An-Najah National University

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Salt Stress Response in Hydroponic Tomato (*Solanum lycopersicum L*) Treated with Plant Growth Promoting Bacteria *(PGPB)*

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Dedications

My efforts exerted in completing this work, which had a great role in achieving my ambitions in the master's degree, to give it to my father and mother and to my family.

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الاقرار

أنا الموقع أدناه، مقدّم الرسالة التي تحمل العنوان:

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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: عفاف طلال صالحات

Signature: التوقيع:

Date: التاريخ: 14/2/2021

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List of Abbreviations

C°	Celsius
CFU	Colonies forming Units
Cm	Centimeter
dS m^{-1}	Desiemens per meter
DW	Distilled Water
Ec	Electrical Conductivity
Ecw	Electrical conductivity for irrigation water
FAO	Food and Agriculture Organization
g	Gram
h	hour
M	Molar
ml	Millilieter
mM	milliMolar
Mpa	Mega Pascal
NFT	Nutrient Film technique
O.D	Optical Density
P . *fluorescence*	*Preseudomonas fluorescence*
PGPB	Plant Growth Promoting Bacteria
PGPR	Plant Growth Promoting Rhizobacteria
PPM	Part per million
ROS	Reactive Oxygen Species
Rpm	Revolutions per minutes
T	Temperature
TDS	Total Dissolved Solids
TSS	Total Soluble Solids
V	Volume
wt	Weight

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Abstract

This research was designed to evaluate and measure the impact of various level of sodium chloride (NaCl) on tomato plant in the presence or absence of *Pseudomonas fluorescence* bacteria. The study conducted under hydroponic system using one variety of tomato plant under different salinity levels (0,100,150) mM with and without *P. fluorescence*.

The lines in the system was irrigated with different concentrations of NaCl, each salinity level was subjected to inoculation with *P. fluorescence* and no inoculation. The result of this study showed that salt stress without *P. fluorescence* inoculation caused reduction in growth and yield parameter such as (shoot height, fruit number, flowering intensity, number of leaves, root mass, and fresh and dry weight.....). the most remarkable effect of *P. fluorescence* inoculation was a twofold increase in flowering intensity and fruit number and more than threefold increase in fruit weight. Which indicate higher productive due to the *P. fluorescence* inoculation.

The chemical analysis showed accumulation of sodium and chloride in root for inoculated plant with bacteria in relation to salinity and no interaction between bacterial inoculation and salinity in Ca, N, Na and Cl leaf content, which might indicates a response of osmotic potential. results

that plant inoculated with *P. fluorescence* revealed less N content than non-inoculated plant with 0.18% compared to 0.29% respectively.

However, Plant Growth Promoting Bacteria (PGPB) can improve and enhance plant growth and development, also stress adaptation in present of salinity this lead to improve and enhance plant growth and yield.

The inoculation of remarkably of *P. fluorescence* increased plant height, number of leaves and flower, total biomass of plant, early flowering, enhance root system also increased absorption of (K and P) in root and leaf, The Ca in root was 5% for inoculated plant with *P. fluorescence* at control level compared with 4.83% for non-inoculated plant at the same level of salinity. Plant inoculated with *P. fluorescence* showed moderate tolerance to salt stress than non-inoculated plant.

Many studies revealed that the effect of high salinity on bacteria activity throw increase osmotic strength and toxic effect but present of salt tolerant bacteria as (*P. fluorescence*) might increase productivity of plant under saline condition.

The study revealed that the effect of saline irrigation water in (hydroponic system),degree of effect that reduced by addition of *P. fluorescence* to plant than non-inoculated.

Chapter One
Introduction

1.1 Introduction

Plants in general respond and perceive quickly to the environmental changes. Plants have incubated within a complicated biochemical, physiological and molecular mechanisms to adapt into various stresses. The plants stress divided due to its origins into two basic types, those are: The a biotic stress which include of physical or chemical reactions (light, salinity…etc.). The second is biotic stress which caused by living organism (bacteria, fungus…etc.) (Kovács, 2017). Plants count on a phytohormones array to regulate responses of biotic and a biotic stresses (Bostock et al, 2014).

One of the most important plants around the world is the tomato (*Solanum lycopersicum*), It considered as the second most significant horticultural product with great economic importance which is cultivated in the worldwide. Tomato has its food importance which led to be bred in order to improve productivity, fruit quality, and resistance to all stress's types. Tomato has been widely also used as a research material which considered as organism model of the Solanaceae family which made it take a huge place as a main subject of the studies (Kimura & Sinha, 2008; Gutierrez, 2018). Moreover, tomato has a high content of potassium and antioxidants such as Vitamin A, ascorbic acid, lycopene, and tocopherols

which offers a beneficial effect on the human being health (Naranjo et al, 2016; Renna et al, 2018).

On the other hand, one of the most common affective a biotic stresses worldwide is the soil saline which is an agriculture virtual problem that decrease plants growth and reduce the crop productivity (Allakhverdiev et al, 2000; Munns, 2002). Salinity is a prevailing stress that generates Reactive Oxygen Species (ROS), and those are (H_2O_2), (O^{-2}) and (OH^-) which lead to the damages in the plants DNA, RNA and proteins (Jaleel et al, 2009; Mittler, 2002). These ROS also lead to the destruction of clorophy11 and damage the activity of root meristem (Foeman et al, 2003).

The records of soil Stalinization history can be followed even since the early civilization centuries where the humanity and salinity have lived aside each other. In Mesopotamia there is a good proof of early civilizations that flourished and failed according to human-induced Stalinization.

In later soil salinity records it was considered as a dynamic and globally spreading issue in over than 100 countries; there is no continent completely free from salinity, where the affected salt areas in each continent are Australia 38.4%, Asia 33.9%, America 15.8%, Africa 8.6%, Europe 3.30% (Abrol et al. 1988; Szabolcs 1974; Massoud 1977). Its projected in the future that Soil Stalinization will increase due to the scenarios of climate change, sea level rise, coastal areas impact, and

temperature rise which will inevitably lead to increment evaporation and extra Stalinization. Soil salinity can affect the ecosystems to an extent where they no longer can provide ‘environmental services’ to their full potential. It can be assumed according to the earlier gathered data in the 1970s and 1980s, salinization has expanded as newly affected areas most probably exceed the areas restored through rehabilitation and reclamation (Shahid et al, 2018).

Soil salinization is one of the serious problems that is increasing steadily in many regions of the world, precisely in arid and semi-arid areas (Abdel Latef, 2010). There is a long list of countries where salt-induced land degradation occurs. Some well-known regions where salinization is extensively reported include the Aral Sea Basin in Central Asia, the Indo-Gangetic Basin in India, the Indus Basin in Pakistan, the Yellow River Basin in China, the Euphrates Basin in Syria and Iraq, the Murray-Darling Basin in Australia, and the San Joaquin Valley in the United States (Qadir et al. 2014). Salinity affects 50% of cultivated lands and 20% of irrigated lands around the world, while Food and Agriculture Organization (FAO) statistics salinity affects 800 million hectares of lands worldwide (Cheng et al, 2012; Hernández, 2019). Salinized soil occupies 7% of the earth’s surface land (Ruiz-Lozano et al., 2001) and in arable land increased salinization lead to 50% land loss through the 21st century middle years (Wang et al., 2003). At the present time, around 77 million hectares out of 1.5 billion hectares which is around of 5% of the worldwide cultivated land is affected by excess salt content (Sheng et al., 2008). In agriculture, the

usage of saline water gradually increased in front of the short usage of fresh water. Accordingly, areas affected by Salt increased while arable lands abandoned due to salinity (Habib et al, 2016).

In Palestine, salinity is a main threat where the lands in West Bank is composed mostly of limestone hills with heights from 700 to 900 meters, the lowest point is the dead sea area with 410 meters below the sea level while the highest is Tall Assure with 1,022 meter above the sea level, 12% of the West Bank land is desert, saline or eroded. Furthermore, the water in West Bank has a high salinity, according to spring saline presence and the return of irrigation water. Moreover, Jericho city one of the most affected cities of soil salinity in West Bank which is related to its location near Jordan River; the salinity problem is rapidly spreading due to the huge accumulation of chemicals such as fertilizers and pesticides in addition to the low rainfall percentage which makes the dilution very slow (United Nation Environment Programme, 2002).

On the other side of Palestine lands, Gaza Strip lands and those are a sand dune along the Mediterranean Sea, it’s a foreshore plain form that slopes up to 90 meters elevation, where the sea is warm and saline. However, the main reason of Stalinization in West Bank and Gaza Strip is the subterranean saline water bodies with other natural environmental effects that expected to escalate the salinity threat in Palestinians lands. Accordingly, desalination became increasingly one of the most important

strategies in Palestine in order to achieve environmentally sustainable use of the lands (United Nation Environment Programme, 2002).

Salinity tolerance property is not a simple attribute, but it is a result of several features that depend on different physiological interactions, which are complicated to determine. The morphological appearance appeared on the plant in response to salinity, may not be enough to specify salinity effect accordingly it is important to perceive other factors such as the physiological and biochemical, those include toxic ions, lack of elements, osmotic potential and other disorders, as well as the interactions within or between these several stresses (Munns, 1993, 2002; Neumann, 1997; Yao, 1998; Hasegewa et al., 2000).

The effect of salt stress on plants growth can't be strictly determined, but the main effects are: the huge connection between the decrease in plant length and the increase in the sodium chloride concentration (Houimli et al., 2008; Rui et al., 2009; Memon et al., 2010). Several studies showed that the effect of different NaCl concentrations is negative on the leaf area (Zhao et al., 2007; Yilmaz and Kina, 2008; Rui et al., 2009). The salinity has also a harmful influence on the leaf number which increases with the increase in concentration (Jamil et al. 2005; Gama et al. 2007; Ha et al. 2008). The shoot system fresh and dry weights are also affected by saline soil, either negatively or positively through the changes in salinity concentration (Rui et al., 2009; Taffouo et al., 2009, 2010; Memon et al., 2010). Increasing the negativity of the osmotic

potential of the leaf sap is a result of salt stress of many plants undergo osmotic regulation (Kaymakanova and Stoeva, 2008; Kaymakanova et al., 2008). Salinity although has an inhibitory effect on biochemical processes, of which photosynthesis is the most important. The studies of (Misra et al., 2006; Murillo-Amador et al., 2007; Taffouo et al., 2010) clearly indicated that salinity reduces the pigments content of photosynthetic in treated plants. Protein content can also be affected negatively or positively by salt stress (Beltagi et al., 2006; Chen et al., 2007; Kapoor and Srivastava, 2010) these studies also demonstrated changes in protein content in plants treated by various salt concentrations.

Agriculture plays a pioneering role in the development of economic in many countries. However, salinity, which affects most world areas, represents one of the main obstacles that terminate the expansion of the agricultural area or the agricultural production evolution for many crops. High salinity caused mainly by the high soluble salts concentration in irrigation waters and the high evaporation rate caused by the high temperatures, inefficient drainage, or soil type. Tomato is one of the important economic crops used as food for both people and animals, besides its capacity to tolerate salinity.

In light of these problems and other factorial struggles made by the occupation against the Palestinians to enhance their lands and environment, this study investigates an approach that can help in minimizing salinity effects on plants in Palestine, the method assessed on the most essential and

economical plant which is tomato. Where the study examines the effects of inoculation with a strain of *Preseudomonas fluorescence* on the plant growth it is a widespread species that survive in the soil and the water with various chemical textures under various climatic statuses. It has a robust variability with secondary pathogen for nosocomial infections. The study examined under hydroponic system which is a modified and customized mechanism due to nutrition solution and supporting media reuse and recycling. Although it is the most popular technique in relative to its efficient resource's management and food production.

1.2 *Preseudomonas fluorescence*

Generally, *Preseudomonas fluorescence* is a widespread species that survive in the soil and the water with various chemical textures under various climatic statuses. Because of its robust variability it is a secondary pathogen for nosocomial infections. In phytopathology, it is recognized as a portion of the soil resident microflora and as a co-pathogen in several plants' diseases (Stoyanova & Bogatzevska, 2015). *Preseudomonas fluorescence* is a heterogeneous species that is classified mainly as a saprophyte but it also associated with food spoilage (Palleroni, 1984).

The group of *P. fluorescence* species are mainly based on a diverse group of bacteria that can in general be visually distinct from other pseudomonades' through their ability in producing a water-soluble yellow-green pigment. According to (Palleroni et al, 1973) who defined it as they are "typically gram-negative, chemo heterotrophic motile rods with polar flagella

and are grouped in rRNA homology group I". This method of classification provides the division of all *Pseudomonas spp.* types to five groups based on the relationship to their rRNA genes, which in the evolution course undergo fewer changes than most other DNA sequences. *Preseudomonas fluorescence* as mentioned before is divided into five biovars (Palleroni, 1984). Biovar V is the most diverse in the strains of nutritional needs and it includes of strains that have lost some diagnostic characteristics (Palleroni, 1984; Bradbury, 1986). The strains of phytopathogenic cause soft rot in onions, garlic, hyacinth, gloxinia, dahlia, lettuce, cabbage, alfalfa, flax, tobacco, potato and some lesser-known plants in Russia and Europe. Atypical strain is the pathogen of cacti six genera (Kabashna, 1975; Bradbury, 1986). The types of *Preseudomonas fluorescence* that known as plant pathogens are beneficial for plants. Several strains lead to systemic resistance induction, it's a phenomenon where plants hypersensitive response is activated instead of disease development, through at least two mechanisms (Nelson, 2004; Compant et al, 2005). Moreover, *fluorescence preseudomonads* have simple requirements of nutrition's which is reflected by the relative to these organism's abundance in nature. Those organisms found in soils, foliage, sediments, fresh water, and seawater. The group species type, *Preseudomonas aeruginosa*, is classified as a secondary pathogen of animals. The *fluorescence preseudomonads* as a group are of primary significance in diverse areas such as medical pathogenicity, food spoilage, plant pathogenicity, and biological control (O'sullivant & O'gara, 1992)

Through the last three decades, research illustrated the implicit potential of exploiting certain bacteria for the biocontrol of plant crop diseases. According to (Burr & Caesar, 1984; Schroth & Hancock, 1981) plant growth promotion rhizobacteria have been isolated and demonstrated to protect plants root crop. While due to (Lifshitz et al, 1981) some plant growth-promoting rhizobacteria can promote plant growth through plant hormones secreting. Due to (Kloepper et al, 1988; Kloepper et al, 1980; Suslow, 1982; Suslow & Schroth, 1982) *Fluorescent Pseudomonas spp*. have been emerged as the largest and most promising group with high potential for plant growth-promoting rhizobacteria(PGPR).

P. fluorescence species for plant growth stimulation highly reported, where the bacteria ideally suited as soil inoculants because of their rapid potential. This feature alone is suggested as a disease control mechanism by preventing the detrimental soil microorganism's invasion onto the root surface (Altman, 1970). Significant increases in potatoes growth and yield in greenhouse and field trials reported by (Burr et al, 1978; Kloepper et al, 1988; Geels et al, 1986) with specified strains. Sugar beet yield increased from 20 to 85%, for disease control by *fluorescence preseudomonas* obtained in greenhouse trials (Suslow & Schroth. 1982). The root and shoot fresh weight increased for tomato, cucumber, lettuce, and potato as a bacterization result of Preseudomonas strains documented by (Van & Schippers. 1988). *Fluorescent Pseudomonas* has been also implied in the control of phytophthora root rot of soybean (Lifshitz et al, 1987), tobacco black root rot (Keel et al, 1989), potato seed decay according to Erwinia

carotovora (Xu & Gross, 1986), several wilt diseases according to Fusarium spp. (Kloepper et al, 1980; Scher & Baker, 1982; Sneh et al, 1984), besides the fungal diseases of orange and lemon citrus roots (Gardner et al, 1984) and ornamental plants (Yuen & Schroth, 1986).

1.3 Hydroponic System

The word hydroponics derived from a combination of two Greek words, *hydro,* which means water, and *ponos,* which means labor "working water". Hydroponic growing techniques began experimentally in the late 1920s (Gericke, 1940; Glass, 1989). Gericke suggested that the capability of crops production would no longer be "chained to the soil but certain commercial crops could be grown in larger quantities without soil in basins containing solutions of plant food". Gericke failed to contemplate that the hydroponic growing would be essentially bounded to enclosed environments for growing high cash value crops and would not find its way into a wide range production of commercially grown crops in an open environment (Jones, 2014; Gericke, 1940).

Hydroponics have many definition statements through dictionaries and encyclopedias, it defined by (*Webster's New World College Dictionary,* 4th edition, 1999) as "the science of growing or the production of plants in nutrient-rich solutions or moist inert material, instead of soil"; according to the (*Random House Webster's College Dictionary,* 1999) defined as "the cultivation of plants by placing the roots in liquid nutrient solutions rather than in soils; soilless growth of plants"; while in the

(*Encyclopedia Americana*, international edition, 2000), hydroponics is defined as “the practice of growing plants in liquid nutrient cultures rather than in soil”

The definitions of hydroponics differ due to various books and articles, the most comprehensive definition implied by (Devries, 2003) who defined hydroponic plant culture as “one in which all nutrients are supplied to the plant through the irrigation water, with the growing substrate being soilless (inorganic), and that the plant is grown to produce flowers or fruits that are harvested for sale”. In addition, “Hydroponics used to be considered a system where there was no growing media at all, such as the Nutrient Film Technique(NFT) in vegetables. But today it’s accepted that a soilless growing medium is often used to support the plant root system physically and provide for a favorable buffer of solution around the root system”.

Figure 1:Hydrobonic System

Among the previous hydroponic definitions, it can be generally defined as a plant growing technique in nutrition solution with or without the usage of inert medium in order to provide the mechanical support. Purdue University researchers in 1940 developed nutria-culture system, through 1960s and 70s many countries developed commercial hydroponics farms. However, most hydroponic systems automatically operate in order to control the amount of water, nutrients and photoperiod based on different plants requirements (Resh, 2013; Sharma et al, 2018). Methods for sufficiently food growth have been evolved due to the urbanization and industrialization. Growth medium modification is an alternative for sustainable production and to conserve land and water resources. In the present scenario, soil less cultivation might be initiated successfully and its alternate option for healthy food growing plants, crops or vegetables (Butler and Oebker, 2006).

Agriculture without soil mechanisms includes hydro agriculture (Hydroponics), aqua agriculture (Aquaponics) and aerobic agriculture (Aeroponics) besides the substrate culture. Among these hydroponics techniques is the most popular because of its efficient resource's management and food production. The Hydroponic system is modified and customized due to nutrition solution and supporting media reuse and recycling. The most common used systems are the wick, ebb-flow, drip, nutrition film technique (NFT), and deep-water culture (Sharma et al, 2018)

Improving salt tolerance is one of the farthest soil problems, despite the massive work amount that has been done on it most studies evaluated genetic variation in salt resistance in crop plants had been performed in controlled or semi-controlled environments at single level of salt stress with no validation of the results under field conditions. The majority of work on developing selection criteria for salt tolerance improvement has been done using solution culture, either in hydroponic or supported hydroponic systems (Munns *et al*. 2002; Genc *et al*. 2007), or by using sand-based systems (Munns 2002), with the potential supposition of the Na+ exclusion differences in hydroponic systems it will result in improved field performance. Strong proof to support this is the ability and lacking of the solution culture to identify genotypes that have optimum yield under stressed conditions within the field needs (Gregory *et al*. 2009). The soil solid matrix can affect salinity in two primary ways; First, the soil influences cation exchange complex where the relative cations and anions activities in the soil solution, is a factor that does not take place in hydroponics. Second, an important salinity feature in the field is the effects of the soil's physical properties, in addition to the soil solution characteristics, together determines soil water potential and water uptake. Plants growing in saline soils not only have to cope with the effects of soil solution high salts but also with the effects of the potential soil matric, whereas water uptake in hydroponics is only affected by the nutrient solution osmotic potential (Tavakkoli et al, 2012).

Furthermore, studies made under controlled conditions generally involve imposing Stalinization on seedlings over a relative short period whereas the salinity stress in the field effects on a higher level of spatial and temporal variation (James et al., 2008; Rajendran et al., 2009; Kopittke et al., 2011; Tavakkoli, 2011). Although, efforts to improve crop yields under salinity stress also had a limited success because of the mechanisms available knowledge of salt tolerance has not been turned into beneficial selection criteria to evaluate a genotypes wide range within across species. Experiments have been made to assess salt tolerance at germination and emergence stages in wheat and barley, and large genotypic differences were reported (Munns et al., 2000; Chen et al., 2008; James et al., 2008), but this early assessment appears to have little relationship to the overall performance under saline conditions (Munns et al., 2002).

Where the expected outcome is the toxicity effect reduction of saline water in plant which will be associated with increase in growth and production. Where this research focus on answering the following questions:

1. What is the impact or function of *Preseudomonas fluorescence* on tomato plant irrigated with saline water?

2. What is the impact or function of *Preseudomonas fluorescence* inoculums on tomato using the hydroponic system?

1.4 Objectives

The study objectives divided into two main sections, those are the general objectives where the main work idea introduced and the specified objectives where the sub ideas of the work described.

1.4.1 General Objectives

The study investigates the effect of *Preseudomonas fluorescence* on hydroponic tomato plant irrigated with saline water.

1.4.2 Specific Objectives

The specific objectives are the sub objectives of the main idea and those are:

1. To evaluate the impact of *Preseudomonas fluorescence* on the growth of tomato plant under saline stress conditions.
2. To determine the impact of salinity on some plant growth parameters in the presence or absence of *Preseudomonas fluorescence* to assess the role of *Preseudomonas fluorescence* on improve tolerance of tomato to salinity condition.
3. To determine the growth responses of tomato plant grown under hydroponics system with induced salinity in the presence *Preseudomonas fluorescence.*

Chapter Two
Literature Review

Literature Review

This section of the research concentrates on the study background and the 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. Also, will consider the symbiotic association with Tomato plant that may reduce the effect of salinity on the plant. This review will be classified under the following topics:

2.1 Soil Salinity

According to (Egorov et al, 1997) the soil salinity defined as “The group of salt-affected soils includes soils containing soluble salts or their ions in at least one of their horizons in quantities that are above the threshold of toxicity – the maximal permissible concentration of salts that does not suppress plant growth”.

According to the previous definitions, the researcher define salinity as a major factor that menace agricultural crops capacity to sustain the human population growth. High soluble salts concentration is the main characteristics of salinity which reduce the crops yield significantly. Saline soils are the soils with Electrical Conductivity (EC) of soil saturation that extract more than 4 dS m^{-1} at 25°C and generates osmotic pressure with 0.2

MPa. Generally, salts found in saline soils include sulfates and chlorine of Ca, Mg, K and Na.

Saline soils can be characterized as: (Sharm et al, 2016)

1. Very high soluble salts concentration in the soil solution that accordingly lead to a high osmotic pressure in the soil solution. The osmotic pressure related the up taken water and plant growth. This results plants wilting and nutrient deficiency. The content of more of 0.1% of the salts is injurious to the growth of plants.

2. Soil saturation Electrical Conductivity (EC) extraction is important for the saline soil assessment for the plant growth, it expressed in dS m^{-1}. The salinity affect is negligible under 2 dS m^{-1}. Very sensitive crops have yields restricted between 2 and 4 dS m^{-1}, while many crops have yields restricted to 2 and 8 dS m^{-1}. Moreover, tolerant crops yield only have a satisfactory between (8 – 18)and (2 - 4)dS m^{-1}.

3. The determination of boron concentration of water-soluble is a substantial parameter for saline soils characterization. The boron concentration is unsafe for plant growth in the case it was above 1.5 ppm.

4. Another important soil saline characteristic is the soil texture. In which the sandy soil with 0.1% concentration of salt cause injury to the common crop’s growth, while in clay soils crops grow normally with the same salt concentration. Saturation percentage is a characteristic

property for each and all soils. Soil texture and EC simultaneously extracted for salinity appraisal.

There are two main types of soil salinity, the first is primary salinity according to natural resources which occurs in soils and water. The processes of natural salt accumulation associated with specified types of relief, hydrogeological and geomorphological conditions. It implied with high table of groundwater, impeded or absence of drainage with only the processes of evaporation and transpiration to control the groundwater table. The second type is the secondary salinity due to irrational use of the land inappropriate practices of the agriculture which occurs as an outcome of excessive input of water through the leaching and irrigation of soils in the case of appropriate drainage system absence which lead to rapid raising of groundwater table (Chirva et al, 1990).

The soil salinity is a complex multi-functional phenomenon which caused by various factors. The major source of soil salinity are salts presented originally within parent materials, mineralized ground and surface waters as well as wind-blown deposits. Stalinization causes can be classified as followed:

The Natural Cause: The development of most sodic and saline soils is due to the natural geological, hydrological and pedological processes. Some of the parent materials of those soils include the igneous rocks, volcanic rocks, sandstones, and alluvium deposits (Wanjogu et al., 2001). Another major natural salinization causes are the factors of climate

and management of water. In arid and semi-arid lands evaporation and transpiration processes play a vital role in the pedogenesis of saline and sodic soils. In coastal areas, another type of salinity occurs due to tides and the main cause is saline water intrusion into rivers (Cyrus et al., 1997) or aquifers (Howard and Mullings, 1996). Coastal crops in Asia are frequently affected by sea water exposure introduced by cyclones around the Indian Ocean (Sultana et al., 2001). Rainfall lead to wind and deposited that carried ocean salts inland and those are cyclic salts, and are mainly sodium chloride. Depending on prevailing winds and distance from the sea-coast the composition of rain water greatly varies.

Anthropogenically induced salinity: The salinization of secondary salt affected soils are caused by human factors, fundamentally as a consequence of improper irrigation methods. Poor quality water is predominantly used for irrigation, which eventually builds up the salt within the soil unless the irrigation system management is in the case of salts are leaching from the soil profile. According to (Szaboles,1992) estimated that fifty percent of all irrigated planners are salt affected.

2.2 Salinity Effect on Plant Growth

In high salt environment plants are stressed in two ways, firstly, the imposed water stress by the rooting medium osmotic potential boost as a result of high-solute content, secondly, the toxic effect of ions high concentration. Few plant species have adapted to saline stress, but the majority plants crops are susceptible, they may not survive or survive but

with low yield. Soil salinity cause the reduction in biomass production by affecting substantial physiological and biochemical processes of the plant (Ahmad and John, 2005; Ahmad, 2010; Ahmad and Sharma, 2010).

In the case of low salt concentrations, yields are either mildly affected or not affected at all (Maggio et al. 2001). Through the salt concentration raising the yield reduction is drastic in which most plants crops are not able to grow at high salt concentrations. On the contrary, halophytes can survive salinity and have the capability to grow on saline soils of coastal and arid regions due to specific salt tolerance mechanisms development during their adaptation of phylogenetic. High salinity affects plants in various ways such as the water stress, ion toxicity, nutritional disorders, oxidative stress, metabolic processes alteration, membrane disorganization, cell division and expansion reduction, and genotoxicity (Munns, 2002b; Zhu, 2007). These factors together inhibit plant growth and development which may affect plant survival.

All the major processes are affected during the onset and development of salt stress within a plant, and those consist of photosynthesis, protein synthesis, enzyme activity and energy, and lipid metabolism (Parida and Das, 2005). Therefore, the occurrence of premature senescence of older leaves and toxicity symptoms as the chlorosis and necrosis happen on mature leaves (Hasegawa et al, 2000). In the initial stages, plants experience water stress that lead to the leaf expansion reduction. The salinity stress osmotic effects can be immediately observed

after salt application and continue for the salt exposure duration, which results the inhibition of cell expansion and division along with stomatal closure (Flowers, 2004).

Plants experience ionic stress during long-term salinity exposure, which lead to adult leaves premature senescence and thus a reduction in the available photosynthetic area that support further growth (Cramer and Nowak, 1992). High salinity affects rhizosphere, which is bioenergetically taxing as microorganisms need an osmotic balance to be maintained between their cytoplasm and the surrounding medium while excluding sodium ions from the cell interior, where sufficient energy is required for osmoadaptation (Oren, 2002; Jiang et al, 2007).

The description of characteristic over different time scales in the plant's development from the imposition of salinity stress till maturity provided by (Munns, 2002a). After moments of salinization, cells dehydrate and shrink but regain their original volume after hours. Despite this recovery, cell elongation and cell division are reduced, leading to the reduction of leaf and root growth rates.

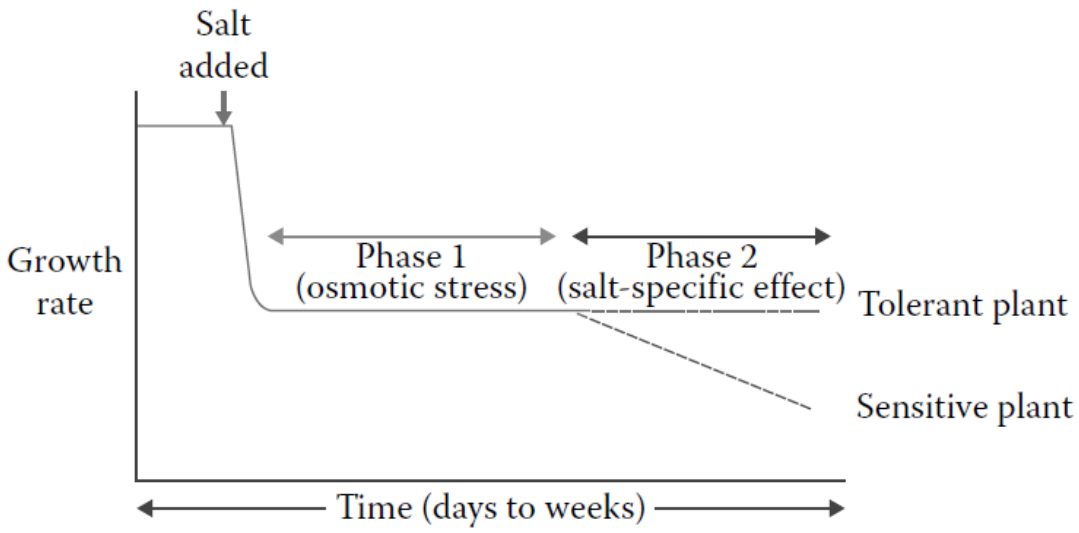

Figure 2: Two-phase growth response to salinity for genotypes differing in the leaves salt toxicity rates. (Munns R., 2005)

Through the next days, reduction in cell division and cell elongation transfer into slower leaf appearance and size. Severely salt-stressed plants often develop visual injury because of excessive salt uptake. After a few weeks, the development of lateral shoot is affected, after some months, obvious differences occur in the overall growth and the injury observed between salt-stressed plants and their non-stressed controls. Based on these sequential differences in plants response to salinity, a two-phase model describing the osmotic and ionic effects of salt stress proposed by (Munns, 2002a; Munns, 2005) shown in (Figure 2).

Plant genotypes identification capable of increased tolerance to salt and incorporation of these desirable traits into an economically useful crop plants may help in the effect of salinity reduction on productivity. Plants sensitive or tolerant to salinity differ in the salt reaches toxic levels rate in the leaves. The timescale is based on days, weeks or months, depending on

the species and the salinity level. During phase 1, growth of both types of plants is reduced because of the osmotic effect of the saline solution outside the roots. During phase 2, old leaves in sensitive plant die and reduce the plant photosynthetic capacity, this exerts oneself an additional effect on growth. However, the salt tolerance mechanisms of physiological, biochemical, and molecular in plants are not yet sufficiently understood, accordingly the progress of developing salt-tolerant crops has been slow (Lauchli and Grattan, 2007).

Many studies investigated the salt stress effect on plants growth reported that plant height decrease due to sodium chloride concentration increasing (Gama et al, 2007; Memon et al, 2010). Another baleful effect of salt stress is the decreasing of leaves number (Gama et al, 2007; Han et al, 2006). Salt accumulation in the root zone causes the development of osmotic stress and disrupts cell ion homeostasis (Paranychianakis et al, 2005). Salt stress although decreases yield due to productivity decreasing (Pascale et al, 2015). Generally, salinity increased fruit dry matter content, total soluble solids (TSS), and acid content. Salt stress also increase carotenoid content and antioxidant activity.

2.3 Salinity Effect on Tomato Plant

Tomato is one of the most important crops around the world, it has growth specification under a wide range of production systems. Soil salinity is a critical constraint for tomato cultivation in optimal climate areas (Yurtseven et al., 2005). Tomato is a moderate crop for salt tolerant

(Maas, 1986) with considerable differences cultivar (Dasgan et al., 2002). Moreover, salt abiotic stress has been found to deactivate several physiological processes in plants which leads to growth and yield reductions (Yurtseven et al., 2005). In recent time, salt stress control applied in tomato cultivation in order to produce greatest market value of fruits (Zushi and Matsuzoe, 2009). Many studies concentrated on the effect of salinity stress on tomato growth system, these can be classified as followed.

2.3.1 Salinity Effects on the Growth of Tomato Root

Root plays a crucial role in plant growth; this related to the direct contact with the solution of salt under soilless cultivation. The plant root growth, physiology and morphology are affected by salinity. Tomato root growth under soilless cultivation affected negatively by salinity. According to (Leo, 1964) revealed that high salinity decreased roots elongation rates and found out that compared with the control nutrient solution, tomato root subjected to 1% NaCl solution reduced at 26% of the elongation rate. According to (Snapp *et al*, 1991), salinity reduced the density of tomato root length in the late growing season. While due to (Albacete *et al*, 2008) had provided data about fresh tomato root where the weight reduced by (30%) after three weeks under saline conditions.

Furthermore, (Evlagon *et al*, 1992) found that the length of the root reduced by (54%) after 4 days Hoagland solution salinized exposure, while the surface area reduced by (20%) when (100 mM Ca) was added to the

salinized solution. (Schwarz and Grosch, 2003) also reported that tomato root fresh and dry mass, total length of the root, adventitious root number, root tap, and lateral root decreased with increasing EC of nutrient solution.

However, root growth reduction under salinity stress is caused by growth restriction of the root cell, water stress of root-zone and the increase of root disease. The growth tomato under salinity stress condition lead to the root cell growth restriction, as a result of external medium low water potential, the ions and/or the toxicity of accumulated ions interference (Cuartero and Fernandez, 1999). Due to (Satti & Lopez, 1994) the root dry matter reduction in could be a result of salinity induced water stress. (Snapp *et al*, 1991) had also reported that salinity reduced net root growth in field grown tomato.

2.3.2 Salinity Effects on the Growth of Tomato Leaf

Many studies examined the salinity effects on several functions at the leaf scale. The senior impacts of the increasing salinity are leaf photosynthesis reduction (Maggio et al, 2007), and the transpiration in the leaf besides the plant water status (Romero-Aranda et al, 2001; Maggio et al, 2004). In addition to the leaf and plant functions variations, another important aspect of salinity in plants is salinity strong effect on plant structure (Maggio et al, 2004; Romero-Aranda et al, 2006).

The increase of salinity has been documented to affect varied morphological variables. Such as the stem elongation and thickening reduction (Bartolini et al, 1991; Franco et al, 1993), total leaf area, leaf size

and maximum leaf length (Maggio et al, 2004; Romero-Aranda et al, 2006), rates of leaf growth (Munns, 1993; Yilmaz et al, 2004; Chenu et al, 2008*a*), absolute and relative growth rates of plant (Carneiro et al. 2004), and the increase of leaf thickness (Sanchez-Blanco et al, 1991). The salinity influence on organogenesis varies with the species. For instance, salinity decreases the leaves number per plant in spring wheat (Grieve et al. 1994) but it does not affect the leaves number in lettuce (Jeroˆnimo et al, 2005). In tomato, extreme salinity reduces the inflorescences number per plant, the flowers number per inflorescence (Grunberg et al, 1995; Van Ieperen, 1996) and fruit set, particularly on upper inflorescences (Adams and Ho, 1992).

2.3.3 Salinity Effects on the Growth of Tomato Shoot

Salinity has a negative impact on tomato shoot growth under soilless cultivation. Many studies investigated the effects of salinity on tomato shoots according to (Bolarin *et al*; 1991, 1993) suggested that twenty-one genotypes belonging to four *Lycopersicon* wild tomato species showed reductions in fresh and dry weight of shoots significantly in response to salinity stress. Due to (Kamrani *et al*, 2013) had shown that salinity should reach 20Mm to have an effect on tomato shoot development; the research also pointed that increased salinity decreases shoot height significantly.

Moreover (Oztekin & Tuzel, 2011) provided a comparison that resulted a 29.03% reduction in plant height for the average tomato (twenty-one commercially available cultivars) under 200 mM NaCl treatment when

compared with no salinity treatment. While the study of (Bustomi *et al*. 2014) reported a significant reduction in tomato plant height started from eight weeks and ten weeks after transplant under 4dS m^{-1} and 3dS m^{-1}, respectively. The research of (Cruz *et al*., 1990) concluded that the reduction in the tomato stem length considered as one of the most reliable indicators for a wide range of tomato genotypes under saline stress. In addition to (Saberi *et al*, 2011) who reported that increasing salinity lead to stem diameter decreasing which as one of the growth parameters, similarly in forage sorghums (*Sorghum bicolor* L.) stem diameter decreased with increasing salinity.

Shoot reduction under salinity stress is caused by photosynthesis reduction, which leads to the tissue's expansion reduction and disturbance in the mineral supply. (Zhu, 2002) had inferred that shoot growth reduction under saline conditions is possible according to three reasons:

(1) "Salinity reduced photosynthesis, which in turn limits the supply of carbohydrate needed for growth".

(2) "Salinity reduced shoot and roots growth by reducing turgid in expanding tissues resulting from lowered water potential in root growth medium"

(3) "Salinity disturbs mineral supply, either an excess or deficiency; induced changes in concentrations of specific ions in the growth medium, may have a direct influence on growth".

2.3.4 The Salinity Effect on Tomato Yield

One of the unquestioned facts that tomato yield is reduced under salinity above threshold values condition. Many studies investigated that fact, according to (Qaryouti *et al*, 2007) had reported that the tomato total yield is significantly reduced under salinity stress, while the yield per unit reduction increase. In addition, (Magan *et al*, 2008) reported that tomato total fresh fruit yield decreased significantly with increasing salinity. While (Dalton *et al*, 1997) observed the relationship between yield which is reduced uniformly with the osmotic potential of the nutrient solution decreasing. (Hajiboland *et al*, 2010) had proposed that the tomato growth reduction and yield affected by the salinity could be the causes of the variation in photosynthetic products translocation toward root, decrease of plant top especially leaves, partial or total enclosed of stomata, direct effect of salt on photosynthesis system and ion balance. Moreover, (Del Amour *et al*, 2001) showed that tomato fruit yield reduction by salinity was according to the reduction in both size and number of fruits. The study of (Rodríguez-Ortega et al, 2019) investigated the tomato plants agricultural and physiological responses that grown in different soilless culture systems with saline water under greenhouse conditions. The yield decreased according to the soilless culture system. The salinity treatments improved the quality of fruits and plants cultivated with the nutrient film technique enhanced nutrition concentration. According to (Maggio et al, 2006) investigation the response of salt stress on tomato beyond threshold of salinity tolerance. Where the study examined the relationships of crop salt

tolerance which is usually assessed as the relative yield response to increasing root zone salinity, that is expressed as soil (EC) or irrigation Water (ECw) Electrical Conductivity.

Chapter Three

Materials & Methods

3.1 Plant material

The experiment was carried and grown in greenhouse (control irrigation), at (An-Nassariya Village at An-Najah National University Research Center) in the North Central West Bank, located 14 kilometers East of Nablus using (*Solanum lycopersicum L.)* plant, in the experiment used one variety of tomato (local market variety).

3.2 Preparing and sowing of seedling

Intact seedlings, which were homogeneous and identical in size, shape, color, age and free from wrinkles, diseases and pests were chosen. Seedlings grown in March-19-2018 inside the greenhouse using hydroponic system- pyramidal shape(Picture2) ,build from wood in 4 meter long, 2.5 width and 2 meter height, Seedlings grown under natural lighting (15-35)C ±4 (day night) and 40% relative humidity. The experiment was designed (complete factorial 2*3*10) including two different salinity level and one with fresh tab water (0,100, 150) mM of salinity, the first one treatment inoculated with *P. fluorescence* for each salinity degree and tab water, with ten replicates for each treatment in line (each line one treatment).

3.2.1 The pyramidal shape of experiment consists of:

- Six plastic pipes (6 inches diameter).
- Six water tank (20 liter) provides plant with water.
- Six water pump (1200liter_hour) on 2-meter height.
- Water tank (1000 liter) to provide system with water.
- Plastic planting cups (20cm height).
- Timer (adjustment circulation water in pipes).
- Plastic connectors (between pipes and water pump).
- Plastic pipes 16 ml (between pipes and water pump).
- Electric cable (to provide water pump with electricity).
- PH meter (acidity measurement).
- EC meter (salinity measurement).

Plastic Pipes and Waters Tank, was painted with white color to reflect sun light and gives shades to plant and water. The seedlings were grown in plastic cups (holes making under cups to facilitate root and water passage), distance between plants was 40 centimeters, and timer were adjustment every 15 minutes.

Figure 3: Pyramidal shape of experiment

3.3 Bacteria propagation and inoculation

P. fluorescence bacteria were prepared before two weeks of inoculation or added to plant, it was activated in lab, freeze dried 1 ml of nutrient broth was added to rehydrate the bacteria, then the suspension was transferred to new 500 ml nutrient broth the culture was incubated at 28 ºC for 24 h. The culture will be centrifuged (350 *g* for 10 min), washed with sterile water and pellets will be re suspended in sterile water to achieve 10^8 CFU g–1concentration. To inoculate the plants, 1L of bacterial suspension, prepared as we described above, will be mixed with 1050 ml of water. Inoculation was carried out with 1 ml of bacterial suspension with 10^8 CFU ml–1 per plant. Inoculations was repeated every 20 days until flowering. The experiment design was a 10×3×2 complete factorial which was comprised of one cultivar, three salinity levels (0, 100 and 150) mM NaCl and inculcated and none inculcated plant and 10 replicates for each treatment.

Optical Density (O.D) measured (number of colonies forming units),1ml by Spectrophotometer at 600 nm (UV-1601PC,Shimadzu).The final O.D unit approximately equivalent 7×10^8 CFU,1 ml added per plant.

Inoculation of bacteria after 20 days for planting, then after 20 days from first addition.

3.4 Treatments with NaCl

After 4 days from planting, different concentration of NaCl (0,100,150) mM were used in irrigation water for each treatment with NaCl, EC adjustment at the right degree of salinity, especially in this period due to increase of evaporation, EC Meter was used.

Nutrition solution Liquid Fertilizer used, Mour T.R (4-2.5-6+3+2Ca+0.5Mg) was added to pipelines after 3 days from planting and repeated every 4 day 1cm per plant.

Iron element (Jeo Gold T.R) also added every month 0.4g per plant.

Phosphoric acid prepared throw dilution of one-liter phosphoric acid per 20 liter of water, during the growing season the pH was monitored and adjusted to reach pH 6 using pH meter.

- Trt.1: different salinity levels on plant with *P. fluorescence*
- Trt2.: different salinity level on plants without *P. fluorescence*
- Trt3.: control (fresh water) on plants with *P. fluorescence*

- Trt.4: control (fresh water) on plants without *P. fluorescence*

3.5 Growth Parameters

Growth Parameter were taken for the plant during the period of growth and after 100 days from planting date, the ten replicates was taken for each treatment, and the following measurement was taken from each treatment:

- Number of flowers after 10 days of first flowering.
- Shoot height (cm) using regular meter from root to the top of the plant.
- Number of main tillers.
- Number of true leaves.
- Shoot fresh weight (g) using regular electronic balance.
- Shoot dry weight (g) after dried by oven (*Electrotherm, Bifa*) at 70°C for 48 hours.
- Root fresh weight (g).
- Root dry weight (g).
- Number of mainly nodules on root.
- Leaf fresh weight (g).
- Leaf dry weight (g).

- Leaf area (cm).
- Length of main roots (cm).
- Weight of plant without roots (g).
- Total biomass (g), weight of all fresh part of plant.
- Main stem diameter (inch), using Calipers.

3.6 Yield and its components

Number of fruits per plant.

Fruit weight (g).

3.7 Nutrient element content

The study of plant nutrients is very important in plant research also in nutritional value, nutrient elements content were carried in laboratory of An-Najah National University- Nablus, Methodology of Motsara, M.R. Guide to laboratory establishment for plant nutrient analysis it started with drying the sample (leaves, roots) at 70°C for 48 hours in oven using electric stainless steel cups and stored in regular plastic bottles for analysis time.

Sample Drying: the fresh sample (leaves. roots and stem) was dried using oven, where plant parts was kept inside paper bag at 70°C for 24 hours, the period extended if for stem and root for 48 hours then the sample was cracked into powder to prepare for ashing.

Sample Preparation: four replicates from each sample were chosen.

Dry ash: from each sample, 2 gm were taken using sensitive balance then the sample was heated at 500°C for 6 hours in laboratory oven(Carbolite LHT 6/30,UK), this step was to destroy organic matter and to form Ash, so that we can obtain and dissolve it in acids to prepare the sample in liquid form for estimate of the elements.

3.7.1 Nitrogen and Protein content

Nitrogen Percentage can be estimation by Kjeldahl (Gerhardt, Germany) method.

Digestion: 2g from each sample are taken, then putted in pipit specialist for digestion process, 20 ml of H2SO4(the main solution for digestion) was added, ½ spoon of catalyst (1000gm of Na2SO4 with 30 gm of CUSO4) to accelerate the digestion process, boiling chips (2_3 pieces) to prevent boiling sample from exit out of pipit digestion process in kjeldahl take two rounds, each round(15 minutes at 80°C,15 minutes at 90°C and 90 minutes at 100°C), Sample completely digested and gives a clear color solution.

Distillation: Distillation process using by 25 ml boric acid which was added to each solution this step was conducted to catch ammonia gas that result from the process, a 80 ml of NaOH (Reagent) was added and 80 ml of H2O to reduce the temperature of the solution, this process take 4 minutes, the color of boric acid changed from purple to green color as an indicator for ammonia presence or availability.

Titration: Titration process of solution was carried out using HCL (0.1mM), the solution was titrated until the color of solution was changed from green to purple and the volume required was used in the equation to estimate Nitrogen percentage. To calculate the protein percentage the percentage of nitrogen was multiplying by the factor (6.25).

% of Nitrogen(N) =

$$\frac{(\text{V. of acid used} - \text{V . of Blank}) \times \text{Normality of acid} \times 1.4007}{\text{Weight of sample}}$$

% Protein = % Nitrogen × 6.25

Figure 4: Vapodest (Gerhardt, German), Unit for distillation.

3.7.2 Phosphorus Content

Phosphorus percentage were estimated using Spectrophotometer (UV-1601PC,Shimadzu). A 2g of plant sample (root and leaves) was taken,

and digested with 10-15 ml of H2SO4, distilled water, and heating for 2-4 hours at 200-400°C. Phosphorus Reagent was prepared before testing, samples was titrated on pH=5, filtrated using filter paper, then prepared 100 ml of phosphorus reagent mix with 0.54g of ascorbic acid, prepared blank sample 4 ml of phosphorus reagent mixed with 25 ml of distilled water. To measure phosphorus percentage 0.1 ml of sample filtered was mix with 4 ml of solution that contain phosphorus reagent and ascorbic acid. For the control a 0.1 ml was mixed with phosphorus reagent and distilled water, the percentage was estimated using Spectrophotometer.

$$\% \text{ P} = \frac{Spectrometer\ reading \times Volume\ of total\ sample(ml)}{\text{Prepared Volume for reading(ml)} \times Wight\ of\ fresh\ sample(g)}$$

Figure 5: Spectrophotometer*(UV-1601PC,Shimadzu)* and Data view

3.7.3 Sodium ,Potassium and Calcium Content

Sodium, Potassium and Calcium content Digestion of samples done using 1 gm of ashed samples with 10 ml of HCL mixed together in flask and heated to 90°C at using hotplate. After digestion, completing to 100ml with distilled water. Each sample filtered before using Flamephotometer

(Sherwood, UK) Sodium, potassium and calcium were estimated Flame photometrically using Sherwood Flamephotometer 410. The percent were estimated for shoot samples taken for all replicates.

Figure 6: Flamephotometer (Sherwood, UK).

3.7.4 Chloride content

The estimation of chloride in shoot samples were done using 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 $AgNO_3$ × Normality) – (V. of NH_4SCN×Normality)

Cl (ppm) = M mole of Cl × M.W of Cl× dilution factor

Figure 7: Ash samples and Dry Oven(Electrotherm,Bifa)

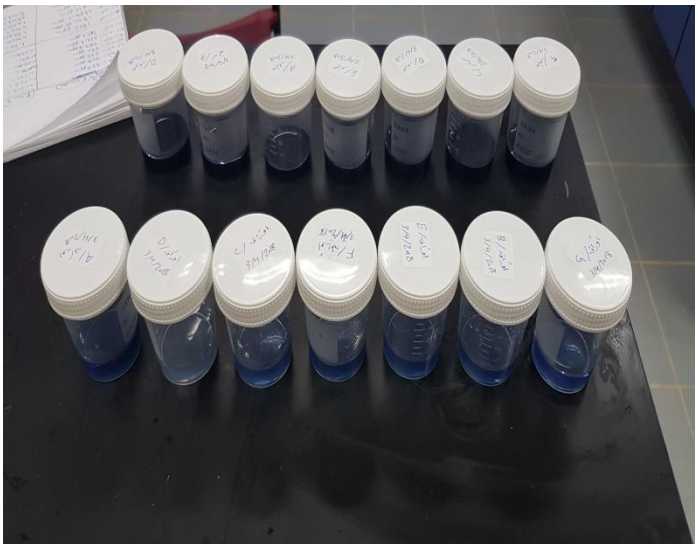

Figure 8: Sample prepared for testing

Chapter Four
Result

4.1 The effect of *P. fluorescence* inoculation on flowering intensity of Tomato plant under different salinity levels:

The analysis of variance revealed that salinity and bacteria was significantly influenced flowering intensity for tomato. The plants inoculated with *P. fluorescence* revealed higher plant flowering intensity compared with plants not inoculated with *P. fluorescence* 32.47 and 13.4 respectively. The results revealed as salinity increased the plant flowering intensity increase in which the flowering intensity was 25.05 at salinity 100 mM level compared with 20.05 at control level of salinity. Moreover, as salinity increased the flowering intensity decrease the bacterial inoculation reduce the effect of salinity where the maximum flowering intensity was 36.2 at 150 mM salinity level for inoculated plant compared to 11.2 at the same level of salinity without bacterial inoculation. Based on the mean separation, the effect of bacteria was highly significant ($P \leq 0.0001$), salinity was not significant ($P \leq 0.0708$) and bacteria x salinity was significant ($P \leq 0.0039$),(Table1) (see list of appendix, table 34-36).

Table 1: The analysis of variance for the effect of *P. fluorescence* on flowering intensity of Tomato under different salinity levels.

Effect	Num DF	Den DF	F Value	Pr > F
Replicate	9	45	0.28	0.9758
Bacteria	1	45	114.51	<.0001
Salinity	2	45	2.81	0.0708
Bacteria*Salinity	2	45	6.30	0.0039

Num DF: Numerator Degree of Freedom, Den DF: Denominator Degree of Freedom, F Value: Degrees of Freedom, Pr.: Probability.

4.2 The effect of *P. fluorescence* inoculation on Number Fruit Plant of Tomato plant under different salinity levels:

The analysis of variance revealed that salinity and bacteria was significantly influenced plant fruit number for tomato. The plants inoculated with *P. fluorescence* revealed higher plant fruit number compared with plants not inoculated with *P. fluorescence* 7.43 and 3.43 respectively. The results revealed as salinity increased the plant fruit number increase in which the fruit number was 5.75 at salinity 150mM level compared with 4.9 at control level of salinity. Moreover, as salinity increased the fruit number decrease the bacterial inoculation reduce the effect of salinity where the maximum fruit number was 8.5 at 150 mM salinity level for inoculated plant compared to 3 at the same level of salinity without bacterial inoculation. Based on the mean separation, the effect of bacteria was highly significant ($P \leq 0.0001$), salinity was not significant ($P \leq 0.2206$) and bacteria x salinity was significant ($P \leq 0.0185$) ,(Table2) (see list of appendix, table 37-39).

Table 2: The analysis of variance for the effect of *P. fluorescence* on Fruit Number of Tomato under different salinity levels.

Effect	Num DF	Den DF	F Value	Pr > F
Replicate	9	45	0.15	0.9976
Bacteria	1	45	86.91	<.0001
Salinity	2	45	1.56	0.2206
Bacteria*Salinity	2	45	4.36	0.0185

Num DF: Numerator Degree of Freedom, Den DF: Denominator Degree of Freedom, F Value: Degrees of Freedom, Pr.: Probability.

4.3 The effect of *P. fluorescence* inoculation on Fruit Weight of Tomato plant under different salinity levels:

The analysis of variance revealed that salinity and bacteria was significantly influenced plant fruit weight for tomato. The plants inoculated with *P. fluorescence* revealed higher plant fruit weight compared with plants not inoculated with *P. fluorescence* 97.4g and 27.53g respectively. The results revealed as salinity increased the plant fruit weight increase in which the fruit weight was 55.8g at salinity mM level compared with 73g at control level of salinity. Moreover, as salinity increased the fruit weight decrease, the bacterial inoculation reduce the effect of salinity where the maximum fruit weight was 104.6g at 150 mM salinity level for inoculated plant compared to 12.6g at the same level of salinity without bacterial inoculation. Based on the mean separation, the effect of bacteria, salinity and bacteria x salinity were highly significant ($P \leq 0.0001$), (Table3) (see list of appendix, table 40-42).

Table 3: The analysis of variance for the effect of *P. fluorescence* on Fruit Weight of Tomato under different salinity levels.

Effect	Num DF	Den DF	F Value	Pr > F
Replicate	9	45	0.33	0.9613
Bacteria	1	45	2701.49	<.0001
Salinity	2	45	62.85	<.0001
Bacteria*Salinity	2	45	70.73	<.0001

Num DF: Numerator Degree of Freedom, Den DF: Denominator Degree of Freedom, F Value: Degrees of Freedom, Pr.: Probability.

4.4 The effect of *P. fluorescence* inoculation on Root Length of Tomato plant under different salinity levels:

The analysis of variance revealed that salinity and bacteria was significantly influenced plant root length for tomato. The plants inoculated with *P. fluorescence* revealed higher root length compared with plants not inoculated with *P. fluorescence* 48.33cm and 33.72cm respectively. The results revealed as salinity increased the plant root length decrease in which the root length was 42.27cm at salinity control level compared with 39.75cm at 100 mM of salinity level. Moreover, as salinity increased the plant root length decrease however the bacterial inoculation reduce the effect of salinity where the maximum root length number was 50.8cm at 150 mM salinity level for inoculated plant compared to 31.3cm at the same level of salinity without bacterial inoculation. Based on the mean separation, the effect of bacteria was highly significant ($P \leq 0.001$). on the other hand, salinity and bacteria x salinity were not significant ($P \leq 0.6072$, 0.2134 respectively), (Table4) (see list of appendix, table 43-45).

Table 4: The analysis of variance for the effect of *P. fluorescence* on Root Length of Tomato under different salinity levels.

Effect	Num DF	Den DF	F Value	Pr > F
Replicate	9	45	1.83	0.0897
Bacteria	1	45	50.70	<.0001
Salinity	2	45	0.50	0.6072
Bacteria*Salinity	2	45	1.60	0.2134

Num DF: Numerator Degree of Freedom, Den DF: Denominator Degree of Freedom, F Value: Degrees of Freedom, Pr.: Probability.

4.5 The effect of *P. fluorescence* inoculation on Fresh Root Weight of Tomato plant under different salinity levels.

The analysis of variance revealed that salinity and bacteria was significantly influenced plant fresh root weight for tomato. The plants inoculated with *P. fluorescence* revealed higher plant fresh root weight compared with plants not inoculated with *P. fluorescence* 13.44g and 11.76g respectively. The results revealed as salinity increased the plant fresh root weight increase in which the fresh root weight was 13.31g at salinity 150 mM level compared with 10.31 g at control level of salinity. Moreover, as salinity increased the fresh root weight decrease, the bacterial inoculation reduce the effect of salinity where the maximum fresh root weight was 16.31g at 150 mM salinity level for inoculated plant compared to 10.32g at the same level of salinity without bacterial inoculation. Based on the mean separation, the effect of bacteria was not significant ($P \leq 0.2012$), salinity and bacteria x salinity were significant ($P \leq 0.0488$ and 0.0568 respectively) ,(Table5) (see list of appendix, table 46-48).

Table 5: The analysis of variance for the effect of *P. fluorescence* on Fresh Root Weight of Tomato under different salinity levels.

Effect	Num DF	Den DF	F Value	Pr > F
Replicate	9	45	2.47	0.0222
Bacteria	1	45	1.68	0.2012
Salinity	2	45	3.23	0.0488
Bacteria*Salinity	2	45	3.06	0.0568

Num DF: Numerator Degree of Freedom, Den DF: Denominator Degree of Freedom, F Value: Degrees of Freedom, Pr.: Probability.

4.6 The effect of *P. fluorescence* inoculation on Root Dry Weight of Tomato plant under different salinity levels:

The analysis of variance revealed that salinity and bacteria was significantly influenced plant root dry weight for tomato. The plants inoculated with *P. fluorescence* revealed higher plant root dry weight compared with plants not inoculated with *P. fluorescence* 12.34g and 9.96g respectively. The results revealed as salinity increased the plant root dry weight increase in which the root dry weight was 11.725g at salinity 150 mM level compared with 9.635g at control level of salinity. Moreover, as salinity increased the root dry weight decrease the bacterial inoculation reduce the effect of salinity where the maximum root dry weight was 14.65g at 150 mM salinity level for inoculated plant compared 8.80g at the same level of salinity without bacterial inoculation. Based on the mean separation, the effect of bacteria was significant ($P \leq 0.0415$), salinity and bacteria x salinity were not significant ($P \leq 0.1754$ and 0.1085 respectively) ,(Table6) (see list of appendix, table 49-51).

Table 6: The analysis of variance for the effect of *P. fluorescence* on Root Dry Weight of Tomato under different salinity levels.

Effect	Num DF	Den DF	F Value	Pr > F
Replicate	9	45	2.79	0.0110
Bacteria	1	45	4.41	0.0415
Salinity	2	45	1.81	0.1754
Bacteria*Salinity	2	45	2.33	0.1085

Num DF: Numerator Degree of Freedom, Den DF: Denominator Degree of Freedom, F Value: Degrees of Freedom, Pr.: Probability.

4.7 The effect of *P. fluorescence* inoculation on Root Number of Tomato plant under different salinity levels.

The analysis of variance revealed that salinity and bacteria was not significantly influenced plant main root number for tomato. The plants inoculated with *P. fluorescence* revealed higher plant main root number compared with plants not inoculated with *P. fluorescence* 6.43 and 3.93 respectively. The results revealed as salinity increased the plant main root number decrease in which the main root number was 4.95 at salinity 100 mM level compared with 5.5 at control level of salinity. Moreover, as salinity increased the main root number decrease, the bacterial inoculation reduce or decrease the effect of salinity where the maximum main root number was 6.50 at 100 mM salinity level for with bacterial inoculation plant compared 3.40 at the same level of salinity without bacterial inoculation. Based on the mean separation, the effect of bacteria was highly significant ($P \leq 0.0007$), salinity and bacteria x salinity were not significant ($P \leq 0.7962$ and 0.7389 respectively), (Table7) (see list of appendix, table 52-54).

Table 7: The analysis of variance for the effect of *P. fluorescence* on Root Number of Tomato under different salinity levels.

Effect	Num DF	Den DF	F Value	Pr > F
Replicate	9	45	0.98	0.4704
Bacteria	1	45	13.29	0.0007
Salinity	2	45	0.23	0.7962
Bacteria*Salinity	2	45	0.30	0.7389

Num DF: Numerator Degree of Freedom, Den DF: Denominator Degree of Freedom, F Value: Degrees of Freedom, Pr.: Probability.

4.8 The effect of *P. fluorescence* inoculation on Main Root Length of Tomato plant under different salinity levels.

The analysis of variance revealed that salinity and bacteria was not significantly influenced plant main root length for tomato. The plants inoculated with *P. fluorescence* revealed higher plant main root length compared with plants not inoculated with *P. fluorescence* 7.07cm and 5.63cm respectively. The results revealed as salinity increased the plant main root length decrease in which the main root length was 7.05cm at salinity 150 mM level compared with 5.45cm at control level of salinity. Moreover, as salinity increased the main root length decrease, the bacterial inoculation reduce the effect of salinity where the maximum main root length was 8.50cm at 100 mM salinity level for with bacterial inoculation plant compared 4.60cm at the same level of salinity without bacterial inoculation. Based on the mean separation, the effect of bacteria and salinity were significant ($P \leq 0.0105$ and 0.0548 respectively) and bacteria x salinity was highly significant ($P \leq 0.0086$) ,(Table8) (see list of appendix, table 55-57).

Table 8: The analysis of variance for the effect of *P. fluorescence* on Main Root Length of Tomato under different salinity levels.

Effect	Num DF	Den DF	F Value	Pr > F
Replicate	9	45	3.75	0.0014
Bacteria	1	45	7.13	0.0105
Salinity	2	45	3.10	0.0548
Bacteria*Salinity	2	45	5.29	0.0086

Num DF: Numerator Degree of Freedom, Den DF: Denominator Degree of Freedom, F Value: Degrees of Freedom, Pr.: Probability.

4.9 The effect of *P. fluorescence* inoculation on Node Number of Tomato plant under different salinity levels:

The analysis of variance revealed that salinity and bacteria was significantly influenced plant node number for tomato. The plants inoculated with *P. fluorescence* revealed higher node number compared with plants not inoculated with *P. fluorescence* 43.47 and 31.47 respectively. The results revealed as salinity increased the plant node number decrease in which the node number was 34.1 at salinity control level compared with 40.55 at 100 mM of salinity level. Moreover, as salinity increased the node number decrease however the bacterial inoculation reduce the effect of salinity where the maximum node number was 51.1 at 100 mM salinity level for inoculated plant compared to 30 at the same level of salinity without bacterial inoculation. Based on the mean separation, the effect of bacteria was highly significant ($P \leq 0.0003$). on the other hand, salinity and bacteria x salinity were not significant ($P \leq 0.2401$, 0.0940 respectively) ,(Table9) (see list of appendix, table 58-60).

Table 9: The analysis of variance for the effect of *P. fluorescence* on Node Number of Tomato under different salinity levels.

Effect	Num DF	Den DF	F Value	Pr > F
Replicate	9	45	3.62	0.0018
Bacteria	1	45	15.21	0.0003
Salinity	2	45	1.47	0.2401
Bacteria*Salinity	2	45	2.49	0.0940

Num DF: Numerator Degree of Freedom, Den DF: Denominator Degree of Freedom, F Value: Degrees of Freedom, Pr.: Probability.

4.10 The effect of *P. fluorescence* inoculation on Plant Length of Tomato plant under different salinity levels in Relation to Bacteria and Salinity:

The analysis of variance revealed that salinity and bacteria was significantly influenced plant length for tomato. The plants inoculated with *P. fluorescence* revealed higher length compared with plants not inoculated with *P. fluorescence* 11.50 cm and 137.63 cm respectively. The results revealed as salinity increased the plant length decrease in which the length was 126.15 cm compared with 116.45cm at 150 mM of salinity level. Moreover, as salinity increased the plant length decrease however the bacterial inoculation reduce the effect of salinity where the maximum length was 140.20cm at 150mM salinity level for inoculated plant compared to 4.60 cm at the same level of salinity without bacterial inoculation. Based on the mean separation, the effect of bacteria was highly significant ($P \leq 0.001$). On the other hand, salinity and bacteria x salinity were not significant ($P \leq 0.0821$, 0.0179 respectively) ,(Table10) (see list of appendix, table 61-63).

Table 10: The analysis of variance for the effect of *P. fluorescence* on Plant Length of Tomato under different salinity levels.

Effect	Num DF	Den DF	F Value	Pr > F
Replicate	9	45	2.30	0.0323
Bacteria	1	45	24.38	<.0001
Salinity	2	45	2.64	0.0821
Bacteria*Salinity	2	45	4.40	0.0179

Num DF: Numerator Degree of Freedom, Den DF: Denominator Degree of Freedom, F Value: Degrees of Freedom, Pr.: Probability.

4.11 The effect of *P. fluorescence* inoculation on Branch Number of Tomato plant under different salinity levels:

The analysis of variance revealed that salinity and bacteria was significantly influenced plant branch number for tomato. The plants inoculated with *P. fluorescence* revealed higher branch number compared with plants not inoculated with *P. fluorescence* 6.27 and 4.9 respectively. The results revealed as salinity increased the plant branch number increase in which the branch number was 5.3 at salinity control level compared with 6.05 at 100 mM of salinity level. Moreover, as salinity increased the plant branch number decrease, however the bacterial inoculation reduce the effect of salinity where the maximum branch number was 7.5 at 100 mM salinity level for inoculated plant compared to 4.6 at the same level of salinity without bacterial inoculation. Based on the mean separation, the interaction between bacteria and bacteria x salinity were highly significant ($P \leq 0.001$, 0.0004 respectively). on the other hand, salinity was not significant ($P \leq 0.1203$), (Table11) (see list of appendix, table64-66).

Table 11: The analysis of variance for the effect of *P. fluorescence* on Branch Number of Tomato under different salinity levels.

Effect	Num DF	Den DF	F Value	Pr > F
Replicate	9	45	1.57	0.1541
Bacteria	1	45	18.76	<.0001
Salinity	2	45	2.22	0.1203
Bacteria*Salinity	2	45	9.25	0.0004

Num DF: Numerator Degree of Freedom, Den DF: Denominator Degree of Freedom, F Value: Degrees of Freedom, Pr.: Probability.

4.12 The effect of *P. fluorescence* inoculation on Plant Weight of Tomato plant under different salinity levels:

The analysis of variance revealed that salinity and bacteria was significantly influenced plant weight for tomato. The plants inoculated with *P. fluorescence* revealed higher weight compared with plants not inoculated with *P. fluorescence* 223.67g and 104.10g respectively. The results revealed as salinity increased the plant weight increase in which the plant weight was 158.30g at salinity control level compared with 177.80g at 100 mM of salinity level. Moreover, as salinity increased the plant weight decrease ,however the bacterial inoculation reduce the effect of salinity where the maximum plant weight was 232.40g at 150mM salinity level for inoculated plant compared to 78.70 g at the same level of salinity without bacterial inoculation. Based on the mean separation, the effect of bacteria was highly significant ($P \leq 0.0003$). on the other hand, salinity and bacteria x salinity were not significant ($P \leq 0.8137$, 0.4870 respectively) ,(Table12) (see list of appendix, table 67-69).

Table 12: The analysis of variance for the effect of *P. fluorescence* on Plant Weight of Tomato under different salinity levels.

Effect	Num DF	Den DF	F Value	Pr > F
Replicate	9	45	2.80	0.0108
Bacteria	1	45	15.09	0.0003
Salinity	2	45	0.21	0.8137
Bacteria*Salinity	2	45	0.73	0.4870

Num DF: Numerator Degree of Freedom, Den DF: Denominator Degree of Freedom, F Value: Degrees of Freedom, Pr.: Probability.

4.13 The effect of *P. fluorescence* inoculation on Stem Diameter of Tomato plant under different salinity levels.

The analysis of variance revealed that salinity and bacteria was significantly influenced plant stem diameter for tomato. The plants inoculated with *P. fluorescence* revealed higher stem diameter compared with plants not inoculated with *P. fluorescence* 0.22inch and 0.20inch respectively. The results revealed as salinity increased the plant stem diameter decrease in which the stem diameter was 0.29inch at salinity control level compared with 0.175inch at 100 mM of salinity level. Moreover, as salinity increased the plant stem diameter decrease however the bacterial inoculation ameliorate or decrease the effect of salinity where the maximum stem diameter was 0.30inch at 100 mM level for inoculated plant compared to 0.28inch at the same level of salinity without bacterial inoculation. Based on the mean separation, the effect of salinity was highly significant ($P \leq 0.0001$). On the other hand, bacteria and bacteria x salinity interaction were not significant ($P \leq 0.5866$, 0.7847 respectively) ,(Table13) (see list of appendix, table 70-72).

Table 13: The analysis of variance for the effect of *P. fluorescence* on Stem Diameter of Tomato under different salinity levels.

Effect	Num DF	Den DF	F Value	Pr > F
Replicate	9	45	2.43	0.0243
Bacteria	1	45	0.30	0.5866
Salinity	2	45	10.86	0.0001
Bacteria*Salinity	2	45	0.24	0.7847

Num DF: Numerator Degree of Freedom, Den DF: Denominator Degree of Freedom, F Value: Degrees of Freedom, Pr.: Probability.

4.14 The effect of *P. fluorescence* inoculation on Fresh Stem Weight of Tomato plant under different salinity levels:

The analysis of variance revealed that salinity and bacteria was significantly influenced plant fresh stem weight for tomato. The plants inoculated with *P. fluorescence* revealed higher plant fresh stem weight compared with plants not inoculated with *P. fluorescence* 23.83g and 19.90g respectively. The results revealed as salinity increased the plant fresh stem weight increase in which the fresh stem weight was 25.42g at salinity 100 mM level compared with 19.1g at control level of salinity. Moreover, as salinity increased the fresh stem weight decrease the bacterial inoculation doesn't affect of salinity where the maximum fresh stem weight was 26.23g at 100 mM salinity level for non- inoculation plant compared 24.61 g at the same level of salinity with bacterial inoculation. Based on the mean separation, the effect of bacteria, salinity and bacteria x salinity were not significant ($P \leq 0.2632$, 0.3205 and 0.5308 respectively) ,(Table14) (see list of appendix, table 73-75).

Table 14: The analysis of variance for the effect of *P. fluorescence* on Stem Weight of Tomato under different salinity levels.

Effect	Num DF	Den DF	F Value	Pr > F
Replicate	9	45	5.19	<.0001
Bacteria	1	45	1.28	0.2632
Salinity	2	45	1.17	0.3205
Bacteria*Salinity	2	45	0.64	0.5308

Num DF: Numerator Degree of Freedom, Den DF: Denominator Degree of Freedom, F Value: Degrees of Freedom, Pr.: Probability.

4.15 The effect of *P. fluorescence* inoculation on Stem Dry Weight of Tomato plant under different salinity levels

The analysis of variance revealed that salinity and bacteria was not significantly influenced plant stem dry weight for tomato. The plants inoculated with *P. fluorescence* revealed higher plant stem dry weight compared with plants not inoculated with *P. fluorescence* 19.86g and 17.50g respectively. The results revealed as salinity increased the plant stem dry weight increase in which the stem dry weight was 22.30g at salinity 100 mM level compared with 14.94g at control level of salinity. Moreover, as salinity increased the stem dry weight decrease ,the bacterial inoculation doesn't effect of salinity where the maximum stem dry weight was 23.04g at 100 mM salinity level for non- inoculation plant compared 21.57g at the same level of salinity with bacterial inoculation. Based on the mean separation, the effect of bacteria, salinity and bacteria x salinity were not significant ($P \leq 0.3820$, 0.0907 and 0.5813 respectively) ,(Table15) (see list of appendix, table 76-78).

Table 15: The analysis of variance for the effect of *P. fluorescence* on Stem Dry Weight of Tomato under different salinity levels.

Effect	Num DF	Den DF	F Value	Pr > F
Replicate	9	45	5.06	<.0001
Bacteria	1	45	0.78	0.3820
Salinity	2	45	2.53	0.0907
Bacteria*Salinity	2	45	0.55	0.5813

Num DF: Numerator Degree of Freedom, Den DF: Denominator Degree of Freedom, F Value: Degrees of Freedom, Pr.: Probability.

4.16 The effect of *P. fluorescence* inoculation on Leaf Number of Tomato plant under different salinity levels in Relation to Bacteria and Salinity.

The analysis of variance revealed that salinity and bacteria was significantly influenced plant leaf number for tomato. The plants inoculated with *P. fluorescence* revealed higher plant leaf number compared with plants not inoculated with *P. fluorescence* 245.3 and 171.7 respectively. The results revealed as salinity increased the plant leaf number decrease in which the leaf number was 187.85 at salinity control level compared with 228.9 at 100 mM of salinity level. Moreover, as salinity increased the leaf number decrease however the bacterial inoculation reduce the effect of salinity where the maximum leaf number was 240 at 150 mM salinity level for inoculated plant compared to 177.5 at the same level of salinity without bacterial inoculation. Based on the mean separation, the effect of bacteria was highly significant (P≤ 0.0001). on the other hand, salinity not significant (P≤ 0.1664) while bacteria x salinity were significant (P≤ 0.0023), (Table16) (see list of appendix, table 79-81).

Table 16: The analysis of variance for the effect of *P. fluorescence* on Leaf Number of Tomato under different salinity levels.

Effect	Num DF	Den DF	F Value	Pr > F
Replicate	9	45	2.93	0.0081
Bacteria	1	45	18.00	0.0001
Salinity	2	45	1.87	0.1664
Bacteria*Salinity	2	45	6.95	0.0023

Num DF: Numerator Degree of Freedom, Den DF: Denominator Degree of Freedom, F Value: Degrees of Freedom, Pr.: Probability.

4.17 The effect of *P. fluorescence* inoculation on Fresh Leaf Weight of Tomato plant under different salinity levels in Relation to Bacteria and Salinity.

The analysis of variance revealed that salinity and bacteria was significantly influenced plant fresh leaf weight for tomato. The plants inoculated with *P. fluorescence* revealed higher plant fresh leaf weight compared with plants not inoculated with *P. fluorescence* 37.8 g and 28.1g respectively. The results revealed as salinity increased the plant fresh leaf weight decrease in which the fresh -leaf weight was 33.25g at salinity control level compared with 34.3 at 150 mM of salinity level. Moreover, as salinity increased the fresh leaf weight decrease however, the bacterial inoculation ameliorate the effect of salinity where the maximum fresh leaf weight was 46g at 150 mM salinity level for inoculated plant compared to 22.6g at the same level of salinity without bacterial inoculation. Based on the mean separation, the effect of bacteria, salinity and bacteria x salinity were not significant ($P \leq 0.1045$, 0.9140 and 0.2494 respectively), (Table17) (see list of appendix, table 82-84).

Table 17: The analysis of variance for the effect of *P. fluorescence* on Fresh Leaf Weight of Tomato under different salinity levels.

Effect	Num DF	Den DF	F Value	Pr > F
Replicate	9	45	4.75	0.0002
Bacteria	1	45	2.75	0.1045
Salinity	2	45	0.09	0.9140
Bacteria*Salinity	2	45	1.43	0.2494

Num DF: Numerator Degree of Freedom, Den DF: Denominator Degree of Freedom, F Value: Degrees of Freedom, Pr.: Probability.

4.18 The effect of *P. fluorescence* inoculation on Leaf Dry Weight of Tomato plant under different salinity levels in Relation to Bacteria and Salinity.

The analysis of variance revealed that salinity and bacteria was significantly influenced plant leaf dry weight for tomato. The plants inoculated with *P. fluorescence* revealed higher plant leaf dry weight compared with plants not inoculated with *P. fluorescence* 23.7g and 20.53g respectively. The results revealed as salinity increased the plant leaf dry weight increase in which the leaf dry weight was 23.9g at salinity 150 mM level compared with 18.45g at control level of salinity. Moreover, as salinity increased the leaf dry weight decrease the bacterial inoculation reduce the effect of salinity where the maximum leaf dry weight was 29.4g at 150 mM salinity level for inoculated plant compared to 18.4g at the same level of salinity without bacterial inoculation. Based on the mean separation, the effect of bacteria, salinity and bacteria x salinity were not significant (P≤ 00.4222, 0.4218 and 0.3163 respectively) ,(Table18) (see list of appendix, table 85-87).

Table 18: The analysis of variance for the effect of *P. fluorescence* on Leaf Dry Weight of Tomato under different salinity levels.

Effect	Num DF	Den DF	F Value	Pr > F
Replicate	9	45	3.10	0.0056
Bacteria	1	45	0.66	0.4222
Salinity	2	45	0.88	0.4218
Bacteria*Salinity	2	45	1.18	0.3163

Num DF: Numerator Degree of Freedom, Den DF: Denominator Degree of Freedom, F Value: Degrees of Freedom, Pr.: Probability.

4.19 The effect of *P. fluorescence* inoculation on Leaf Width of Tomato plant under different salinity levels in Relation to Bacteria and Salinity.

The analysis of variance revealed that salinity and bacteria was not significantly influenced plant leaf width for tomato. The plants inoculated with *P. fluorescence* revealed higher plant leaf width compared with plants not inoculated with *P. fluorescence* 11.48cm and 7.35cm respectively. The results revealed as salinity increased the plant leaf width decrease in which the leaf width was 9.03cm at salinity 150 mM level compared with 10.17cm at control level of salinity. Moreover, as salinity increased the leaf width decrease, the bacterial inoculation reduce the effect of salinity where the maximum leaf width was 12.25cm at 150 mM salinity level for with bacterial inoculation plant compared 5.82cm at the same level of salinity without bacterial inoculation. Based on the mean separation, the effect of bacteria and bacteria x salinity were highly significant (P≤ 0.0001 and 0.0003 respectively) while the salinity was not significant (P≤ 0.1367) ,(Table19) (see list of appendix, table 88-90).

Table 19: The analysis of variance for the effect of *P. fluorescence* on Leaf Width of Tomato under different salinity levels.

Effect	Num DF	Den DF	F Value	Pr > F
Replicate	9	45	0.40	0.9292
bacteria	1	45	61.07	<.0001
salinity	2	45	2.08	0.1367
bacteria*salinity	2	45	9.89	0.0003

Num DF: Numerator Degree of Freedom, Den DF: Denominator Degree of Freedom, F Value: Degrees of Freedom, Pr.: Probability.

4.20 The effect of *P. fluorescence* inoculation on Leaf Length of Tomato plant under different salinity levels in Relation to Bacteria and Salinity.

The analysis of variance revealed that salinity and bacteria was not significantly influenced plant leaf length for tomato. The plants inoculated with *P. fluorescence* revealed best leaf length compared with plants not inoculated with *P. fluorescence* 11.14cm and 8.22cm respectively. The results revealed as salinity increased the plant leaf length decrease in which the leaf length was 9.88cm at salinity 100 mM level compared with 10.05cm at control level of salinity. Moreover, as salinity increased the leaf length decreased, the bacterial inoculation reduce the effect of salinity where the maximum leaf length was 12.47cm at 150mM salinity level for with bacterial inoculation plant compared 5.75cm at the same level of salinity without bacterial inoculation. Based on the mean separation, the effect of bacteria and bacteria x salinity were highly significant ($P \leq 0.0001$ and 0.0001 respectively) while the salinity was not significant ($P \leq 0.2535$), (Table20) (see list of appendix, table 91-93).

Table 20: The analysis of variance for the effect of *P. fluorescence* on Leaf Length of Tomato under different salinity levels.

Effect	Num DF	Den DF	F Value	Pr > F
Replicate	9	45	1.85	0.0849
Bacteria	1	45	36.07	<.0001
Salinity	2	45	1.42	0.2535
Bacteria*Salinity	2	45	23.33	<.0001

Num DF: Numerator Degree of Freedom, Den DF: Denominator Degree of Freedom, F Value: Degrees of Freedom, Pr.: Probability.

4.21 The effect of *P. fluorescence* inoculation on Total Biomass of Tomato plant under different salinity levels in Relation to Bacteria and Salinity.

The analysis of variance revealed that salinity and bacteria was significantly influenced plant total biomass for tomato. The plants inoculated with *P. fluorescence* revealed higher plant total biomass compared with plants not inoculated with *P. fluorescence* 172.48g and 87.31g respectively. The results revealed as salinity increased the plant total biomass decrease in which the total biomass was 135.65g at salinity control level compared with 126.69g at 100 mM of salinity level. Moreover, as salinity increased the total biomass decrease the bacterial inoculation decrease the effect of salinity where the maximum total biomass was 191.25g at 150 Mm salinity level for inoculated plant compared to 63.43g at the same level of salinity without bacterial inoculation. Based on the mean separation, the effect of bacteria was highly significant ($P \leq 0.0001$). on the other hand, salinity was not significant

(P≤ 0.7100) while bacteria x salinity was significant (P≤ 0.0137), (Table21) (see list of appendix, table 94-96).

Table 21: The analysis of variance for the effect of *P. fluorescence* on Total Biomass of Tomato under different salinity levels.

Effect	Num DF	Den DF	F Value	Pr > F
Replicate	9	45	5.11	<.0001
Bacteria	1	45	75.32	<.0001
Salinity	2	45	0.35	0.7100
Bacteria*Salinity	2	45	4.73	0.0137

Num DF: Numerator Degree of Freedom, Den DF: Denominator Degree of Freedom, F Value: Degrees of Freedom, Pr.: Probability.

4.22 The effect of *P. fluorescence* inoculation on Nitrogen Content in Root of Tomato plant under different salinity levels in Relation to Bacteria and Salinity.

The analysis of variance revealed that salinity and bacteria was significantly influenced plant by nitrogen effect on roots for tomato. The plants inoculated with *P. fluorescence* revealed higher nitrogen content on roots compared with plants not inoculated with *P. fluorescence* 0.23% and 0.21% respectively. The results revealed as salinity increased the nitrogen content on roots decrease in which the nitrogen content on roots was 0.24% at 150 mM of salinity level compared with 0.22% at control salinity level. Moreover, as salinity increased the nitrogen content on roots increase however, the bacterial inoculation reduce the effect of salinity where the maximum content was 0.29% at 150 mM salinity level for inoculated plant compared to 0.18% at the same salinity level of salinity without bacterial inoculation. Based on the mean separation, the interaction between bacteria

x salinity was highly significant (P≤ 0.001). on the other hand, salinity was significant (P≤ 0.0031) and bacteria was not significant (P≤ 0.1011), (Table22) (see list of appendix, table 97-99).

Table 22: The analysis of variance for the effect of *P. fluorescence* on Nitrogen Content in Root of Tomato under different salinity levels.

Effect	Num DF	Den DF	F Value	Pr > F
Rep	2	10	2.50	0.1318
Bacteria	1	10	3.26	0.1011
Salinity	2	10	10.87	0.0031
Bacteria*Salinity	2	10	152.07	<.0001

Num DF: Numerator Degree of Freedom, Den DF: Denominator Degree of Freedom, F Value: Degrees of Freedom, Pr.: Probability.

4.23 The effect of *P. fluorescence* inoculation on Nitrogen Content in Leaf of Tomato plant under different salinity levels in Relation to Bacteria and Salinity.

The analysis of variance revealed that salinity and bacteria was significantly influenced plant by nitrogen content on leaf for tomato. The plants not inoculated with *P. fluorescence* revealed higher nitrogen content on leaf compared with plants inoculated with *P. fluorescence* 0.81% and 0.80% respectively. The results revealed as salinity increased the nitrogen content on leaf decrease in which the nitrogen content on roots was 0.9% at 150 mM of salinity level compared with 0.7% at control salinity level. Moreover, as salinity increased the bacterial inoculation reduce the effect of salinity where the maximum nitrogen content on leaf was 0.93% at 100mM salinity level for inoculated plant compared to 0.78% at the same

level of salinity without bacterial inoculation. Based on the mean separation, the effect of bacteria was significant (P≤ 0.003). On the other hand, salinity and bacteria were highly significant (P≤ 0.0001) ,(Table 23) (see list of appendix, table 100-102).

Table 23: The analysis of variance for the effect of *P. fluorescence* on Nitrogen Content in Leaf of Tomato under different salinity levels.

Effect	Num DF	Den DF	F Value	Pr > F
Rep	2	10	0.52	0.6085
Bacteria	1	10	15.13	0.0030
Salinity	2	10	995.62	<.0001
Bacteria*Salinity	2	10	567.64	<.0001

Num DF: Numerator Degree of Freedom, Den DF: Denominator Degree of Freedom, F Value: Degrees of Freedom, Pr.: Probability.

4.24 The effect of *P. fluorescence* inoculation on Chlorine Content in Root of Tomato plant under different salinity levels in Relation to Bacteria and Salinity.

The analysis of variance revealed that salinity and bacteria were significantly influenced plant by chlorine content on roots for tomato. The plants inoculated with *P. fluorescence* revealed higher chlorine effect on roots compared with plants not inoculated with *P. fluorescence* 1.04% and 0.30% respectively. The results revealed as salinity increased the chlorine content on roots decrease in which the chlorine content on roots was 0.98% at control level of salinity compared with 0.5 % at 150 mM level of salinity level. Moreover, as salinity increased the chlorine content on roots however, the bacterial inoculation reduce the effect of salinity was the maximum 0.95% at 150mM salinity level for inoculated plant compared to

0.04% at the same level of salinity without bacterial inoculation. Based on the mean separation, the effect of bacteria, salinity and bacteria x salinity were highly significant (P ≤ 0.0001). (Table 24), (see list of appendix, table 103-105),(Figure 9).

Table 24: The analysis of variance for the effect of *P. fluorescence* on Chlorine Content in Root of Tomato under different salinity levels.

Effect	Num DF	Den DF	F Value	Pr > F
rep	2	10	2.48	0.1333
bacteria	1	10	891.06	<.0001
salinity	2	10	149.34	<.0001
bacteria*salinity	2	10	80.91	<.0001

Num DF: Numerator Degree of Freedom, Den DF: Denominator Degree of Freedom, F Value: Degrees of Freedom, Pr.: Probability.

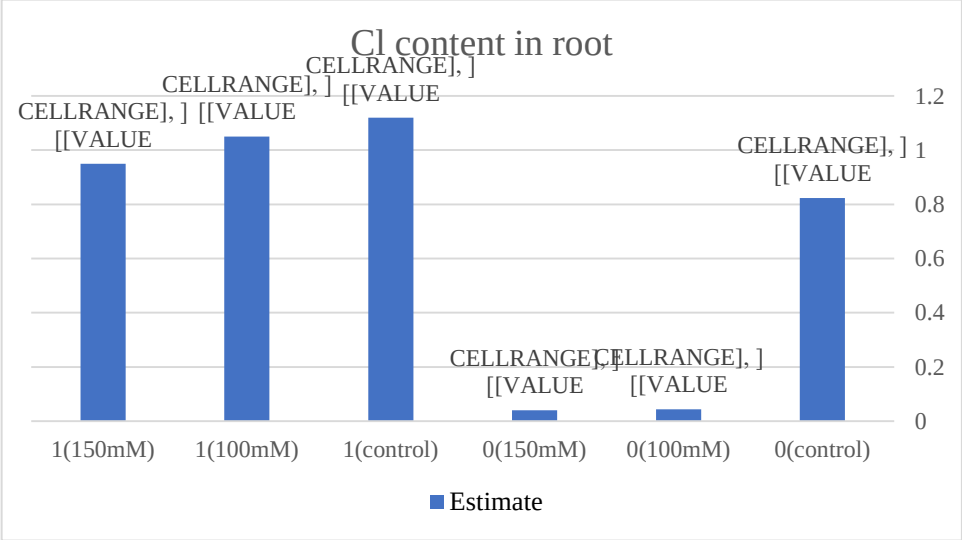

Figure 9: Effect of the interaction between salinity and *P. fluorescence* on chlorine content in root of Tomato plant.0: without P. *fluorescence* 1: with *P. fluorescence*, Salinity: (control, 100,150) mM.

4.25 The effect of *P. fluorescence* inoculation on Sodium Content in Root of Tomato plant under different salinity levels in Relation to Bacteria and Salinity.

The analysis of variance revealed that salinity and bacteria were significantly influenced plant by sodium content on roots for tomato. The plants inoculated with *P. fluorescence* revealed higher sodium content on roots compared with plants not inoculated with *P. fluorescence* 0.07% and 0.03% respectively. The results revealed as salinity increased the sodium effect on roots decrease in which the sodium content on roots was 0.05% at control level of salinity compared with 0.05% at 150 mM level of salinity. Moreover, as salinity, increased the content of sodium on roots however, the bacterial inoculation reduce the effect of salinity was the maximum 0.08% at salinity 100 mM level for inoculated plant compared to 0.04% at the same level of salinity without bacterial inoculation. Based on the mean separation, the effect of bacteria was highly significant ($P \leq 0.0001$), on the other hand, salinity and bacteria x salinity were not significant ($P \leq 0.0917$), (Table 25) (see list of appendix, table 106-108),(Figure 10).

Table 25: The analysis of variance for the effect of *P. fluorescence* on Sodium Content in Root of Tomato under different salinity levels.

Effect	Num DF	Den DF	F Value	Pr > F
rep	2	10	1.75	0.2230
bacteria	1	10	52.56	<.0001
salinity	2	10	3.06	0.0917
bacteria*salinity	2	10	3.06	0.0917

Num DF: Numerator Degree of Freedom, Den DF: Denominator Degree of Freedom, F Value: Degrees of Freedom, Pr.: Probability.

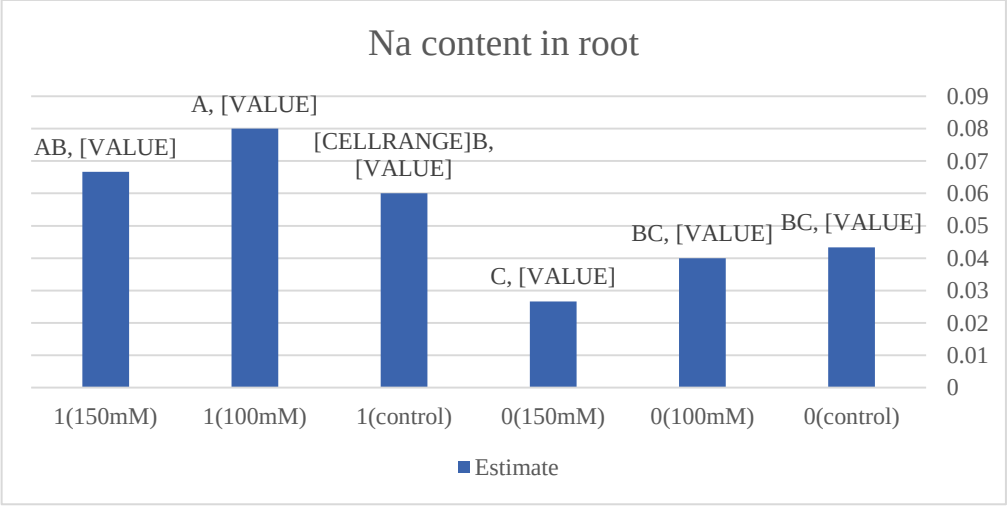

Figure 10: Effect of the interaction between salinity and *P. fluorescence* on sodium content in root of Tomato plant. 0: without P. *fluorescence* 1: with *P. fluorescence*, Salinity: (control, 100,150) mM

4.26 The effect of *P. fluorescence* inoculation on Potassium Content in Root of Tomato plant under different salinity levels in Relation to Bacteria and Salinity.

The analysis of variance revealed that salinity and bacteria were significantly influenced plant by Potassium content on roots for tomato. The plants inoculated with *P. fluorescence* revealed higher Potassium content on roots compared with plants not inoculated with *P. fluorescence* 1.05% and 0.32% respectively. The results revealed as salinity increased the Potassium content on roots decrease in which the Potassium content on roots was 0.74% at control level of salinity compared with 0.8% at 150 mM level of salinity level. Moreover, as salinity increased the Potassium content on roots however, the bacterial inoculation reduce the effect of salinity was the maximum 1.22% at 150mM salinity level for inoculated plant compared to 0.30% at the same level of salinity without bacterial inoculation. Based on the mean separation, the effect of bacteria and

salinity were highly significant (P ≤ 0.0001). on the other hand, bacteria x salinity was significant (P ≤ 0.0007), (Table 26) (see list of appendix, table 109-111), (Figure 11).

Table 26: The analysis of variance for the effect of *P. fluorescence* on Potassium Content in Root of Tomato under different salinity levels.

Effect	Num DF	Den DF	F Value	Pr > F
rep	2	10	1.33	0.3087
bacteria	1	10	751.93	<.0001
salinity	2	10	28.97	<.0001
bacteria*salinity	2	10	16.38	0.0007

Num DF: Numerator Degree of Freedom, Den DF: Denominator Degree of Freedom, F Value: Degrees of Freedom, Pr.: Probability.

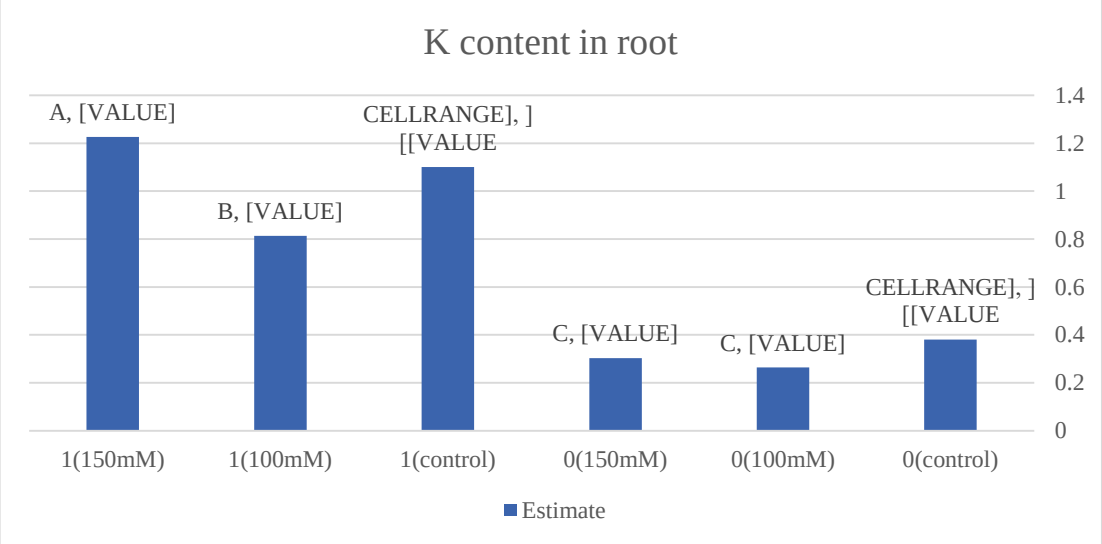

Figure 11: Effect of the interaction between salinity and *P. fluorescence* on potassium content in root of Tomato plant. 0: without P. *fluorescence* 1: with *P. fluorescence*, Salinity: (control, 100,150) mM

4.27 The effect of *P. fluorescence* inoculation on Calcium Content in Root of Tomato plant under different salinity levels in Relation to Bacteria and Salinity:

The analysis of variance revealed that salinity and bacteria were significantly influenced plant by content on roots for tomato. The plants inoculated with *P. fluorescence* revealed higher Potassium content on roots compared with plants not inoculated with *P. fluorescence* 3.6% and 2.2% respectively. The results revealed as salinity increased the Calcium content on roots decrease in which the Calcium content on roots was 2.83% at control level of salinity compared with 3% at 150 mM level of salinity level. Moreover, as salinity increased the Calcium content on roots however, in the result was revealed the bacterial inoculation reduce the effect of salinity was the maximum 4.50% at salinity control level for inoculated plant compared to 1.17% at the same level of salinity without bacterial inoculation that give positive effect, in contrast when compared calcium content in root for inoculated plant was 3.30% at 100mM compared with non inoculated 2.50% at the same level of salinity . Based on the mean separation, the effect of bacteria and bacteria x salinity were highly significant ($P \leq 0.0001$). on the other hand, salinity was not significant ($P \leq 0.7543$), (Table 27) (see list of appendix, table 112-114),(Figure 12).

Table 27: The analysis of variance for the effect of *P. fluorescence* on Calcium Content in Root of Tomato under different salinity levels.

Effect	Num DF	Den DF	F Value	Pr > F
rep	2	10	0.24	0.7878
bacteria	1	10	58.69	<.0001
salinity	2	10	0.29	0.7543
bacteria*salinity	2	10	31.21	<.0001

Num DF: Numerator Degree of Freedom, Den DF: Denominator Degree of Freedom, F Value: Degrees of Freedom, Pr.: Probability.

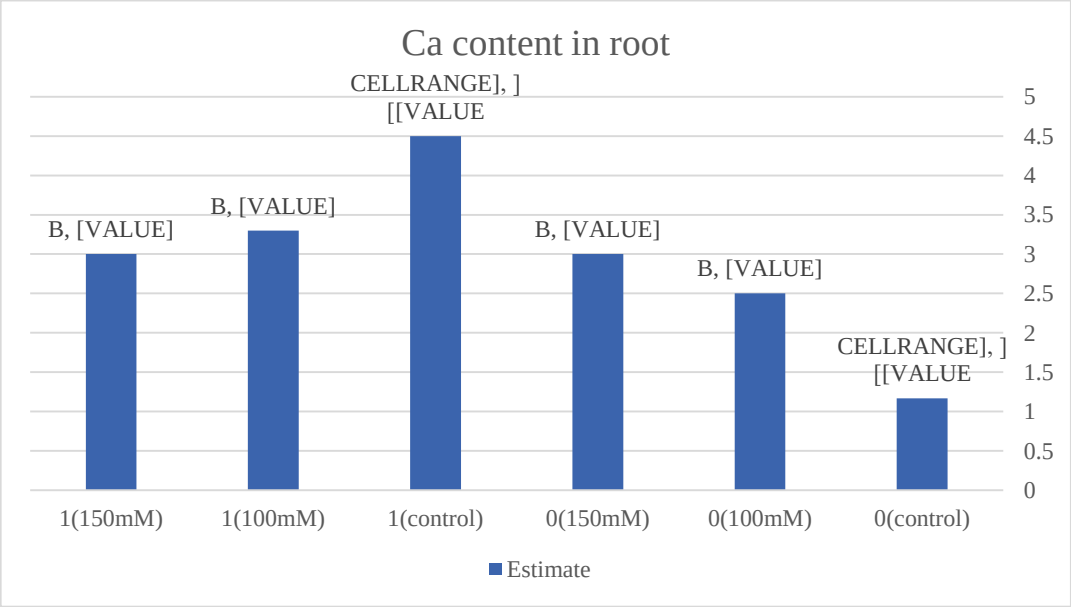

Figure 12: Effect of the interaction between salinity and *P. fluorescence* on calcium content in root of Tomato plant. 0: without P. *fluorescence* 1: with *P. fluorescence*, Salinity: (control, 100,150) mM

4.28 The effect of *P. fluorescence* inoculation on Phosphorus Content in Root of Tomato plant under different salinity levels in Relation to Bacteria and Salinity.

The analysis of variance revealed that salinity and bacteria were significantly influenced plant by Phosphorus content on roots for tomato.

The plants inoculated with *P. fluorescence* revealed higher Phosphorus content on roots compared with plants not inoculated with *P. fluorescence* 1897.97ppm and 1882.29ppm respectively. The results revealed as salinity increased the Phosphorus content on roots decrease in which the Phosphorus content on roots was 1867.08ppm at control level of salinity compared with 1959.67ppm at 100 mM level of salinity level. Moreover, as salinity increased the Phosphorus content on roots increase however, the bacterial inoculation reduce the effect of salinity was the maximum 2010.17ppm at salinity control level for inoculated plant compared to 1724ppm at the control level of salinity without bacterial inoculation, the result revealed higher positive content of phosphorus content in root ,in contrast when compared at 100mM salinity level of for inoculated plant was 1952.17ppm compared with non-inoculated plant 1967.17ppm at the same level of salinity. Based on the mean separation, the effect of salinity and bacteria x salinity were highly significant ($P \leq 0.0001$). on the other hand, bacteria was not significant ($P \leq 0.1491$), (Table 28) (see list of appendix, table 115-117), (Figure 13).

Table 28: The analysis of variance for the effect of *P. fluorescence* on Phosphorus Content in Root of Tomato under different salinity levels.

Effect	Num DF	Den DF	F Value	Pr > F
rep	2	10	1.31	0.3126
bacteria	1	10	2.44	0.1491
salinity	2	10	49.88	<.0001
bacteria*salinity	2	10	218.02	<.0001

Num DF: Numerator Degree of Freedom, Den DF: Denominator Degree of Freedom, F Value: Degrees of Freedom, Pr.: Probability.

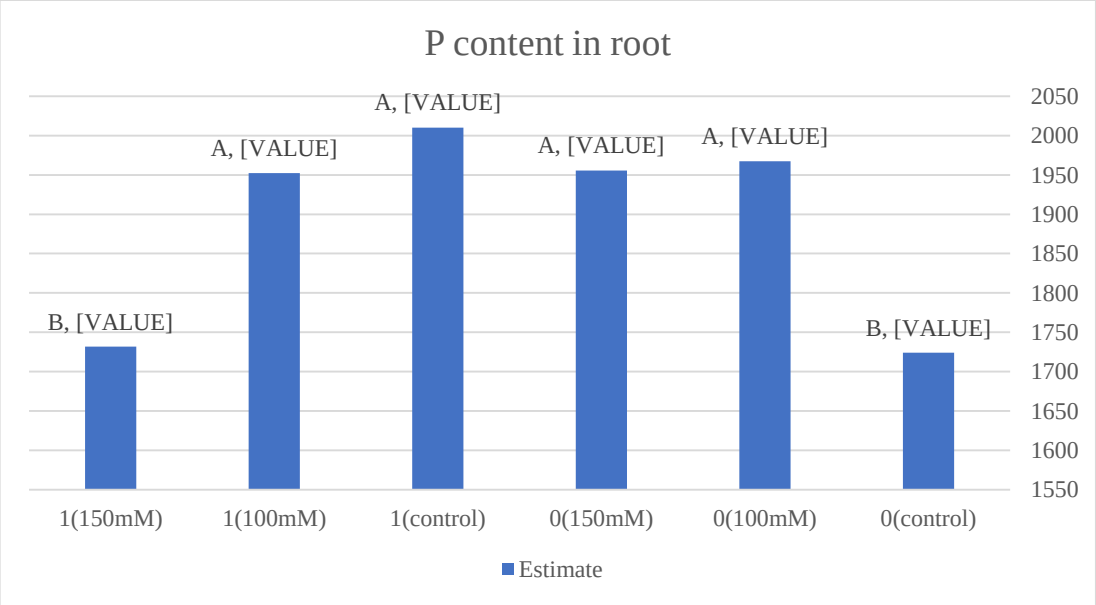

Figure 13: Effect of the interaction between salinity and *P. fluorescence* on phosphorus content in root of Tomato plant. 0: without P. *fluorescence* 1: with *P. fluorescence*, Salinity: (control, 100,150) mM

4.29 The effect of *P. fluorescence* inoculation on Sodium Content in Leaf of Tomato plant under different salinity levels in Relation to Bacteria and Salinity.

The analysis of variance revealed that salinity and bacteria were significantly influenced plant by sodium content on leaf for tomato. The plants inoculated with *P. fluorescence* revealed higher Sodium effect on leaf compared with plants not inoculated with *P. fluorescence* 0.14% and 0.12% respectively. The results revealed as salinity increased the sodium content on leaf decrease in which the sodium content on leaf was 0.13% at control level of salinity compared with 0.14% at 100 mM level of salinity. Moreover, as salinity increased the sodium content on leaf decrease however ,the bacterial inoculation ameliorates the effect of salinity was the maximum 0.15% at salinity control level for inoculated plant compared to

0.11% at the same level of salinity without bacterial inoculation ,that give percent of sodium in leaf in contrast when compared at 150mM for inoculation plant was 0.13% and 0.12% for non-inoculated plant at the same level of salinity. Based on the mean separation, the effect of bacteria was highly significant, salinity and bacteria x salinity were not significant ($P \leq 0.0345$, 0.4662 and 0.1667 respectively), (Table 29) (see list of appendix, table 118-120),(Figure 14).

Table 29: The analysis of variance for the effect of *P. fluorescence* on Sodium Content in Leaf of Tomato under different salinity levels.

Effect	Num DF	Den DF	F Value	Pr > F
rep	2	10	1.70	0.2311
bacteria	1	10	5.98	0.0345
salinity	2	10	0.82	0.4662
bacteria*salinity	2	10	2.15	0.1667

Num DF: Numerator Degree of Freedom, Den DF: Denominator Degree of Freedom, F Value: Degrees of Freedom, Pr.: Probability.

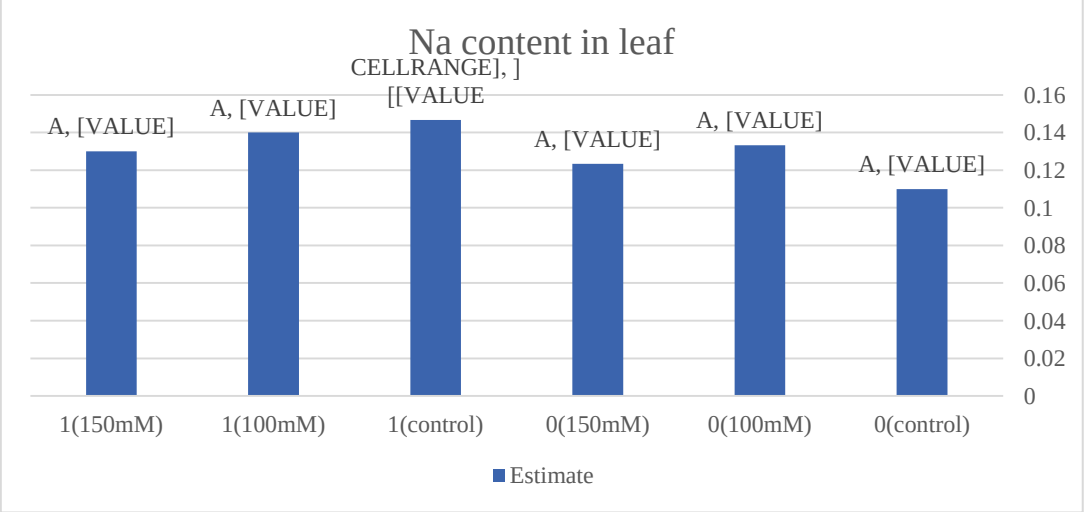

Figure 14: Effect of the interaction between salinity and *P. fluorescence* on sodium content in leaf of Tomato plant. 0: without P. *fluorescence* 1: with *P. fluorescence*, Salinity: (control, 100,150) mM

4.30 The effect of *P. fluorescence* inoculation on Potassium Content in Leaf of Tomato plant under different salinity levels in Relation to Bacteria and Salinity.

The analysis of variance revealed that salinity and bacteria were significantly influenced plant by Potassium content on leaf for tomato. The plants inoculated with *P. fluorescence* revealed higher Potassium content on roots compared with plants not inoculated with *P. fluorescence* 2.02% and 1.63% respectively. The results revealed as salinity increased the Potassium content on leaf decrease in which the Potassium content on leaf was 1.81% at control level of salinity compared with 1.88% at 150 mM level of salinity. Moreover, as salinity increased the Potassium content on roots decrease however, the bacterial inoculation reduce in which the effect of salinity was the maximum 2.16% at salinity 150mM level for inoculated plant compared to 1.55% at the same level of salinity without bacterial inoculation. Based on the mean separation, the effect of bacteria was significant ($P \leq 0.004$). on the other hand, salinity and bacteria x salinity were not significant ($P \leq 0.7429$ and 0.2291 respectively), (Table 30) (see list of appendix, table 121-123),(Figure 15).

Table 30: The analysis of variance for the effect of *P. fluorescence* on Potassium Content in Leaf of Tomato under different salinity levels.

Effect	Num DF	Den DF	F Value	Pr > F
rep	2	10	1.28	0.3208
bacteria	1	10	13.86	0.0040
salinity	2	10	0.31	0.7429
bacteria*salinity	2	10	1.71	0.2291

Num DF: Numerator Degree of Freedom, Den DF: Denominator Degree of Freedom, F Value: Degrees of Freedom, Pr.: Probability.

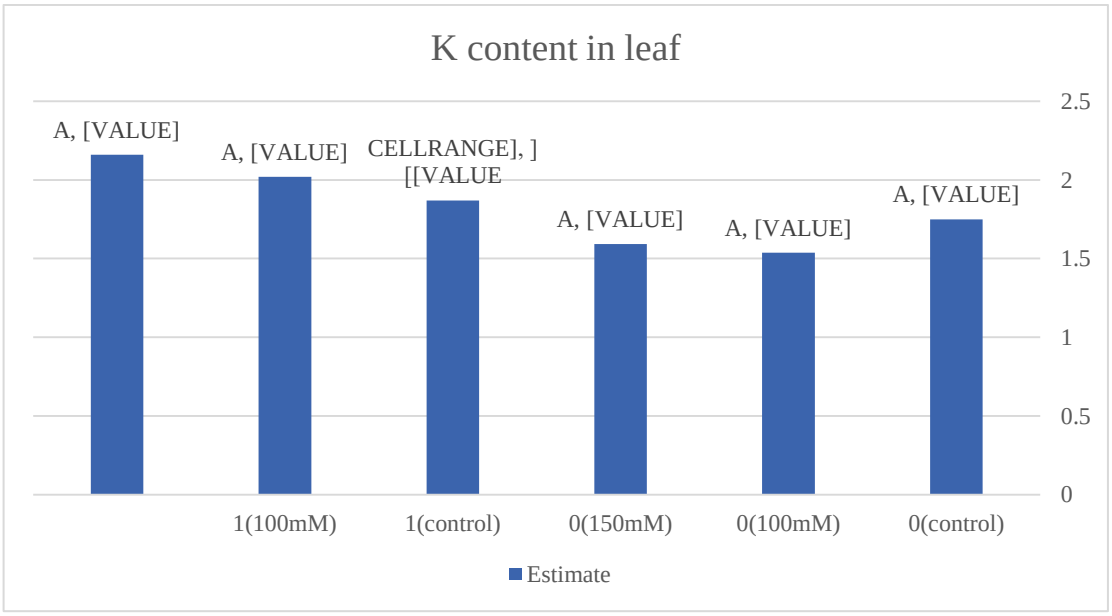

Figure 15: Effect of the interaction between salinity and *P. fluorescence* on potassium content in leaf of Tomato plant. 0: without P. *fluorescence* 1: with *P. fluorescence*, Salinity: (control, 100,150) mM

4.31 The effect of *P. fluorescence* inoculation on Calcium Content in Leaf of Tomato plant under different salinity levels in Relation to Bacteria and Salinity:

The analysis of variance revealed that salinity and bacteria were significantly influenced plant by Calcium content on leaf for tomato. The plants inoculated with *P. fluorescence* revealed higher Calcium content on roots compared with plants not inoculated with *P. fluorescence* 4.13% and 3.66% respectively. The results revealed as salinity increased the Calcium content on leaf decrease in which the Calcium content on leaf was 4.92% at control level of salinity compared with 3.12% at 150 mM level of salinity level. Moreover, as salinity increased the Calcium content on leaf decrease however, the bacterial inoculation reduce the effect of salinity was equally that 5% at salinity control level for inoculated plant and 5% at the same

level of salinity without bacterial inoculation, result that revealed higher calcium content in contrast when compared at 100mM for inoculated plant was 3.39% compared 3.36% for non-inoculated plant . Based on the mean separation, the effect of bacteria and bacteria x salinity were significant ($P \leq 0.0026$ and 0.0071 respectively). on the other hand, salinity was highly significant ($P \leq 0.0001$), (Table 31) (see list of appendix, table 124-126), (Figure 16).

Table 31: The analysis of variance for the effect of *P. fluorescence* on Calcium Content in Leaf of Tomato under different salinity levels.

Effect	Num DF	Den DF	F Value	Pr > F
rep	2	10	1.68	0.2353
bacteria	1	10	15.83	0.0026
salinity	2	10	79.04	<.0001
bacteria*salinity	2	10	8.46	0.0071

Num DF: Numerator Degree of Freedom, Den DF: Denominator Degree of Freedom, F Value: Degrees of Freedom, Pr.: Probability.

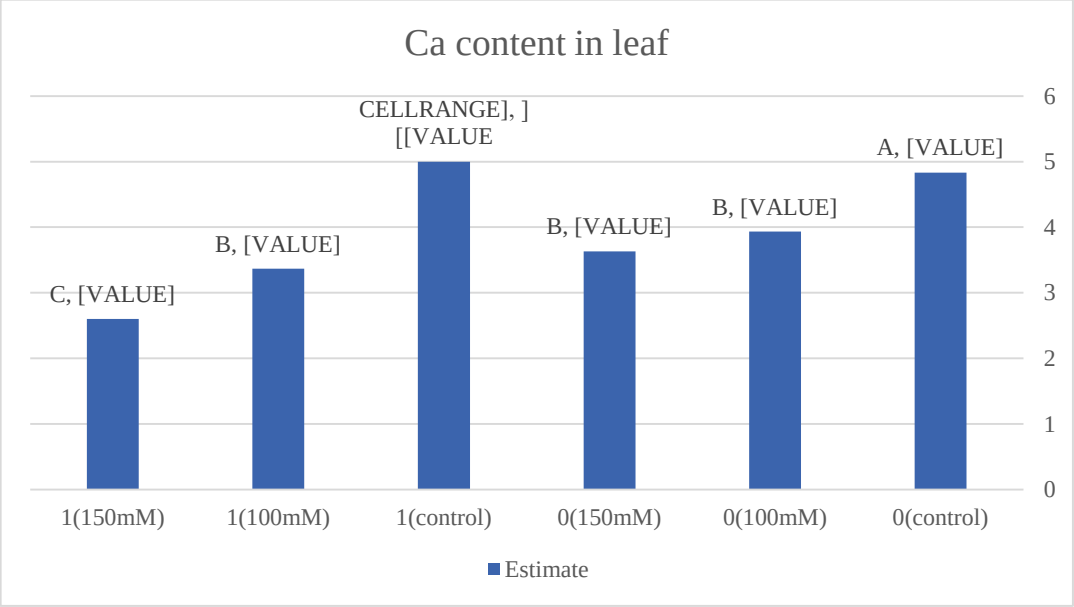

Figure 16: Effect of the interaction between salinity and P. fluorescence on calcium content in leaf of Tomato plant. 0: without P. *fluorescence* 1: with *P. fluorescence*, Salinity: (control, 100,150) mM

4.32 The effect of *P. fluorescence* inoculation on Phosphorus Content in Leaf of Tomato plant under different salinity levels in Relation to Bacteria and Salinity.

The analysis of variance revealed that salinity and bacteria were significantly influenced plant by Phosphorus content on leaf for tomato. The plants not inoculated with *P. fluorescence* revealed higher Phosphorus content on leaf compared with plants inoculated with *P. fluorescence* 320ppm and 293.17ppm respectively. The results revealed as salinity increased the Phosphorus content on leaf decrease in which the Phosphorus content on roots was 307.17ppm at control level of salinity compared with 333.78ppm at 150mM level of salinity level. Moreover, as salinity increased the Phosphorus content on leaf increase however ,the bacterial inoculation reduce the effect of salinity was the maximum 357.33ppm at salinity control level for non- inoculated plant compared to 257ppm at the same level of salinity for bacterial inoculation plant ,phosphors content of leaf give positive impact and best at (zero salinity) in contrast when compared at 100Mm for inoculated plant was 285.27ppm than with non-inoculated plant 272.33ppm at the same level of salinity. Based on the mean separation, the effect of salinity, bacteria and bacteria x salinity were highly significant ($P \leq 0.0001$), (Table 32) (see list of appendix, table 127-129), (Figure 17).

Table 32: The analysis of variance for the effect of *P. fluorescence* on Phosphorus Content in Leaf of Tomato under different salinity levels.

Effect	Num DF	Den DF	F Value	Pr > F
rep	2	10	1.80	0.2149
bacteria	1	10	297.25	<.0001
salinity	2	10	416.16	<.0001
bacteria*salinity	2	10	558.81	<.0001

Num DF: Numerator Degree of Freedom, Den DF: Denominator Degree of Freedom, F Value: Degrees of Freedom, Pr.: Probability.

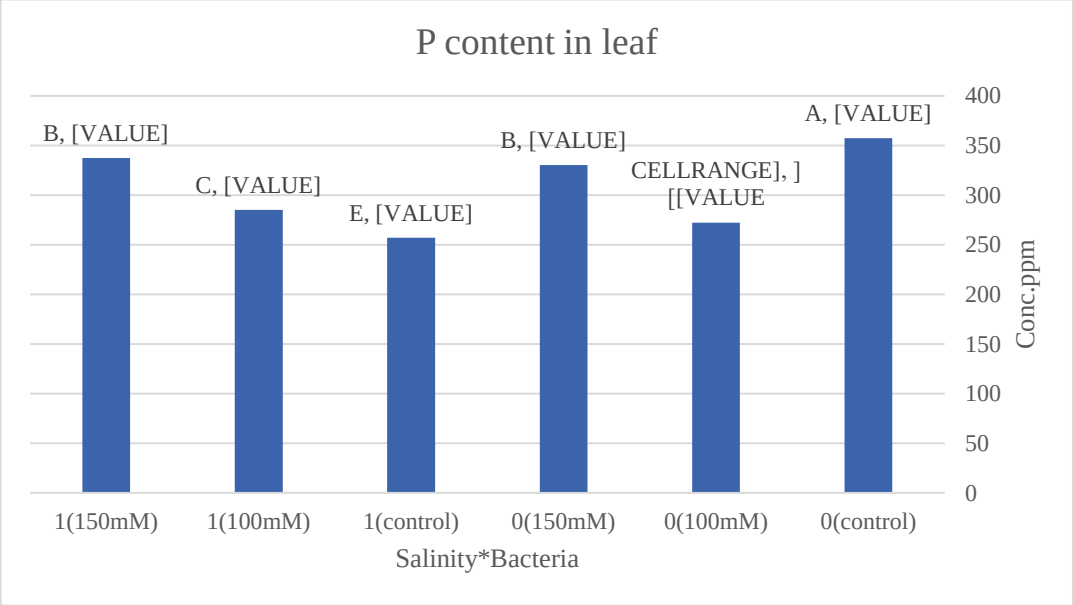

Figure 17: Effect of the interaction between salinity and *P. fluorescence* on Phosphorus content in leaf of Tomato plant. 0: without *P. fluorescence* 1: with *P. fluorescence*, Salinity: (control, 100,150) mM

4.33 The effect of *P. fluorescence* inoculation on Chlorine Content in Leaf of Tomato plant under different salinity levels in Relation to Bacteria and Salinity:

The analysis of variance revealed that salinity and bacteria were significantly influenced plant by chlorine content on leaf for tomato. The plants not inoculated with *P. fluorescence* revealed higher chlorine content

on leaf compared with plants inoculated with *P. fluorescence* 4.23% and 3.89% respectively. The results revealed as salinity increased the chlorine effect on leaf decrease in which the chlorine content on leaf was 3.99% at control content of salinity compared with 4.22% at 150mM level of salinity level. Moreover, as salinity increased the chlorine content on leaf increase however, the bacterial inoculation reduce the effect of salinity was the maximum 4.27% at100mM salinity level for inoculated plant compared to 3.65% at the same level of salinity with non-inoculation. Based on the mean separation, the effect of bacteria was significant ($P \leq 0.0015$). on the other hand, salinity was not significant ($P \leq 0.0490$). While bacteria x salinity was highly significant ($P \leq 0.0001$), (Table 33) (see list of appendix, table 130-132),(Figure18).

Table 33: The analysis of variance for the effect of *P. fluorescence* on Chlorine Content in Leaf of Tomato under different salinity levels.

Effect	Num DF	Den DF	F Value	Pr > F
rep	2	10	2.62	0.1216
bacteria	1	10	18.59	0.0015
salinity	2	10	4.14	0.0490
bacteria*salinity	2	10	38.30	<.0001

Num DF: Numerator Degree of Freedom, Den DF: Denominator Degree of Freedom, F Value: Degrees of Freedom, Pr.: Probability.

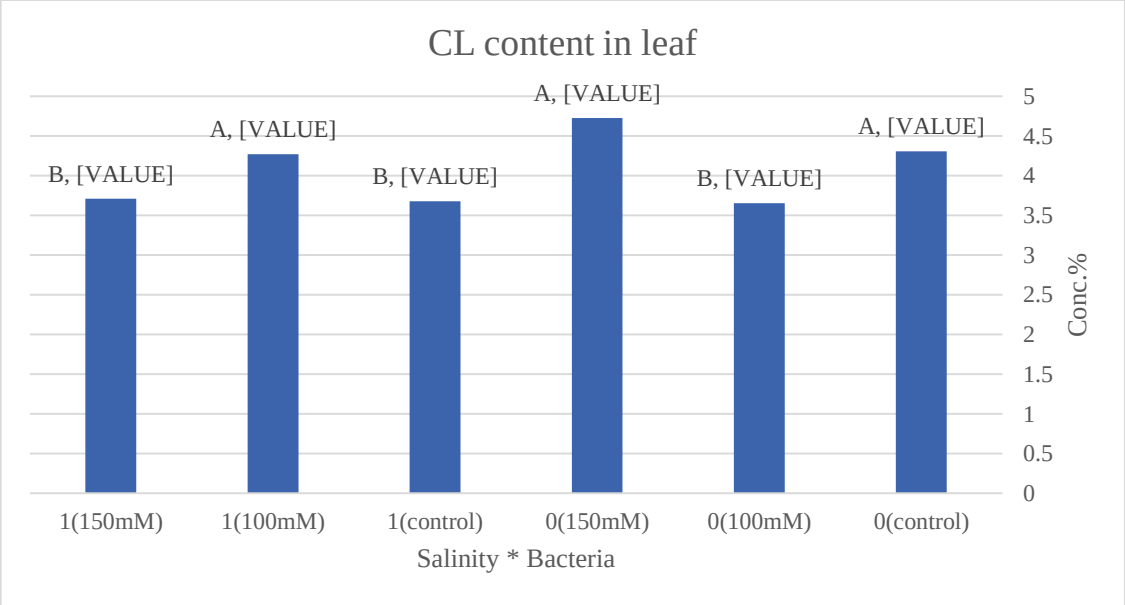

Figure 18: Effect of the interaction between salinity and *P. fluorescence* on Chlorine content in leaf of Tomato plant. 0: without *P. fluorescence* 1: with *P. fluorescence*, Salinity: (control, 100,150) mM .

Chapter Five
Discussion

5.1 The Effect of *P. fluorescence* on yield and yield component.

Salinity effect one of the major factor that influence plant and agriculture component represented in soluble salts concentrations in soils and irrigation water. Higher concentration of soluble salts lead to reduction in crop yields, the degree of this effect depends on (EC) the conductivity of saline water in the soil. In this study, the use of P. fluorescence was evaluated for their effectiveness in sustainable agriculture.

Sharm et al., (2016) proposed that saline soil can be characterized by high soluble salts concentration in saline water that have effect on osmotic pressure in plant and lead to wilting of the plant. Also a reduction in electrical conductivity (EC)Several studies indicated that salt stress lead to decreases in yields (Pascale et al, 2015), Chretien et al., 2000; Fernandez et al., 2004). Li et al. (2001) and Eltez et al. (2002) also reported that number of fruit are un affected by moderate salinity and yield reduction was smaller fruit. This study shown that the inoculation of tomato plant with *P. fluorescence* using hydroponic system reduce the effect of salinity. The analysis of yield components in this study revealed higher results for shoot height, number of main branches, number of leaves, shoot fresh weight, shoot dry weight, root dry weight, root fresh weight, number of mainly nodules on root, leaf fresh weight, leaf dry weight, leaf area, length of main root, total biomass, main stem diameter, number of fruit per plant and fruit

weight with or without bacterial inoculation. Several studies have shown a positive effect of inoculated plants with PGP bacteria which lead significant improvement in plants productivity, include (PGPR) that increase growth and yields of potato, sugar beet, radish and sweet potato Farzana Y et al,2009)

Salinity reduce the yields and yield components of plant in non-inoculated tomato compared with inoculated plant with *P. fluorescence* bacteria that fruit number was 3.43 and 7.43 respectively, also, salinity might influence bacteria function in soil leads to toxicity of plant, but some bacteria have the ability to tolerate salinity and can live a long period of time in saline soil and these bacteria have positive impact on plant, yields, survival and proliferate for long periods.

Salinity treatment improved the quality of fruits and plants cultivated with the nutrient film technique enhanced nutrient concentrations.(Maggio et al, 2006).

Some of study about flowering intensity indicated that increasing salinity lead to reduction in the number of flowers for plant (Grunberg et al, 1995; Van Ieperen, 1996),also decreased of fruit set and upper inflorescence of plant (Adams and Ho, 1992).

In this study the data revealed that salinity and bacteria was significantly influenced flowering intensity of tomato plant, also plants inoculated with *P. fluorescence* revealed higher plant flowering intensity compared with plants not inoculated with *P. fluorescence* 32.47 and 13.4

respectively, the result revealed that increase of salinity lead to increase flowering intensity, in which the flowering intensity was 25.05 at salinity 100 mM level compared to 20.05 at control level of salinity, moreover inoculation with bacteria alleviate the effect of salinity on plant by three fold precisely 36.2 at 150 mM with bacteria compared to 11.2 without bacteria at the same level of salinity. In the study the result showed highly significant in relation to bacteria effect, not significant shown regarding the salinity, however, a significant difference was observed for combined treatments of bacteria and salinity (Table1) (see list of appendix, table 34-36).

Some studies about yields of tomato (Qaryouti *et al*, 2007), founds that total tomato yields is significantly reduced under salinity stress, in addition, Magan *et al*, (2008) founds that the total fresh fruits yields of tomato decreased significantly with increasing salinity, Del Amour *et al*, (2001) showed that tomato fruit yields reduced by salinity, the reduction was according to both size and number of fruit. A study conducted by Neelam Tank & Meenu Saraf (2010) showed that salinity reduce primary tomato root length by 60%.

Fruit number of tomato plant in the study revealed that salinity and bacteria was significantly influence this parameter, also the plant inoculated with *P. fluorescence* revealed higher plant fruit number compared with non-inoculated plants 7.43 and 3.43 respectively, moreover salinity increase lead to decreasing in fruit number. However, in comparison to plant treated *P. fluorescence* at the same salinity level,

treated plants produced higher fruits number compared with non-inoculated plants 8.5 fruit at 150 mM with bacteria compared to 3 fruit without bacteria at the same level of salinity. Result in the study showed highly significant in bacteria effect but not significant in salinity effect, (Table2) (see list of appendix, table 37-39).

Lucas et al., (2004) indicated that the number of tomato fruits produced in hydroponic medium were increased significantly by inoculation with PGPR.

This study revealed that salinity and bacteria have influence on fruit weight of tomato, plants inoculated with *P. fluorescence* produced higher fruit weight of tomato compared with non-inoculated plants, however increasing salinity lead to decreasing fruit weight. Despite the negative effect of salinity inoculated plant showed the maximum fruit weight was 104.6 g at 150 mM compared to non-inoculated plant at same salinity 12.6 g, this result was highly significant in relation of bacteria and salinity (Table3) (see list of appendix, table 40-42).and indicated the pronounced effect of *P. fluorescence* as growth promoting bacteria.

The root growth in plant affected negatively with increase salinity, root length in relation to bacteria and salinity in this study revealed significant on plant growth and development. Some study such as 1% NaCl decreased root length approximately 26%(Leo, 1964). However, the plant inoculated with *P. fluorescence* revealed higher root length compared with plant that was none inculcated with *P. fluorescence* 48.33cm and 33,72cm

respectively. The result revealed as salinity increase the root length of plant decrease in which the root length was 42.27cm at salinity control level compared 39.75cm at 100 mM salinity level, root length for inoculated plant with *P.fluorescence* was 50.8cm compared with non inoculated plant 31.3cm at the same level of salinity 150 mM (Table4) (see list of appendix, table 43-45).

Evlagon *et al*, (1992) found the root length decreased by 54%, surface area decreased by 20% after 4 weeks at 100 mM of salinity. Also growth of the root decreased under salinity effect. The tomato growth under salinity condition showed deleterious effect on the growth of root cell and toxic (ions) accumulation (Cuartero and Fernandez, 1999).

In this study the analysis showed that salinity and bacteria was significantly influenced fresh root weight of tomato plant, the plant inoculated with *P. fluorescence* revealed higher fresh root weight compared with non-inoculated plant 13.44g and 11.76 g respectively.

The result from this study revealed that as salinity increase the root fresh weight increase as it recorded 13.32 g at salinity 150 mM compared with 10.32 g at control level of salinity, root fresh weight that inoculated with *P.fluorescence* was 16.31g when compared with non inoculated plant 10.32g at the same level of salinity 150Mm. The result showed non-significant difference of bacteria on root fresh weight due to many factors, such as nutrient absorption of element. (Table5) (see list of appendix, table 46-48).

Many studies proposed the root fresh weight decreased 30% after 3 weeks when salinity solution present (Albacete *et al*, 2008), also Schwarz and Grosch, (2003) suggested that root fresh weight, dry mass, total length of the root, adventitious root number, root tab and lateral root decreased as salinity increase.

The root dry weight of plant showed that salinity and bacteria was significantly influenced the root dry weigh in plant inoculated with *P. fluorescence* compared to non-inoculated 12.34g and 9.96g respectively, the result revealed as salinity increase the root dry weight increase the bacterial inoculation enhance the effect of salinity where the maximum root dry weight was 14.65 g at 150 mM salinity level for inoculated plant compared 8.80 g at the same level of salinity without bacterial inoculation , (Table6) (see list of appendix, table 49-51).

The tomato main root number in this study was not significantly influenced by bacteria and salinity, however, the plant inoculated with *P. fluorescence* revealed higher number of main root compared with non-inoculated *P. fluorescence* 6.43 and 3.93 respectively, and the results revealed as salinity increase the root main number decrease was 4.95 at salinity 100 mM compared to 5.5 at control. However inoculated tomato with *P. fluorescence* give higher main root number compared to non – inoculated plant for instance at the same level of salinity100 mM was 6.50 and 3.40 respectively, (Table7) (see list of appendix, table 52-54).

The main root length was 7.05 cm compared with 5.45 cm at control level of salinity, main root length with inoculated with *P.fluorescence* bacteria that higher length compared with non inoculated plant bacteria at the same level of salinity 100 mM was 8.50cm and 4.60 cm respectively , in this study, main root length was significantly influenced with salinity and bacteria ,(Table 8) (see list of appendix, table 55-57).

Number of nudes of tomato plant revealed that salinity and bacteria was significantly influenced of nude number of tomato plant, plant inoculation with bacteria has higher nude number compared with non-inoculation plant 43.47 and 31.47 respectively, also increasing salinity reducing nude number 34.1 at control level compared with 40.55 at 100 mM , node number of inoculated plant with *P.fluorescence* was 51.10 when compared with non inoculated bacteria was 30 at the same level of salinity 100 Mm, (Table9) (see list of appendix, table 58-60).

These results are in agreement with Naseby et al. (2001) who proposed that *P. fluorescence spray on pea plant showed* increased dry weight of aerial parts, number of nodes and pods and seed weight.

Several study showed that salinity have effect on growth of tomato shoot of plant grown under hydroponic system. Kamrani *et al*, (2013), showed that salinity at 20 mM influence tomato shoot development also decrease shoot height of tomato plant. Oztekin & Tuzel, (2011), revealed that at 200 mM salinity plant height reduced by 29.03% from the average tomato when compared with non salinity, Bartolini et al, (1991) and Franco

et al, (1993) proposed that salinity as increase the plant length and thickness of stem reduced.

This study revealed that salinity and bacteria have a significant influence on plant length of tomato, the results suggested that when salinity increase the plant length decrease when compared to control treatment in which plant length was 126.15 cm at the control compared with 116.45 cm at 150 mM salinity level. However inoculation of bacteria under the same level of salinity150 mM increase plant height compared with non-inoculation bacteria in which 140.20 cm plant height compared with 92.70cm respectively, (Table10) (see list of appendix, table 61-63).

Bacterial inoculation revealed significant influence on branch number compared with non-inoculated 6.27 and 4.9 respectively, also branch number increasing with salinity increase was 5.3 at control level of salinity compared to 6.05 at 100 mM, branch number inoculated plant with *P.fluorescence* compared with non inoculated plant at the same level of salinity 100Mm was 7.50 and 4.60 respectively, (Table11) (see list of appendix, table 64-66).

Plant weight of tomato revealed that salinity and bacteria was significantly influenced, plant inoculated with bacteria that higher weight of plant compared with non-inoculation 223.67g and 104.10g respectively, also increasing of salinity decrease plant weight at 100 mM was 177.80g compared with 158.30g at control level , plant weight for inoculated plant with *P.fluorescence* was 232.40g compared with non inoculated plant

78.70 g at the same level of salinity 150 Mm, (Table12) (see list of appendix, table 67-69).

Similarly plant stem diameter of tomato, influenced by inoculation with P. fluorescence as the stem diameter was higher in inoculated plant compared with non-inoculation 0.22inch and 0.20inch respectively, stem diameter for inoculated plant with *P.fluorescence* was 0.30 inch compared with non inoculated 0.28 inch at the same level of salinity 100 mM, (Table13) (see list of appendix, table 70-72).

These results was in agreement with many of studies that shown the effect of salinity on tomato shoot, such as fresh and dry weight of shoot (Bolarin *et al*; 1991, 1993). In addition to effect of salinity on stem diameter (Saberi *et al*, 2011). Santoro et al., (2016) suggested that the increase of shoot fresh weight can be attributed to greater leaf and stem size, leading to increased aerial biomass.

This study showed that plants inoculated with *P. fluorescence* give higher fresh stem weight compared with non-inoculation 23.83 g and 19.90g respectively, in addition increasing salinity showed positive impact on fresh stem weight 25.42g at 100mM salinity level compared with 19.1 g at control level of salinity , inoculated plant with *P.fluorescence* fresh stem weight was 24.61 compared with non inoculated plant 26.23g at the same level of salinity 100 mM, (Table14) (see list of appendix, table 73-75).

Similarly stem dry weight of tomato plant was not significantly influenced by salinity and bacteria however, the plants inoculated with *P. fluorescence* give higher stem dry weight compared with non-inoculated plants 19.86 g and 17.50 g respectively, the result showed that salinity increase stem dry weight in which the stem dry weight was 22.30g at 100 mM salinity level compared with 14.94g at the control , stem dry weight for inoculated plant with *P.fluorescence* was 21.57g compared with non inoculated plant 23.04g at the same level of salinity 100mM, (Table15) (see list of appendix, table 76-78).

These result in agreement with Kumar et al., whom found that inoculation of *Preseudomonas fluorescence* enhance plant growth in terms of shoot height, root length and dry weight in pea. The effect of *Preseudomonas* on plant growth could be due to enhancing the production of growth promoter such as Ghibelline and Auxin as Eklund (1970) proposed that gibberellins and other hormones were produced by *Pseudomonas* spp.

Several studies shown that the effect of salinity on plant growth parameter such as total leaf area, leaf size and maximum leaf length reduced as salinity increase (Maggio et al, 2004; Romero-Aranda et al, 2006), also the higher the salinity level the lower the rate leaf photosynthesis (Maggio et al, 2007), rate of leaf growth (Munns, 1993; Yilmaz et al, 2004; Chenu et al, 2008*a*), and higher leaf thickness (Sanchez-Blanco et al, 1991). This study demonstrated that leaf number of

tomato plant was significantly influenced by salinity and bacteria, the plants inoculation with *P. fluorescence* revealed higher leaf number compared with non-inoculation bacteria 245.3 and 171.7 respectively, leaf number for inoculated plant with *P. fluorescence* was 240 compared with non inoculated plant177.5 at the same level of salinity 150mM. the effect of *P. fluorescence* on leaf number was significant in relation to leaf number, (Table16) (see list of appendix, table 79-81). The results of this study might be due to the PGPB characteristics of *P. fluorescence*, which might promote nutrient uptake or enhanced the production of other natural hormones such as auxin and cytokinin (Silverstone et al., 2003)

Fresh leaf weight was significantly influenced by salinity and bacteria treatments. Plants inoculated with *P. fluorescence* revealed higher fresh leaf weight compared with non-inoculated plants 37.8 g and 28.1g respectively, however the effect of the combination between bacteria inoculation and same level of salinity on fresh leaf weight showed 50% reduction in the fresh weight was 46g for inoculated plant with *P.fluorescence* compared with non inoculated plant 22.6g at the same level of salinity 150mM., (Table17)(see list of appendix, table 82-84).This might be attributed to the threshold of salinity tolerance for tomato approximately 9.6 dS m^{-1} at which transpiration and growth reduced sharply (Maggio et al., 2007).

Leaf dry weight of tomato plant revealed that salinity and bacteria was significantly influenced, *P. fluorescence* revealed higher plant leaf dry weight compared with plants not inoculated with *P. fluorescence* 23.7g and 20.53g respectively, the result showed that when salinity increase leaf dry weight increase 23.9 g at 150 mM compared with control level of salinity 18.45g,leaf dry weight of inoculated plant with *P.fluorescence* was 29.4g compared with non-inoculated plant 18.40g at the same level of salinity 150mM , (Table18)(see list of appendix, table 85-87).In other studies conducted on tomato using PGPR such as *Pseudomonas*, *Azotobacter* and *Azospirillum* have been assessed, the results showed significant differences between the fresh and dry weight of the plant, compared to tomato plants that was not inoculated with PGPR (Sharafzadeh, 2012)

Leaf width of tomato plant revealed that salinity and bacteria was not significantly influenced this parameter, inoculation of *P. fluorescence* on plant shown higher width of leaf compared with non-inoculation bacteria was 11.47 cm and 7.35 cm respectively, the result showed that the increase of salinity lead to decrease in leaf width of tomato plant 9.03cm at 150 mM compared with 10.17cm at control level of salinity, leaf width for inoculated plant with *P.fluorescence* was 12.25cm compared with non inoculated plant 5.82cm at the same level of salinity 150mM. In this study, highly significant impact of bacteria and salinity combination on plant, but no significant difference was shown for salinity , (Table19)(see list of appendix, table 88-90).due to heat and shade condition in the current study.

Leaf length of tomato plant revealed that salinity and bacteria have no significant influence on this parameter, however, plants inoculated with P. fluorescence revealed higher plant leaf length compared to non-inoculated 11.14cm and 8.23cm respectively, the result also showed that as salinity increase the leaf length decrease from 9.88cm at 100 mM to10.05 cm at control, leaf length for inoculated plant with *P.fluorescence* was 12.47cm compared with non inoculated plant that 5.75cm at the same level of salinity 150mM.. In the study highly significant difference was shown in relation to the effect of bacteria and salinity on plant but not significant in relation effect of salinity, (Table20)(see list of appendix, table91-93).this might be due to shading.

Some studies about total biomass of tomato plant showed that soil salinity cause the reduction in biomass production by affecting physiological and biochemical processes of the plant (Ahmad and John, 2005; Ahmad, 2010; Ahmad and Sharma, 2010).

In this study salinity and bacteria have been significant influenced on total biomass of tomato plant, The plants inoculated with *P. fluorescence* revealed higher plant total biomass compared with plants not inoculated with *P. fluorescence* 172.48 g and 87.31 g respectively, also increasing salinity lead to decreasing of total biomass, total biomass at 150 mM was 191.25g for inoculated plants compared to 63.43 g for plants without inoculation at the same level of salinity. Singh et al. (2008) proposed that biomass reduction under salinity condition might be due to the inhibition or

hydrolysis of reserved synthesizing food and its translocation to growing shoot parts.

The result showed highly significant effect in relation to bacterial inoculation, but no significant effect was revealed due to salinity, however, a significant difference was observed for the combination of salinity and bacteria treatments (Table21)(see list of appendix, table 94-96).

5.2 Effect of salinity and *P. fluorescence* on chemical composition

Effects of salinity that released from soil solution is high salts whereas or compared with water uptake in hydroponics is only affected by the nutrient solution osmotic potential (Tavakkoli et al, 2012) .

Salinity has inhibitory effect on biochemical processes in which photosynthesis is most important, some of studies showed increasing salinity might influence osmotic potential of leaf sap resulting in osmotic regulation of plant (Kaymakanova and Stoeva, 2008; Kaymakanova et al., 2008).

Nitrogen analysis in root revealed that salinity and bacteria was significantly influenced, the plant inoculated with *P. fluorescence* acquired higher nitrogen content in root compared with non-inoculated plant root was 0.23% and 0.21% respectively, The results revealed as salinity increase the nitrogen content on roots decrease in which the nitrogen content was 0.24% at 150 mM of salinity level compared to 0.22% at control salinity

level, nitrogen content for inoculated plant was 0.18% compared with non inoculated plant 0.29% at the same level of salinity 150mM..

The result in the study was highly significant in relation to bacteria and salinity effect, significant effect of salinity, but not significant effect of bacteria might be due to toxic effect of salinity on bacteria ,(Table22)(see list of appendix, table 97-99). Some of study about nitrogen showed that, protein could be affected negatively or positively by increasing salinity (Beltagi et al., 2006; Chen et al., 2007; Kapoor and Srivastava, 2010) these studies also demonstrated changes in protein content in plants treated by various salt concentrations.

Nitrogen content in tomato leaf, not significant effect of bacteria on nitrogen content on plant root, the non-inoculated plant was 0.81% and 0.8% for inoculated plant, result addressed that as salinity increased the nitrogen content in the leaf increased 0.9 %at 150 mM compared with 0.7% at control salinity, bacterial inoculation effect on increasing salinity where maximum nitrogen leaf content was 0.93% for inoculated plant compared to non inoculated plant 0.78% at the same level of salinity 100mM.. In the study result that significant effect of bacteria to the plant, highly significant effect in salinity and bacteria, (Table23) (see list of appendix, table 100-102).

The analysis of chlorine content in root revealed that salinity and bacteria significantly influenced chlorine content in the root of tomato plant. The plant inoculation with P. fluorescence was higher chlorine content on root compared to non- inoculated plant 1.04% and 0.30%

respectively, the result was high chlorine content on root with increasing salinity that 0.98% at control level compared with 5% at 150 mM of salinity level, however, chlorine content for inoculated plant was 0.95% compared with non inoculated plant 0.04% at the same level of salinity 150 mM. The result showed effect of bacteria and salinity highly significant, (Table24) (see list of appendix, table 103-105), (Figure9).

This study showed that sodium content in root was significantly influenced by salinity and bacteria, the plants roots inoculated with *P. fluorescence* acquired higher sodium content in root compared with non-inoculated plants root by two fold 0.069% and 0.037% respectively, the result showed that increasing salinity level have no effect on sodium accumulation in plant roots as it was 0.05 % at control level of salinity compared with 0.05 % at 150 mM level of salinity , sodium content in root for inoculated plant with *P. fluorescence* was 0.08% compared with non inoculated plant 0.04% at the same level of salinity 100mM. . In the contrary in the presence of bacteria and salinity the level of sodium content in root was increased by two fold, for example, the non-inoculated plant contain 0.03 % at 150 mM compared with 0.07% at the 150 mM level of salinity in inoculated plant root. In the study was highly significant with effect of bacteria and not significant in the effect of bacteria and salinity due to other reasons such as toxic elements, (Table25) (see list of appendix, table 106-108), (Figure10). Ashraf, et al., (2004) proposed that Inoculating wheat seedling with ex polysaccharide producing bacteria restricts sodium uptake and stimulates plant growth under salt stress.

Bacterial inoculation increase potassium content in tomato root significantly, plants inoculated with *P. fluorescence* was higher in potassium content on root compared with non-inoculated plants 1.05% and 0.32% respectively, potassium content in root decrease with increasing salinity, but inoculation of *P. fluorescence* bacteria reduced the effect of salinity on plant the potassium content in root was 1.22% compared with non inoculated plant 0.30% at the same level of salinity 150Mm, (Table26) (see list of appendix, table 109-111), (Figure11). Some study about of potassium in relation to salinity (Shabala & Cuin 2007) demonstrated that the potassium plays a crucial role in salt tolerance in plant and that the effect of imbalance potassium content lead to sever water deficit, as a result is important in maintaining turger pressure and plant weight through maintenance of water in the plant tissue.

Calcium content in tomato root was significantly influenced by salinity and bacteria, plants inoculated with *P. fluorescence* give higher calcium content compared with non inoculated plant was 3.6% and 2.2% respectively. Result showed that as salinity increase the calcium content in root decrease was 2.83% at salinity control compared with 3% at 150mM of salinity level, but inoculation of *P. fluorescence* bacteria reduced the effect of salinity on calcium content and in same control level (zero salinity) revealed best result as it showed 4.50% with inoculated plant compared with 1.17% with non inoculated plant at the same control of salinity level in contrast when compared at 100 mM was 3.30 % for inoculated plant and 2.50% without bacteria at the same salinity level

100mM. In this study highly significant difference in calcium content due to bacteria and, but no significant difference in relation to salinity this might be due to hydroponic system and water circulation, (Table27)(see list of appendix, table 112-114),(Figure12).

The chemical analysis of root showed that salinity and bacteria have significant influence on the accumulation of phosphorus in tomato root, plants inoculated with *P. fluorescence* showed higher content compared with non inoculated plant 1897.97 ppm and 1882.29 ppm respectively, in addition, it showed that as salinity increasing phosphorus content in root decreased, for example at 100 mM phosphorus content was 1959.67 ppm compared to 1867.08 ppm at control level of salinity. However, bacterial inoculation ameliorate the effect of salinity when compared with non inoculated plant as it was 2010.17ppm with *P. fluorescence* bacteria inoculated plant compared with 1724 ppm without bacteria at the same level of control salinity, phosphorus content in root revealed higher result effect of bacteria at (zero salinity) in contrast when compared effect of bacteria at 100mM was 1967.17ppm for non inoculated plant and 1952.17ppm for inoculated plant, this might be a good indicator even the statistical analysis prove not significant effect of bacteria. The data revealed highly significant effect of salinity and salinity with bacteria on plant, (Table28) (see list of appendix, table 115-117), (Figure13). In this regards several studies demonstrated positive effect of PGP bacteria to produce more root hairs hence increase the nutrients uptake such as nitrogen and phosphorus (Sharma et al., 2013; Ahemad and Kibret, 2014).

Some study should that sodium content on plant leaf significantly influenced by increase salt stress this lead to reduction in plant growth in addition, Na concentration inhibit K ,Ca and Mg uptake (Mayak et al. 2004, Cuartero & Fernández-Muñoz 1999). In this study sodium content in leaf significantly influenced by salinity and bacteria treatment, higher sodium content in leaf due to *P. fluorescence* inoculation than non inoculated plant 0.14% and 0.12% respectively , Sodium content increase as salinity increase 0.14% at 100 mM compared with 0.13% at control salinity level ,sodium content in leaf revealed positive result for non-inoculated plant with *P. fluorescence* was 0.11% compared with inoculated plant 0.15% at the same level of control salinity, in contrast when compared at 150mM was 0.12% for non-inoculated plant and 0.13% for inoculated plant at same salinity ,(Table29)(see list of appendix, table 118-120),(Figure14).

Potassium content in leaf was influenced by salinity and bacterial inoculation, plants inoculated with *P. fluorescence* showed higher potassium content in leaf compared to non inoculated plant 2.02% and 1.63% respectively, the result showed that potassium decrease when salinity increase where Potassium content was 1.88% at 150 mM level of salinity compared with 1.81% at control level of salinity, bacterial inoculation have effect on the level of potassium content as the result showed maximum k content 2.16 at 150 mM for inoculated plant compared with non inoculated plant 1.55% at the same level of salinity without bacterial inoculation. In the study, the effect of bacteria was significant, not

significant effect of bacteria and salinity combination this might be due to soluble fertilizers' in the hydroponic system, (Table30) (see list of appendix, table 121-123), (Figure15).

The analysis of calcium content in leaf revealed that salinity and bacteria was significantly influenced its accumulation in plant leaf. Plants inoculated with *P. fluorescence* give higher calcium content compared with non-inoculated plant 4.13% and 3.66% respectively, furthermore the result showed that as salinity increase the level of calcium content decrease 3.12% at 150 mM compared with 4.92% at salinity control, However, calcium content in leaf revealed higher result at (zero salinity) was 5% for inoculated and non-inoculated plant, in contrast when compared inoculated plant was 3.36% and 4% for without inoculation bacteria. In this study, bacteria and salinity effect was significant, moreover a highly significant was also prevailed for salinity, (Table31) (see list of appendix, table 124-126), (Figure16).

The phosphorus content in tomato leaf in relation to salinity and bacteria was significantly influenced, the non inoculated plant showed higher phosphorus content in leaf than plants inoculated with bacteria 320ppm and 293.17ppm respectively, result also showed that phosphorus content in leaf decrease with increasing salinity 307.17ppm at control level of salinity compared with 333.78ppm at 150 mM level of salinity level, non-inoculation of bacteria at the same (zero salinity) level give higher phosphorus content in leaf was 357.33ppm compared with inoculation

bacteria was 257ppm,incontrast when compared at 100mM for inoculated plant was 285.27ppm compared with 272.33ppm for non-inoculation plant. In this study a highly significant difference when tomato plant treated with bacteria under saline condition, (Table32) (see list of appendix, table127-129), (Figure17). Fan et al., 2017 suggested that inoculation with PGPR may increase plant growth and N, P uptake by tomato grown in calcareous soils. However, the effect of PGPR varied and was influenced by many factors, in contrast Reyes-Castillo et al (2019) proposed that P solubilizing strains did not show a positive effect on tomato plant growth or increase in available soil P.

Chlorine content in tomato leaf revealed that salinity and bacteria was significantly influenced it content, as the non-inoculated plants accumulated higher chlorine in leaf than inoculation plant 4.23% and 3.89% respectively, the result also showed the increasing salinity lead to more chlorine content in tomato leaf 3.99% at control level of salinity compared with 4.22% at 150 mM level of salinity, inoculation of *P. fluorescence* bacteria under saline condition decrease chlorine content as it showed 4.27% compared with non inoculated bacteria 3.65% at the same level of salinity 150 mM . The data of this study showed that the effect of bacteria was significant, salinity effect was not significant due to irrigation water, while highly significant effect of bacteria and salinity interaction, (Table33) (see list of appendix, table 130-132), (Figure18).

Conclusions

Tomato plant is highly affected with high salinity grown in hydroponic system or even growing in soil, using *Pseudomonas fluorescence*, provide positive effect on plants that treated with high salinity and reduce the negative effect of salinity.

Several main points arise from this study:

i. *P. fluorescence* has significant effect in reducing salinity effect on growth parameters such as (plant length, branch number, root length, node number, leaf number, fresh root weight, total biomass, plant weight).

ii. *Preseudomonas fluorescence* (double increased yields) fruit weight, fruit number of tomato fruit significantly even at high level of salinity.

iii. Plants inoculation with *Pseudomonas fluorescence* was significantly (double increased flowering intensity) and decrease the period required for flowering (early flowering) from 10-14 day.

iv. Accumulation of Na and Cl in plant root that inoculated with *Pseudomonas fluorescence* compared with non-inoculated plant might be due to osmotic potential that released from stress or antagonism with other nutrients.

v. No effect of plant that inoculated with *Pseudomonas fluorescence* in relation to the content of Na, N, Ca and Cl in plant leaf.

vi. At 150mM for non-inoculated plants showed higher N content in root, the result revealed 0.29% compared with inoculated plant 0.18% at the same level of salinity in relation to bacteria and salinity.

vii. Inoculation of bacteria enhance plant absorption for P and K content in root and leaf ,also Ca content in root that was higher in plant inoculated with bacteria under salinity condition.

viii. Bacteria have beneficial effect in decreasing the effect of salinity.

ix. The inoculated plant with *P. fluorescence* can maintenance a longer period of time (longer age plant) at around 10-15 day.

Recommendations

Based on the results of this study, the following recommendations could be given based on the effect *Pseudomonas fluorescence* on early flowering which lead to early production and higher price and also long maintenance period in the field.

- *Preseudomonas fluorescence* can be used in tomato as a fertilizers addition.
- *P. fluorescence* can be use in hydroponic system with salinity level around 100_150 mM.
- *P. fluorescence* might be studied on the different plant species and different level of salinity.

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Appendix

Table 34. Mean separation for the flowering intensity based on the effect of P. fluorescence inoculation. Effect= Bacteria Method = Turkey (P<.05)

Obs	bacteria	Estimate	Standard Error	Letter Group
1	1	13.4000	1.2599	B
2	2	32.4667	1.2599	A

1= without bacteria, 2= with bacteria. Value with different latter are significant.

Table 35. Mean separation for the flowering intensity based on the effect salinity. Effect= Salinity Method=Turkey (P<.05)

Obs	salinity	Estimate	Standard Error	Letter Group
3	0	20.0500	1.5430	A
4	1	25.0500	1.5430	A
5	2	23.7000	1.5430	A

Salinity= (0, 1=100,2=150) mM. Value with similar latter are not significant.

Table 36. Mean separation for the flowering intensity based on the effect of Bacteria interaction with salinity. Effect= Bacteria*Salinity Method=turkey (P<.05)

Obs	bacteria	salinity	Estimate	Standard Error	Letter Group
6	1	0	14.9000	2.1822	C
7	1	1	14.1000	2.1822	C
8	1	2	11.2000	2.1822	C
9	2	0	25.2000	2.1822	B
10	2	1	36.0000	2.1822	A
11	2	2	36.2000	2.1822	A

1= without bacteria, 2= with bacteria, Salinity= (0, 1=100,2=150) mM. Value with different latter are significant.

Table 37. Mean separation for the number of fruit plant based on the effect of P. fluorescence inoculation. Effect= Bacteria Method = Turkey (P<.05)

Obs	bacteria	Estimate	Standard Error	Letter Group
1	1	3.4333	0.3034	B
2	2	7.4333	0.3034	A

1= without bacteria, 2= with bacteria. Value with different latter are significant.

Table 38. Mean separation for the number of fruit plant based on the effect salinity. Effect= Salinity Method=Turkey (P<.05)

Obs	salinity	Estimate	Standard Error	Letter Group
3	0	4.9000	0.3716	A
4	1	5.6500	0.3716	A
5	2	5.7500	0.3716	A

Salinity= (0, 1=100,2=150) mM .Value with similar latter are not significant.

Table 39. Mean separation for the number of fruit plant based on the effect of Bacteria interaction with salinity. Effect= Bacteria*Salinity Method=turkey (P<.05)

Obs	bacteria	salinity	Estimate	Standard Error	Letter Group
6	1	0	3.7000	0.5255	C
7	1	1	3.6000	0.5255	C
8	1	2	3.0000	0.5255	C
9	2	0	6.1000	0.5255	B
10	2	1	7.7000	0.5255	AB
11	2	2	8.5000	0.5255	A

1= without bacteria, 2= with bacteria, Salinity= (0, 1=100,2=150) mM Value with different latter are significant.

Table 40. Mean separation for the fruit weight based on the effect of P. fluorescence inoculation. Effect= Bacteria Method = Turkey (P<.05)

Obs	bacteria	Estimate	Standard Error	Letter Group
1	1	27.5333	0.9505	B
2	2	97.4000	0.9505	A

1= without bacteria, 2= with bacteria .Value with different latter are significant.

Table 41. Mean separation for the fruit weight based on the effect salinity. Effect= Salinity Method=Turkey (P<.05)

Obs	salinity	Estimate	Standard Error	Letter Group
3	0	73.0000	1.1641	A
4	1	55.8000	1.1641	B
5	2	58.6000	1.1641	B

Salinity= (0, 1=100,2=150) mM .Value with different latter are significant.

Table 42. Mean separation for the fruit weight based on the effect of Bacteria interaction with salinity. Effect= Bacteria*Salinity Method=turkey (P<.05)

Obs	bacteria	salinity	Estimate	Standard Error	Letter Group
6	1	0	45.6000	1.6463	C
7	1	1	24.4000	1.6463	D
8	1	2	12.6000	1.6463	E
9	2	0	100.40	1.6463	A
10	2	1	87.2000	1.6463	B
11	2	2	104.60	1.6463	A

1= without bacteria, 2= with bacteria, Salinity= (0, 1=100,2=150) mM .Value with different latter are significant.

Table 43. Mean separation for the root length based on the effect of P. fluorescence inoculation. Effect= Bacteria Method = Turkey (P<.05)

Obs	bacteria	Estimate	Standard Error	Letter Group
1	1	33.7167	1.4515	B
2	2	48.3333	1.4515	A

1= without bacteria, 2= with bacteria

Table 44. Mean separation for the root length based on the effect salinity. Effect= Salinity Method=Turkey (P<.05)

Obs	salinity	Estimate	Standard Error	Letter Group
3	0	39.7500	1.7777	A
4	1	42.2750	1.7777	A
5	2	41.0500	1.7777	A

Salinity= (0, 1=100,2=150) mM

Table 45. Mean separation for the root length based on the effect of Bacteria interaction with salinity. Effect= Bacteria*Salinity Method=turkey (P<.05)

Obs	bacteria	salinity	Estimate	Standard Error	Letter Group
6	1	0	32.9000	2.5141	C
7	1	1	36.9500	2.5141	BC
8	1	2	31.3000	2.5141	C
9	2	0	46.6000	2.5141	AB
10	2	1	47.6000	2.5141	A
11	2	2	50.8000	2.5141	A

1= without bacteria, 2= with bacteria, Salinity= (0, 1=100,2=150) mM

Table 46. Mean separation for the fresh root weight based on the effect of P. fluorescence inoculation. Effect= Bacteria Method = Turkey (P<.05)

Obs	bacteria	Estimate	Standard Error	Letter Group
1	1	11.7567	0.9195	A
2	2	13.4433	0.9195	A

1= without bacteria, 2= with bacteria

Table 47. Mean separation for the fresh root weight based on the effect salinity. Effect= Salinity Method=Turkey (P<.05)

Obs	salinity	Estimate	Standard Error	Letter Group
3	0	10.3150	1.1261	A
4	1	14.1700	1.1261	A
5	2	13.3150	1.1261	A

Salinity= (0, 1=100,2=150) mM

Table 48. Mean separation for the fresh root weight based on the effect of Bacteria interaction with salinity. Effect= Bacteria*Salinity Method=turkey (P<.05)

Obs	bacteria	salinity	Estimate	Standard Error	Letter Group
6	1	0	9.9100	1.5926	A
7	1	1	15.0400	1.5926	A
8	1	2	10.3200	1.5926	A
9	2	0	10.7200	1.5926	A
10	2	1	13.3000	1.5926	A
11	2	2	16.3100	1.5926	A

1= without bacteria, 2= with bacteria, Salinity= (0, 1=100,2=150) mM

Table 49. Mean separation for the root dry weight based on the effect of P. fluorescence inoculation. Effect= Bacteria Method = Turkey (P<.05)

Obs	bacteria	Estimate	Standard Error	Letter Group
1	1	9.9567	0.8029	B
2	2	12.3400	0.8029	A

1= without bacteria, 2= with bacteria

Table 50. Mean separation for the root dry weight based on the effect salinity. Effect= Salinity Method=Turkey (P<.05)

Obs	salinity	Estimate	Standard Error	Letter Group
3	0	9.6350	0.9833	A
4	1	12.0850	0.9833	A
5	2	11.7250	0.9833	A

Salinity= (0, 1=100,2=150) mM

Table 51. Mean separation for the root dry weight based on the effect of Bacteria interaction with salinity. Effect= Bacteria*Salinity Method=turkey (P<.05)

Obs	bacteria	salinity	Estimate	Standard Error	Letter Group
6	1	0	9.2500	1.3907	A
7	1	1	11.8200	1.3907	A
8	1	2	8.8000	1.3907	A
9	2	0	10.0200	1.3907	A
10	2	1	12.3500	1.3907	A
11	2	2	14.6500	1.3907	A

1= without bacteria, 2= with bacteria, Salinity= (0, 1=100,2=150) mM

Table 52. Mean separation for the main root number based on the effect of P. fluorescence inoculation. Effect= Bacteria Method = Turkey (P<.05)

Obs	bacteria	Estimate	Standard Error	Letter Group
1	1	3.9333	0.4850	B
2	2	6.4333	0.4850	A

1= without bacteria, 2= with bacteria

Table 53. Mean separation for the main root number based on the effect salinity. Effect= Salinity Method=Turkey (P<.05)

Obs	salinity	Estimate	Standard Error	Letter Group
3	0	5.5000	0.5940	A
4	1	4.9500	0.5940	A
5	2	5.1000	0.5940	A

Salinity= (0, 1=100,2=150) mM

Table 54. Mean separation for the main root number based on the effect of Bacteria interaction with salinity. Effect= Bacteria*Salinity Method=turkey (P<.05)

Obs	bacteria	salinity	Estimate	Standard Error	Letter Group
6	1	0	4.6000	0.8400	A
7	1	1	3.4000	0.8400	A
8	1	2	3.8000	0.8400	A
9	2	0	6.4000	0.8400	A
10	2	1	6.5000	0.8400	A
11	2	2	6.4000	0.8400	A

1= without bacteria, 2= with bacteria, Salinity= (0, 1=100,2=150) mM.

Table 55. Mean separation for the main root length based on the effect of P. fluorescence inoculation. Effect= Bacteria Method = Turkey (P<.05)

Obs	bacteria	Estimate	Standard Error	Letter Group
1	1	5.6333	0.3796	B
2	2	7.0667	0.3796	A

1= without bacteria, 2= with bacteria

Table 56. Mean separation for the main root length based on the effect salinity. Effect= Salinity Method=Turkey (P<.05)

Obs	salinity	Estimate	Standard Error	Letter Group
3	0	5.4500	0.4649	B
4	1	6.5500	0.4649	AB
5	2	7.0500	0.4649	A

Salinity= (0, 1=100,2=150) mM

Table 57. Mean separation for the main root length based on the effect of Bacteria interaction with salinity. Effect= Bacteria*Salinity Method=turkey (P<.05)

Obs	bacteria	salinity	Estimate	Standard Error	Letter Group
6	1	0	5.3000	0.6574	B
7	1	1	4.6000	0.6574	B
8	1	2	7.0000	0.6574	AB
9	2	0	5.6000	0.6574	B
10	2	1	8.5000	0.6574	A
11	2	2	7.1000	0.6574	AB

1= without bacteria, 2= with bacteria, Salinity= (0, 1=100,2=150) mM

Table 58. Mean separation for the nude number based on the effect of P. fluorescence inoculation. Effect= Bacteria Method = Turkey (P<.05)

Obs	bacteria	Estimate	Standard Error	Letter Group
1	1	31.4667	2.1759	B
2	2	43.4667	2.1759	A

1= without bacteria, 2= with bacteria

Table 59. Mean separation for the nude number based on the effect salinity. Effect= Salinity Method=Turkey (P<.05)

Obs	salinity	Estimate	Standard Error	Letter Group
3	0	34.1000	2.6649	A
4	1	40.5500	2.6649	A
5	2	37.7500	2.6649	A

Salinity= (0, 1=100,2=150) mM

Table 60. Mean separation for the nude number based on the effect of Bacteria interaction with salinity. Effect= Bacteria*Salinity Method=turkey (P<.05)

Obs	bacteria	salinity	Estimate	Standard Error	Letter Group
6	1	0	28.9000	3.7687	B
7	1	1	30.0000	3.7687	B
8	1	2	35.5000	3.7687	AB
9	2	0	39.3000	3.7687	AB
10	2	1	51.1000	3.7687	A
11	2	2	40.0000	3.7687	AB

1= without bacteria, 2= with bacteria, Salinity= (0, 1=100,2=150) mM

Table 61. Mean separation for the plant length based on the effect of P. fluorescence inoculation. Effect= Bacteria Method = Turkey (P<.05)

Obs	bacteria	Estimate	Standard Error	Letter Group
1	1	111.50	3.7423	B
2	2	137.63	3.7423	A

1= without bacteria, 2= with bacteria

Table 62. Mean separation for the plant length based on the effect salinity. Effect= Salinity Method=Turkey (P<.05)

Obs	salinity	Estimate	Standard Error	Letter Group
3	0	126.15	4.5833	A
4	1	131.10	4.5833	A
5	2	116.45	4.5833	A

Salinity= (0, 1=100,2=150) mM

Table 63. Mean separation for the plant length based on the effect of Bacteria interaction with salinity. Effect= Bacteria*Salinity Method=turkey (P<.05)

Obs	bacteria	salinity	Estimate	Standard Error	Letter Group
6	1	0	115.80	6.4818	AB
7	1	1	126.00	6.4818	A
8	1	2	92.7000	6.4818	B
9	2	0	136.50	6.4818	A
10	2	1	136.20	6.4818	A
11	2	2	140.20	6.4818	A

1= without bacteria, 2= with bacteria, Salinity= (0, 1=100,2=150) mM

Table 64. Mean separation for the branch number based on the effect of P. fluorescence inoculation. Effect= Bacteria Method = Turkey (P<.05)

Obs	bacteria	Estimate	Standard Error	Letter Group
1	1	4.9000	0.2231	B
2	2	6.2667	0.2231	A

1= without bacteria, 2= with bacteria

Table 65. Mean separation for the branch number based on the effect salinity. Effect= Salinity Method=Turkey (P<.05)

Obs	salinity	Estimate	Standard Error	Letter Group
3	0	5.3000	0.2733	A
4	1	6.0500	0.2733	A
5	2	5.4000	0.2733	A

Salinity= (0, 1=100,2=150) mM

Table 66. Mean separation for the branch number based on the effect of Bacteria interaction with salinity. Effect= Bacteria*Salinity Method=turkey (P<.05)

Obs	bacteria	salinity	Estimate	Standard Error	Letter Group
6	1	0	5.5000	0.3865	B
7	1	1	4.6000	0.3865	B
8	1	2	4.6000	0.3865	B
9	2	0	5.1000	0.3865	B
10	2	1	7.5000	0.3865	A
11	2	2	6.2000	0.3865	AB

1= without bacteria, 2= with bacteria, Salinity= (0, 1=100,2=150) mM

Table 67. Mean separation for the plant weight based on the effect of P. fluorescence inoculation. Effect= Bacteria Method = Turkey (P<.05)

Obs	bacteria	Estimate	Standard Error	Letter Group
1	1	104.10	21.7650	B
2	2	223.67	21.7650	A

1= without bacteria, 2= with bacteria

Table 68. Mean separation for the plant weight based on the effect salinity. Effect= Salinity Method=Turkey (P<.05)

Obs	salinity	Estimate	Standard Error	Letter Group
3	0	158.30	26.6566	A
4	1	177.80	26.6566	A
5	2	155.55	26.6566	A

Salinity= (0, 1=100,2=150) mM

Table 69. Mean separation for the plant weight based on the effect of Bacteria interaction with salinity. Effect= Bacteria*Salinity Method=turkey (P<.05)

Obs	bacteria	salinity	Estimate	Standard Error	Letter Group
6	1	0	124.40	37.6981	AB
7	1	1	109.20	37.6981	AB
8	1	2	78.7000	37.6981	B
9	2	0	192.20	37.6981	AB
10	2	1	246.40	37.6981	A
11	2	2	232.40	37.6981	AB

1= without bacteria, 2= with bacteria, Salinity= (0, 1=100,2=150) mM

Table 70. Mean separation for the stem diameter based on the effect of P. fluorescence inoculation. Effect= Bacteria Method = Turkey (P<.05)

Obs	bacteria	Estimate	Standard Error	Letter Group
1	1	0.2033	0.01721	A
2	2	0.2167	0.01721	A

1= without bacteria, 2= with bacteria

Table 71. Mean separation for the stem diameter based on the effect salinity. Effect= Salinity Method=Turkey (P<.05)

Obs	salinity	Estimate	Standard Error	Letter Group
3	0	0.1750	0.02108	B
4	1	0.2900	0.02108	A
5	2	0.1650	0.02108	B

Salinity= (0, 1=100,2=150) mM

Table 72. Mean separation for the stem diameter based on the effect of Bacteria interaction with salinity. Effect= Bacteria*Salinity Method=turkey (P<.05)

Obs	bacteria	salinity	Estimate	Standard Error	Letter Group
6	1	0	0.1600[b]	0.02981	B
7	1	1	0.2800	0.02981	AB
8	1	2	0.1700	0.02981	B
9	2	0	0.1900	0.02981	AB
10	2	1	0.3000	0.02981	A
11	2	2	0.1600	0.02981	B

1= without bacteria, 2= with bacteria, Salinity= (0, 1=100,2=150) mM

Table 73. Mean separation for the fresh stem weight based on the effect of P. fluorescence inoculation. Effect= Bacteria Method = Turkey (P<.05)

Obs	bacteria	Estimate	Standard Error	Letter Group
1	1	19.9067	2.4507	A
2	2	23.8333	2.4507	A

1= without bacteria, 2= with bacteria

Table 74. Mean separation for the fresh stem weight based on the effect salinity. Effect= Salinity Method=Turkey (P<.05)

Obs	salinity	Estimate	Standard Error	Letter Group
3	0	19.0650	3.0014	A
4	1	25.4200	3.0014	A
5	2	21.1250	3.0014	A

Salinity= (0, 1=100,2=150) mM

Table 75. Mean separation for the fresh stem weight based on the effect of Bacteria interaction with salinity. Effect= Bacteria*Salinity Method=turkey (P<.05)

Obs	bacteria	salinity	Estimate	Standard Error	Letter Group
6	1	0	15.5800	4.2447	A
7	1	1	26.2300	4.2447	A
8	1	2	17.9100	4.2447	A
9	2	0	22.5500	4.2447	A
10	2	1	24.6100	4.2447	A
11	2	2	24.3400	4.2447	A

1= without bacteria, 2= with bacteria, Salinity= (0, 1=100,2=150) mM. Value with similar latter are not significant.

Table 76. Mean separation for the stem dry weight based on the effect of P. fluorescence inoculation. Effect= Bacteria Method = Turkey (P<.05)

Obs	bacteria	Estimate	Standard Error	Letter Group
1	1	17.5033	1.8900	A
2	2	19.8633	1.8900	A

1= without bacteria, 2= with bacteria

Table 77. Mean separation for the stem dry weight based on the effect salinity. Effect= Salinity Method=Turkey (P<.05)

Obs	salinity	Estimate	Standard Error	Letter Group
3	0	14.9400	2.3148	A
4	1	22.3050	2.3148	A
5	2	18.8050	2.3148	A

Salinity= (0, 1=100,2=150) mM

Table 78. Mean separation for the stem dry weight based on the effect of Bacteria interaction with salinity. Effect= Bacteria*Salinity Method=turkey (P<.05)

Obs	bacteria	salinity	Estimate	Standard Error	Letter Group
6	1	0	13.2400	3.2736	A
7	1	1	23.0400	3.2736	A
8	1	2	16.2300	3.2736	A
9	2	0	16.6400	3.2736	A
10	2	1	21.5700	3.2736	A
11	2	2	21.3800	3.2736	A

1= without bacteria, 2= with bacteria, Salinity= (0, 1=100,2=150) mM.

Table 79. Mean separation for the leaf number based on the effect of P. fluorescence inoculation. Effect= Bacteria Method = Turkey (P<.05)

Obs	bacteria	Estimate	Standard Error	Letter Group
1	1	171.70	12.2658	B
2	2	245.30	12.2658	A

1= without bacteria, 2= with bacteria

Table 80. Mean separation for the leaf number based on the effect salinity. Effect= Salinity Method=Turkey (P<.05)

Obs	salinity	Estimate	Standard Error	Letter Group
3	0	187.85	15.0225	A
4	1	228.90	15.0225	A
5	2	208.75	15.0225	A

Salinity= (0, 1=100,2=150) mM

Table 81. Mean separation for the leaf number based on the effect of Bacteria interaction with salinity. Effect= Bacteria*Salinity Method=turkey (P<.05)

Obs	bacteria	salinity	Estimate	Standard Error	Letter Group
6	1	0	187.60	21.2450	BC
7	1	1	150.00	21.2450	C
8	1	2	177.50	21.2450	BC
9	2	0	188.10	21.2450	BC
10	2	1	307.80	21.2450	A
11	2	2	240.00	21.2450	AB

1= without bacteria, 2= with bacteria, Salinity= (0, 1=100,2=150) mM.

Table 82. Mean separation for the fresh leaf weight based on the effect of P. fluorescence inoculation. Effect= Bacteria Method = Turkey (P<.05)

Obs	bacteria	Estimate	Standard Error	Letter Group
1	1	28.1000	4.1396	A
2	2	37.8000	4.1396	A

1= without bacteria, 2= with bacteria

Table 83. Mean separation for the fresh leaf weight based on the effect salinity. Effect= Salinity Method=Turkey (P<.05)

Obs	salinity	Estimate	Standard Error	Letter Group
3	0	33.2500	5.0700	A
4	1	31.3000	5.0700	A
5	2	34.3000	5.0700	A

Salinity= (0, 1=100,2=150) mM

Table 84. Mean separation for the fresh leaf weight based on the effect of Bacteria interaction with salinity. Effect= Bacteria*Salinity Method=turkey (P<.05)

Obs	bacteria	salinity	Estimate	Standard Error	Letter Group
6	1	0	33.1000	7.1700	A
7	1	1	28.6000	7.1700	A
8	1	2	22.6000	7.1700	A
9	2	0	33.4000	7.1700	A
10	2	1	34.0000	7.1700	A
11	2	2	46.0000	7.1700	A

1= without bacteria, 2= with bacteria, Salinity= (0, 1=100,2=150) mM

Table 85. Mean separation for the leaf dry weight based on the effect of P. fluorescence inoculation. Effect= Bacteria Method = Turkey (P<.05)

Obs	bacteria	Estimate	Standard Error	Letter Group
1	1	20.5333	2.7643	A
2	2	23.7000	2.7643	A

1= without bacteria, 2= with bacteria

Table 86. Mean separation for the leaf dry weight based on the effect salinity. Effect= Salinity Method=Turkey (P<.05)

Obs	salinity	Estimate	Standard Error	Letter Group
3	0	18.4500	3.3855	A
4	1	24.0000	3.3855	A
5	2	23.9000	3.3855	A

Salinity= (0, 1=100,2=150) mM

Table 87. Mean separation for the leaf dry weight based on the effect of Bacteria interaction with salinity. Effect= Bacteria*Salinity Method=turkey (P<.05)

Obs	bacteria	salinity	Estimate	Standard Error	Letter Group
6	1	0	17.4000	4.7878	A
7	1	1	25.8000	4.7878	A
8	1	2	18.4000	4.7878	A
9	2	0	19.5000	4.7878	A
10	2	1	22.2000	4.7878	A
11	2	2	29.4000	4.7878	A

1= without bacteria, 2= with bacteria, Salinity= (0, 1=100,2=150) mM.

Table 88. Mean separation for the leaf width based on the effect of P. fluorescence inoculation. Effect= Bacteria Method = Turkey (P<.05)

Obs	bacteria	Estimate	Standard Error	Letter Group
1	1	7.3500	0.3734	B
2	2	11.4767	0.3734	A

1= without bacteria, 2= with bacteria

Table 89. Mean separation for the leaf width based on the effect salinity. Effect= Salinity Method=Turkey (P<.05)

Obs	salinity	Estimate	Standard Error	Letter Group
3	0	10.1750	0.4573	A
4	1	9.0275	0.4573	A
5	2	9.0375	0.4573	A

Salinity= (0, 1=100,2=150) mM

Table 90. Mean separation for the leaf width based on the effect of Bacteria interaction with salinity. Effect= Bacteria*Salinity Method=turkey (P<.05)

Obs	bacteria	salinity	Estimate	Standard Error	Letter Group
6	1	0	9.7250	0.6467	A
7	1	1	6.5000	0.6467	B
8	1	2	5.8250	0.6467	B
9	2	0	10.6250	0.6467	A
10	2	1	11.5550	0.6467	A
11	2	2	12.2500	0.6467	A

1= without bacteria, 2= with bacteria, Salinity= (0, 1=100,2=150) mM

Table 91. Mean separation for the leaf length based on the effect of P. fluorescence inoculation. Effect= Bacteria Method = Turkey (P<.05)

Obs	bacteria	Estimate	Standard Error	Letter Group
1	1	8.2250	0.3428	B
2	2	11.1367	0.3428	A

1= without bacteria, 2= with bacteria

Table 92. Mean separation for the leaf length based on the effect salinity. Effect= Salinity Method=Turkey (P<.05)

Obs	salinity	Estimate	Standard Error	Letter Group
3	0	10.0500	0.4199	A
4	1	9.8800	0.4199	A
5	2	9.1125	0.4199	A

Salinity= (0, 1=100,2=150) mM

Table 93. Mean separation for the leaf length based on the effect of Bacteria interaction with salinity. Effect= Bacteria*Salinity Method=turkey (P<.05)

Obs	bacteria	salinity	Estimate	Standard Error	Letter Group
6	1	0	10.7250	0.5938	AB
7	1	1	8.2000	0.5938	CD
8	1	2	5.7500	0.5938	D
9	2	0	9.3750	0.5938	BC
10	2	1	11.5600	0.5938	AB
11	2	2	12.4750	0.5938	A

1= without bacteria, 2= with bacteria, Salinity= (0, 1=100,2=150) mM.

Table 94. Mean separation for the total biomass based on the effect of P. fluorescence inoculation. Effect= Bacteria Method = Turkey (P<.05)

Obs	bacteria	Estimate	Standard Error	Letter Group
1	1	87.3067	6.9393	B
2	2	172.48	6.9393	A

1= without bacteria, 2= with bacteria

Table 95. Mean separation for the total biomass based on the effect salinity. Effect= Salinity Method=Turkey (P<.05)

Obs	salinity	Estimate	Standard Error	Letter Group
3	0	135.65	8.4989	A
4	1	126.69	8.4989	A
5	2	127.34	8.4989	A

Salinity= (0, 1=100,2=150) mM

Table 96. Mean separation for the total biomass based on the effect of Bacteria interaction with salinity. Effect= Bacteria*Salinity Method=turkey (P<.05)

Obs	bacteria	salinity	Estimate	Standard Error	Letter Group
6	1	0	104.22	12.0193	B
7	1	1	94.2700	12.0193	B
8	1	2	63.4300	12.0193	B
9	2	0	167.07	12.0193	A
10	2	1	159.11	12.0193	A
11	2	2	191.25	12.0193	A

1= without bacteria, 2= with bacteria, Salinity= (0, 1=100,2=150) mM

Table 97. Mean separation for the nitrogen on root based on the effect of P. fluorescence inoculation. Effect= Bacteria Method = Turkey (P<.05)

bacteria	Estimate	Standard Error	Letter Group
0	0.2189	0.003220	A
1	0.2271	0.003220	A

0= without bacteria, 1= with bacteria

Table 98. Mean separation for the nitrogen on root based on the effect salinity. Effect= Salinity Method=Turkey (P<.05)

salinity	Estimate	Standard Error	Letter Group
0	0.2230	0.003943	AB
1	0.2100	0.003943	B
2	0.2360	0.003943	A

Salinity= (0, 1=100,2=150) mM

Table 99. Mean separation for the nitrogen on root based on the effect of Bacteria interaction with salinity. Effect= Bacteria*Salinity Method=turkey (P<.05)

bacteria	salinity	Estimate	Standard Error	Letter Group
0	0	0.1927	0.005577	C
0	1	0.1760	0.005577	C
0	2	0.2880	0.005577	A
1	0	0.2533	0.005577	B
1	1	0.2440	0.005577	B
1	2	0.1840	0.005577	C

1= without bacteria, 2= with bacteria, Salinity= (0, 1=100,2=150) mM

Table 100. Mean separation for the nitrogen on leaf based on the effect of P. fluorescence inoculation. Effect= Bacteria Method = Turkey (P<.05)

bacteria	Estimate	Standard Error	Letter Group
0	0.7969	0.002262	B
1	0.8093	0.002262	A

0= without bacteria, 1= with bacteria

Table 101. Mean separation for the nitrogen on leaf based on the effect salinity. Effect= Salinity Method=Turkey (P<.05)

salinity	Estimate	Standard Error	Letter Group
0	0.7022	0.002771	B
1	0.8535	0.002771	A
2	0.8537	0.002771	A

Salinity= (0, 1=100,2=150) mM

Table 102. Mean separation for the nitrogen on leaf based on the effect of Bacteria interaction with salinity. Effect= Bacteria*Salinity Method=turkey (P<.05)

bacteria	salinity	Estimate	Standard Error	Letter Group
0	0	0.7590	0.003918	D
0	1	0.7787	0.003918	C
0	2	0.8530	0.003918	B
1	0	0.6453	0.003918	E
1	1	0.9283	0.003918	A
1	2	0.8543	0.003918	B

1= without bacteria, 2= with bacteria, Salinity= (0, 1=100,2=150) mM

Table 103. Mean separation for the chlorine on root based on the effect of P. fluorescence inoculation. Effect= Bacteria Method = Turkey (P<.05)

bacteria	Estimate	Standard Error	Letter Group
0	0.3022	0.01748	B
1	1.0400	0.01748	A

0= without bacteria, 1= with bacteria

Table 104. Mean separation for the chlorine on root based on the effect salinity. Effect= Salinity Method=Turkey (P<.05)

salinity	Estimate	Standard Error	Letter Group
0	0.9717	0.02140	A
1	0.5467	0.02140	B
2	0.4950	0.02140	B

Salinity= (0, 1=100,2=150) mM

Table 105. Mean separation for the chlorine on root based on the effect of Bacteria interaction with salinity. Effect= Bacteria*Salinity Method=turkey (P<.05)

bacteria	salinity	Estimate	Standard Error	Letter Group
0	0	0.8233	0.03027	C
0	1	0.04333	0.03027	D
0	2	0.04000	0.03027	D
1	0	1.1200	0.03027	A
1	1	1.0500	0.03027	AB
1	2	0.9500	0.03027	BC

1= without bacteria, 2= with bacteria, Salinity= (0, 1=100,2=150) mM

Table 106. Mean separation for the sodium on root based on the effect of P. fluorescence inoculation. Effect= Bacteria Method = Turkey (P<.05)

bacteria	Estimate	Standard Error	Letter Group
0	0.03667	0.003143	B
1	0.06889	0.003143	A

0= without bacteria, 1= with bacteria

Table 107. Mean separation for the sodium on root based on the effect salinity. Effect= Salinity Method=Turkey (P<.05)

salinity	Estimate	Standard Error	Letter Group
0	0.05167	0.003849	A
1	0.06000	0.003849	A
2	0.04667	0.003849	A

Salinity= (0, 1=100,2=150) mM

Table 108. Mean separation for the sodium on root based on the effect of Bacteria interaction with salinity. Effect= Bacteria*Salinity Method=turkey (P<.05)

bacteria	salinity	Estimate	Standard Error	Letter Group
0	0	0.04333	0.005443	BC
0	1	0.04000	0.005443	BC
0	2	0.02667	0.005443	C
1	0	0.06000	0.005443	AB
1	1	0.08000	0.005443	A
1	2	0.06667	0.005443	AB

1= without bacteria, 2= with bacteria, Salinity= (0, 1=100,2=150) mM

Table 109. Mean separation for the potassium on root based on the effect of P. fluorescence inoculation. Effect= Bacteria Method= Turkey (P<.05)

bacteria	Estimate	Standard Error	Letter Group
0	0.3156	0.01885	B
1	1.0467	0.01885	A

0= without bacteria, 1= with bacteria

Table 110. Mean separation for the potassium on root based on the effect salinity. Effect= Salinity Method=Turkey (P<.05)

salinity	Estimate	Standard Error	Letter Group
0	0.7400	0.02309	A
1	0.5383	0.02309	B
2	0.7650	0.02309	A

Salinity= (0, 1=100,2=150) mM

Table 111. Mean separation for the potassium on root based on the effect of Bacteria interaction with salinity. Effect= Bacteria*Salinity Method=turkey (P<.05)

bacteria	salinity	Estimate	Standard Error	Letter Group
0	0	0.3800	0.03265	C
0	1	0.2633	0.03265	C
0	2	0.3033	0.03265	C
1	0	1.1000	0.03265	A
1	1	0.8133	0.03265	B
1	2	1.2267	0.03265	A

1= without bacteria, 2= with bacteria, Salinity= (0, 1=100,2=150) mM

Table 112. Mean separation for the calcium on root based on the effect of P. fluorescence inoculation. Effect= Bacteria Method = Turkey (P<.05)

bacteria	Estimate	Standard Error	Letter Group
0	2.2222	0.1272	B
1	3.6000	0.1272	A

0= without bacteria, 1= with bacteria

Table 113. Mean separation for the calcium on root based on the effect salinity. Effect= Salinity Method=Turkey (P<.05)

salinity	Estimate	Standard Error	Letter Group
0	2.8333	0.1558	A
1	2.9000	0.1558	A
2	3.0000	0.1558	A

Salinity= (0, 1=100,2=150) mM

Table 114. Mean separation for the calcium on root based on the effect of Bacteria interaction with salinity. Effect= Bacteria*Salinity Method=turkey (P<.05)

bacteria	salinity	Estimate	Standard Error	Letter Group
0	0	1.1667	0.2203	C
0	1	2.5000	0.2203	B
0	2	3.0000	0.2203	B
1	0	4.5000	0.2203	A
1	1	3.3000	0.2203	B
1	2	3.0000	0.2203	B

1= without bacteria, 2= with bacteria, Salinity= (0, 1=100,2=150) mM

Table 115. Mean separation for the phosphorus on root based on the effect of P. fluorescence inoculation. Effect= Bacteria Method = Turkey (P<.05)

bacteria	Estimate	Standard Error	Letter Group
0	1882.29	7.0927	A
1	1897.97	7.0927	A

0= without bacteria, 1= with bacteria

Table 116. Mean separation for the phosphorus on root based on the effect salinity. Effect= Salinity Method=Turkey (P<.05)

salinity	Estimate	Standard Error	Letter Group
0	1867.08	8.6868	B
1	1959.67	8.6868	A
2	1843.63	8.6868	B

Salinity= (0, 1=100,2=150) mM

Table 117. Mean separation for the phosphorus on root based on the effect of Bacteria interaction with salinity. Effect= Bacteria*Salinity Method=turkey (P<.05)

bacteria	salinity	Estimate	Standard Error	Letter Group
0	0	1724.00	12.2850	B
0	1	1967.17	12.2850	A
0	2	1955.70	12.2850	A
1	0	2010.17	12.2850	A
1	1	1952.17	12.2850	A
1	2	1731.57	12.2850	B

1= without bacteria, 2= with bacteria, Salinity= (0, 1=100,2=150) mM.

Table 118. Mean separation for the sodium on leaf based on the effect of P. fluorescence inoculation. Effect= Bacteria Method = Turkey (P<.05)

bacteria	Estimate	Standard Error	Letter Group
0	0.1222	0.004818	B
1	0.1389	0.004818	A

0= without bacteria, 1= with bacteria

Table 119. Mean separation for the sodium on leaf based on the effect salinity. Effect= Salinity Method=Turkey (P<.05)

salinity	Estimate	Standard Error	Letter Group
0	0.1283	0.005900	A
1	0.1367	0.005900	A
2	0.1267	0.005900	A

Salinity= (0, 1=100,2=150) mM

Table 120. Mean separation for the sodium on leaf based on the effect of Bacteria interaction with salinity. Effect= Bacteria*Salinity Method=turkey (P<.05)

bacteria	salinity	Estimate	Standard Error	Letter Group
0	0	0.1100	0.008344	A
0	1	0.1333	0.008344	A
0	2	0.1233	0.008344	A
1	0	0.1467	0.008344	A
1	1	0.1400	0.008344	A
1	2	0.1300	0.008344	A

1= without bacteria, 2= with bacteria, Salinity= (0, 1=100,2=150) mM.

Table 121. Mean separation for the potassium on leaf based on the effect of P. fluorescence inoculation. Effect= Bacteria Method = Turkey (P<.05)

bacteria	Estimate	Standard Error	Letter Group
0	1.6267	0.07406	B
1	2.0167	0.07406	A

0= without bacteria, 1= with bacteria

Table 122. Mean separation for the potassium on leaf based on the effect salinity. Effect= Salinity Method=Turkey (P<.05)

salinity	Estimate	Standard Error	Letter Group
0	1.8100	0.09071	A
1	1.7783	0.09071	A
2	1.8767	0.09071	A

Salinity= (0, 1=100,2=150) mM

Table 123. Mean separation for the potassium on leaf based on the effect of Bacteria interaction with salinity. Effect= Bacteria*Salinity Method=turkey (P<.05)

bacteria	salinity	Estimate	Standard Error	Letter Group
0	0	1.7500	0.1283	A
0	1	1.5367	0.1283	A
0	2	1.5933	0.1283	A
1	0	1.8700	0.1283	A
1	1	2.0200	0.1283	A
1	2	2.1600	0.1283	A

1= without bacteria, 2= with bacteria, Salinity= (0, 1=100,2=150) mM.

Table 124. Mean separation for the calcium on leaf based on the effect of P. fluorescence inoculation. Effect= Bacteria Method = Turkey (P<.05)

bacteria	Estimate	Standard Error	Letter Group
0	4.1333	0.08491	A
1	3.6556	0.08491	B

0= without bacteria, 1= with bacteria

Table 125. Mean separation for the calcium on leaf based on the effect salinity. Effect= Salinity Method=Turkey (P<.05)

salinity	Estimate	Standard Error	Letter Group
0	4.9167	0.1040	A
1	3.6500	0.1040	B
2	3.1167	0.1040	C

Salinity= (0, 1=100,2=150) mM.

Table 126. Mean separation for the calcium on leaf based on the effect of Bacteria interaction with salinity. Effect= Bacteria*Salinity Method=turkey (P<.05)

bacteria	salinity	Estimate	Standard Error	Letter Group
0	0	4.8333	0.1471	A
0	1	3.9333	0.1471	B
0	2	3.6333	0.1471	B
1	0	5.0000	0.1471	A
1	1	3.3667	0.1471	B
1	2	2.6000	0.1471	C

1= without bacteria, 2= with bacteria, Salinity= (0, 1=100,2=150) mM.

Table 127. Mean separation for the phosphorus on leaf based on the effect of P. fluorescence inoculation. Effect= Bacteria Method = Turkey (P<.05)

bacteria	Estimate	Standard Error	Letter Group
0	320.00	1.1005	A
1	293.17	1.1005	B

0= without bacteria, 1= with bacteria

Table 128. Mean separation for the phosphorus on leaf based on the effect salinity. Effect= Salinity Method=Turkey (P<.05)

salinity	Estimate	Standard Error	Letter Group
0	307.17	1.3479	B
1	278.80	1.3479	C
2	333.78	1.3479	A

Salinity= (0, 1=100,2=150) mM

Table 129. Mean separation for the phosphorus on leaf based on the effect of Bacteria interaction with salinity. Effect= Bacteria*Salinity Method=turkey (P<.05)

bacteria	salinity	Estimate	Standard Error	Letter Group
0	0	357.33	1.9062	A
0	1	272.33	1.9062	D
0	2	330.33	1.9062	B
1	0	257.00	1.9062	E
1	1	285.27	1.9062	C
1	2	337.23	1.9062	B

1= without bacteria, 2= with bacteria, Salinity= (0, 1=100,2=150) mM

Table 130. Mean separation for the chlorine on leaf based on the effect of P. fluorescence inoculation. Effect= Bacteria Method = Turkey (P<.05)

bacteria	Estimate	Standard Error	Letter Group
0	4.2289	0.05630	A
1	3.8856	0.05630	B

0= without bacteria, 1= with bacteria

Table 131. Mean separation for the chlorine on leaf based on the effect salinity. Effect= Salinity Method=Turkey (P<.05)

salinity	Estimate	Standard Error	Letter Group
0	3.9917	0.06896	A
1	3.9617	0.06896	A
2	4.2183	0.06896	A

Salinity= (0, 1=100,2=150) mM

Table 132. Mean separation for the chlorine on leaf based on the effect of Bacteria interaction with salinity. Effect= Bacteria*Salinity Method=turkey (P<.05)

bacteria	salinity	Estimate	Standard Error	Letter Group
0	0	4.3067	0.09752	A
0	1	3.6533	0.09752	B
0	2	4.7267	0.09752	A
1	0	3.6767	0.09752	B
1	1	4.2700	0.09752	A
1	2	3.7100	0.09752	B

1= without bacteria, 2= with bacteria, Salinity= (0, 1=100,2=150) mM

جامعة النجاح الوطنية

كلية الدراسات العليا

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اعداد

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اشراف

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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

الدراسة الحالية أجريت لتقييم الأثر الناتج من المحلول الملحي بدرجات مختلفة على نبات البندورة بوجود أو بإستخدام نظام الزراعة المائية (الهيدروبونيك) على صنف تجاري من نبات البندورة تحت درجات عدم وجود البكتيريا بوجود أو عدم وجود البكتيريا على تراكيز مختلفة من الملوحة mM (0,100,150).

تم إضافة تراكيز الملوحة في الأنابيب المستخدمة في نظام الزراعة، كل تركيز ملوحة يحتوي على مكرر بوجود بكتيريا ومكرر بعدم وجود بكتيريا. الأنابيب التي لا تحتوي على بكتيريا أظهرت إجهاد ملحي على النباتات وخصوصاً على مقاييس النمو (طول الساق، عدد الثمار، كثافة الأزهار، عدد الأوراق، كتلة الجذور، الوزن الجاف والرطب للنبات). تراكم الصوديوم والكلور في الجذور وخصوصاً في النباتات المعاملة في البكتيريا نتيجة الإجهاد الملحي يعمل على زيادة الإمتصاص للماء فيزيد تركيز الأملاح في الجذور أما في الأوراق فلا يوجد تأثير للبكتيريا على الأملاح.

البكتيريا المحفزة للنمو تعمل على تحسين وتطور النبات وتستطيع أن تتأقلم بوجود الملوحة وبالتالي تعمل على تحسين النمو وزيادة الإنتاجية. النباتات المعاملة بالبكتيريا تعمل على زيادة طول النبات، عدد الأوراق والأزهار، الوزن الكلي للنبات، الأزهار المبكر، زيادة المجموع الجذري، زيادة إمتصاص العناصر الغذائية الأساسية للنبات بشكل أفضل (النيتروجين، الفسفور،

البوتاسيوم، الكالسيوم) للنباتات المعاملة بالبكتيريا أفضل ولها القدرة بشكل أقوى في تحمل الملوحة مقارنة مع النباتات الغير معاملة.

النباتات المعاملة بالبكتيريا أظهرت نتائجها زيادة في طول النبات، زيادة ضعف وزن وعدد الثمار وعدد الأزهار، الأزهار المبكر، طول الجذور، الوزن الرطب وعدد التفرعات مقارنة مع النباتات الغير معاملة بالبكتيريا.

العديد من الدراسات أظهرت تأثير زيادة الملوحة على نشاط البكتيريا من خلال زيادة عملية الإمتصاص وتأثير المواد السامة لكن بوجود بكتيريا متحملة للملوحة تعمل على المحافظة على حيوية وإنتاجية النبات تحت ظروف الملوحة.

الدراسة أظهرت أنه يمكن السيطرة على الملوحة في نظام الهيدروبونيك من خلال إضافة البكتيريا المحفزة للنمو مقارنة بالنباتات الغير معاملة.