بناء جزيء صبغة الكلوروفيل وزيادة تخليق البروتين والأحماض الأمينية مما يؤدي إلى زيادة انقسام البلاستيدات وزيادة أصباغ الكلوروفيل، وأدت معالجة SA إلى زيادة محتوى الكلوروفيل بنسبة 6_14٪ كما أدت معالجة BR إلى زيادة محتوى الكلوروفيل بنسبة 6_12٪، والجمع بين SA وBR زاد محتوى الكلوروفيل بنسبة 30_60٪ عند مستويات مختلفة من الملوحة.

أوضحت الدراسة أن إضافة حامض الساليسيليك والبراسيون سترويد قلل من تأثير الملوحة على محصول ونمو نبات الفلفل.