An-Najah National University

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Influence of Strigolactones on Cucumber Growth and Productivity under Salinity Condition

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Dedication

I hope to make them proud for all the hard work they have put into me over the years

My humble effort I dedicate to my sweet and loving

Father & mother

Acknowledgment

First of all, I would like to express my thanks to “ALLAH” who gave me strength and patience and helped me finish this work. I extend my deep thanks and sincere gratitude to Dr. Heba Fares, Assistant Professor of Quantitative Genetic in Plant, faculty of Agriculture, An Najah National University, her supervision, kind encouragement, scientific guidance, research facilities, critically reading the manuscript and her personal assistance, help me to right directions, In fact without her help, this thesis would not have been possible also thanks for Dr. Abdullah Alomri for his help in coordinating the thesis and for his continued support. And thanks also to the laboratory supervisors, eng (Iman, Abdul Hakim) Faculty of Agriculture, An Najah National University for their help, support and encouragement during executing of this study. Many thanks to my beloved family, friends, and colleagues for their continuous support in completing and obtaining a master's degree. Special thanks for Palestinian Water Authority “PWA”, Dr. Subhi Samhan and Middle East Desalination Research Center “MEDRC” For financing my project and supporting me to finish this work.

الاقرار

أنا الموقع أدناه، مقدّم الرسالة التي تحمل العنوان:

Influence of Strigolactones on Cucumber Growth and Productivity under Salinity Condition

أقر بأن ما اشتملت عليه هذه الأطروحة إنما هو نتاج جهدي الخاص، باستثناء ما تمت الإشارة إليه حيثما ورد. وأن هذه الرسالة كاملة، أو اي جزء منها لم يقدم من قبل لنيل اي درجة أو 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: Sharhabeel Omar Ali Jebrini **اسم الطالب:**

Signature: **التوقيع:**

Date: 2021/10/04 **التاريخ:**

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List of Abbreviations

SLs	Strigolactones
Ec	Electrical conductivity
ng\l	Nano gram\liter
AMF	Arbuscular Mycorrhizae Fungi
ABA	Abscisic acid
RCD	Randomized Complete Design
ppm	Parts Per Million

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Abstract

The present experiment was carried at An Najah university campus in Nablus city in North of West Bank, this study was conducted to evaluate the effect of different salinity levels on cucumber plant in the presence or absence of Strigolactone hormone. Cucumber plants were grown in pots at various salt levels (4,6,8 ds/m) using NaCl and fresh water as control with or without Strigolactone hormone. The experimental layout was based on randomized complete design. The results revealed that salt stress reduced growth and productivity parameters of cucumber (leaf area, leaf number, stem diameter, shoot height, aboveground fresh and dry weight, root fresh and dry weight, chlorophyll content, Brix value, fruit number, fruit weight, fruits diameter and fruits length). However, salt stress increased sodium and chloride percentage in leaves, and reduced absorption of other important chemical elements (Nitrogen, Phosphorus, Potassium and Calcium content). This indicates the negative effect of salinity on cucumber plant. Whereas the application of Strigolactone hormone mitigates the effect of salinity stress and improved the growth and productivity of cucumber. The effect of Strigolactone hormone treatment was pronounced on plant height, number of leaves, plant biomass, fruit

number, fruit weight, chlorophyll content, root system, and decreased K, Ca, and P absorption. At 4 ds/m, salinity drastically affects plant yield by 66 percent, according to data analysis. The number of leaves was also reduced by 71 percent. 6 ds/m, chlorophyll concentration reduced by 66 percent which indicates a deleterious effect of salinity and causing plant fragility. At the same salinity level, strigolactone foliar treatment increased yield by 59 percent. This study revealed that the negative impact of soil salinity also could be reduced by treat the plants by Strigolactone hormone.

CHAPTER ONE

INTRODUCTION

Cucumber (*Cucumis sativus L.*) is one of the most important vegetable crops for local consumption and export. The area cultivated with cucumber crop in Palestine was 3234.8 hectares, with a productivity of 208182 tons (MoA, 2013). Cucumber is considered as one of the leading vegetable crop throughout the world for the nourishment of human being and considered as salt-sensitive crop.(Guerrero et al.,2012). Salinity level more than 1.3 $dS{\cdot}m^{-1}$ significantly influenced the growth of cucumber, and with the increase in each unit of EC decreases the crop productivity by 15.9% (Chartzoulakis, 1992)There are various studies on the cucumber plant under salinity conditions (Santana et al., 2010; Medeiros et al., 2009 Colla et al., 2012). All of the results showed that salt stress cause reduction in productivity. More research is needed to reduce the yield loss due to the effect of salinity on cucumber crop.

Soil salinity is a major challenge to food production. The condition significantly limits agricultural yields because it adversely affects plant growth and development, reducing crop yields by more than 20% (Purcell et al., 2012). The area of saline soils is globally increasing, and this phenomenon increase soil deterioration of the irrigated lands. It is estimated that about 20% (45 million hectares) of irrigated land, which produces a third of the world's food, is affected by the salt (Shrivastava P. et al., 2015)

Plants growing in saline soils are subjected to various physiological stresses that lead to nutritional imbalance, damage to cell organelles, and disruption of photosynthesis and respiration (Juniper and Abbott, 1993; Evelyn et al., 2012). Soil salinity reduces the productivity of many agricultural crops, including most vegetable crops, which are not tolerant to soil salinity (Pimentel et al.,2004). Several methods have been used to improve crop tolerance to salinity. One of them is to create beneficial links with the various microorganisms present in the roots that can alleviate symptoms of stress (Stolte.,et al., 2015). One of the well-studied associations of beneficial microorganisms is those that have been created with certain soil fungi known as Arbuscular mycorrhiza fungi (AMF) (Smith and Read, 2008). There is evidence that AMF can alleviate salt stress by improving the physiological process in plants (Khalil et al., 2011, Shinde et al., 2013). In addition some plant hormone prove to alleviate the effect of salinity this includes salicylic acid, barasensteroides, and stregolactone. Stregolactone refers to natural compound that produced by plants. It has two main functions: first, as endogenous hormones to control plant growth, and secondly as components of root exudates to enhance symbiotic interactions between plants and soil microbes. Some parasitic plants over others have established a third function, which is to stimulate the germination of their seeds when close to the roots of a suitable host plant. This is the third function that led to the original discovery and naming of stregolactone.

Where did the name come from?

The lactone originates from the striga and the structure. The substance was first found as highly irritating particles released by plant roots, which induce the germination of extremely destructive parasitic weeds like Striga sp. and Orobanche sp. Striga is derived from the Latin word "striga," which meaning witch or poltergeist. The important stage of symbiosis occurs in the rhizosphere which begins with the production and secretion of signaling molecules by the host plants - under conditions of nutrient deficiency. Strigolactones (SLs) are among these AMF-recognized signals that stimulate hyphal growth (López-Ráez et al., 2011). The importance of SLs during the early stages of AMF colonization has been widely recognized (Aroca et al., 2013). SLs are multifunctional molecules that have recently been classified as a new class of plant hormones (Gómez-Roldán et al., 2008; Kapulnik et al., 2011; Ruyter-Spira et al., 2011; Kohlen et al., 2012). The particles are mainly produced in the roots and have been detected in the root extracts and secretions of monocot and dicot plants (Xie et al., 2010). Besides presenting important biological functions in enhancing symbiotic interactions between plants and AMF, SLs also serve the function in developing plant growth (Akiyama et al., 2005, Koltai et al., 2009, Soto et al., 2010). Under conditions of stress that limit nutrients, SLs is synthesized in the root of the plant to promote the growth of lateral roots and root hairs in an effort to increase the roots' absorption of the inorganic limited nutrients.

At the same time, SLs are transported to above-ground vegetative structures, preventing bud formation or lateral branching and lowering branch requirements for inorganic nutrients (Rani et al., 2008, Kohlen et al., 2011). Emerging evidence suggests that SLs may also influence the later steps of the symbiotic relationship that develop in response to environmental stimuli, such as salt and drought stresses (Ruiz et al., 2016). Recent studies have revealed the important function of SLs and ABA for regulating salt stress responses and establishing symbiotic relationships between host plants and AM fungi (Zhao et al., 2013, pozo et al., 2015).

Exposure to stresses, such as salinity, leads to an accumulation of abscisic acid (ABA), which leads to increased tolerance (Zhu, 2002). Exogenous ABA may enhance accumulation of SLs, especially under stress conditions (Lopez et al., 2010). However, it is unclear whether SLs and ABA are involved in a synergistic effect during stress responses. These results indicate that the potential relationship between SLs and ABA during plant stress tolerance induction is complex. However, little information was available to explain the effects of processing SLs on the growth and productivity of plants under pressure of salinity.

Objectives

General Objectives

The main objective of the study is to investigate the use of Strigolactones on cucumber under salinity condition.

Specific objectives

1. To compare the impact of Strigolactones on the growth of cucumber plants under salinity conditions to plants without Strigolactones.
2. Determine the impact of salinity on some plant growth parameters (plant height, stem length, root length, plant fresh weight., shoot dry wt., root dry weight.,and chlorophyll content) with or without the adition of strigolactones.

CHAPTER TWO

LITERATURE REVIEW

The review in this study will consider the previous and current studies on the influence of salinity stress on the different growth parameters, yield and its components and other parameters.

2.1. Effect of salinity stress on Growth parameters of Cucumber plants:

Cucumber (Cucumis sativus), having a place with the Cucurbitaceae family. This plant is considerd moderate sensitivity to saltiness, displaying limit saltiness of 2.5 dS m-1 of the immersion concentrate and relative yield loss of 13% per unit increment in saltiness (Maas and Hoffman, 1977) .Saltiness is one of the major abiotic stress in horticulture crops production Zuh (2001)

In saline condition, NaCl is normally the most abundant salt which makes high ionic awkwardness that may hinder the selectivity of root layer (Navarro et al., 1999; Yahya, 1998; Yamaguchi and Blumwald, 2005) Cucumber has been named salt sensitive (Sonneveld and Voogt, 1978). The decrease in cucumber vegetative growth at high saltiness was communicated as reduced plant highet (Chartzoulakis, 1992), stem diameter (Al-Harbi, 1994) reduce leaf area and expansion rate (Chartzoulakis, 1994).

Gathering of solvent salts in the rhizosphere will reduce the water potential and subsequently decrease the water availability to plants. Moreover, the take-up of these salts will, without a doubt, influence the physiological procedures of plants developing in these situations. In this way, the plant when presented to high saltiness, will in general change metabolic movement to deliver certain organic compounds, for example, sucrose, to synthesize amino acids especially proline and accumulate inside the cells which will lead to reduction in the internal water potential to counterbalance the soil water potential and to maintain cell osmotic balance. (Heyster and Nabors, 1982).

Cucumber is the most important greenhouse plants in semi-arid regions with saline ground water. So, it is required more research on effect of salinity on germination, growth and chemical structure of this plant. Because salinity has negative effects on yield of cucumber and tomato plants by reducing germination, seedling growth, in addition it lead to establishment of weak plant, reduce dry weight and marketable fruits (Sato et al, 2006). Moreover, Haier et al., (2006) show up decline fresh and dry weight of tomato in saline conditions. Researches showed that the percentage and rate of germination of all varieties of greenhouse tomatoes delayed and lower by increasing salinity and whole seedling growth characteristics (fresh and dry weight of roots and stems) were decreased with increasing salinity. Most plants have a lot of genetic variation in tolerance to salinity. Selection and recognition of plant varieties tolerant to salinity is the most successful strategies to minimize the effects of salinity on the growth and yield of the plants (Kaveh et al., 2011). The major result of plants subjected to salt stress is water shortage due to low osmotic potential in rhizosphere and ion excess. Mainly Na+ and Cl are high in salty environments and are potentially taken up at high rates by plants (Greenway and Munns, 1980). Uptake of these ions negatively affects membrane permeability of crops and interferes with the uptake of other ions (Hu and Schmidhalter, 2005). Extra of salt also cause either stomatal closure or restricting the ability of CO2 fixation which in turn cause lower in photosynthetic capacity (Brugnoli and Lauteri, 1991). High salt accumulation in leaf causes leaf injuries and death (Munns et al., 2006).

The general effect of salinity is to lower the growth rate resulting in smaller leaves, shorter stem, and sometimes less leaves. The initial and primary effect of salinity, especially at low to moderate concentrations, is due to its osmotic effects (Munns and Termaat, 1986; Jacoby, 1994). Roots are also reduced in length and mass but may become thinner or thicker. Maturity rate may be delayed or advanced depending on species. The degree to which growth is reduced by salinity differs greatly with species and to a lesser extent with varieties within a species. The severity of salinity response is also mediated by environmental interactions such as relative humidity, temperature, radiation and air pollution (Shannon et al., 1994). The osmotic impacts of saltiness add to decreased development rate, changes in leaf color, and developmental characteristics, for example, root/shoot proportion and maturity rate. Ionic impacts are showed all the more by and large in leaf and meristem harm or as side effects run of the mill of nutritional disorders.. Accordingly, high concentrations of Na or Cl may gather in leaves or segments thereof and bring about `burning' or `firing' of leaves; though, nutritional deficiency manifestations are commonly like those that happen without saltiness. Calcium insufficiency side effects are regular when Na/Ca proportion is high in soil water. All salinity effects may not be bad side; salinity may have some good side at yield, quality, and disease resistance. In spinach, for example, yields may initially increase at low to moderate salinity (Osawa, 1963). Sugar contents increase in carrot and starch content decreases in potatoes as salinity increases (Bernstein, 1959); cabbage heads are more solid at low salinity levels, but are less compact as salinity increases (Osawa, 1961).

M.C. Shannon, C.M. Grieve / Scientia Horticulturae 78 (1999) 5–38

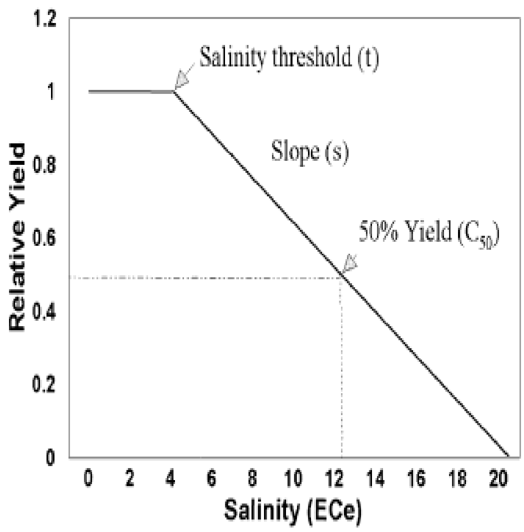


Figure (1): Salt tolerance parameters relating relative yield to increasing salinity in the root zoon.

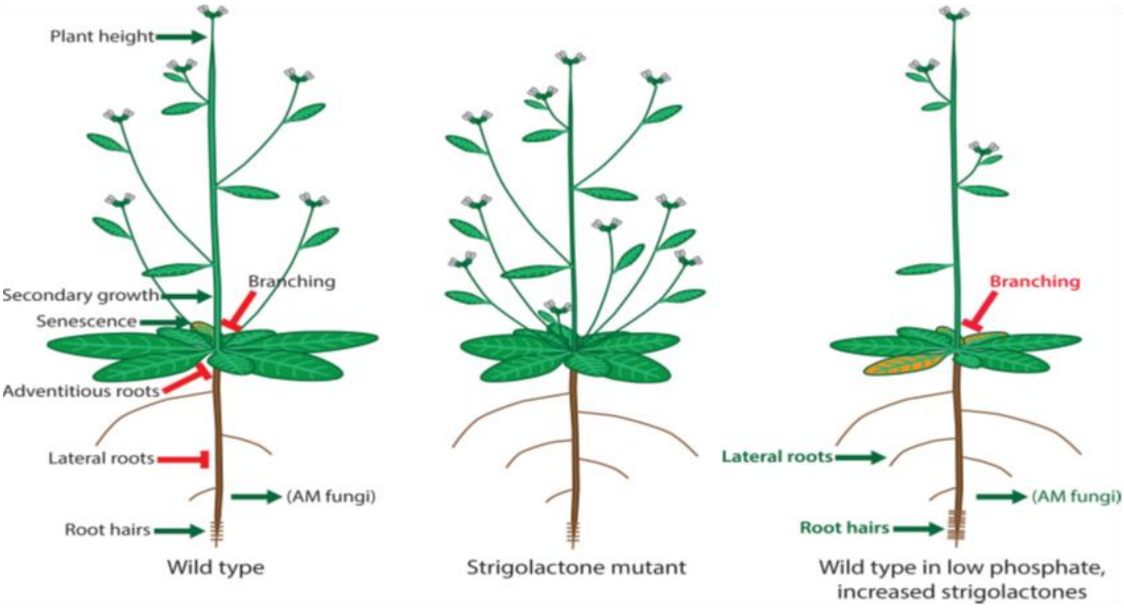
Salinity affects the vegetative and reproductive stages of the plant. May reduce the growth and development of the plant as the water potential in the root medium will decrease (osmotic effect), Most of the salt stress in nature is the result of sodium salts. It is mainly sodium chloride (NaCl) (Levitt, 1980; Muns & Termaat, 1986).

Excess of Na^+ and Cl^- concentrations in the root zone that lead to minimize nutrient elements action and make extreme rations of Na^+/Ca^{2+}, Na^+/K^+, Ca^{2+}/Mg^{2+} and Cl^-/NO_3^- (Grattan and Grieve, 1999). Osmotic effect resulting from salinity may lead to problems in the water balance of the plant, including a reduction of turgor and an inhibition of growth as well as stomatal closure and lower of photosynthesis (Navarro et al., 2000; Romero-Aranda et al., 2001; Sanghellini, 2001; Heuvelink et al., 2003).

When the salt concentration reaches a level that is detrimental to the plant in terms of growth and development, where the stage in which growth and metabolism can be maintained is called the stage of salt tolerance, also that there are differences in salt tolerance between vegetables due to the variety and the nature of the conditions in which they are grown. Soil, water, plants, and the environment can affect the plant's salt tolerance to the plant, so it is not possible to predict how a plant will respond to a particular salt concentration on an absolute basis but on the basis of relative performance basis. There are three methods of assessing vegetable crops for salinity: the ability of plants to survive in saline conditions, the absolute plant growth or yield and the relative growth or yield in saline conditions as compared with non-saline conditions (Mangal and Singh, 1993). Photosynthesis is the most vital process affected in plants growing under the influence of salinity .The lack of photosynthesis under the influence of salinity is not only caused by the closing of stomata, which leads to a decrease in the concentration of carbon dioxide between cells, but also to reduction in enzymes that involve in CO_2 fixation (Hnilickova et al., 2021).

2.2 Effect of Strigolactone hormone on plants

Strigolactones are also involved in hormonal crosstalk during root development. Under optimal growth conditions, strigolactones supress lateral root initiation (Figure 2) (Kapulnik et al., 2011; Ruyter-Spira et al., 2011) and motivate root hair elongation (Figure 1) (Kapulnik et al.,2011).



Figuer (2). The Proposed Roles of Strigolactones in Adult Plant Growth and Development

In the case of lateral root formation, auxin is a key regulator and the distribution of auxin determines lateral root positioning, initiation, and elongation reviewed by (De Smet, 2012). Strigolactones may affect lateral root formation by changes in auxin efflux in the root. Arbuscular Mycorrhizal Fungi (AMF) are one of the most abundant organisms on earth, and there is a very conservative estimate that they represent 5-10% of the microbial biomass of global soil. (Lanfranco and Young, 2012). These symbiotic relationships are usually described as a result of co-evolutio between fungi and plants and are considered a strategy for plant growth under different stress conditions (Bandou et al., 2006; Bonfante and Genre, 2008). AMF associate with the roots of plants and are found in 480% of different plant species (Parniske, 2008). They institute a familiar association with the roots of most land plants (Gutjahr and Paszkowski, 2013), with the fungi provide mineral nutrients from the soil while gain carbon compounds from the photosynthetic host (Lanfranco and Young, 2012). There is a symbiotic relationship between plants and MF. The fungus helps the plant absorb water and provide it with nutrients, growth and disease resistance, while the host plant provides the fungus with organic carbon and the substrate required for fungal growth and reproduction (Smith and Read, 2008). AMF play an important role in nutrient cycling with the help of their mycelium in uptake soil nutrients and providing them to the plant, although their role in carbon flux is less well defined. Recent work by different workers has established that AMF can effect plant fitness (Hoffmann et al., 2011; Wilson et al., 2009), productivity and biodiversity (Wilson et al., 2009).

2.3 Salinity stress alleviation:

In the salinity situation, there is a response and reaction of the plant as it makes adjustments at the morphological, anatomical and cellular level, allowing the plant to avoid stress or increase its tolerance, These modifications are of vital significance for some plant species, but are not found as a common response in all plants (Jamil et al., 2011). In addition to the fact that plants have a genetic adaptation to stress, they also create a relationship with many rhizospheric soil microorganisms that can reduces the effect of stress. The salinity has an effect on the plant and its survival by causing an imbalance in many physiological mechanisms such as photosynthesis efficiency, membrane integrity and water condition (Evelin et al., 2009). There is evidence that AMF Besides what has been mentioned above mechanisms it can relieve salt stress by improving the physiological processes in the plant. However, salinity does not only negatively affect the host plant, but also affects the growth of AMF by impeding colonization, spore germination and hyphal elongation (Kumar et al., 2010; Porcel et al., 2012; Sheng et al., 2008). Contrary to some reports, there has been an increase in sporulation and colonization (Aliasgharzadeh et al., 2001).

The Mycorrhizal association in plants improves plant growth, yield and water status, supports the accumulation of nutrients, affects plant hormones, and affects the chemical and biological properties of the plant in saline and alkaline soil conditions (Abdel Latef and Chaoxing, 2010;

Bandou et al., 2006; Evelin et al., 2009; Kashyap et al., 2004; Kumar et al., 2010; Murkute et al., 2006).

Many of mechanisms have been suggested to clarify the protection of plants from the adverse effect of salt stress. Improvement in the nutrient status of colonized plants can be attributed not only to the uptake of nutrients via the mycorrhizal pathway, but also to indirect effects carried out by morphological and physiological changes in roots due to colonization. Studies indicated that arbuscular mycorrhizal inoculated plants had a higher water content than those non-inoculated plants (Colla et al., 2008; Evelin et al., 2009; Jahromi et al., 2008; Sheng et al., 2008), Which aids it is the hydraulic conduction of the root at low water potential (Kapoor et al., 2008). This improved root conductance is associated with changes in the morphogenetic characters of roots. AMF decrease the meristem action of root apices and thus guide to raise in the formation of adventitious roots and these AMF mediated modifications in root morphology might support in maintaining nutrient uptake and water balance in the host plant under salinity stress. Sukumar et al. (2013), recent studies have shown that a change in the root system is caused by AM, and this leads to an increase in the branches of the roots and an increase in the area of the roots. Giri et al. (2003) reported increased water uptake per unit root length in colonized plants under stress conditions. All of these measures are improved by colonizing the fungi, which helps the host plant to use water more efficiently and to maintain a low concentration of carbon dioxide between cells, and therefore increases the gas exchange capacity in the mycorrhizal plants (Evelin et al., 2009). Arbuscular Mycorrhizal Fungi and Plant-abiotic Stress Tolerance AM fungi are known for improving plant growth, development and production under conditions of abiotic stress (Abdel Latef, 2013; Abdel Latef and Chaoxing, 2014). Mechanisms underlying the protective roles of AM are credited to AMF-assisted alleviation of oxidative stress in plants (Abdel Latef and Chaoxing, 2014) fast water uptake and nutrient intake (Hajiboland, 2013) and change of transcript levels of genes involved in signaling pathway or stress response (López-Ráez et al., 2010). Many efforts have been made to discuss reports available on AMF mediated improvement in growth and metabolism in plants exposed to major abiotic stresses including salinity, drought, cold, heat, mineral deficiency and metals. There are constant interactions between plants and the microorganisms present in their environment (Raaijmakers et al., 2009; López-Ráez et al., 2011b). It is worth noting that they are able to establish mutually beneficial relationships with some microorganisms present in the root zone, One of the most well-studied beneficial plant microorganism relation is that established with certain soil fungi known as arbuscular mycorrhizal (AM) fungi (Smith and Read, 2008). Interestingly, the big majority of land plants, including most agricultural crop species, are able to establish AM symbiosis (Smith and Read, 2008). AM Fungi are ubiquitous and are known to exist in salty environments (Giri et al., 2003). There is evidence to show that this symbiotic life mitigates the negative effects of soil salinity (Evelin et al., 2009; Porcel et al., 2012). In fact, AM symbiosis has been shown to improve soil salinity resistance in a variety of host plants such as corn, tomato, lettuce (Al-Karaki, 2000; Feng et al., 2002; Jahromi et al., 2008), although the intimate mechanisms are not well understood (Ruiz-Lozano et al., 2012). The connection is in the root zone by secreting signaling molecules from the host plant (under the lack of nutrients) that are recognized by AM fungi and encourage hyphal growth. Among these signals, the strigolactones have been as essential signals acting as a 'cry for help' under unfavourable conditions (López- Ráez et al., 2011b). Strigolactones are multifunctional molecules that have been newly classified as a new class of plant hormones organising above- and below-ground plant architecture, and reproductive development (Gómez-Roldán et al., 2008; Kapulnik et al., 2011; Ruyter-Spira et al., 2011; Kohlen et al., 2012). The hormone is mainly produced and synthesized in the roots and has been discovered in root extracts and secretions of dicot and monocot plants (Xie et al., 2010). It is derived from carotenoids by oxidative cleavage (Matusova et al., 2005; López-Ráez et al., 2008) and thus belongs to the class of apocarotenoids as the phytohormone ABA (Ohmiya, 2009). It has an essential role in the symbiotic life, in addition to protecting from stress in the mycorrhizal roots, recent studies have shown that ABA is important in this symbiotic life, because it is important in completing the formation of arbusculer and encourage sustained colonization of the plant root (reviewed in López-Ráez et al., 2011). It is worth noting: that the ABA is related to the manufacture of the hormone Strigolactone (López Ráez et al., 2010) The negative effect of salinity is not only on the host plant, but also on the AM fungus It can minimize colonization capacity, spore germination and growth of fungal hyphae (Juniper and Abbott, 2006; Jahromi et al., 2008). However, some of studies have shown an increased AM fungal sporulation and colonization under salt stress conditions, or even no effect in colonization rates (Aliasgharzadeh et al., 2001; Yamato et al., 2008). In the same way, the effects of salinity on the production of signaling molecules such as stregolactone have not yet been studied.

Stigolactones are stimulated when nutrients are deficient and are considered to mediate a plant's response to environmental conditions, it might be that they are regulated by other adverse environmental conditions, thus affecting the AM fungal colonization (García-Garrido et al., 2009). Strigolactones (SLs) are a new group of putatively carotenoid-derived terpenoid lactones which was extracted from root secretions, which helps germination of seeds of the root parasite plant Striga (Cook et al., 1972; Yoneyama et al., 2008). These new group of phytohormones have been proposed to play a pivotal part in the regulation of above ground plant structure and root development (Koltai et al., 2010; Brewer et al., 2013; Foo and Reid, 2013; Cuyper et al., 2015). GR24, a synthesized strigolactone, is involved in response to abiotic stress. It acts as a positive regulator in the stress response, exogenous GR24 can promote the drought and salt tolerance of Arabidopsis (Ha et al., 2014; Kapulnik and Koltai, 2014). Underground, SLs participate in plant interactions with parasitic plants Orobanche and Striga (Yokota et al. 1998; Matusova et al. 2005; Bouwmeester et al. 2007; Goldwasser et al., 2008; Xie et al., 2008) and

With symbiotic arbuscular fungi (Akiyama et al., 2005; Akiyama and Hayashi, 2006; Besserer et al., 2006, 2008; Gomez-Roldan et al., 2008; Yoneyama et al., 2008; Garcıa-Garrido et al., 2009). In addition, SLs have been suggested to influence root growth in the presence of externally applied auxin (Koltai et al. 2010). It is believed that it is synthesized in the roots and lower parts of the stem reviewed by (Dun et al., 2009), as a product of a new branching pathway of carotenoid cleavage (Gomez Roldan et al., 2008; Rani et al., 2008; Oumhara et al., 2008; Floss and Walter 2009; revised by Dan et al. 2009), and to move horizontally toward the shoot apex reviewed by (Ongaro and Leyser, 2008; Leyser 2009; Stirnberg et al., 2010). Additional studies have suggested an overlap between SLs and auxin in determining shoot structure, based on several hypotheses: SLs work primarily by reducing the plant's ability to transport polar auxin from the apical meristem, thus inhibiting polar auxin transport from buds resulting in a restricted bud and outgrowth(Bennett et al., 2006; Mouchel and Leyser 2007; Ongaro and Leyser, 2008; Leyser, 2009); as another option, SLs react as auxin induced secondary messengers that move up into the buds to supress their outgrowth(Brewer et al., 2009; Ferguson and Beveridge, 2009); reviewed by (Dun et al., 2009). Another model suggested that auxin, which is moved by polar transport, enhances the expression of genes for SL synthesis; This increases SL production, which in turn leads to reduced auxin export, mediated by polar auxin transport from buds, and reduced bud growth. (Hayward et al., 2009). More recently, it has been suggested that strigolactone plays a pivotal role in regulating plant structure above ground by inhibiting shoot branching; This was inferred from studies of Arabidopsis, peas and rice mutaation in the production or visualization of stregolactone (Gomez Roldan et al., 2008; Umhara et al., 2008). However, the mechanisms underlying the effects of stregolactone on plant growth remain elusive. Strigolactones (SLs), a small class of compounds derived from carotene, were first classified more than 45 years ago as seed germination stimuli in parasitic root plants, such as Striga, Orobanche, and Phelipanche species. Strigolactones function as a new class of plant hormones that regulate shoot (Gomez-Roldan et al., 2008; Umehara et al., 2008), and root structure (Koltai, 2011; Ruyter-Spira et al., 2011), photosynthesis (Tsuchiya et, 2010), secondary growth (Agusti et al., 2011), leaf senescence (Snowden et al., 2005), and seed germination stimulation of crops and weeds (Pepperman et al., 1988).

However, strigolactones are intermittently transported to plant parts where they exert their function. This is supported by the fact that in both Arabidopsis and Solanum lycopersicum (tomato) there is at least one strigolactone - orobanchol - in the xylem (Kohlen et al., 2011a). The fact that it is also expressed near axillary buds appears to indicate a role in loading of strigolactone into xylem / apoplast in the shoot as well, but it remains unclear how this is involved in regulating shoot branching (Kretzschmar et al., 2012). Stregolactone production is stimulated under phosphate-limiting conditions in several plant species (Yoneyama et al., 2007; Lo´pezRa´ez et al., 2008a; Umehara et al., 2008; Kohlen et al., 2011a), from It likely stimulated the establishment of symbiosis AM (Akiyama et al., 2005; Bouwmeester et al., 2007). More recently, it has been suggested that these elevated concentrations of strigolactone may also serve an additional function in plants, as they may participate in reducing shoot branching under these unfavorable conditions (Umehara et al., 2010; Kohlen et al., 2011a). However, the mechanisms underlying the effects of stregolactone on plant growth remain elusive. Strigolactones (SLs), a small class of compounds derived from carotene, were first classified more than 45 years ago as seed germination stimuli in parasitic root plants, such as Striga, Orobanche, and Phelipanche species. Strigolactones function as a new class of plant hormones that regulate shoot (Gomez-Roldan et al., 2008; Umehara et al., 2008), and root structure (Koltai, 2011; Ruyter-Spira et al., 2011), photosynthesis (Tsuchiya et, 2010), secondary growth (Agusti et al., 2011), leaf senescence (Snowden et al., 2005), and seed germination stimulation of crops and weeds (Pepperman et al., 1988).

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A recent study reports that stregolactone (SL) positively modulates drought and high salinity responses in Arabidopsis. Both SL-deficient mutations and SL response [more axillary (maximal) growth] showed hypersensitivity to drought and salt stress, which was associated with short traits rather than root-related traits. Exogenous SL treatment rescued the drought-sensitive phenotype of SL-deficient mutants, but not SL response mutations, and enhanced drought tolerance in WT plants, confirming SL's role as a positive regulator in the stress response (Ha CV et al, 2013). The role of SLs has been suggested in response to salt stress. Since symbiosis with AMF may also increase plant resistance to soil salinity, lettuce plants grown under high concentration of NaCl were analyzed in terms of perfusion of SLs (Aroca et al., 2013).In the case of non-fungal plants, the exudation of strigolactones was lower than in the control under salt pressure. However, SL exudation increased by more than 5-fold in response to salinity when AMF was present in the medium. Since saline stress adversely affects the growth and symbiotic capabilities of AMF, it may be necessary to increase the secretion of SLs in these conditions to ensure an adequate level of mycobacterial reactions SL(Aroca et al., 2013).

CHAPTER THREE

MATERIAL AND METHOD

3.1 Plant material

The experiments were conducted in a greenhouse in Nablus in the northern of West Bank (Palestine)

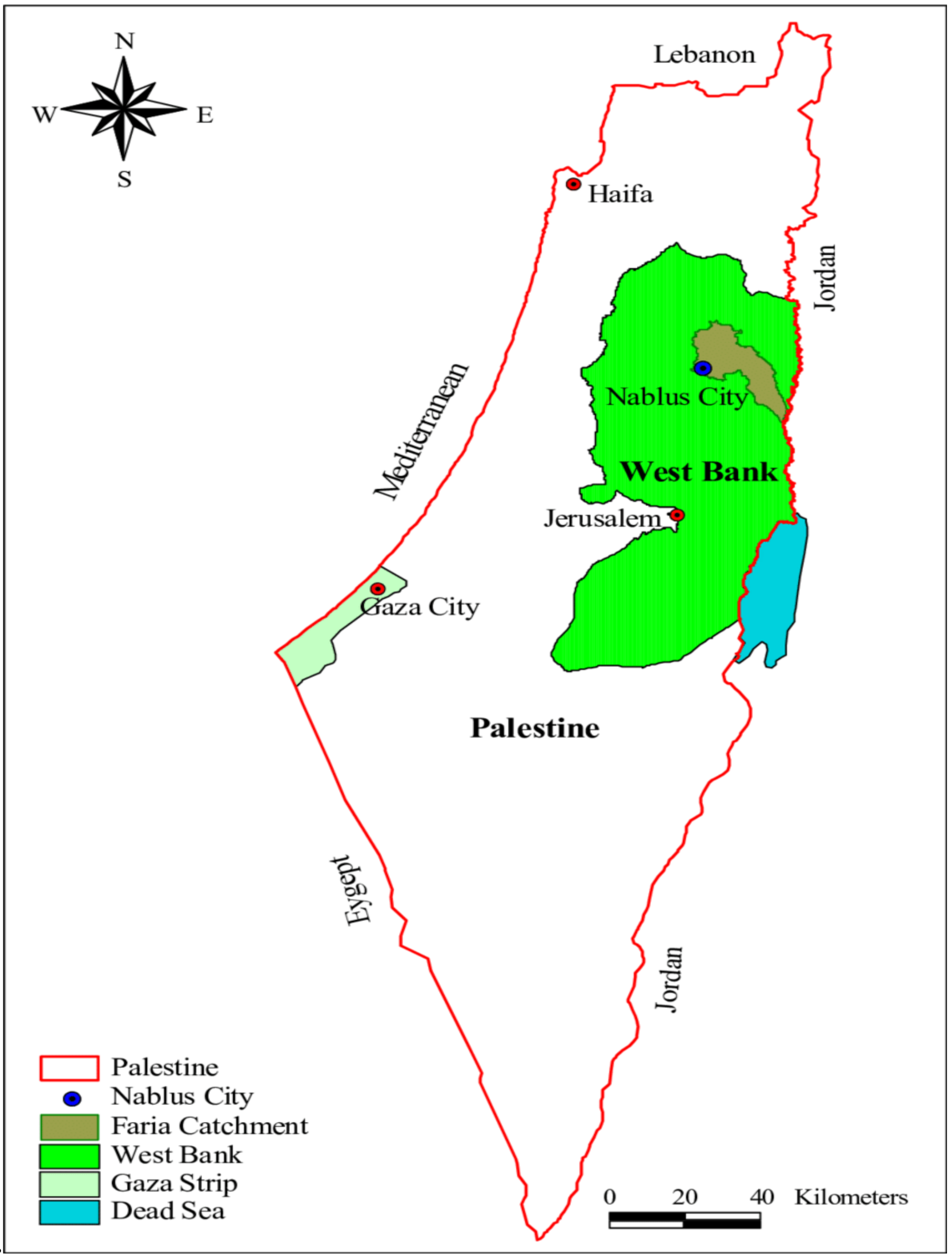

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Figure (3): Nablus City, the location of the experiment

Homogenous healthy cucumber seedlings variety (Zain) was used in the experiment. The seedlings were grown in a greenhouse under natural light conditions during the period from the 7th of March until 4th of July 2020. One plant was grown in each plastic pot, (30 cm in diameter and 33 cm height). The pots contained sand and peat moss with mixing ratio 2: 1 and with three replicates for each treatment (Figure 2).

3.2 Experimental design

The experiment was designed as a factorial treatment (4x4) design in a CRD with 3 replicates. Four treatments; three of which was salinity levels (4, 6 and 8 ds/m NaCl) and the fourth was fresh water, in addition to four strigolactones GR24 concentration (0, 10, 50 and 100 ng\l), with 3 replicates for each treatment.

The irrigation with different salinity levels were started before 2 days of hormone application. The seedlings were planted on 7th of March 2020

3.3 Treatments with NaCl

After 18 days of planting, different concentrations of salinity (4, 6, and 8 ds/M), were used in irrigation in addition to the fresh water as control. A 150 ml hormone treatment was added 20 days after planting by foliar spray for each treatment with the hormone.

The irrigation process was carried out according to the needs of the plant depended on the soil moisture, the pots divided to lines depending on salt concentration, each line contains one of the concentrations of NaCl.

Figure (4). Cucumber plants

3.4 Growth parameter:

The growth parameters were as follows:

- Shoot height (cm) using regular meter from the soil surface to the top of the plant.
- Number of True leaves.
- Shoot fresh weight (g) using Precision balance (Kern 440-46,Germany).
- Shoot dry weight (g) after being dried by oven (P Selecta, Spain) at 70 C for 48 hours.
- Roots fresh weight (g).
- Roots dry weight (g).

Leaf area: The leaf area was measured by Area meter AM350

Figure (5). Leaf area meter (area meter AM350)

- **Chlorophyll content**

Readings of chlorophyll and leaf greenness of cucumber plants were taken two days prior to harvest using a chlorophyll meter (SPAD-502Plus Chlorophyll Scale, Konica Minolta Sensing, Inc., Japan), for each plant three readings were taken at three sites for each replicate and then the average of the three estimated reads was taken (the upper leaf, middle leaf and lower leaf). SPAD units are defined by the manufacturer as “1” equivalent to very pale green (greenish) and “50 equivalent to very dark green.

Figure (6). Chlorophyll Meter SPAD-502Plus, Konica Minolta Sensing, Inc., Japan.

3.5 Yield and it`s components

The following yield parameters were measured:

Fruit number, fruit weight and sucrose content (Brix) estimated using digital Refractometer

Figure (7). A.KRUSS Optronic gmbH – DR6100-T (digital Refractometer)

3.6 Nutrient element content:

The chemical analysis was carried out at laboratory of scientific research center at An Najah National University, Nablus, Palestine. The analysis of chemical content in cucumber leaves was based on Motsara's methodology, M.R. 2008. Most of the leaves were collected for each plant, and all leaves were oven-dried at 70C° for 48 hours, milled with a stainless steel electric grinder using a 0.5 mm sieve, and stored in airtight plastic bottles for analysis this step was carried out at the Faculty of Agriculture and Veterinary Medicine in Tulkarm.

Dry ash: From each sample, 1 gram was taken with a sensitive balance, placed in a crucible and heated at 550 ° C for 3 hours in a high temperature laboratory oven (Carbolite LHT 6/30, UK) to destroy OM, and the resulting ash could be dissolved in acids to bring the sample in to a liquid form for estimation.

3.6.1 Nitrogen content

Digestion : 0.5g of each sample is placed in the pipet, (0.04g of CuSo4 and 15g of Na2So4) as a catalyst, adding 20ml of H2So4 for digestion, and the pipet is heated in the turbotherm (Gerhard, Germany) 15 minutes at 80 ° C, 15 minutes at 90 ° C, 90 minutes at 100 ° C. Digest the sample and it becomes a clear solution.

Distillation:

We take 25 ml of boric acid and add it to the solution to capture the ammonia gas resulting from the process. The solution is placed on the Vapodest distillation unit (Gerhardt, Germany), and it begins with adding 70 ml of NaOh and 30 ml of H2O and takes 4 minutes, the color of the boric acid changes from purple to green, this indicates the availability of ammonia gas.

Titration:

The solution was titrated with 0.095 mM HCl, the color of the solution changed from red to yellow, the volume of acid required was recorded and we used it in the high temperature equation of the laboratory oven (Carbolite LHT 6/30, UK)

3.6.2 Sodium, Calcium and potassium content

For sodium: 100 ml form each sample are filtrated (don’t need digestion)

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

Sodium and potassium were estimated photometrically by sherwood flame photometer 410.

3.6.3 Chloride content

The amount of chloride in the leaf sample was quantified by the volumetric method (A.O.A.C formal method 937.09).

M mole of CL = m mole of $AgNO_3$ – m mole of NH4SCN

= (V. OF $AgNO_3$ X Normality _ V. OF NH4SCN X Normality)

Cl (Ppm) = M mole of CLX M.W of CL X dilution value

3.6.4 Phosphorus content

Phosphorus content were measured by using Spectrophotometric vanadium phosphomolybdate method (Motsara, M. R., & Roy, R. N., 2008). 25 ml from each sample (solution) was taken, 1 spoon of K2S2O8 added, 2 ml of H_2SO_4 for digestion and heated in the hood to become clear, after digestion we completing to 50 ml with distilled water, 2_3 drop of naphthalene and NaOH to change color, 10 ml of vanadomolybdate reagents added, and kept for 15 minutes.

The relevant calculation is:

P content (micro g) in 1 g of sample = C * df

C= concentration of P (micro g / ml) as read from the standard curve;

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

Figure (8). Spectrophotometer, Pharmacia, biotech

3.6.5 Statistical analysis

All statistical tests were performed using analysis of variance (ANOVA) using the Minitab, Tukey-Kramer range test was used for evaluating mean separation at 5% level of probability. In addition, used the PDMIX800 macro to convert pairwise differences between least square means to letter groupings, where means sharing the same letter code are not significantly different (Saxton, 1998).

CHAPTER FOUR

RESALT

4.1 The effect of hormone on vegetative growth

4.1.1 The effect of strigolactone on leaf area of cucumber under different salinity concentration

The analysis of variance of leaf area of cucumber variety revealed that different concentration of salinity and hormone had a significant ($p < 0.0001$) effect on leaf area. In which, the effect of highest concentration of strigolactone significantly increase leaf area (12165.1mm^2) (Table 1). In addition, irrigation with only saline water have a negative effect on leaf area (7372mm^2) compared with control (Table 2). Based on the interaction, moderate salinity with highest hormone have a positive effect on leaf area (12.130) (Table 23, see list of appendix).

4.1.2 The effect of strigolactone on leaf number of cucumber under different salinity concentration.

The analysis variance of number of leaves for cucumber plant revealed that different concentration of salinity had a highly significant ($p < 0.0001$) impact on this parameter. In addition, the different concentration of strigolactone have a significantly ($p< 0.0015$) impact on the number of leaves (Table 10, see list of appendix). The high concentration of hormone has a positive impact on leaves number (26.2) compared with low concentration of hormone (23.4) Table (1). On other hand, irrigation with high concentration of saline water have a negative impact on number of leaves (16,1) compared with low concentration of saline water (32.8) Table (2). Based on the interaction, moderate salinity with high hormone have a positive impact on leaf number (31.67) (Table 23, see list of appendix).

4.1.3 The effect of strigolactone on stem diameter of cucumber under different salinity concentration.

The analysis of variance of stem diameter of cucumber plant revealed that different concentration of salinity had a highly significant ($p < 0.0001$) impact on this parameter. Similarly, different concentration of strigolactone have a significant impact on stem diameter ($p< 0.0014$) (Table 11, see list of appendix). The high concentration of hormone has a positive impact on stem diameter (1cm) compared with low concentration of hormone (0.9 cm) Table (1). while, irrigation with high concentration of saline water have a negative impact on stem diameter (0.8 cm) compared with low concentration of saline water (1.1 cm) Table (2). Based on the interaction, moderate salinity with moderate hormone have a positive impact on stem diameter (1 cm) (Table 23, see list of appendix).

4.1.4 The effect of strigolactone on height of cucumber under different salinity concentration.

The analysis of variance of plant height of cucumber variety revealed that different concentration of salinity and hormone had a significant ($p < 0.0001$) impact on this parameter (Table 12, see list of appendix). In general, the impact of the highest concentration of strigolactone significantly impact on plant height (65.4 cm) Table (1).Whereas, irrigation with only saline water have a negative impact on plant height (40.4 cm) Table (2). Based on the interaction, moderate salinity with highest hormone have a positive impact on height plant (74.13 cm) (Table 23, see list of appendix).

4.1.5 The effect of strigolactone on aboveground fresh weight of cucumber under different salinity concentration.

Cucumber plant considered as one of the most highly sensitive plant to salinity, according to analysis of variance of above ground fresh weight for cucumber variety revealed that different concentration of salinity and hormone had a significant ($p < 0.0001$) impact on this parameter (Table 13, see list of appendix). In general, the impact of the highest concentration of strigolactone was significant impact (69.55 g) on above ground fresh weight. Whereas, irrigation with only saline water have a negative impact on above ground fresh weight (41.19 g) (Table 2). Based on the interaction, moderate salinity with highest hormone have a positive impact on above ground fresh weight (77.73 g) (Table 23, see list of appendix).

4.1.6 The effect of strigolactone on aboveground dry weight of cucumber plant under different salinity concentration.

Cucumber plant considered as one of the most plant are highly sensitive to salinity, according to analysis of variance of above ground dry weight for cucumber variety revealed that different concentration of salinity and hormone had a high significant ($p < 0.0001$) impact on this parameter

(Table 14, see list of appendix). In general, the impact of the highest concentration of strigolactone significantly effect on above ground dry weight (31.61 g) Table(1). Whereas, irrigation with only saline water have a negative impact on above ground dry weight (16.64 g) Table (2). Based on the interaction, moderate salinity with highest hormone have a positive impact on above ground fresh weight (37.27 g) (Table 23, see list of appendix).

4.1.7 The effect of strigolactone on root fresh weight of cucumber plant under different salinity concentration.

According to analysis of variance of for root fresh weight for cucumber variety revealed that different concentration of salinity and hormone had a high significant ($p < 0.0001$) impact on this parameter (Table 15, see list of appendix). In general, the impact of the highest concentration of strigolactone significantly effect on root fresh weight (4.84 g) Table (1). Whereas, irrigation with only saline water have a negative impact on root fresh weight (2.6 g) Table (2). Based on the interaction, moderate salinity with highest hormone have a positive impact on above ground fresh weight (6.33 g) (Table 23, see list of appendix).

4.1.8 The effect of strigolactone on root Dry weight of cucumber fruit under different salinity concentration.

According to analysis of variance of for root dry weight for cucumber variety revealed that different concentration of salinity had a highly significant ($p < 0.0001$) impact on this parameter. Whereas, the different concentration of hormone has a significant ($p<0.0026$) impact on this parameter (Table 16, see list of appendix). In general, the impact of the highest concentration of strigolactone significantly effect on root dry weight (0.725 g) Table (1). Whereas, irrigation with only saline water have a negative impact on root dry weight (0.333 g) Table (2). Based on the interaction, moderate salinity with highest hormone have a positive impact on above ground fresh weight (40 g) (Table 23, see list of appendix).

Table (1): The effect of strigolactone hormone on vegetative growth.

Strigolactone concentrations	Leaf area	Leaf number	Stem diameter	Plant height	Above FW	Above DW	Root FW	Root DW
0	11430.7^{AB}	23.4^{B}	0.9^{B}	52.1^{D}	53.38 ^{D}	18.533^{D}	3.633 ^{C}	0.5416^{B}
10	8346.4^{C}	25.2^{A}	0.92^{B}	54.3^{C}	56.84^{C}	20.6^{C}	3.833^{C}	0.483^{B}
50	10853.6^{B}	26.2^{A}	1^{A}	59.1^{B}	63.9 ^{B}	25.341^{B}	4.375 ^{B}	0.5 ^{B}
100	12165.1^{A*}	25.6^{A}	1 ^{A}	65.4^{A}	69.55 ^{A}	31.616^{A}	4.841 ^{A}	0.725 ^{A}

*Numbers followed by the same letters are not significantly different at 5 level according to LCD test

Table (2): The effect of salinity on vegetative growth

Salinity concentrations	Leaf area	Leaf number	Stem diameter	Plant height	Above FW	Above DW	Root FW	Root DW
Fresh water	14036.7^{A}	32.8 ^{A}	1.1 ^{A}	75.9 ^{A}	85.4 ^{A}	32.666^{A}	5.4 ^{A}	0.958^{A}
4	11625.3^{B}	28.3^{B}	1.0 ^{A}	63.1 ^{B}	64.61^{B}	26.475^{B}	5.35^{A}	0.616^{B}
6	9761.8^{C}	23.2^{C}	0.9 ^{B}	51.4^{C}	52.47 ^{C}	20.308^{C}	3.333^{B}	0.341^{C}
8	7372.0^{D}	16.1^{D}	0.8^{C}	40.4^{D}	41.19 ^{D}	16.641^{D}	2.6^{C}	0.333^{C}

*Numbers followed by the same letters are not significantly different at 5 level according to LCD test

4.1.9 The effect of strigolactone on chlorophyll content of cucumber leaf under different salinity concentration

The analysis of variance of chlorophyll content of cucumber plant revealed that different concentration of salinity and hormone had a highly significant ($p < 0.0001$) impact on this parameter (Table 17, see list of appendix). Irrigation with highly concentration of saline water have a negative impact on chlorophyll content (18.183) compared with low concentration of saline water (Table 3). While, the highest concentration of hormone has a positive impact on chlorophyll content (38.091) compared with low concentration of strigolactone (32.258) Table (4). Based on the interaction, moderate salinity with highest hormone have a positive impact on chlorophyll content (45.20) (Table 24, see list of appendix).

Table (3): for the effect of salinity on chlorophyll

Salinity concentrations	Chlorophyll content
Fresh water	50.7167^{A}
4	37.650^{B}
6	33.50^{C}
8	18.183^{D}

*Numbers followed by the same letters are not significantly different at 5 level according to LCD test

Table (4): the effect of SLs on chlorophyll

Strigolactone concentrations	Chlorophyll content
0	32.258^{D}
10	33.833^{C}
50	35.866^{B}
100	38.091^{A}

*Numbers followed by the same letters are not significantly different at 5 level according to LCD test

4.1.10 The effect of strigolactone on brix value of cucumber fruit under different salinity concentration.

The analysis of variance of brix content of cucumber fruit revealed that different concentration of salinity and hormone had a highly significant ($p < 0.0001$) impact on this parameter (Table18, see list of appendix). Irrigation with highly concentration of water have a negative impact on brix content (3.375) compared with low concentration of saline water (3.250) Table (5). While, the highest concentration of hormone has a positive impact on brix content (3.33) compared with low concentration of strigolactone (3.308) Table (6). Based on the interaction, moderate salinity with highest hormone have a positive impact on brix content (3.53) (Table 24, see list of appendix).

Table (5): The effect of salinity on sugar content (Brix)

Salinity concentrations	Brix value
Fresh water	2.950^{C}
4	3.250^{B}
6	3.316^{AB}
8	3.375^{A}

*Numbers followed by the same letters are not significantly different at 5 level according to LCD test

Table (6): The effect of Sls on sugar content (Brix)

Strigolactone concentrations	Brix value
0	3.308^{A}
10	3.308^{A}
50	2.941^{B}
100	3.333^{A}

*Numbers followed by the same letters are not significantly different at 5 level according to LCD test

4.2 The effect of hormone on productivity.

4.2.1 The effect of strigolactone on fruit number of cucumber plant under different salinity concentration.

The analysis of variance of Number of fruits of cucumber plant revealed that different concentration of salinity and hormone had a highly significant ($p < 0.0001$) impact on this parameter (Table 19, see list of appendix). Irrigation with highly concentration of saline water have a negative impact (9.083) on number of fruits compared with low concentration of saline water (16.166) Table (7). While, the highest concentration of hormone has a positive impact on number of fruits (16.582) compared with low concentration of strigolactone Table (8). Based on the interaction, moderate salinity with moderate hormone have a positive impact on fruit number (14.67) (Table 24, see list of appendix).

Table (7): The effect of salinity on productivity

	Fruit number	Fruit weight	Fruit diameter	Fruit length
0	21.666^{A}	1300.33^{A}	3.591^{A}	16.075^{A}
4	16.166^{B}	860.33^{B}	2.916^{B}	12.791^{B}
6	14.250^{C}	562.17^{C}	2.366^{C}	10.591^{C}
8	9.083^{D}	249.08^{D}	1.850^{D}	9.408^{D}

*Numbers followed by the same letters are not significantly different at 5 level according to LCD test

Table (8): The effect of Sls on productivity

	Fruit number	Fruit weight	Fruit diameter	Fruit length
0	13.833^{B}	654.333^{D}	2.500^{C}	11.466^{C}
10	14.833^{B}	694.667^{C}	2.466^{C}	12.025^{B}
50	15.916^{A}	767.667^{B}	2.725^{B}	12.450^{AB}
100	16.583^{A}	855.250^{A}	3.033^{A}	12.925^{A}

*Numbers followed by the same letters are not significantly different at 5 level according to LCD test

4.2.2 The effect of strigolactone on fruit weight of cucumber fruit under different salinity concentration.

The analysis of variance of fruit weight of cucumber plant revealed that different concentration of salinity and hormone had a highly significant ($p < 0.0001$) impact on this parameter (Table20, see list of appendix). Irrigation with highly concentration of saline water have a negative impact on fruits weight (249 g) compared with low concentration of saline water (860.33g). Table (7) While, the highest concentration of hormone has a positive impact on fruits weight (855.25g) compared with low concentration of strigolactone (694.66g) Table(8). Based on the interaction, moderate salinity with highest hormone have a positive impact on brix content (1150g) (Table 24, see list of appendix).

4.2.3 The effect of strigolactone on fruit diameter of cucumber fruit under different salinity concentration.

The analysis of variance of diameter of fruits of cucumber plant revealed that different concentration of salinity and hormone had a highly significant ($p < 0.0001$) impact on this parameter (Table21, see list of appendix). Irrigation with highly concentration of saline water have a negative impact on fruit diameter (1.850 cm) compared with low concentration of saline water (2.916 cm) Table (7). While, the highest concentration of hormone has a positive impact on fruits diameter (3.033 cm) compared with low concentration of strigolactone (2.466 cm) Table (8). Based on the interaction, moderate salinity with highest hormone have a positive impact on fruit diameter (3.57 cm) (Table 24, see list of appendix).

4.2.4 The effect of strigolactone on fruit length of cucumber plant under different salinity concentration

The analysis of variance of fruits length of cucumber plant revealed that different concentration of salinity and hormone had a highly significant ($p < 0.0001$) impact on this parameter (Table22, see list of appendix). Irrigation with highly concentration of saline water have a negative impact on fruits length content (9.408 cm) compared with low concentration of saline water (12.791cm) Table (7). While, the highest concentration of hormone has a positive impact on fruits length (12.92cm) compared with low concentration of strigolactone (12.025cm) Table (8). Based on the interaction, moderate salinity with moderate hormone have a positive impact on fruit length (15,20cm) (Table 24, see list of appendix).

4.3 The effect of hormone on nutrients

4.3.1 The effect of strigolactone on Nitrogen content in cucumber plant under different salinity concentration.

Based on the analysis of chemical content for nitrogen percent in cucumber plant as salinity increase the nitrogen content decrease. However, untreated plant recorded the highest nitrogen content (3.4%) compare with other treatment. Otherwise, SLs treatment of cucumber plant with highest concentration of strigolactone companied with moderate salinity concentration (2.9%) revealed better result than the highest concentration of strigolactone with the highest concentration of salinity (1.5) (Fig,9). In general, strigolactone hormone and salinity level have a little impact on nitrogen percentage for cucumber plant. On other hand the effect of strigolactone on nitrogen percentage was variable.

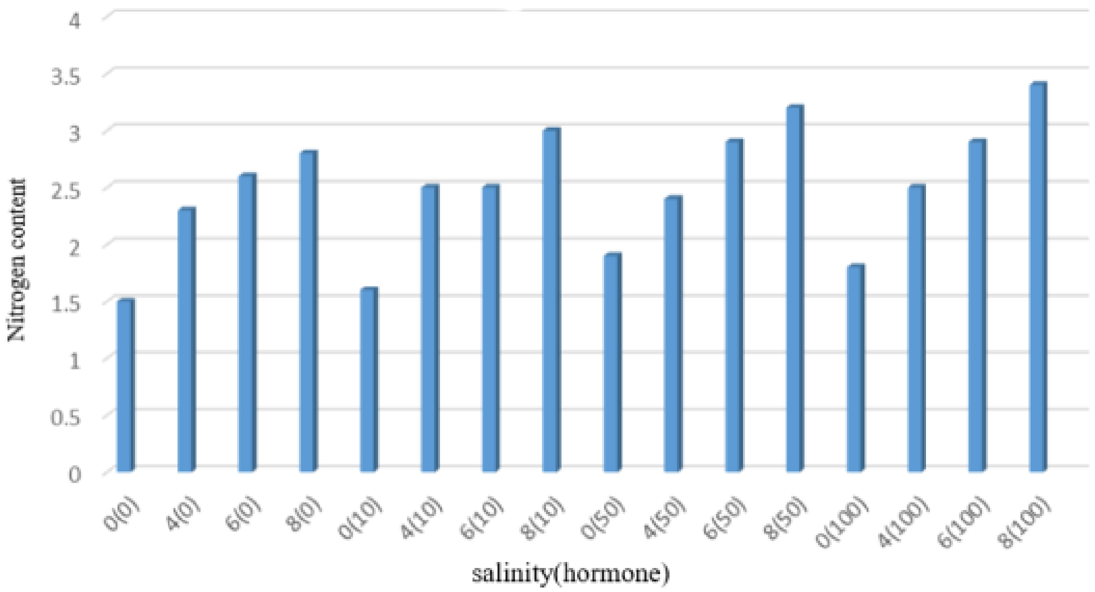

Figure (9): The effect of strigolactone on Nitrogen content in cucumber plant under different salinity concentration.

4.3.2 The effect of strigolactone on phosphorus content in cucumber plant under different salinity concentration.

Based on the analyses for phosphorus percent in cucumber plant revealed that salinity extremely reduce its content in plant. In which, untreated plant (without hormone and salinity) recorded a high percent of phosphorus compared with other treatments. While, treated plant with moderate hormone and moderate salinity recorded the highest phosphorus content (0.33) compared with other treatment (0.1 – 0.24). Otherwise, treatment of cucumber plant with highest concentration of striglactone with moderate salinity concentration (4-6 ds\l) revealed better result than the highest concentration of strigolactone with the highest concentration of salinity (8 ds\l) (Fig, 10). In general, strigolactone hormone and salinity level have a [AA(1]little impact on phosphorus percentage for cucumber plant.

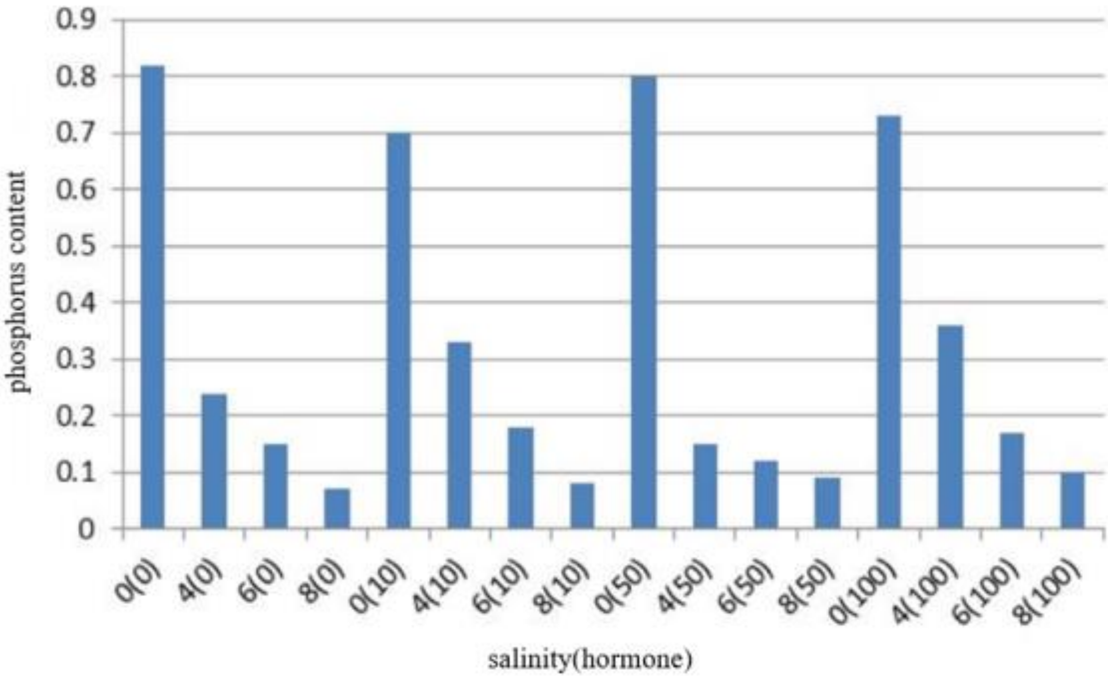

Figure (10): The effect of strigolactone on phosphorus content in cucumber plant under different salinity concentration.

4.3.3 The effect of strigolactone on potassium content in cucumber plant under different salinity concentration.

Based on the analysis for Potassium percent treated plant (with highly concentration of hormone and without salinity) recorded a highly percent of Potassium (3.6) compared with other treatments. While, treated plant with moderate hormone and moderate salinity recorded the highest Potassium content (2.6) compared with other treatment (1.2-2.5).

Otherwise, treatment of cucumber plant with highest concentration of strigolactone with moderate salinity concentration (ds\l) revealed better result than the highest concentration of strigolactone with the highest concentration of salinity (8 ds\l) (Fig, 11). In general, strigolactone hormone and salinity level have a highly impact on Potassium percentage for cucumber plant.

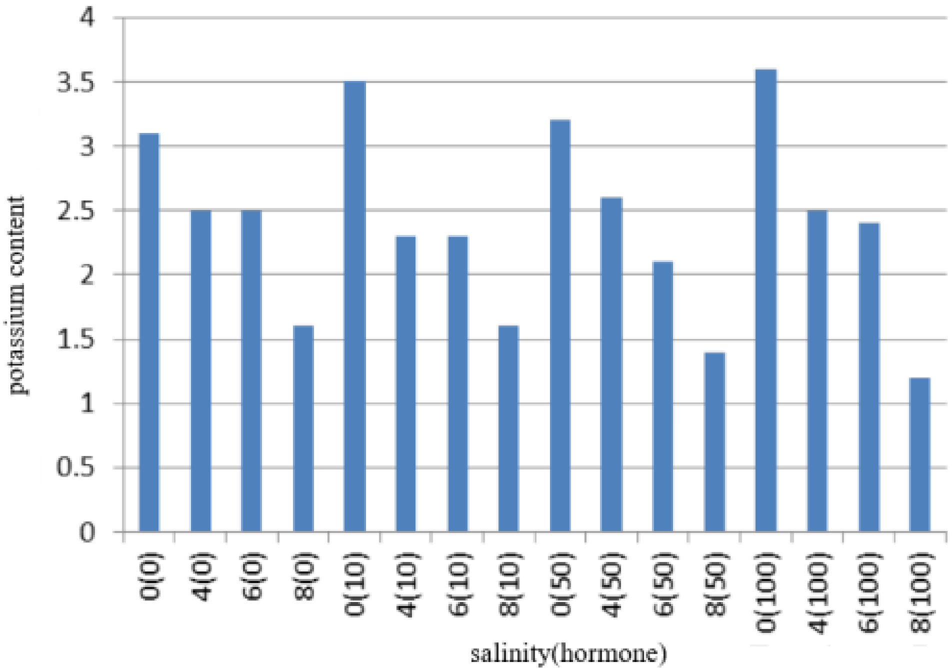

Figure (11): The effect of strigolactone on potassium content in cucumber plant under different salinity concentration.

4.3.4 The effect of strigolactone on Calcium content in cucumber plant under different salinity concentration.

The analysis for calcium content in cucumber plant revealed strigloactone have a positive impact on calcium content (Fig, 12) compared none treated plant. Otherwise, cucumber plant with highest concentration of striglactone under moderate salinity concentration revealed better result (6.3) than the highest concentration of strigolactone with the highest concentration of salinity (5.8) (Fig, 12). In general, strigolactone hormone and salinity level have a highly impact on calcium content for cucumber plant.

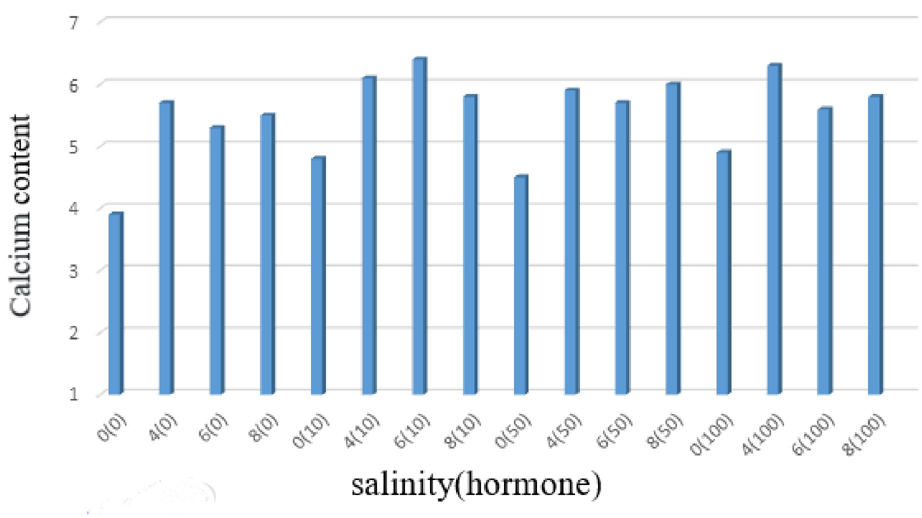

Figure (12): The effect of strigolactone on Calcium content in cucumber plant under different salinity concentration.

4.3.5 The effect of strigolactone on Sodium content in cucumber plant under different salinity concentration.

The analysis for sodium content in cucumber plant revealed a highly difference between the treatments. However, plant treated with strigloactone showed a positive impact on Sodium content (Fig,6) compared untreated plant. Otherwise, treatment of cucumber plant with highest concentration of strigolactone compined with moderate salinity concentration revealed better result (0.63) than the highest concentration of strigolactone with the highest concentration of salinity (1.6) (Fig, 13). In general, strigolactone hormone and salinity level have a highly impact on sodium content for cucumber plant.

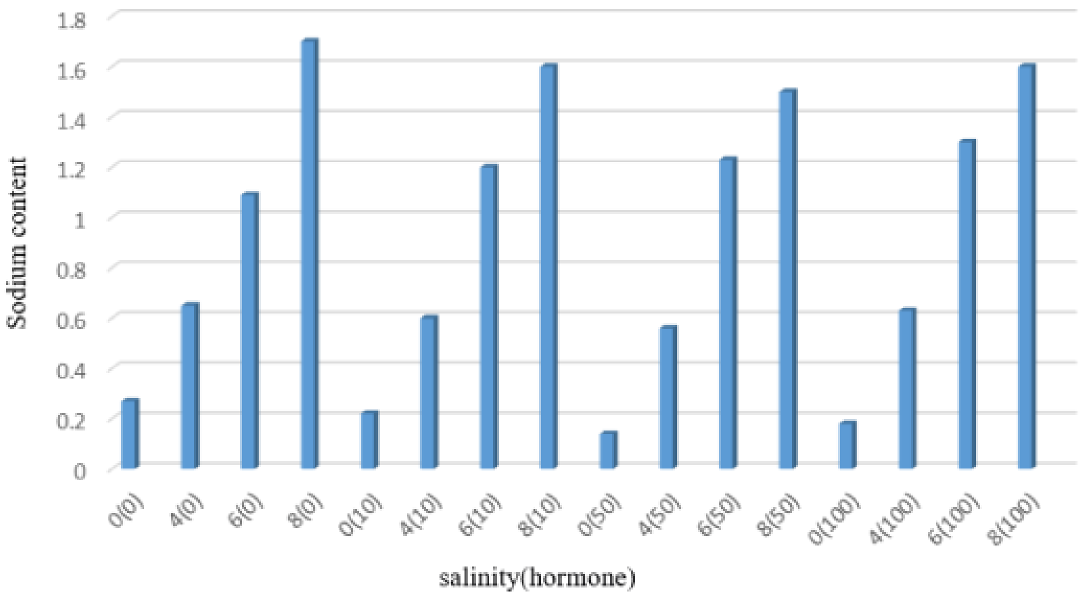

Figure (13). The effect of strigolactone on Sodium content in cucumber plant under different salinity concentration.

4.3.6 The effect of strigolactone on chloride content in cucumber plant under different salinity concentration.

The analysis for chloride content in cucumber plant revealed a highly difference between the treatments. However, spraying cucumber plant with strigloactone have a positive impact on cl content (Fig,7) compared unsprayed plant. Otherwise, treatment of cucumber plant with highest concentration of striglactone with highest salinity concentration revealed better result (4-4.1) than the highest concentration of strigolactone with the lowest concentration of salinity (3.4-3.6) (Fig, 14). In general, strigolactone hormone and salinity level have a highly impact on chloride content for cucumber plant.

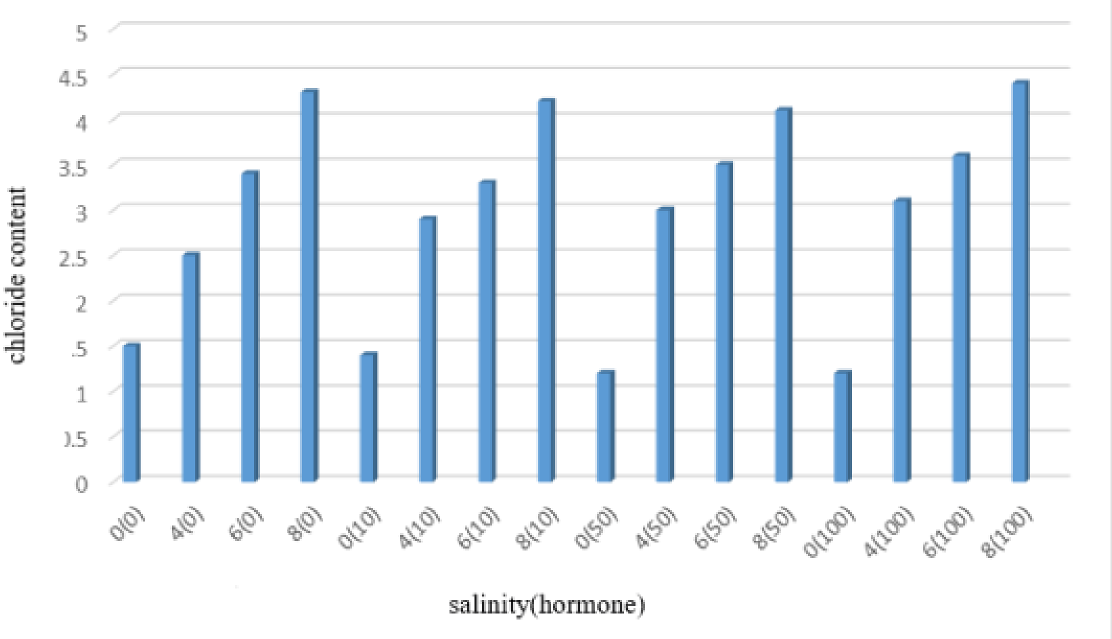

Figure (14). The effect of strigolactone on chloride content in cucumber plant under different salinity concentration.

CHAPTER FIVE

DISCUSSION

5.1 The impact of Strigolactone on productivity and productivity component.

Soil salinization is a major factor contributing to the loss of planted soil productivity. Although it is difficult to estimate accurately, the area of salted soil is increasing, and this is a phenomenon particularly intense in irrigated soils. It is estimated that about 20% (45 million hectares) of irrigated land, which produces a third of the world's food, is affected by salt (Shrivastava et al., 2015). Soil salinity affects an estimated 1 million hectares in the European Union, especially in the Mediterranean countries, and is a major cause of desertification. This study shows the effect of adding the Strigolactone hormone on the cucumber plant grown under the condition of salinity.

Cucumber (Cucumis sativus L.) is one of the most popular vegetable crops in the world, and is considered highly sensitive to salt stress. However, SL was subsequently reported as a root-derived signal that could promote symbiosis between plants and mycorrhizal fungi (AMF), possibly through its ability to induce hyphal AMF branching (Akiyama K et al., 2005). More recently, it has been reported that SLs plays an important role in suppressing plant branching by inhibiting the growth of axillary buds (Umehara M, et al. (2008). Inhibition of shoot branching by new terpenoid plant hormones. Gomez-Roldan V, et al. (2008) Strigolactone inhibition of shoot branching. Nature 455(7210):189–194.). High salt concentrations impose osmotic and ionic stresses on plants leading to many morphological and physiological changes (Jampeetong and Brijx, 2009). Significant plant stunting is observed due to salinity stress (Takemura, et al., 2002). Parreda and Das (2005) reported that the adverse effects of high salinity on plants can be observed at the whole plant level such as plant death and / or reduced productivity. The high salt content, especially chloride and sodium sulfate, affects plant growth by modifying its morphological, anatomical (Huang and Redmann, 1995) and physiological characteristics .The analysis of vegetative parameters in this study showed a significant positive response to strigolactones treatment, as the shoot height (cm) , number of leaves, above ground fresh weight, above ground dry weight, main stem diameter, roots fresh weight (g), roots dry weight (g) for plant with SLs exceed the growth of plant without hormone. For instance, leaf area is an important variable for most physiology and agricultural studies involving plant growth, light interception, photosynthesis efficiency, evapotranspiration. In addition the leaf area index is consider indicator for plant health and productivity. Leaf area is an important variable for most physiological and agronomic studies which considered indicator for plant growth, light interception efficiency, photosynthetic efficiency, evapotranspiration and response to fertilizers and irrigation (Blanco et al., 2005). Vegetable crops are very sensitive to the environmental conditions, such as soil salinity, which generally affects leaf area as well as plant yield and growth (Munns, 2005; Jamil et al.,

2011) (Table 9, see list of appendix). However salinity influence plant growth parameter and cause reduction in leaf area, plant height, stem diameter, fruit production, fresh and dry weight of plant) several study supported this conclusion (Chartzoulakis, 1994; Folegatti and Blanco, 2000; Blanco et al., 2002).

The analysis of data showed that salinity significantly reduce plant productivity by 66% (from 1300 g without salinity to 860.3 g at 4ds\m) on the contrary foliar application of strigolactone showed increase in the productivity by 59% at the same level of salinity. Salinity also influence leaf chlorophyll content which might contribute to the reduction in crop productivity and sugar content (brix)

Our result showed as salinity increase all the aforementioned parameters decrease either in biomass number or length. However as the strigolactone concentration increase vegetative growth parameter enhanced positively. This could be due to the increase production of antioxidant such as chlorophyll, this in agreement with (Nusrat et al., 2014). Torres-Vera, Rocío et al (2014) strigolactones contribute to plant defense.

Strigolactone spraying significantly reduce the effect of salinity on leaf area in which the positive impact of hormone. Otherwise moderate and highly salinity concentration have a negative impact on leaf area compared to strigolactone with salinity and that agreement with (Tester and Davenport 2003), the smaller leaf area of plants under salinity reflects the osmotic effect. The ability of soil solution to inhibit water uptake by plant;

additionally, the decrease in leaf area may be related one of the mechanisms of plant adaptation to salt stress and to decrease the surface of transpiration. Even the salinity has a negative effect at stem diameter as a several researchers reported that with increased salinity there was a decrease in xylem development. Pimmongkol et al., (2002). It was reported that the width of the vascular bundles and the diameters of the rice stems decreased in the NaCl medium. The analysis of data showed that salinity significantly reduce stem diameter from (1.1mm without salinity to 0.9 mm at 6ds\m) on the contrary foliar application of strigolactone showed increase in the stem diameter (from 0.8 to 1 mm at the same level of salinity) .

5.2 Number of leaf

SLs are also recognized as repressors of bud growth Umehara et al., (2008) Therefore, cytokinins act antagonistically with SLs (Dun et al0, 2012). Application of certain concentrations of GR24 to the rms1 mutant plant retarded the growth of lateral bud. Similarly, exogenous application of SLs inhibited shoot branching and growth of axillary buds (Dun et al., 2013; Barbier et al., 2019). The analysis of data showed that salinity significantly reduce number of leaf (from 32.8 without salinity to 23.2 at 6ds\m) on the contrary foliar application of strigolactone showed increase in the leaf number (from 19.6 to 24 at the same level of salinity)

5.3 Plant height

Vegetable crops are very sensitive to the environmental conditions, such as soil salinity, which generally affects plant height as well as plant yield and growth. The results showed that the salinity had a nigative effect on the length of the plant and this agree with Shalhevet mentioned that salinity generally reduces plant height more than root growth. (Shalhevet et al 1995). Also the results showed that salinity reduced the plant height from (75.9 to 63.1 cm at 4 ds\m) on the contrary foliar application of strigolactone showed increase in the plant height from (54 to 74 cm) at same level of salinity concentration this might be sue to the effect of SLs on internode elongation reported by de Saint Germain et al. (de Saint Germain et al., 2013) as the strigolactone hormone also had a positive effect on the plant height without salinity.

5.4 Fresh and dry weight for shoot and root

Salinity has bad effect on above plant fresh weight and dry weight, root fresh weight and dry weight and this agree with (Jamil et al. 2007) observed that shoot length, root lengths and dry weights of paddy were decreased with increasing salt stress. The reduction in root and shoot development may be due to toxic effects of NaCl as well as unbalanced nutrient uptake by the seedlings (Datta et al.). The data analysis showed that the fresh weight reduced from (85.4 to 52.4 gm at 6ds\m) on the contrary foliar application of strigolactone showed positive results at above ground fresh weight from (44.1 to 60.5 gm at same concentration of salinity) and the root fresh weight reduced by salinity from (5.4 to 3.3 gm at 6 ds\m). on the contrary foliar application of strigolactone showed increase in the root fresh weight from (3.9 to 6.3 gm at 4ds\m) this in agreement with Ma, N., et al., 2017 how showed that fresh and dry weight significantly influenced with foliar application of SLs due to regulation of gene expression (Ma, N., et al., 2017)

5.5 Chlorophyll

The data analysis showed that salinity has negative effect on chlorophyll content and that agreed with other studies such as who reported decrease in leaf chlorophyll content under NaCl stress is attributed to the destruction of chlorophyll pigments and the instability of the pigment protein complex (Levit J et al, 1980). It is also attributed to the interference of salt ions with the synthesis of proteins, the structural component of chlorophyll, rather than the breakdown of chlorophyll (Jaleel et al, 2007). In this study chlorophyll content decreased from (50.7 to 33.6 at salinity concentration 6 ds\m). On the contrary foliar application of strigolactone showed increase in the chlorophyll content from (28.8 to 36.9 at same salinity concentration) this in agreement with Ma, N., et al., 2017 as they suggested the effect of SLs on increasing the capacity of photosystem.

5.6 Brix

The data analysis showed that salinity cause increasing for brix content, and that agree with (Bolarin et al., 2001; Chretien et al., 2000; Ehret and Ho, 1986; Li et al., 2001). Increases in sugar and total soluble solids in tomato fruits exposed to salt or water stress are due to decreased water absorption. In this study the brix increased from (2.9 to 3.2 at 4 ds\m salinity concentration) and when applied spraying strigolactone hormone the brix increased from (3.3 to 3.5 at same salinity concentration) which is indicator of increased photosynthetic activity.

Salinity had negative effect at fruit production and this agree with previous studies on the cucumber crop under salt stress (Santana et al., 2010; Medeiros et al., 2009; Colla et al., 2012) and in all of them the salt stress caused reduction in the yield production. On this study salinity had significantly negative effect. Fruit weight reduced from (1300 to 562 gm at 6 ds\m salinity concentration) on the contrary when we applied strigolactone hormone the production increased from (678 to 1150 gm at 4ds\m salinity concentration) the increase in fruit production mighy be attributed to increase in nutrients distribution and photosynthesis activity.

5.7 Chemical analysis

Nitrogen is an essential nutrient for plant growth, development and reproduction. Despite nitrogen being one of the most abundant elements on earth, nitrogen deficiency is probably the most common nutritional problem affecting plants worldwide – nitrogen from the atmosphere and earth's crust is not directly available to plants. Phosphorus is an essential nutrient both as a part of several key plant structure compounds and as a catalysis in the conversion of numerous key biochemical reactions in plants. Phosphorus is noted especially for its role in capturing and converting the sun's energy into useful plant compounds. Potassium (K) is an essential nutrient for plant growth. It’s classified as a macronutrient because plants take up large quantities of K during their life cycle.

Potassium is associated with the movement of water, nutrients and carbohydrates in plant tissue. It's involved with enzyme activation within the plant, which affects protein, starch and adenosine triphosphate (ATP) production. The production of ATP can regulate the rate of photosynthesis. The data analysis showed that salinity has negative affect at nitrogen, phosphorus, potassium content in cucumber plant and that in agreement with Paranychianakis, N.V.et al (2005) results, as they reported that the accumulation of salt in the root zone causes the development of osmotic stress and disrupts the cell ion balance by stimulating the inhibition of uptake of essential elements such as K^+, Ca^{2+} and NO_3 and the accumulation of Na^+ and Cl. The data analysis showed that the best nitrogen content was at control without hormone application, on other hand the hormone application showed positive effect on potassium content in cucumber plant. Salinity have negative effect on calcium content in plant and that agree with

Calcium is an essential plant nutrient. As the divalent cation (Ca^{2+}), it is required for structural roles in the cell wall and membranes, as a counter-cation for inorganic and organic anions in the vacuole, and as an intracellular messenger in the cytosol

Adams, P. (1998) mentioned that symptoms of calcium deficiency are common when the Na^+ / Ca^{2+} ratio is high in the soil water. However, lower calcium uptake by tomato plants has been linked to lower transpiration rate rather than competition effects with Na^+. Treated plant by strigloactone have a positive impact on calcium content compared with un treated plant. Although Sodium is not an essential element for plants but it can be used in a small quantities, similar to micronutrients, to aid in metabolism and synthesis of chlorophyll. In some plants, it can also be used as a partial replacement for potassium and aids in the opening and closing of stomata, which helps regulate internal water balance. Plants take up chloride as Cl- ion from soil solution. (Cerda et al. 1995, Lynch and Lauchli 1985) It plays some important roles in plants, including in photosynthesis, osmotic adjustment and suppression of plant disease. However, high concentrations of chloride can cause toxicity problems in crops and reduce the yield. The toxicity results from accumulation of chloride in the leaves.

The data analysis in this experiment was in agreement with the aforementioned studies, as salinity increase the sodium and chloride content increased in plant. However, data didn't show clear differences between treated plant with strigolactone and control in relation to sodium and chloride content.

5.8 Conclusion

Cucumber plant and most of vegetables plants is highly effected by the salinity in soil or even in irrigation water.

Salinity had negative effect at plant growth and yield**,** using Strigolactone hormone revealed positive effects on the stressed plants to reduce the negative effect of salinity.

Strigolactone hormone has significant effect in alleviating salinity stress on growth parameters (number of leaves, increased, fresh weight of shoot increased, and fresh weight of roots, fruit diameter, fruit length, chlorophyll content increased)

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Appendix

Table(9): Analysis of variance for leaf area of cucumber plant.

Source	DF*	Sum square	Mean square	F-Value	P-Value
T1 salinity	3	287345745	95781915	43.02	0.000
T2 SLs	3	98919369	32973123	14.81	0.000
T1 salinity*T2 SLs	9	183867373	20429708	9.18	0.000
Error	32	71248835	2226526		
Total	47	641381323			

* df mean degree of freedom, SLs strigolactone, P value ≥ 0.0001 highly significant

Table (10): Analysis of Variance for leaf number of cucumber plant.

Source	DF*	Sum square	Mean square	F-Value	P-Value
T1 salinity	3	1857.17	619.056	213.77	0.000
T2 SLs	3	50.50	16.833	5.81	0.003
T1 salin.*T2 SLs	9	123.33	13.704	4.73	0.000
Error	32	92.67	2.896		
Total	47	2123.67			

* df mean degree of freedom, SLs strigolactone, P value ≥ 0.0001 highly significant

Table (11): Analysis of Variance for stem diameter of cucumber plant

Source	DF	Sum square	Mean square	F-Value	P-Value
T1 salin.	3	0.90229	0.300764	46.57	0.000
T2 horm.	3	0.13729	0.045764	7.09	0.001
T1 salin.*T2 horm.	9	0.05354	0.005949	0.92	0.520
Error	32	0.20667	0.006458		
Total	47	1.29979			

df mean degree of freedom, SLs strigolactone, P value ≥ 0.001 highly significant

Table (12) : Analysis of Variance for height of cucumber plant.

Source	DF*	Sum square	Mean square	F-Value	P-Value
T1 salin.	3	8456.31	2818.77	2684.01	0.000
T2 horm.	3	1252.98	417.66	397.69	0.000
T1 salin.*T2 horm.	9	160.65	17.85	17.00	0.000
Error	32	33.61	1.05		
Total	47	9903.55			

* df mean degree of freedom, SLs strigolactone, P value ≥ 0.0001 highly significant

Table (13): Analysis of Variance for above ground fresh weight of cucumber plant.

Source	DF*	Sum square	Mean square	F-Value	P-Value
T1 salin.	3	12880.8	4293.60	2264.51	0.000
T2 horm.	3	1881.5	627.17	330.78	0.000
T1 salin.*T2 horm.	9	134.2	14.91	7.86	0.000
Error	32	60.7	1.90		
Total	47	14957.1			

* df mean degree of freedom, SLs strigolactone, P value ≥ 0.0001 highly significant

Table (14): Analysis of Variance for above ground dry weight of cucumber plant.

Source	DF*	Sum square	Mean square	F-Value	P-Value
T1 salin.	3	1788.10	596.032	456.51	0.000
T2 SLs	3	1215.07	405.024	310.21	0.000
T1 salin.*T2 SLs	9	201.22	22.357	17.12	0.000
Error	32	41.78	1.306		
Total	47	3246.16			

* df mean degree of freedom, SLs strigolactone, P value ≥ 0.0001 highly significant

Table (15): Analysis of Variance for root fresh weight of cucumber plant.

Source	DF*	Sum square	Mean square	F-Value	P-Value
T1 salin.	3	72.842	24.2808	192.32	0.000
T2 SLs	3	10.734	3.5781	28.34	0.000
T1 salin.*T2SLs.	9	10.882	1.2092	9.58	0.000
Error	32	4.040	0.1263		
Total	47	98.499			

* df mean degree of freedom, SLs strigolactone, P value ≥ 0.0001 highly significant

Table (16): Analysis of Variance for root dry weight of cucumber plant.

Source	DF*	Sum square	Mean square	F-Value	P-Value
T1 salin.	3	3.1308	1.04361	42.45	0.000
T2 SLs	3	0.4442	0.14806	6.02	0.002
T1 salin.*T2 SLs	9	0.6108	0.06787	2.76	0.016
Error	32	0.7867	0.02458		
Total	47	4.9725			

* df mean degree of freedom, SLs strigolactone, P value ≥ 0.0001 highly significant

Table (17): Analysis of Variance for chlorophyll content of cucumber plant.

Source	DF*	Sum square	Mean square	F-Value	P-Value
T1 salin.	3	6469.0	2156.34	619.45	0.000
T2 SLs	3	230.2	76.75	22.05	0.000
T1 salin.*T2 SLs	9	157.3	17.48	5.02	0.000
Error	32	111.4	3.48		
Total	47	6968.0			

* df mean degree of freedom, SLs strigolactone, P value ≥ 0.0001 highly significant

Table (18): Analysis of Variance for brix of cucumber plant.

Source	DF*	Sum square	Mean square	F-Value	P-Value
T1 salin.	3	1.2856	0.42854	32.65	0.000
T2 SLs	3	1.2706	0.42354	32.27	0.000
T1 salin.*T2 SLs	9	0.6685	0.07428	5.66	0.000
Error	32	0.4200	0.01313		
Total	47	3.6448			

* df mean degree of freedom, SLs strigolactone, P value ≥ 0.0001 highly significant

Table (19): Analysis of Variance for number of fruits of cucumber plant.

Source	DF*	Sum square	Mean square	F-Value	P-Value
T1 salin.	3	972.42	324.139	219.14	0.000
T2 SLs	3	52.75	17.583	11.89	0.000
T1 salin.*T2 SLs	9	43.42	4.824	3.26	0.006
Error	32	47.33	1.479		
Total	47	1115.92			

* df mean degree of freedom, SLs strigolactone, P value ≥ 0.0001 highly significant

Table (20): Analysis of Variance for fruits weight of cucumber plant

Source	DF*	Sum square	Mean square	F-Value	P-Value
T1 salin.	3	7212503	2404168	1608.77	0.000
T2 horm.	3	280877	93626	62.65	0.000
T1 salin.*T2 horm.	9	198606	22067	14.77	0.000
Error	32	47821	1494		
Total	47	7739807			

* df mean degree of freedom, SLs strigolactone, P value ≥ 0.0001 highly significant

Table (21): Analysis of Variance for fruits diameter of cucumber plant

Source	DF*	Sum square	Mean square	F-Value	P-Value
T1 salin.	3	20.091	6.69687	176.62	0.000
T2 SLs	3	2.457	0.81910	21.60	0.000
T1 salin.*T2 SLs	9	1.052	0.11687	3.08	0.009
Error	32	1.213	0.03792		
Total	47	24.813			

* df mean degree of freedom, SLs strigolactone, P value ≥ 0.0001 highly significant

Table (22): Analysis of Variance for fruits length of cucumber plant

Source	DF*	Sum square	Mean square	F-Value	P-Value
T1 salin.	3	308.94	102.979	298.67	0.000
T2 SLs	3	13.86	4.622	13.40	0.000
T1 salin.*T2 SLs	9	27.01	3.001	8.70	0.000
Error	32	11.03	0.345		
Total	47	360.85			

* df mean degree of freedom, SLs strigolactone, P value ≥ 0.0001 highly significant

Table (23): Inter reaction for vegetative growth

Level of	Level of	N	Leaf area	Leaf Number	Stem diameter	height	Aboveground FW	Root FW	Aboveground DW	rootDW
T1salin	T2horm		Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
0	0	3	14993.3^{A}	34.67^{A}	1.10^{ABC}	72.73^{C}	78.87^{D}	4.83^{EF}	25.23^{E}	1.00^{B}
0	10	3	14775.7^{A}	34.00^{AB}	1.07^{ABCD}	74.33^{C}	82.17^{C}	4.43^{FG}	28.53^{D}	0.70^{CD}
0	50	3	11804.3^{CDE}	31.33^{B}	1.10^{ABC}	76.07^{B}	88.13^{B}	5.47^{CD}	34.53^{C}	0.77^{BCD}
0	100	3	14573.3^{AB}	31.33^{B}	1.17^{A}	80.83^{A}	92.43^{A}	6.87^{A}	42.37^{A}	1.37^{A}
4	0	3	10781.7^{DEF}	25.33^{CD}	0.93^{DE}	54.67^{G}	55.17^{H}	3.97^{GH}	19.07^{GH}	0.53^{DEF}
4	10	3	11963.7^{CD}	28.00^{C}	1.03^{ABCD}	57.67^{F}	59.10^{FG}	5.07^{DE}	21.00^{F}	0.53^{DEF}
4	50	3	11625.3^{CDE}	31.67^{B}	1.07^{ABCD}	66.00^{D}	66.43^{E}	6.03^{BC}	28.57^{D}	0.60^{CDE}
4	100	3	12130.7^{BCD}	28.00^{C}	1.13^{AB}	74.13^{C}	77.73^{D}	6.33^{AB}	37.27^{B}	0.80^{BC}
6	0	3	11431.3^{CDE}	19.67^{E}	0.83^{EF}	44.70^{I}	44.17^{J}	3.57^{HI}	15.93^{IG}	0.23^{G}
6	10	3	4546.3^{H}	23.67^{D}	0.83^{EF}	47.30^{H}	48.03^{I}	3.20^{IJKL}	17.57^{HI}	0.37^{EFG}
6	50	3	9340.3^{EFG}	24.00^{D}	1.00^{BCD}	53.07^{G}	57.13^{GH}	3.30^{IJ}	20.27^{FG}	0.40^{EFG}
6	100	3	13729.0^{ABC}	25.33^{CD}	0.97^{CDE}	60.33^{E}	60.56^{F}	3.27^{IJK}	27.47^{D}	0.37^{EFG}
8	0	3	8516.3^{FG}	14.00^{G}	0.67^{G}	36.13^{L}	35.33^{L}	2.17^{M}	13.90^{K}	0.40^{EFG}
8	10	3	2100.0^{H}	15.00^{FG}	0.73^{FG}	37.87^{K}	38.07^{K}	2.63^{LM}	15.30^{JK}	0.33^{FG}
8	50	3	10644.3^{DEFG}	17.67^{EF}	0.83^{EF}	41.23^{J}	43.90^{J}	2.70^{KLM}	18.00^{H}	0.23^{G}
8	100	3	8227.3^{G}	17.67^{EF}	0.77^{FG}	46.23^{HI}	47.47^{I}	2.90^{JKL}	19.37^{FGH}	0.37^{EFG}

Table (24): Inter reaction of productivity

Level of T1salin	Level of T2horm	N	Chlorophyll content Mean	brix Mean	Fruits number Mean	Fruit weight Mean	Fruit diameter Mean	Fruit length Mean
0	0	3	48.80^{B}	2.90^{HI}	20.67^{BC}	1261.00^{B}	3.67^{AB}	16.46^{A}
0	10	3	50.13^{AB}	3.03^{FGH}	20.33^{C}	1216.67^{B}	3.43^{B}	16.00^{AB}
0	50	3	52.47^{A}	2.80^{I}	23.00^{A}	1367.00^{A}	3.50^{AB}	16.10^{AB}
0	100	3	51.47^{AB}	3.07^{FGH}	22.67^{AB}	1356.67^{A}	3.77^{A}	15.70^{AB}
4	0	3	33.57^{E}	3.30^{CD}	13.00^{E}	678.00^{F}	2.57^{D}	10.60^{EF}
4	10	3	34.40^{DE}	3.27^{CDE}	15.00^{DE}	765.00^{E}	2.60^{D}	11.83^{D}
4	50	3	37.43^{D}	2.90^{HI}	17.00^{D}	848.33^{D}	2.93^{C}	13.53^{C}
4	100	3	45.20^{C}	3.53^{AB}	19.67^{C}	1150.00^{C}	3.57^{AB}	15.20^{B}
6	0	3	28.83^{F}	3.63^{A}	13.33^{E}	469.00^{I}	2.03^{EF}	10.00^{FGH}
6	10	3	33.03^{E}	3.50^{AB}	14.67^{E}	558.33^{H}	2.10^{E}	10.47^{EFG}
6	50	3	35.23^{DE}	2.97^{GHI}	14.67^{E}	592.00^{GH}	2.53^{D}	10.73^{EF}
6	100	3	36.90^{D}	3.17^{DEF}	14.33^{E}	629.33^{FG}	2.80^{CD}	11.17^{DE}
8	0	3	17.83^{G}	3.40^{BC}	8.33^{F}	209.33^{K}	1.73^{F}	8.80^{I}
8	10	3	17.77^{G}	3.43^{BC}	9.33^{F}	238.67^{JK}	1.73^{F}	9.80^{FGH}
8	50	3	18.33^{G}	3.10^{EFG}	9.00^{F}	263.33^{JK}	1.93^{EF}	9.43^{HI}
8	100	3	18.80^{G}	3.57^{AB}	9.67^{F}	285.00^{J}	2.00^{EF}	9.60^{GHI}

جامعة النجاح الوطنية

كلية الدراسات العليا

تأثير هرمون (Strigolactones) على نمو وإنتاجية نبات الخيار تحت ظروف الملوحة

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

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الملخص

أجريت التجربة الحالية في حرم جامعة النجاح في مدينة نابلس شمال الضفة الغربية، وهدفت هذه الدراسة لتقييم تأثير مستويات الملوحة المختلفة على نبات الخيار في وجود أو عدم وجود هرمون (strigolactone) تمت معاملة محصول الخيار بإضافة تراكيز مختلفة من هرمون (strigolactone) مع اضافة مستويات ملوحة مختلفة (ds\m 6,4,8) باستخدام كلوريد الصوديوم, وتم استخدام نفس المحصول وبنفس الظروف كشاهد لجميع المعاملات. بحيث أشارت هذه الدراسة أن الإجهاد الملحي بدون المعالجة بهرمون (strigolactone) أثّر سلبيا على نمو وإنتاجية الخيار(مساحة الورقة، عدد الأوراق، قطر الساق، ارتفاع الساق، الوزن الرطب والجاف فوق الأرض، الوزن الرطب والجاف للجذر، محتوى الكلوروفيل، محتوى السكر، عدد الثمار، وزن الثمار، قطر الثمار، طول الثمار، محتوى النتروجين، الفوسفور، الكالسيوم، الصوديوم، والكلوريد)، بالإضافة الى زيادة نسبة الصوديوم والكلوريد في الأوراق، وانخفاض امتصاص العناصر الكيميائية الهامة الأخرى، مما يشير إلى الآثار السلبية للملوحة على الخيار. في حين أن استخدام هرمون (strigolactone) يخفف من تأثير إجهاد الملوحة ويحسن من نمو وإنتاجية الخيار. من ناحية أخرى، أدت المعالجة بهرمون (strigolactone) إلى تحسين طول النبات، عدد الأوراق، الكتلة الحيوية النباتية، عدد الثمار، وزن الفاكهة، محتوى الكلوروفيل، وهيكلية الجذر، امتصاص البوتاسيوم، والكالسيوم، والفوسفور. من خلال التحليل الاحصائي تبين ان نسبة الري بمستوى ملوحة بتركيز (ds\m4) ادى الى انخفاض محصول النبات بنسبة (66%) مقارنة بالشاهد، كما ان عدد الأوراق قل بنسبة (71%) بالمائة. من ناحية أخرى، ملوحة بتركيز(ds\m 6) ادت الى انخفاض في تركيز الكلوروفيل بنسبة (66%) مما يشير إلى التأثير الضار للملوحة والتسبب في

ضعف النبات. عند تركيز(ds\m4)، ادى رش هرمون (strigolactone) الى زيادة المحصول بنسبة (59%). مما ينتج من خلال هذه التجربة ان التأثير السلبي لملوحة التربة على نبات الخيار يمكن تقليله عن طريق العلاج بهرمون (strigolactone).