An-Najah National University

Faculty of Graduate Studies

Evaluation of the Impacts of Selected Trace Elements and Salinity on the Growth, Yield, and Uptake of Bell Pepper Grown Under Sequential Vertical Flow Hydroponic Conditions

By

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This thesis was defended successfully on 14 / 8 /2014 and approved by:

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– **Dr. Hassan Abu Qaoud (Internal examiner)**	.....

Dedication

To our prophet Mohamed who is the first teacher

To my parents who always encouraged me to science, progress, and knowledge

To my dear husband who stood by my side and supported me by all he has, and all he can

To my daughters Mayar and Yara, who gave me hope to complete this work

To my aunt- Um Waseem, and uncle- Abu Waseem, who encouraged and supported me

To my sisters and brothers

To everyone who helped and supported me in my research with love and respect

Acknowledgment

First of all, praise be to Allah for helping me make write this thesis possible.

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Great thanks also to all my friends for their encouragement and support.

إقرار

أنا الموقع أدناه مقدم الرسالة التي تحمل العنوان:

Evaluation of the Impacts of Selected Trace Elements and Salinity on the Growth, Yield, and Uptake of Bell Pepper Grown Under Sequential Vertical Flow Hydroponic Conditions

أقر بأن ما اشتملت عليه هذه الرسالة إنما هي نتاج جهدي الخاص، باستثناء ما تم الإشارة إليه حيثما ورد، وأن هذه الرسالة ككل، أو أي جزء منها لم يقدم لنيل أي درجة أو لقب علمي أو بحثي لدى أية 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:**

Signature **التوقيع:**

Date: **التاريخ:**

Table of Contents

List of Tables

List of Figures

Evaluation of the Impacts of Selected Trace Elements and Salinity on the Growth, yield, and Uptake of Bell Pepper Grown under Sequential Vertical Flow Hydroponic Conditions

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Abstract

This study aims at assessing the growth and productivity of sweet pepper under special circumstances in two experiments. The first of them was conducted with three salinity concentrations of NaCl. The second was conducted using some heavy minerals which are Cu, Cr, Cd, and Zn. Both experiments were conducted under under Sequential Vertical Flow Hydroponic Conditions.

The experiment was conducted using 26 containers arranged in pairs, one of each pair for growing the pepper and the other for collecting the leaking water. The containers were arranged in rows, each row represents the kind of treatment. The fifth row was left with one pair of containers for the blank sample.

The water that was used to irrigate the plant in the first container in each row was used to irrigate the next container in the same row.

The first row was treated with the first salinity treatment (S1) with a concentration of 1000 ppm, the 2nd row with (S2) treatment with a concentration of 3000 ppm, and the 3rd row with (S3) treatment with a concentration of 7000 ppm. The 4th row was treated with trace metals (TM) with a concentration of 0.2 ppm for each metal. The water was manually

stirred every day. The number of leaves, buds, and fruit was calculated. The length of stems was measured before and after adding the salinity solutions and the selected heavy minerals.

Salinity was measured with the (EC) device with the (µs) unit while the concentration of the heavy minerals was measured using (ICPMS). A continuous increase was noticed in the parts of the sweet pepper when adding the heavy metals .These parts were affected when the solutions were added. This was clearly noticed when the leaves fell and lost connection with the stem. Statistical differences also appeared at (α =0.05) for the third salinity treatment (S3). The same was also noticed about the stem and roots. Statistical differences were also noticed on the fruit of the first salinity treatment (S1) and mainly on the first container. No statistical differences were noticed when comparing all concentrations as a whole, which shows that the number of fruits was not clearly influenced by salinity.

As for the experiment of the trace metals (TM), it was noticed that Cu concentrated in the roots, while Zn concentrated in the fruits. As for the Cd, it concentrated most in the roots and leaves. Cr was most in roots. It was also noticed that those minerals had contradictory effects as was reflected in the different concentrations of these minerals in the parts of the hot pepper. The exterior effect of the plant was not clearly influenced. The danger of these minerals lies in their accumulation in the edible parts of the fruit.

Chapter One

1. Introduction

1.1. General

It is clear that soil salinity is one of the most environmental stresses that makes agricultural productivity limited worldwide. (Lauchli , and Grattan, 2007), (. Shiyab, 2011), (Lolaei, et al, 2012).

The world suffers from lack of availability of fresh water for irrigation, especially on arid and semi-arid regions, so using low quality water (saline water) had to be used for irrigation as mentioned in a study by (Chartzoulakis and Klapaki, 2000).

Low quality water can be using sewage water (waste water) for irrigation, that contains many harmful components from which heavy metal represents very concerning component, which can reach plant tissues and adversely affect it due to their bioaccumulative properties.(Koldabadi, et al, 2012).

Despite the challenges that the agricultural sector faces and the limitations in this area, the agricultural sector is one of the most important production sectors in Palestine. As Palestine is an agricultural country, its people depend on agriculture and hardly devoid of the house agriculture whether they are productive or unproductive plants.

In Palestine hydroponic agriculture became one of our agricultural problem solutions, where little water is used. Recently the Ministry of Agriculture in Gaza strip has conducted a series of experiments on

agricultural hydroponics systems, and agriculture without soil, as a simulation of different models of the world. (Rajab L., 2014).

Palestine, as many other countries, suffers from lack of water resources due to the decline of water quality, availability of water resources and the political situation. Salinity problem worsens the problem which represents a special situation in Palestine that researchers must try to solve and overcome. Gaza strip in Palestine represents a good example of similar situation, because it's suffering from leaching of sea water to ground water aquifers.

Salinity in Palestine is concentrated in Gaza strip and in Jericho governorates and its villages. As confirmed by a member of Jericho's agricultural department (Ministry of Agriculture , 2014), it was found that the areas affected by salinity and suffering from this problem and on which researchers concentrate their studies, were in Jeftliek, Zbedat, Mashro'a Arabi, Der Hejleh, Alzour, and Marj Na'ajeh. Where water is desalinated for agricultural purposes to make different crops after the treatment, making EC values for it reach 6 millimose. The areas mentioned are suffering not only from water salinity, but also suffering from soil salinity. Because of that, they are planted with crops that tolerate salinity such as palm trees that can live, reproduce and yield under high salinity ranges. Most researchers in Jericho focus on palm trees, because this kind of plant is considered as salinity tolerant, that can live and yield under high salt conditions.

The study focuses on bell pepper which is considered to be one of the most prevalent crops which are used in Palestine as one of the main priorities, either for economic importance or for the area of cultivation according to Ministry of Agricultural, 2014.

Pepper is chosen because it is one of the most commune crops that grow in Palestine, and studies found that it can grow under saline conditions (moderate and with low concentration).Also it is suitable to grow under the experiment conditions, and under hydroponic system in early summer.

The pepper grows under different conditions; for example in the open environments such as farms and fields, or in greenhouses, which make it in addition to other crops available all year round.

The study uses bell pepper under a special hydroponic system, which has recently become one of the most common systems used by farmers and the agricultural sector. Many countries worldwide used this system successfully, and it is well used in Arab countries especially in Egypt and UAE.

1.2. Problem definition

Studying the effect of salinity and trace element on one of the most common crops in Palestine - bell pepper, by depending on a special conditions of hydroponic system**.**

1.3. Objectives

1.3.1. Main objectives

1. To evaluate salinity effects on the growth and yield of bell pepper.

2. To evaluate the effects of trace elements uptake on growth and yield of bell pepper.
3. To find out the efficiency of using hydroponic system under special conditions.

1.4. Motivation

This research is conducted to improve my research skills, to improve my career as a teacher, and to get impressive opportunities in related fields.

1.5. Research Question

What are the effects of salinity and trace metals on the growth and yield of bell pepper under special irrigation using the hydroponic system?

Chapter Two

Literature Review

2.1. General introduction

Any plant needs special conditions to grow and yield properly. These conditions include salinity, nutrients, pressure, humidity (irrigation) and other elements. To grow and yield plants uptake water and essential nutrients from soil in different ways, such as diffusion, osmosis, and active transport..

Many studies investigate the effects of salinity and trace element on plant growing and yielding all of them in a soil conditions, which contain different nutrients and elements, in this study hydroponic system will be used in which no soil was used, however growing will be in hydroponic system, (hydroponic system is defined as the cultivation of plants in water, and because plants need nutrients as it needs water as special medium was used to maintain plant growth and yielding. (Munoz, H, 2010)

2.2. About Bell pepper plant

According to the brochure published by Ministry of Agriculture, 2005, taste and odor due to the percentage of volatile oils differ depending to the kind of pepper.

The strong taste is due to the capsissene reaches about 0.007% in the sweet kinds and about 1.9% of the dry wight in the strong kinds.

, There were a study by M.D. Fernadez(et.al 2005), on bell pepper and water stress, to determine crop evapotranspiration, efficiency of water

usage and effect of continuous water deflects on crop growth and production of pepper in a greenhouse for two growing seasons with three irrigation treatments - T1, T2,T3. These were applied and evapotranspiration by them was investigated where in T1, an estimate of 100% of crop water was needed, in T2 - 50% and, in T3 an estimate of 20% of water was required. For T2, and T3, the total fruit production was reduced in comparison to T1.

2.2.1. Bell pepper in Palestine

The most common type of bell pepper in Palestine is *Capsicum annum,* The area cultivated with pepper in Palestine is approximately 4864 dunums. 1340 dunums are grown in green houses and in high tunnels.

Pepper is grown in areas of Tulkarem, Tubas and Jericho, mainly; the output is year-round. Production of bell pepper estimated rate of about 8 tons/dunum which is locally consumed. (Palestinian Ministry of Agriculture, 2014).

2.2.2. When to plant pepper

Pepper grows best in a relatively warm climate where the growing season is long and with a little danger of frosts. (Agricultural and Livestock Research, Annual Report, 2009).

According to Ministry of Agriculture; the best time for planting is:

1. Autumn; from 1st Aug. to 30th Sep.
2. Spring; from 1st Feb. to 30th of Apr.
3. In greenhouse from Oct. to November.

2.2.3. Environmental conditions for planting pepper

1. Temperature

Pepper is considered as warmth preferring crop. For seed germination, it was found that the plant does not grow up below 13°C and the perfect temperature for germination and growth, was found to be from 20-25°C from which seedling appears in 8-9 days.

The most suitable temperature for growing and flower appearance was about 25-30°C. Whenever 35°C, buds and fruits flow because of disturbing the water balance within the plant due to the large loss from evapotranspiration.

The low temperature also has bad effects on the plant. Falling to about 15-20°C leads to slowing down the growth, while falling to about 13°C will terminate the growth, the plant dies at the presence of light frost, when the temperature reaches about 0.3-0.5°C.

2. Light

Pepper needs strong light, especially when preparing to transplant, as the light affects the growth and the quality of the fruits. Pepper also needs strong light during the growth of transplant. There are many studies which prove that planting pepper among other trees will adversely affect the yield.

3. Humidity

Pepper is classified with plants that require low amount of water, but it grows perfectly well at the present of enough moisture within soil, so that

it gives the plant a better yield and quality, when soil humidity reaches 80-85% and air moisture within 60-70%. For that, it is preferred to always plant pepper in irrigated planting fields.

4. Irrigation

According to the Ministry of Agricultural, pepper as other vegetative crops, needs special conditions to give its large yield. One of which is to allow enough amount of moisture in the soil to the perfect level of moisture, so that when the plant faces dehydration during flowering and bud appearance, it will not lead and fall down. It will also prevent the plant from spending long time to re-grow strongly due to the damage of dehydration.

Generally the number of irrigations required to reach balanced growth and good yields depends on the kind of soil, air, humidity, and the temperature that prevails.

It was found by Lauchli and Grattan, 2007, that salinity problem was aggravated by the need of irrigation for crop production in arid and semiarid environment.

According to Ibrahim (2011), there are two factors that determine the suitability of irrigation water for agriculture, namely:

1) The amount of dissolved salt and percentage of its concentration, when the dissolved salt moves with irrigation water precipitating at the bottom or concentrating at the soil surface, causing dangerous effect on the plant growth and yield.

2) The percentage of harmful elements, such as sodium, chloride and Boron in irrigation water.

According to Palestinian Ministry of Agriculture, 2014, bell pepper needs 400-600 cubic meter /dunum during the growth season for the open field, while 600-800 cubic meter /dunum are needed for the protected field. The quantity of the required water for the plant can be calculated depending on the evaporation and transpiration processes on the surface of the plant and the soil. Because the roots of the pepper plant are small, it needs close irrigations but in relatively small quantities.

2. 3. Salinity

"Soil salinity: is the quantity of total amount of salts in soil" (Kotaby-Amacher, et al, 2000). The presence of salt in soil where the plant grows will cause water stress for plant, because plant will not extract water easily from soil or planting medium. In the experiment system, soil was not used, but salt was added in different concentrations. This also will affect the uptake of water and nutrients from medium, through osmosis.

Salinity defined in manual for measuring salts concentrations (Way, and Beaverton, 2006), as the total of all non-carbonate salts dissolved in water, usually expressed in part per million.

Salty soil is defined as the soil that contains salt of sodium chloride, calcium, sodium sulfate at high concentrations, on which the percentage of sodium availability for exchange is 15%, and its PH value is about 8.5.

While alkali soil is defined as soil in which sodium ions percentage that is available (for exchange) is about 15% and PH value is higher than 8.5.

Nufal Maram (1012), in a study about soil salinity and its effects on plants divided soil is types to:

1) Saline salty soil, which contains high concentrations of salts with high exchanged sodium that leads to bad effects on plants' growth. This lands EC of soil extraction exceed over 4 millimose/cm , and exchanged sodium percentage ESP; more than 15% and generally PH value is around 8.5. Because nowadays neutral salts are washed out, this type of soil is converted to alkali soil, where PH values are increased. Especially if there are no enough Calcium and Magnesium in the land or in washing water, it results in hydration of exchanged Sodium after washing salts which lead to increasing OH ions concentration in land solution. In this case washing soil with water increase the problem, since it will be essential to add agricultural gypsum as a source of Calcium to balance alkalinity and convert sodic soil to calcium saturated soil, to make it suitable for plant growth.
2) Sodic or alkali soil has a PH of about 8.4, contains high percentage of salts and the exchanges sodium elevated 15%.

Salty soil defined by Nufal, (2012) in a report for Zeraiah.net, as: "The accumulation of salts within soil surrounding roots in high concentration which inhibits the growth of plant and transform soil to be more suitable for agricultural purposes. Dissolved salts in soil are, Sodium, Calcium,

Magnesium, Chloride, and sulfate as number one salts, then Potassium, Bicarbonates, Nitrates, and Boron, came next"

According to Tammy James, (2014) water with less than 1000 ppm is considered as fresh water and this is also the limit for the drinking water. Water with 3000 ppm is considered as salt or saline. For example, the sea water salt concentration is about 3500 ppm.

A member of Ministry of Agricultural told that the salinity ranges are classified as follows: from 1000 ppm the salinity is normal and soil is suitable for plant growth; from 1000-2000 ppm it is considered as moderate values; from 2000-3000 it is considered as high salinity and special conditions are applied; at 3000 ppm and over, salinity is very high and only certain crops can live and yield.

Ibrahim (2011) found that water containing salts can be classified to the following types: if salt concentration is less than 1000 ppm, water is fresh; if salinity reaches 1000-3000 ppm it is considered as littlie salinity water; moderate water at 3000-10000 ppm; high salinity water 10000-35000 ppm; and sea water is considered at salinity more than 35000 ppm.

Way and Beaverton (2006), suggest that salinity levels in sea water is fairly constant, at about 35ppm (35000 mg/l), and most anions in sea water or brackish water are chloride ions, so salinity can be determined from chloride concentration.

2. 3.1. Electrical conductivity

Electrical conductivity is defined by Bruckner (2013) and Agricultural Solutions (2014), as measurement of dissolved materials in aqueous

solution and expresses the ability of materials to conduct electrical current through them, and measured by seimens per unit area, mS/cm, µS/cm, etc. While soil electrical conductivity is defined as the measurement that correlates with soil properties, which affect plant or crop productivity including soil texture cation exchange capacity, drainage conditions organic matter, level salinity, and soluble characteristic. (Grisso et al, 2009). (Eshani et al, 2006), (Barbosa and Overstreet, 2011), (Wiatrak et al, 2009) and (Doerge, 2001).

Nufal Maram (2012) evaluated total dissolved salts using electrical conductivity of soil water extraction that referred to as EC, by millimose/cm. As EC values decreased resulting in lower salt concentration, the soil became more suitable for agricultural purposes. Generally salinity of soil extraction must be no more than 4 millimose/cm, which equals to 2500 ppm, or; 2500mg/l of salts. In these conditions most vegetable crops such as tomato, cucumber and pepper grow without any problems, if required washing, water is added during planting and within irrigation as needed.

Practical Guide to security and optimal use of treated water for irrigation published in 2011 and used by Ministry of Agricultural there are two salinity values; (1).ECe, and (2).ECw. ECe refers to EC reading of soil solution salinity (Electrical Conductivity of soil salinity), while ECw; represents Electrical Conductivity of irrigation water. ECe and ECw both have the same effects on for the plant, but have different ways to be measured.

For ECe value, there are also two values, ECe at 100% yield where plant is not affected and is safe, as salinity is still low or equals to this value.

If the ECe becomes higher than the second value of ECe at zero yield, which is also called maximum, ECe refers to salinity of soil solution and the plant stops to yield. The growth stops, thus the production and yield become zero.

2. 3.2. Salinity sensitivity and tolerance

Pepper is more drought resistant than either tomato or eggplant. (Annual report of Agricultural and Livestock Research by Soil and Water Research Center, 2009).

Bell pepper is classified as moderate sensitive crop to salinity effects, according to Msksimovic, and Llin, (2012), and Kurunc,et al, (2011). The threshold value of salinity for Bell pepper was found to be 1.5ds/m. In another study about salinity and plant tolerance by Amacher et al (2000), the threshold value for pepper tolerance is found to be 1.3 ds/m.

Plants differ in their tolerance degree according to special physiological reasons of each plant. (Nufal, 2012).

Plants appear to be salt tolerant at germination but salt sensitive during emergence and vegetative development, by (Lauchli and Grattan, 2007).

Some plants develop a kind of tolerance to salinity, in saline conditions the plant grows and does not die, but not at the same growth rate, and yield under normal conditions. It was found that fruits, vegetables and ornamentals are more sensitive to salinity than forage and field crops. (Kotaby-Amacher, et al, 2000). This fail of water uptake causes another

problem, that is nutrient uptake of plant. Osmotic pressure will make it impossible for the root to access nutrients such as Nitrogen, which will result in defoliation. (Munns, A.James, 2003).

However the physiological, biochemical and molecular mechanism of salt tolerance in plants are not yet sufficiently understood, and hence progress in developing salt tolerante crops has been slow. (Lauchli, and Grattan, 2007).

2.4. Salinity effect on plant

There are many factors that stimulate growth and reduce abiotic stress such as, drought, low and high temperature, salinity and heavy metals induced inhibitory effects. (Houimli, et al, 2008).

Bell pepper is considered as saline sensitive, and the effect of salinity on it can be at decreased salinity values (25-50%) which decrease the yield. (Eckert and Thomas, 1995).

As we know, according to osmosis water always passes from low to high concentration of salt through a semi permeable membrane, and continues until equilibrium when the concentrations of two parts are equal. So in saline conditions, plant will not extract water easily; instead, water may pass throw plasma membrane of plant tissue to planting media causing drying and death.

Salinity is a major environmental issue that affects plant’s growth and metabolism. Salts inhibit plant growth by osmotic pressure, toxicity of specific ions, ion imbalance and oxidative stress. Pepper as many other crops is susceptible and cannot exist under conditions of high

concentrations or survive with decrease in yield. (Houimli, et al, 2008). There were many forces that can cause soil water decrease its potential energy and make it less available to plant roots' extraction. (Kurunc, et al, 2011).

According to Practical Guide to Security and optimal use of treated water for irrigation published in 2011, and used by Ministry of Agricultural, as salinity increased, the plant begins to produce organic compounds and store it within its tissues (roots mainly), to increase concentration in this tissues, in order to keep osmotic pressure enough to maintain the water flow from media to plant by osmotic process. By this way, the plant tries to face the increase of salinity in soil solution in surrounds absorption zone, but the production of these organics exhausts the plant's production capacity until the effect of salinity appear just as decreasing yield and production of plant without any symptoms on the green parts (shoots, leaves. Because of that salinity it's called "hidden salinity". Because of this farmers may think that the plant does not grow because it needs more fertilizers, so adding of fertilizers will increase the problem, while solve the problem it's enough to use water for irrigation that will wash out salts from absorption zone and decrease salt concentration and stop adding fertilizers.

As salinity becomes near (ECe maximum) production becomes less because organic materials' production faces the increase of salinity. As the problem grows it affects the leaves and stem and becomes visible. That is called "Visible Salinity".

Nufal, (2012) in her study, summarizes the effects of salinity of irrigation water to the plant yield by the following:

1) Saline water affects soil fertility by the accumulation of salts at the soil surface and around root zone according to the soil types.
2) Using saline water especially on clay lands, causes soil damage and decreases its porosity and aeration. It was known that saline water with rich with cation especially sodium, converts clay in soil to soda clay, which is unsuitable and easily damaged by rain water.
3) Saline irrigation water affects yield and production of different vegetative crops, according to their sensitivity and tolerance to salinity.

Salinity has many effects on plant such as salt toxicity, osmotic effects, and /or nutritional disorders (Lauchli, and Grattan, 2007). All these effects affect plants in different ways which depend on many factors such as, species, genotype, plant age, ionic strength, and composition of the Stalinizing solution, and organ in question.

There is relatively little evidence that indicates positively the specific toxicity of sodium into plant growing in saline soil; many species tend to exclude sodium. (Collander, 1941), (Gauch and Waldleigh, 1945), (Hayward et al., 1946), (Norman, 1949).

Salinity effects are not referred to just one element, but it is a combination of effects caused by more than one element, the main three of them are, sodium; by which sensitive plant is affected and burns on leaves appear when that elements reaches from 0.25%_0.5% (according to the weight).

Chloride element moves easily with soil solution and the plants consumes it during evapotranspiration through chloride accumulates on leaves. Most fruit trees can live under concentration percentages from 6-10 mg/l, but the bad effects appear at concentrations of 1-0.6%. (Ibrahim, 2011).

Nufal, 2012, found that the negative effects of salinity on soil and plants are represented by two effects which are;

- Increasing of osmotic pressure; when salt concentration is increases in soil surrounding the plant, osmotic pressure is elevated in the area of root zoon, and to tolerate this effect, the plant increases inner cytoplasm osmotic pressure, which makes plant to lose the biological energy needed for growth and development and causes decreasing in yield and reproduction. Osmotic pressure can be elevated using the following equation:

Osmotic pressure (Atmospheric pressure) =EC (millimose) x 0.36.

- The bad effect of the accumulation of toxic ions - Chloride, Boron, and sodium ions, which are absorbed more than before salinity by root, with the presence of these ions in high concentrations in soil extraction, which is known as (specific effect of salinity). Increasing concentrations of these ions in leaves inhibits nutrition and absorption of other nutrients as the increase of concentration of them is enough to cause toxic effect. For example Boron increase is not considered as specific effect because it affects plant growth if its concentration is elevated as 1 ppm of land extraction. Also, Sodium ions increase causes dangerous effects on the plant.

In a research by Lauchli and Grattan, 2007, provides a brief overview of how growth and development of plant is affected by salinity, Osmotic is the first phase of growth reduction, and it causes the same effect of water pressure and shows little genotypic differences. Other effect is the toxicity of salt in leaves.

Plant cells affected by saline condition show cell dehydration and shrinkage, but cells regain their original volume hours later after salinity pressure. (Lauchli and Grattan, 2007). They also found that root, and shoot growth is inhibited by salinity. Reproduction development is considered less sensitive to salt stress than vegetative growth.

Salinity changes the concentration of some nutrients such as Cu and Zn in soil due to the increase in solubility of micronutrients under saline conditions. (Shiyab, 2011).

Ibrahim in a study about salt stress, 2011, found that there are two effects on plant to the accumulation of salt on soil, which are: 1).salinity and 2). Alkali, when salinity reaches concentration that represents a pressure equal to osmotic pressure, which is 4 Bar. This means that the plant will enter the phase of wilting forever (permanent wilting), which reduces the growth of the plant, which is known to be tolerant to salinity, such as, trefoil, cotton, date palm.

2.4.1. Effects of salinity on plants parameter

Pepper is found to be very susceptible to water pressure at blossom stage being the most sensitive period. (Smittle, et al, 1994).

Reduction of pepper growth as a result of salinity is attributed to ion toxicity associated with increasing Na uptake. (Shiyab, 2011).

Vegetable response to salinity appears in increasing growth. (Maksimovia, and llin, 2012)

It was found that salts decrease the different parameter of growth. However it affects stem (shoot), more than roots' growth. It was also found that salinity is a major environmental issue which adversely affects plant growth and metabolism, by inducing osmotic stress, specific ion toxicity, ion imbalance and oxidative stress. Shoots length and leaf area decreased by salinity, also have a significant effect on reducing root length wet and dry weight. (Houimli, et al, 2008). Chartzoulakis, Kalpaki, 2000, found that when using pepper hybrids, total fruit yield decreases significantly with increasing salinity above 10mM in both hybrids. They also found that, those plants' growth parameters were reduced significantly at saline condition higher than 2.5millimose of NaCl. For two hybrids of bell pepper. They found that Na ions concentrated in roots more than in other parts of the plant. The number of fruits per plant and their weight was reduced by increasing salinity.

Plants that grow in saline conditions are small in size, have fewer and smaller leaves, increased root/shoot ratio and smaller fruits. (Amarcher,et al, 2000), (Jan Kutuby,et al, 2000).

Shoot growth is reduced by v50mg/L NaCl, and concentration of NaCl affected by Ca and K ions. Also annual and accumulated yied, fruit size and vegetative growth ratio were affected by salts, and it was found that

salt pressure induces significant reduction in plant growth and leaf number and weight. (Lolaei,et al, 2012).

Salinity causes membrane destabilization. (Hasegawa Stefania De Pascale, et al, 2003), Pepper was found to be very sensitive to drought stress and moderately sensitive to salt stress.(Roades, et al, 1992).

It was found that the number of fruits per plant is not affected by salinity increase. Instead, the average fruits weight is significantly affected. (Pascale, et al, 2003), (K. Charzoulakis, G. Kalpaki, 2000), (Kurunc, et al, 2011).

High salinity clearly reduced crude proteins in shoots and also in roots. (Shiyab, 2011).

2.5. Trace metals in environment

Metals can naturally be present in the soil, but the development of industrial activity such as metallurgical and chemical industry, and farming such as pesticides and fertilizers, cause many of the metals to become environmental pollutant in recent years. Even with low concentrations they represent a serious public health matter due to their toxicity and bio-accumulative nature.(Baba-Ahmed and Bouhadjera, 2013), (Koldabadi, et al, 2012), Some trace metals are represent in freshwater and as marine pollutants. Their toxicity affects marine organisms such as algae. (Sbihi, et al,2014).

Irrigation and mining could be responsible for the accumulation of heavy metals in vegetables. (Nenman, et al, 2012). The new USEPA regulations

of the sewage sludge allow concentration of particular toxic metals to increase locally on agricultural lands. (McBride, 1995).

Human activities worldwide are affected the biogeochemical cycling of heavy metals, causing the high increase in flux of bio chemical forms available to the atmosphere. (Yildiz, et al 2010).

A study by George et al, 2012, found that trace metals entrance and bioaccumulation from soil into food chain lead to environmental pollution problem. They also found that the total concentration of some trace metals in soil was significantly greater than concentration of metal ions available in plants.

Cataldo, and Wildung, 1978, found that the most affecting factors that increase metal availability to plants in soils are the solubility of metal associated with solid phase, which are reflected in roots up take, that soluble types must exist adjacent to the root membrane for a limited period. Rate of release and form of these soluble types will have the strong effects and influences on the rate and extent of uptake and perhaps mobility and toxicity in plant and consuming animals.

A study of Trace Metal in soil and availability to plant from a long- term bio solids in amended soil, by Beshr and Sukariyah, 2003, found that a large percentage of Cu and Zn is still found in the topsoil, where as bio solids were incorporated.

Increasing Zn, Cu, and Cd, inhibit plant metabolism, leading to various effects depending on the metal applied, the type of the affected plant and environmental condition during the stress. Threshold concentration levels

to toxicity highly depened on type of plant under investigation that causes the plant express different detoxification mechanisms. The order of toxicity generally seems to be as Cu>Cd>Zn. The elevation of these elements in environment causes toxicity, which depend on bioavailability of heavy metals and on free ions' concentrations. Roots defend against metal induced damage by producing peroxides. (Kupper, and Kroneck, 2005)

2.5.1. Copper, Cadmium, Chromium, and Zinc in environment

1. Copper (Cu)

Copper is an important trace element in human's body, but the problem occurring when its concentration becomes high in the body. It is important for bones and connective tissue, energy production in cells, immune response, the glandular system, particularly the thyroid and adrenal glands, reproduction system and nervous system. (Lawrence Wilson, 2014).

Copper is one of the transition elements, a group characterized by the possession of a partly filled set of *d*-orbital's. Today, the main use of Copper is in the form of its various alloys, many of which are of great importance in the electrical industry. (Lepp, 1981).

The recommended limits for Cu constituents in irrigation water, for long term use: 0.2 mg/L, and for short term use 5.0 mg/L. (AgriLife communications)

Cu deficiency symptoms are usually chlorosis, and can be explained in view of the normal function of Cu in plant tissue metabolism. That lack of Cu proteins Plastocyanin and superoxide dismutase will cause malfunction

of photosynthesis and thus lead to oxidative stress, because of this iron assimilation pathway. Cu deficiency stress increases the effects of iron deficiency stress, and in combination with higher iron concentration seems not to induce iron deficiency stress. This indicates the existence of Cu-independent iron uptake pathway in plant. (Kupper, and Kroneck, 2005).

2. Cadmium (Cd)

It is known as a highly toxic metal that represents a major hazard to the environment.(Kupper, and Kroneck, 2005).

Cd as mentioned by (WHO, 2010), can be released to environment in number of ways:

- Natural activities like volcanos.
- Human activities such as tobacco smoking, mining, smelting and refining of nonferrous metals…etc
- Remobilization of historic sources of like contamination of water courses by drainage water from metal mines.

Cd releases can be carried to the disposed areas moving from source of emission by means of long-range atmospheric transport. WHO, 2010. It has also been found that the Zinc impurities in galvanized pipes increase Cd levels in drinking water.

3. Chromium (Cr)

Chromium is steel-grey, lustrous and hard and is used on a large scale in the metallurgical and chemical industries **(**corrosion-doctors).

Naturally occurring chromium is usually present as trivalent Cr (III). Hexavalent Cr (VI) in the environment is almost totally caused by human activities. It can be leach from topsoil and rocks which are the most important natural source of chromium which inters bodies of water. Solid wastes from chromate-processing facilities, when disposed improperly in landfills, can be another source of contamination for groundwater, where the chromium residence time might be several years. (Sen, 2008)

Chromium is rarely found as a free metal in nature. A clean surface of Cr metal reacts strongly with the atmospheric oxygen. (James Jacobs, 2004).

Chromium waste slag containing potentially hazardous levels of Cr (VI) compounds was used as fill material at more than 160 residential, industrial, and recreational sites. People living or working in the vicinity of the sites may have been exposed through inhalation, ingestion, or skin contact with contaminated soils and dusts (Sen, 2008).

The recommended limits for Cr constituent in irrigation water, for long term use: 0.1 mg/L, and for short term use 1.0 mg/L. (AgriLife communications).

People living near chromium waste disposal sites or chromium manufacturing and processing plants were more susceptible to chromium exposure than the general population. (EPA).

Breathing high levels of chromium (VI) can cause irritation to the nose, such as runny nose, nosebleeds, and ulcers and holes in the nasal septum. Ingesting large amounts of chromium (VI) can cause stomach upsets and

ulcers, convulsions, kidney and liver damage, and even death. (corrosion-doctors website).

Chromium mainly affects the respiratory tract following inhalation exposure in human. A high amount of inhalation exposure can cause gastrointestinal and neurological effects. Dermal exposure also accrues and causes skin burns in human. (EPA).

4. Zinc (Zn)

Zn does not like alkaline soils. Salinity may decrease Zn uptake due to the competition with salt cations on root surface. Salinity which may also reduce Zn uptake, increases Cd uptake and this also decreases Zn accumulation by what is known as antagonistic relationship between Zn and Cd.(Dar, et al, 2011).

The recommended limits for Zn constituent in irrigation water, for long term use: 2.0 mg/L, and for short term use 10.0 mg/L. (AgriLife communications)

Zn levels were very low in the past caused by a deficiency economically problem for important crops, but as the human activity increased, Zn increased to a toxic level in the environment. (J.C. Collins, 1981).

There is differences between individual plant species and even among cultures of the same species in their tolerance to Zn nutrition. Mechanisms of Zn efficiency are not well understood. (Kupper and Kroneck, 2005).

2.5.2. Copper Cadmium Chromium and Zinc Accumulation and Effects on Plant

There is a great concern about the effects of trace metals on crop production, food chain, and ecosystems in the complex industrial energy oriented society. (Wallace A., 1980)

Uptake of trace metals affected by many factors such as soil characteristics, such as; salinity, PH values, type of soil, fertilization practices, and organic matter content. For example Cd bioavailability in soil is affected by those factors. Salinity enhances Cd uptake of many crops.(Dar, et al, 2011)

It was found that in a phytoplankton species belonging to diatoms, (*Thalassiosira Weissflogii*), that addition of Cd to Zn- limited culture enhances growth leads to the expression of a carboanyhydrase with properties different from the normal enzyme of Zn-replete culture. It was also found that in most terrestrial plants, the mobility of Cu is rather low, and that the highest concentration of the metal is found in roots and some of Cu entering stems is recycled to roots via phloem, so roots can be target for Cu induced damage. Such as disturbing iron uptake, roots defense against metal induced damage by producing peroxides. (Kupper, and Kroneck, 2005)

2.5.2.1. Copper

Copper is needed in many proteins and enzymes, such as plastocyanin type-1 (blue) copper protein, superoxide, multi-copper oxides, and cytochrome oxides. Cu uptake and its effects in inside plants and

cyanobacteria is still only partially understood. Long range transport in xylem may be mediated by Cu complex ligands, such as like nicotianamine and histidine. Both coordinate Cu with high affecting and were found in xylem sap of tomato in sufficient concentration to bind all Cu.(Kupper, and Kroneck, 2005).

2.5.2.2. Cadmium

Cd found in water or soil can be taken up by certain crops and accumulate in food chain. Cd exposure via drinking water is relatively unimportant compared with that from diet. (WHO, 2010).

The absorption of cadmium (Cd) by plants has not been extensively studied until recently. Essentially, all the data regarding Cd concentrations in plant tissue accumulated during the past decade. Acute toxicity of Cd caused by food is rare, chronic exposure to high Cd levels in food could significantly increase the accumulation of Cd in certain body organs. The World Health Organization (WHO, 1972) has proposed a maximum tolerable intake not to exceed 400–500 μg. (Page, et al 1981).

The recommended limits for Cd constituent in irrigation water, for long-term use: 0.01 mg/L, and for short-term use 0.05 mg/L. (AgriLife communications).

The uptake of Cd into the plant seems to occur via various channels for the transport of other divalent cations, in particular Zn, channel that took Cd but not Zn was detected. (Kupper, and Kroneck, 2005).

2.5.2.3. Chromium

Toxic effects of chromium on plants growth and development including inhibition of germination process, decrease in growth and biomass of plant are known. Chromium's concentration increase causes an increase in the plant tissues, but high concentrations exposure of chromium weaken in some the physiological processes and ultimately reduces the growth of plants and lead to toxic symptoms. (Nematshahi, et al 2012).

Since plants do not have a specific transport system for Cr, it is taken up by carriers of essential ions such as sulfate or iron. Toxicity of Cr on plant growth and development includes alterations in the germination process as well as in the growth of roots, stems and leaves, which affect total dry matter production and yield. Cr also causes harmful effects on plant physiological processes such as photosynthesis, water relations and mineral nutrition. (Shanker, et al 2005).

High concentrations of chromium cause severe chlorosis, necrosis and other growth abnormalities and anatomical disorders. (Samantaray, et al 1998).

2.5.2.4. Zinc

Zn has been known for a long time to be a trace element that is essential for the growth of plant, it was first discovered to be essential in the fungus *Aspergillus niger*. Zn is indispensable to all forms of life and required as an essential constituent of numerous proteins and enzymes, and can bind many proteins in different binding sites, catalytic, co-catalytic and structural and more recently a new type of site at protein interfaces has

become apparent. Zn proteins can be counted to be four proteins, which are charbonic anhydrase, Cu-Zn superoxide dismutase oxygenic photosynthesis, and phosphatases, uptake of Zn is mediated by large number of transporters involving many proteins, most common family were ZIP, some of which seem to be expressed in roots, and also found in shoots, (Kupper, and Kroneck, 2005).

2.6. Hydroponic system

Due to their advantages, hydroponics and soilless cultures, expanding throughout the world, raising a great interest in the commercial as well as scientific community. (Papadopoulos, et al 2008).

An ancient technique that dates back to approximately 2600 years, proves that Egypt and China applied hydroponic system. The term "hydro" in Greek which means water, "ponos" means work, meaning working with water, which means together hydroponic system. It was Dr. Gericke W. F, of the University of California who came up with this term in 1936. (Munoz, 2010).

Hydroponic system gains many advantages, but also some disadvantages. The advantages of this system are; crop can grow where soil is unsuitable, it reduces plant disease, represents more control for irrigation, and bigger yield is obtained of the cultivated plant. The disadvantages are; the initial costs are high, deep knowledge is needed, that if introduced disease can easily spread, and needs more attention. (Howard, 2013).

Many factors affect food security in Palestine, which include drought condition due to climate changes, scarcity of water resources, low

productivity, limited open spaces, urban area growth causes limited agricultural lands, where population increases rapidly and demands on food increase proportionately. Unemployment and poverty rates also increase, so does the number of families who demand more food. All of these challenges have created a need to innovate and introduce a new food production system that is feasible environmentally sound and easily manageable. One that optimizes the utilization of rare natural resources in an effective and sustainable approach. This can be achieved by using hydroponic system, which is applied in Jerusalem, (ARIJ); Applied Research Institute Jerusalem. (Hrimat N. and Doudin M., 2012)

2.6.1. Hydroponics in Palestine

With our situation of water scarcity, hydroponics become one of the solutions and has been used successfully with many crops such as cucumber, tomatoes, eggplant and peppers. (Palestinian Ministry of Agriculture, 2014).

Polish Center for International Aid with Applied Research Institute in Jerusalem found that from their experience that this system provides space, needs lower amount of irrigation water and lower manpower constitute an economic support to farmers. (Ferenc, 2013).

Hydroponics has many advantages such as; it requires small space, could operate with any size of flow, reduce or eliminate soil born weeds, parasites and diseases efficiently, and doesn’t require special drainage system, and grows almost any plant and in various spaces as available around the house. The system has also many proved many advantages over

soil gardening, that growth rate within this system reaching 30-50 percent faster than a soil plant which grows under the same conditions. (Haddad, et al 2008).

2.7. Summary

All researches were conducted for application worldwide, but there are few studies about pepper crop under hydroponic system in Palestine. And our country suffers from limited water research for many reasons, such as political situation, low water resource management. In Palestine, there are no skilled farmers, and the low management in the agricultural sector all lead to use water of low quality, such as saline (seawater), an example of this is Gaza strip which suffers from leaching of sea water to ground water aquifers, or use waste water (untreated), which could contain many harmful materials, such as trace element that can adversely affect crops, and inter crops, when accumulate in its tissues and consequently transferred to animals and human beings, causing many health problems.

Chapter 3

3. Methodology

3.1. Materials and Methods

This study is conducted to evaluate the effect of salinity and trace element uptake on the growth and yield of bell pepper in hydroponic system.

4 rows of containers were used. The first concentrated of salinity number one, the second for concentration of salinity number two, the third one is for concentration of salinity number three, the fourth was for trace elements, and one container used as blank, which is irrigated by normal tap water. Each container was planted with 5 plants.

The design type of sampling was Completely Randomized Design.

The irrigation system was as follows; the first container was irrigated with water (tap, salinity 1, 2, or 3, and trace element), then the percolated water was collected and used to irrigate the next container in the same row. The researcher used the system of vertical irrigation by holding one container above the other. Every week, the length, the number of leaves, and the fruits (buds) were investigated.

The system used was a manual one, so the percolated water collected in the below the container and then was moved to the next couple of containers in the same row.

The following diagram shows the order of containers.

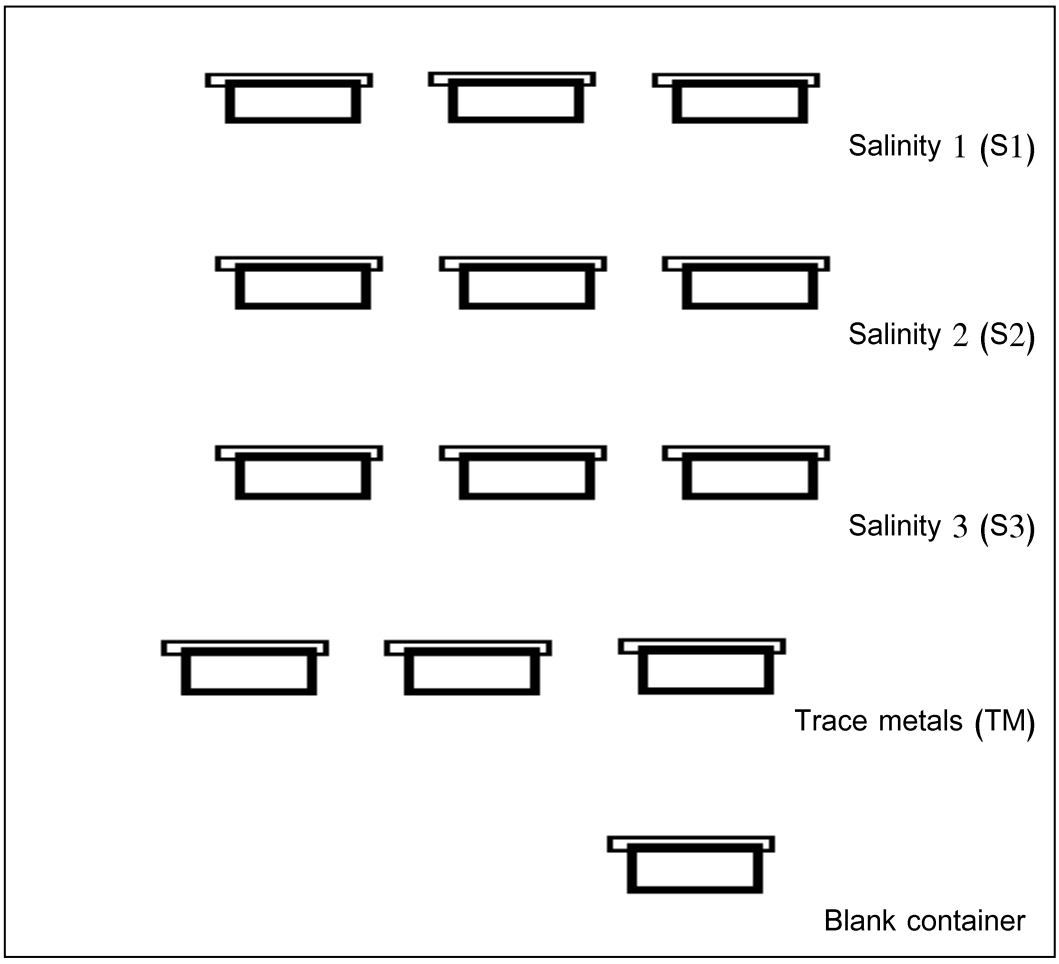


Figure (3.1): Arrangement of containers with different treatments.

Figure (3.2): The arrangement of containers in rows for different treatment solution of salinity and trace metals as diagramed previously.

The solution was added once every week. The other days of the week included irrigation from percolated water, but after that an adequate

amount of water was added to irrigate all containers with circulation of water that was percolated during the week.

A sample of collected water was taken from each container; PH and EC were investigated after each addition of solutions.

Samples were taken after addition and moving of water as represented below.

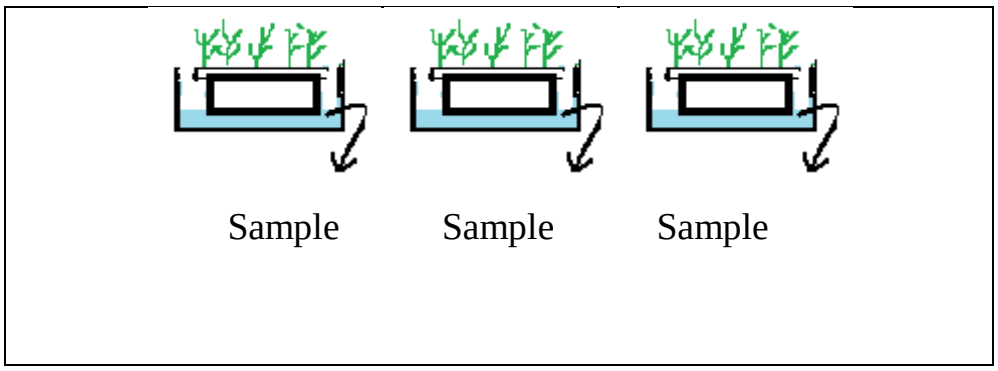


Figure (3.3): Collection of percolated water in the lower container for EC and PH tests.

The same procedure was used for other rows. (The sample of the final container of each row was taken before throwing out the collected water).

During the rest of the week, adequate irrigation for all containers was applied till the second addition in the next week.

3.2. Experimental set-up

3.2.1. Study area

The experiment was implemented in roof home-made garden in Jammaein village-south of Nablus city. Where climate is characterized of being moderate within the Mediterranean Sea region at latitude 32.13, where dry summer season extends for more than five months, and cool, rainy and

short winters, does not exceed three months at most. (Ministry of agriculture, 2014)

Figure (3.4): The roof home-made garden in Jammaein village

Growing period in the experiment was about two months (after planting to harvest), from the end of May, to the end of July.

3.2.2. Seedling

One type of plant-bell pepper, was used in the experiment. The plant has been as a transplant with about 5-6cm tall of stem and about 5-7 leaves. *Capsicum annum* type of bell pepper was used.

Figure (3.5): The transplants used in the experiment.

5 plants in each container were planted and arranged as: one near each corner, and one in the middle of the container. Some of the containers at the end of the growth lost some plants that will be shown in the results' section.

3.2.3. Containers

About 26 containers were used as couples, that each one was held over another for water collection, and arranged in 5 rows. Each consisted of 3 couples in the first, second, third, and the fourth. The fifth contained only one couple used as blank.

Each container was 53cm in length, 40cm in width, and 21cm in depth.

The container was perforated in 5 places to allow water flow (perforation) that was collected in the bottom container pores made by hot metallic wire.

Figure (3.6): perforation positions of containers used for planting.

3.2.4. Media

1. The containers were filled by gravels (large size), in order not to go through the pores.

Figure (3.7): Filling container with the first layer of large gravels.

2. A special planting media (Peat moss) about 10 cm, which did not contain soil, was used. This layer was used to allow roots attach the medium of planting because planting was on water that has no medium for root to attach with.

Figure (3.8): Filling container with the second layer of Peat moss.

3. Some sand was added and then small size gravels were used of about 5 cm layer for the final layer of planting medium.

Figure (3.9): Planting seedlings in the prepared media, five plants in each container.

3.2.5. Irrigation process and collection of water

Every day plants in each container were irrigated with about 3-4 liters of water that was experimentally found to be percolating, and about 1-2 liters, were used to irrigate the next container. The water was collected each time daily.

In the first week the plant was given some nutrients by adding fertilizers to the media. Because no soil was used, organic nutrients were not available, which would affect the growth of the plant.

The plant was irrigated with water alone for about 6-weeks; in each week the growth parameters were taken each week. (Stem length, number of leaves, fruits or buds appearance and number).

Water collected in the bottom container every day was moved manually and was used to irrigate the next container and so on.

Figure (3.10): Containers held to allow water to percolate and collected in the lower container.

3.3. Experimental program

3.3.1. Salinity experiment

3.3.1.1. Salinity levels

In the fifth week, water with different salt (NaCl) concentration was used for irrigation to rows1, 2, and 3 with salinity S1, S2, and S3 respectively. Solutions were S1, with 1000mg/L concentration, S2, with 3003mg/L, and 7000mg/L for S3.

Solutions were prepared as follows: 1000mg/L means 1g/L then for 3L, 3g of NaCl salt needed, for 3000mg/L 9g of salt needed, and 21g for 7000mg/L.

3.3.1.2. Irrigation watering

It was experimentally found that the amount of water needed to be added to the plant that percolate enough amount of water to be used it in irrigation of other containers in the same row was 3L, every day.

As mentioned previously, the plant was irrigated with water every day, adding 3L of water to each container.

3.3.2. Trace element experiment

3.3.2.1. Trace element Experimental description and solution preparation

For TM, solutions were prepared using the following equation:

$M1V1=M2V2$

Where;

M1: the concentration of trace element wanted to be prepared which was 0.2mg/L.

M2: the concentration of trace element in the bottles, which was 1000mg/L for Cd, Cu, and Cr, and 4800mg/L for Zn.

V1: the volume needed to be used to dissolve TM in.

V2: the volume wanted to be calculated which represents the volume that must be taken from TM solution.

So, the volumes were 600µl of Cd, Cu, and Cr, and 125µl of Zn.

After addition of the solution , growth parameters also were observed and collected in tables.

3.4. Data management

Data collected was arranged in tables for stem height, number of leaves, and number of fruits.

Other tables were used to show the plants' wet and dry weight, EC reading for each sample.

There are also tables for water that was collected from irrigation water after each solution of salinity and trace element addition.

Diagrams for those tables also show the relationship between growth and salinity and trace element concentrations.

Figures of plant growth and the effect of saline and trace metals on growth were used.

Statistical analysis of data was used to study the effect on growth and yield of the plant, comparing among data by One Way ANOVA , means, Standard Deviation (SD), and mean separation LSD test.

3.5. Laboratory analysis

The plant was weighed, as fresh firstly (wet weight), then 10g of each part was taken and dried in an oven over 150°C. (samples for less than 10g weight were all taken).

After drying, samples of about half of dried weight were taken for salinity experiment and burned on fernis over 550°C.

Electrical conductivity of the collected water was measured by using electrical conductivity instrument, and the PH value for each sample was measured using PH meter.

3.5.1. Sampling and testing

3.5.1.1. Irrigation water collection

Every time we added solutions, samples from percolated water in each container were taken as shown previously in figure (3.9).

Water samples were taken from irrigation water frequently to evaluate the dissolved salts in irrigation water, and trace metals concentrations considered as ppm(mg/l of water), (Ibrahime, 2011). Electrical conductivity electrode meter was used, as mentioned in the measuring procedure by Vernier manual for salinity evaluation.

3.5.1.2. Removal of plant

After about 6 additions of salinity solution, leaves and fruits were being harvested and weighed for each plant in each container, then the stem and roots were moved from the media by adding a lot of water to allow roots to be released out, then they were let to dry, then the root was cut from the stem and each one was weighed the same as with fruits and leaves of each plant. Samples are collected and transferred to the laboratory in special labeled pages to dry them in an oven quickly in order to avoid rot formation.

3.4.1.3. Drying steps

From each sample, a weight of about 10g was taken to be dried for about 2hrs in an oven of about (150°C) using crucibles, and dry weight was then measured for each sample.

For salinity samples, dried ones were burned using a special oven and the heat samples were over 550°C then the ash was taken and diluted in 100 ml of distilled water.

For TM, the sample was held and kept after being dried, but for salinity, 0.5g of dried samples was taken, and then smaller than 0.5g were all taken.

3.4.3. Measuring methodology

Electrical conductivity instruments were used, using EC electrode, as standard methods, and (Agricultural Solution, 2014).

Before the plant removal, water was collected from the containers after solution addition was taken for PH, and EC measuring.

For the removed plant, salinity was tested by using EC (Electrical Conductivity) instrument, 100ml of D.W (distilled water) was used as a solvent, and then EC values of samples were recorded.

To measure the electrical conductivity of the total dry weight of the plant, the following equation was used:

EC= EC reading of (0.5g of dry weight) x dilution factor, where dilution factor = 100/0.5,

Where 100: volume of distilled water used for dilution of burned sample

And 0.5: dry weight taken from the dry sample.

For containers of trace metals, the samples of leaves, stems, fruits, and roots were mixed; then from each container 4 samples were collected and weighed.

For stem and roots 2g of each container dry weight was taken. From each sample about 2g from stems, roots, and about 1g from leaves were taken

then about 0.5 g were taken to be sampled and prepared for ICPMS instrument, Fruits were sampled; each fruit is tackled alone then samples of the same plant were mixed. That summation of taken samples was about 1g, from each TM treatment container.

Blank samples used for TM test were also mixed. From each sample about 1g was taken so weight was taken and then summation was made, and from the summation about 0.5g was taken. But for salinity, each plant was taken alone as in salinity test.

About 5ml of nitric acid was added to about 0.5g of the dried sample.

Nitric acid was used to:

- preserve samples.
- digest samples
- remove organic matter.

They were kept for a long time (about 2-weeks) during which samples' color turned to be white and the solution was turned yellowish, light orange, or brown.

The samples then were held in a water bath on a hot plate with adjusted temperature for about 70°C_80°C, to complete digestion of samples. This method was lasted for 3 days, 6-8 hrs each day, then hydrogen peroxide of a volume of 1ml was added, which helped in removing the organic matter, and nutrient the media of acidic PH. Then a 100ml volume of D.W. was added to each sample of the 16 samples that were available.

The samples to test TM (Cd, Cu, Cr, and Zn) were then inserted to the ICPMS instrument to measure the concentration of TM, according to standard methods.

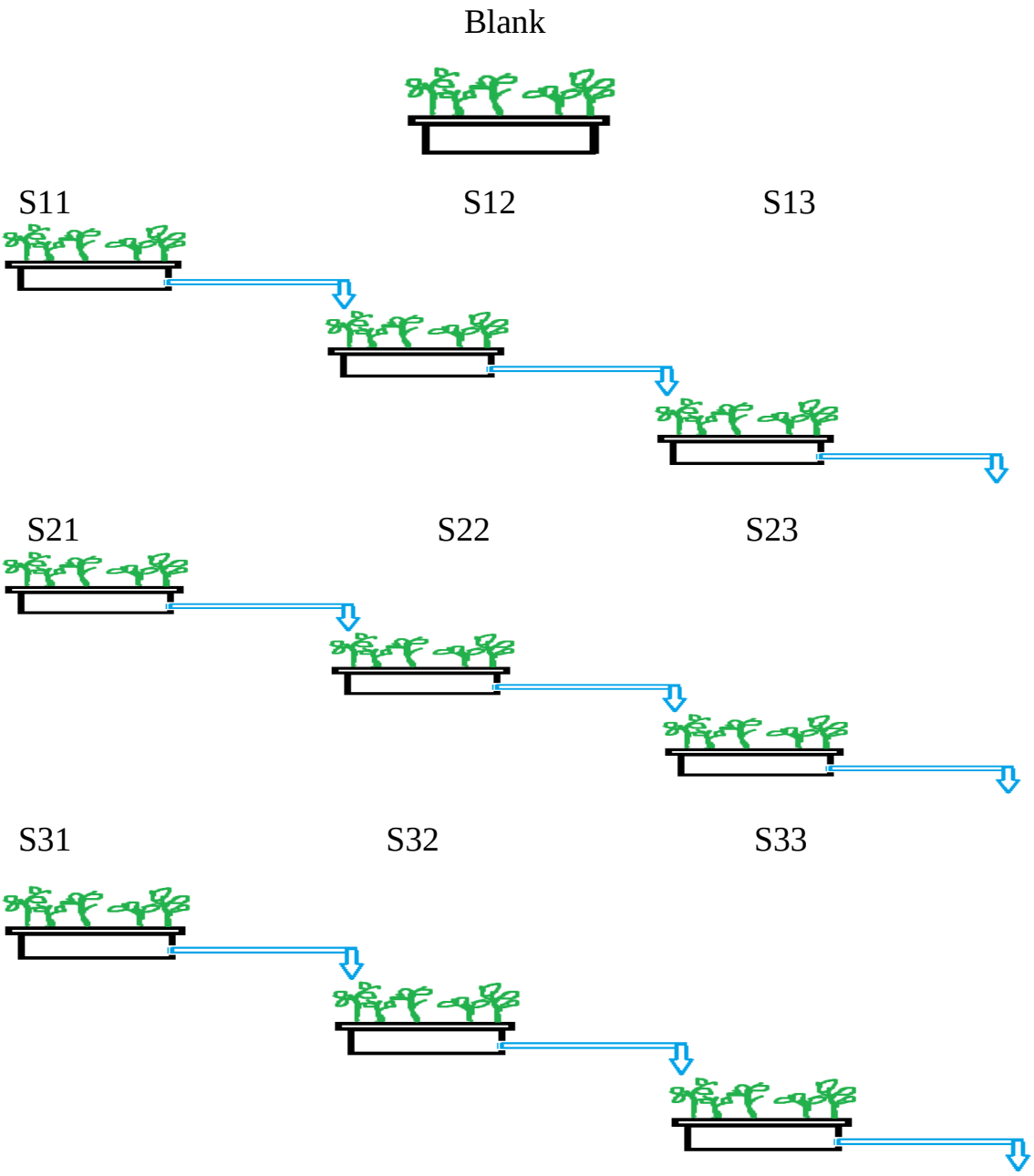


Figure (3.11) Schematic of salinity experiment set up

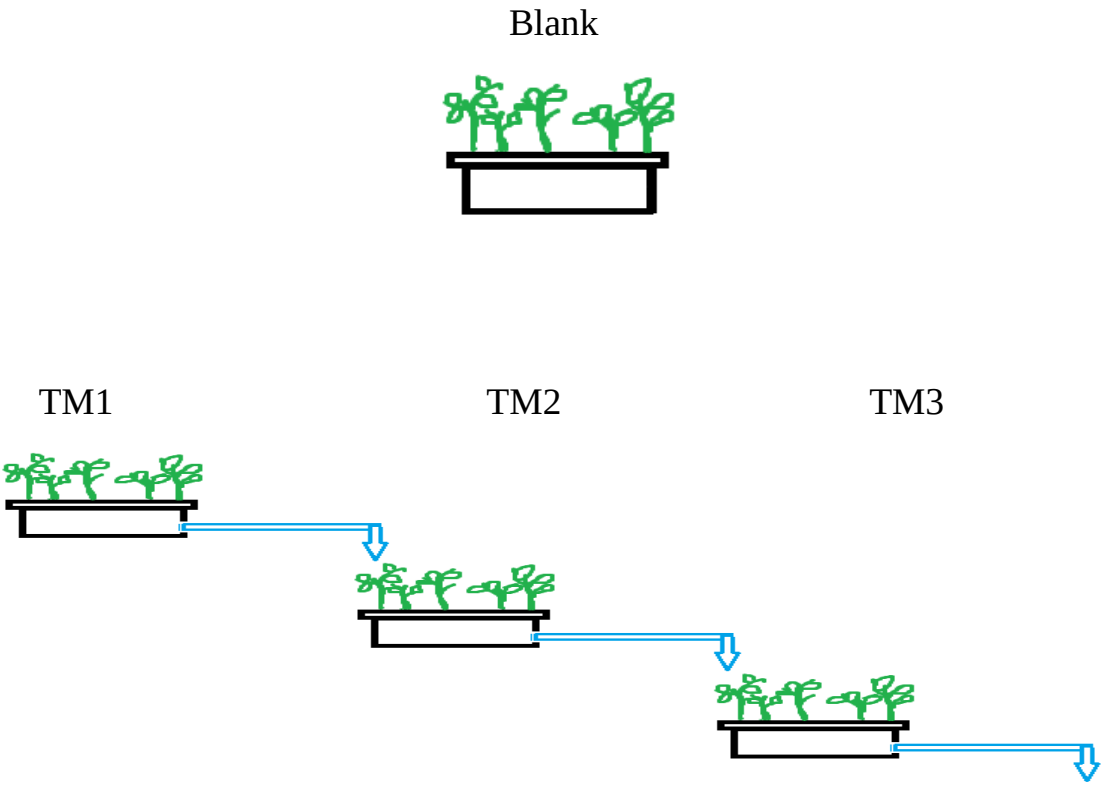


Figure (3.12) Schematic of trace metals experiment set up

Chapter Four

4. Results and discussion

4.1. Salinity experiment

4.1.1. EC values for the collected water from containers

For each time of solution addition, water was collected from containers and EC values were evaluated, the following table represents the results of EC values. Averages of four trails of water collection of samples are arranged in table (4.1).

Blank average for four trials was: (1.300 µs).

Table (4.1): EC values of the collected water after the addition of solution measured by (µs).

	EC values (µs)		
Treatment salinity	**Container 1**	**Container 2**	**Container 3**
Salinity 1	7.203	4.870	3.903
Salinity 2	15.048	13.078	5.960
Salinity 3	19.833	17.625	8.180

It was found that tap water EC values were 0.239 µs which is smaller than the value of blank sample. This is reflecting that water percolated from cultivation media dilute some salts within it elevating the value of EC. In addition to the salinity elevation caused by the addition of fertilizers for media preparation to be ready for cultivation.

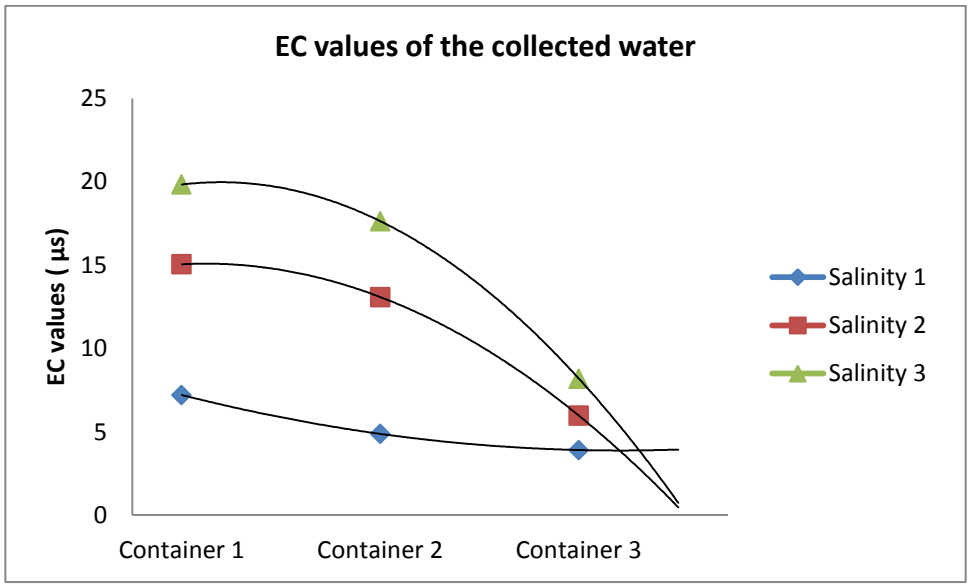


Figure (4. 1): EC values (µs) of the three salinity treatments containers.

The curves show that salinity values which were represented by EC values decrease when moved from one container to another will be reflected in growth and yield for pepper as we will see in the results of each parameter for growth and yield.

4.1.2. Growth parameter evaluation of bell pepper

4.1.2.1. Leaves

Leaves were counted manually, depending on sight. The small leaves surrounding buds were counted as leaves.

4.1.2.1.1. Results of leaves before salinity addition

Linear increase was observed in the number of leaves from the beginning of June and for each container of each treatment of salinity, but the average of leaves count for the first treatment was near the half for that of blank leaves average count. That means that the number of leaves increased slowly for treatment one of salinity(1000 ppm), Note that the containers underwent the same irrigation water before adding solutions of

the experiment of salinity and trace metals; therefore, it must be taken into account when comparing after addition, because there are originally differences in the rates of production of leaves based on the size and age of the seedling, noting that at the beginning of June, all were bearing the same numbers or they are close to each other.

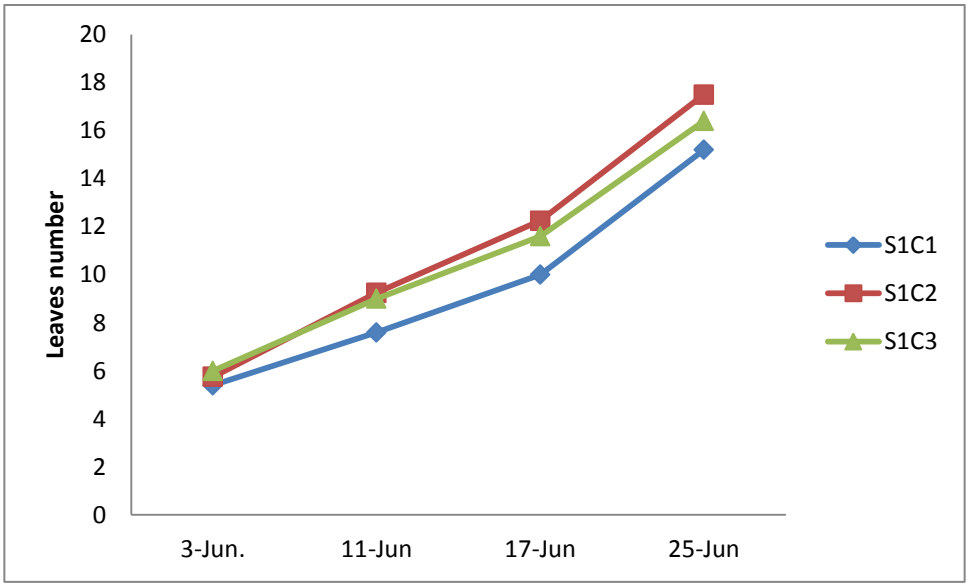


Figure (4.2): Number of leaves for salinity one treatment versus time before addition.

Looking at figure (4.2), we can note that there is a linear increasing in the rates of production of leaves and it is clear that the highest rates of production of leaves were in the second container with 17.5 average of leaves, then the third with 16.4 average of leaves, and at least the first container with 15.2 average of leaves, but the difference was a little by one or two leaves of average.

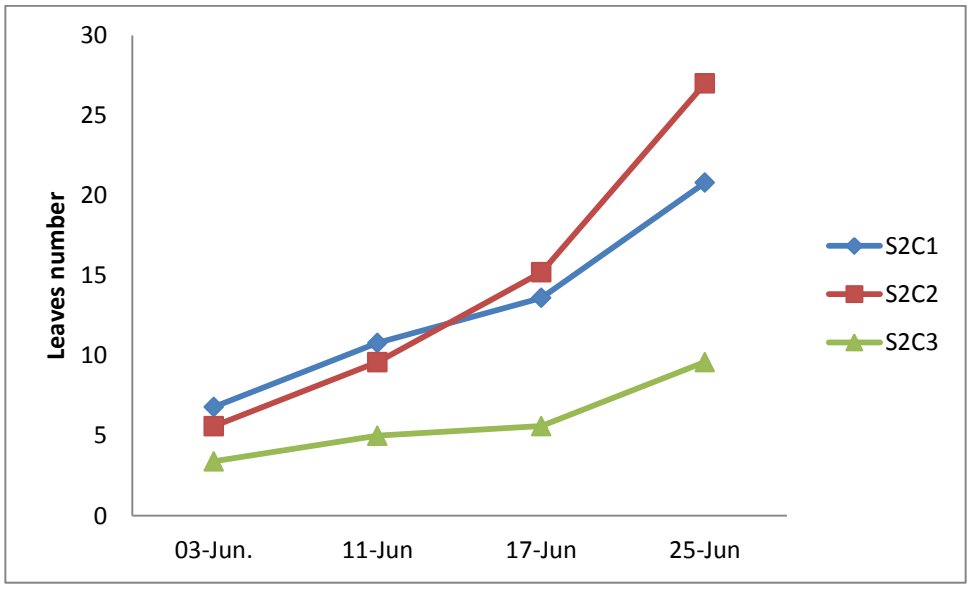


Figure (4.3): Leaves number for salinity two treatment versus time before addition.

It seems that there is an increase in the average number of leaves for the three containers of the second treatment, but increase in the number of leaves in the second container was the highest of all followed the first container, and then the lowest rate of the production of leaves is in the third container. This must be taken into account when comparing it with the average leaves production after the addition of salinity solutions, it is expected that the concentration will be the lowest in the last container of the three treatments, so it must be noted that the average number of leaves was originally lower than the beginning.

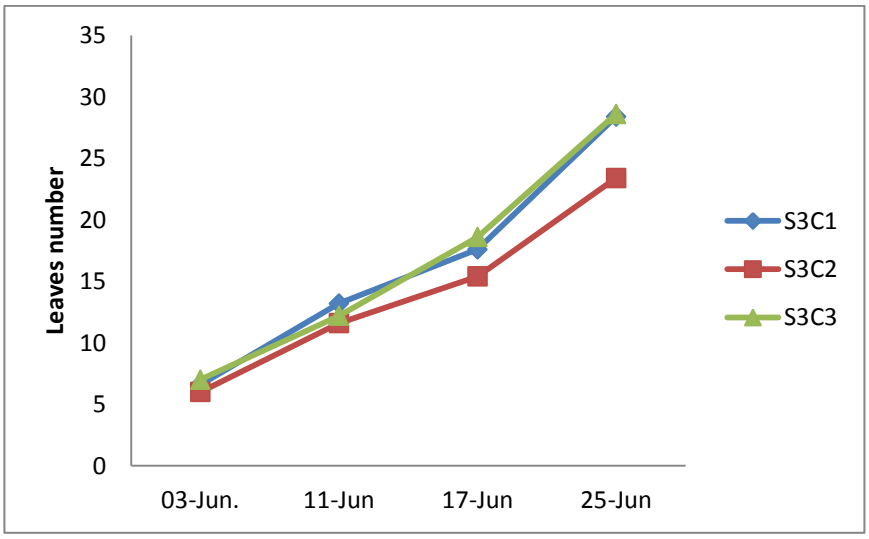


Figure (4. 4): Leaves number for salinity three treatment versus time before addition.

Moving to the third containers of the third treatment before adding salt solutions, it can be noted that the averages of leaves number increased from 3- 25 of June, this is normal and expected, and also they are also close to each other or even equal for the first and third containers, but they appear to be lower in the second one. And have a look at the blank sample it can be seen that the third treatment has the closest rates of averages compared with the other containers as shown in the following figure (4.5).

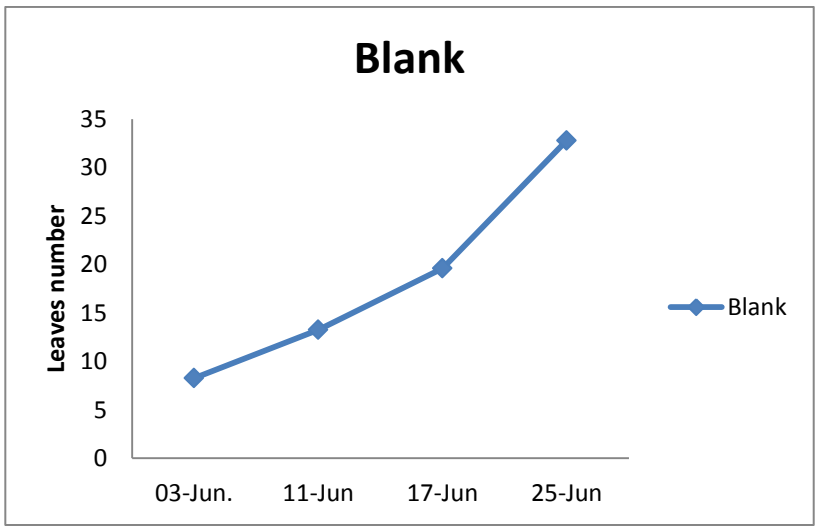


Figure (4.5): Leaves number for blank versus time before addition.

4.1.2.1.2. Results of leaves after salinity solution addition

As mentioned before, counting of peppers' leaves was done manually and depended on senses of sight and touch, so error percentage may be larger here than other parts of pepper parameters such as the stem, and fruits, whose numbers were less than the green cover of leaves, so some differences may have appeared when plants were exposed to the solutions for leaves' results are compared with other parts.

When looking at the blank sample, it noticed that leaves' number increased linearly, and it was significant from beginning of July to the end of the 10th of the same month, then the increase becomes slower as shown in figure (4.6).

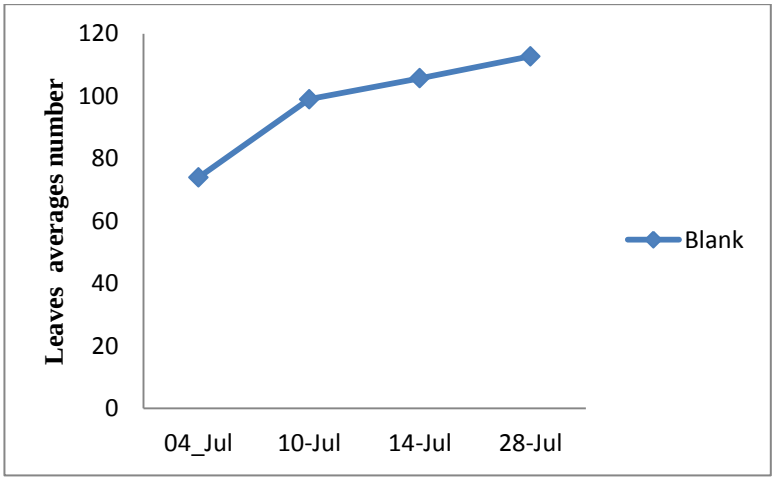


Figure (4. 6): Leaves averages number of blank versus time after addition.

By moving to treatment one containers of salinity 1000 ppm, it can be noticed that there was disorder in the number of leaves after adding the solution. It appears in the first container that the average of leaves' number increased after the addition, from 4-10 July, and these was noticeable

increase by the 14th July. (From 41.25 to 60.33). In the end of month it began to decrease (see table 4.7). Salinity and PH changes due to irrigation, varying some nutrients uptake which may enhance increasing leaves number. (Maksimovic and, Lin, 2012).

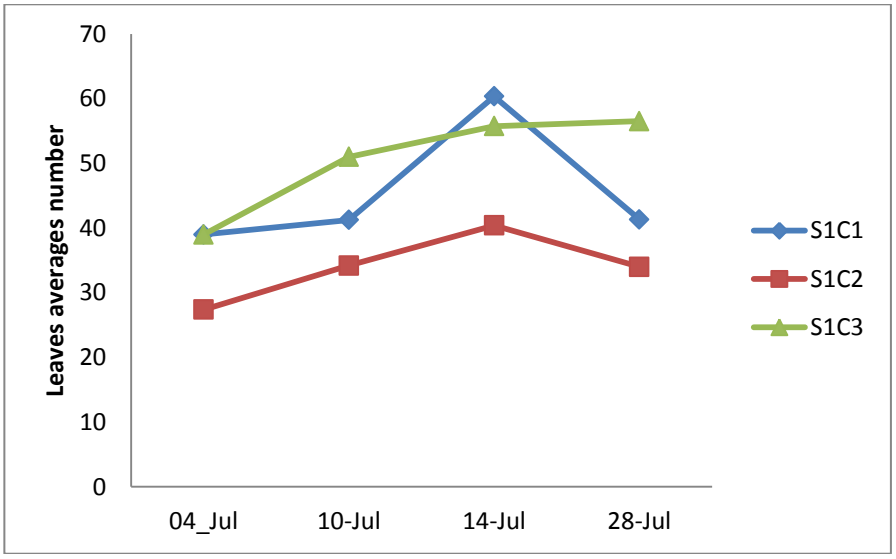


Figure (4.7): Number of leaves for salinity one treatment versus time after addition.

Moving to the second container for the same treatment, it was noted that there was increase in averages of leaves' numbers but the increase rate is different from that of the results before addition (have a look for figures before addition for leaves). The change of number of leaves in the first and second containers was far from each other, but they had the same shape, so they increased even on 14th July. Then the average number of leaves decreased. But the decrease was sharp in container one that was exposed directly to salinity solution of treatment one, while the second container where salinity values were lower, reflected little increasing, then it started to decease but not sharply. This is explained by the fact that the plant was affected at the beginning of solution addition and that the increase in

leaves number was slow, and with the addition of solutions, it seems to have caused accumulation of salts within pepper tissues which led to the decrease of the average of leaves number at 28 of July.

For the third container of treatment one, with concentrations decreasing, there was continues increase in leaves numbers and linearly, and very close to the line that match averages number of leaves in blank container, but with more little leaves, this due to at the beginning averages number of leaves of container three of treatment one were originally lower at the first addition (39 leaves average, while it reached about the double number of leaves average for blank sample, otherwise the increase was similar.

For containers of treatment two, of 3000 ppm, salinity, it was as shown in the following figure that for the first container for which treatment applied directly the average rate of leaves increased till 10 of July.

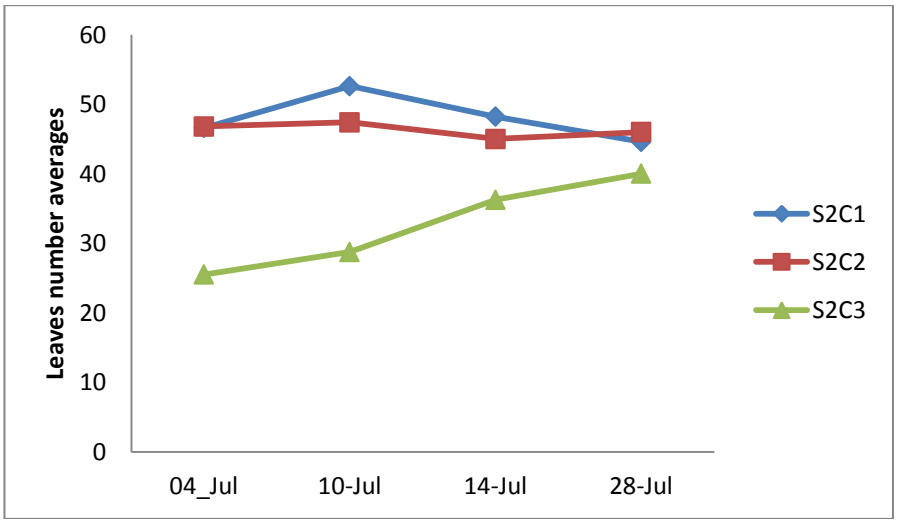


Figure (4. 8): Number of leaves for salinity two treatment versus time after addition

But after repeated addition of solution, salts begin to affect number of leaves which caused decrease in their number averages. Moving to the second container, where salinity decreased, but was still relatively high,

which affected rate number of leaves so some continuity of leaves number from 4-28 of July, but for the third container it was noted that the increase remained steady again, and this reflected that leaves were adversely affected by salinity increasing.

By looking for containers of salinity three treatment, the following figure, represent leaves number averages after salinity three treatment, (7000 ppm).

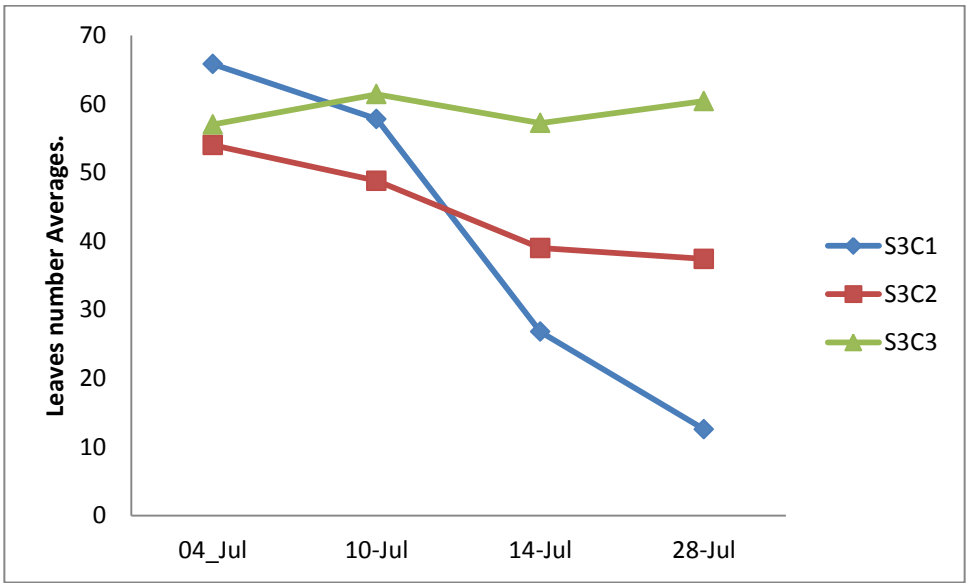


Figure (4. 9): Number of leaves for salinity three treatment versus time after addition.

For these containers, and when comparing them to that of before salinity solution addition, in which the rate of leaves numbers were very close to each other, it was noticed that at the beginning of solution addition the very high concentration of salts (7000 ppm), leaves began to fall down, and that clearly appears in the decrease of leaves number for 4-28 of July for the first container. Then came the second one but with lower decrease. This means that the salinity in still relatively high in the second container (look for EC values of collected water from containers, table (4.1).

Then when the concentration decreased, increase in leaves number, but it is still somewhat turbulent, and it looked like the same increase rate for leaves in the second container of salinity two treatment, with lower values of numbers, but it also took some stability, so the difference between values was very little.

This results conform with to Nufal, 2012, as many symptoms that appear on the plant when it's exposed to saline condition, which appear to be the same symptoms as of dehydration, and they can be summarized by (1). Appearance of dark green on the leaves, (2). Burning of leaves' edges and then dehydration, (3). Shortening of plant stem. And (Lolaei,et al, 2012) who found that salt pressure induce significant reduction in plant growth and leaf number and weight.

Figure (4.10): Loss of leaves and yellowish color of leaves, for container one of salinity three treatment (7000 ppm).

4.1.2.2. Stem

Evaluation of the stem height was taken before and after the addition of salinity solutions, so the results divided into two parts, before and after salinity solution addition.

4.1.2.2.1. Results of stem before salinity solution addition

The results include the containers of the three treatments, beginning with the first treatment containers; the figures and tables, represent the growth of stem from beginning of June until the 25th of the month, so that there were a steady increase in the length of stem, which were expected before the addition of salinity solutions for all treatments containers. However note that in some containers the rate of stem growth was more than others. For example, by looking at the first treatment containers, it can be noted that the growth within the three containers was very close to each other or very near.

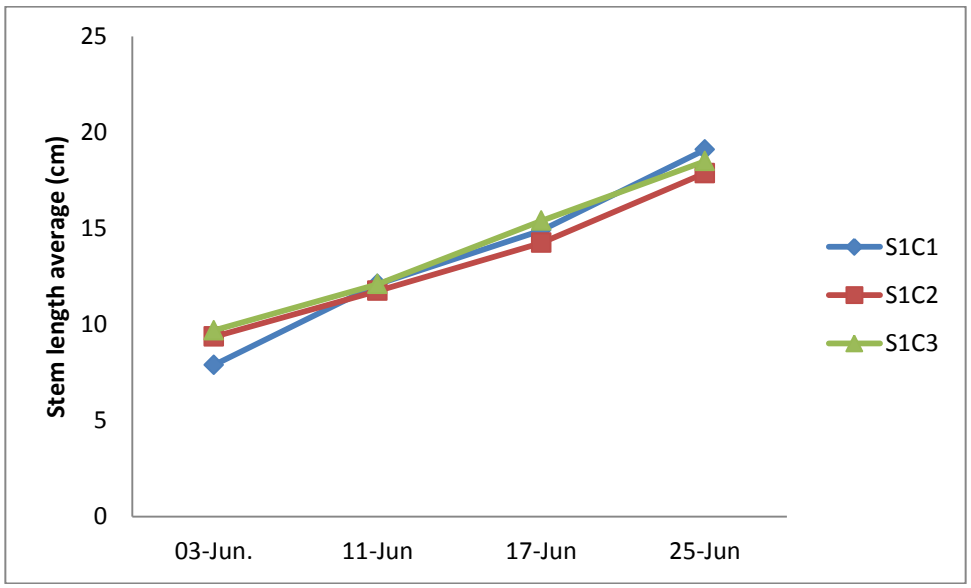


Figure (4. 11): Stem length averages for salinity one treatment, versus time before addition.

Moving to the second treatment containers, the growth in the first and second containers was very similar to each other, or sometime seems to be equaled. But when compared with stem growth in the third container, it seems that the growth was lower. This may mean that the age of seedlings

were not exactly equal, because it has been judged according to the similarity in the height, and the number of small leaves by sight. This must be taken into account when we compare these containers after addition of solutions, so it was expected that the dry weight of stems of those containers, which originally represents lower growth rate, would be lower than those of other stem samples.

And when moving to the third treatment containers, it is noted that the growth rates seem to be very close to each other, especially between the first and third containers, where growth rate for stem appear to be nearly equaled.

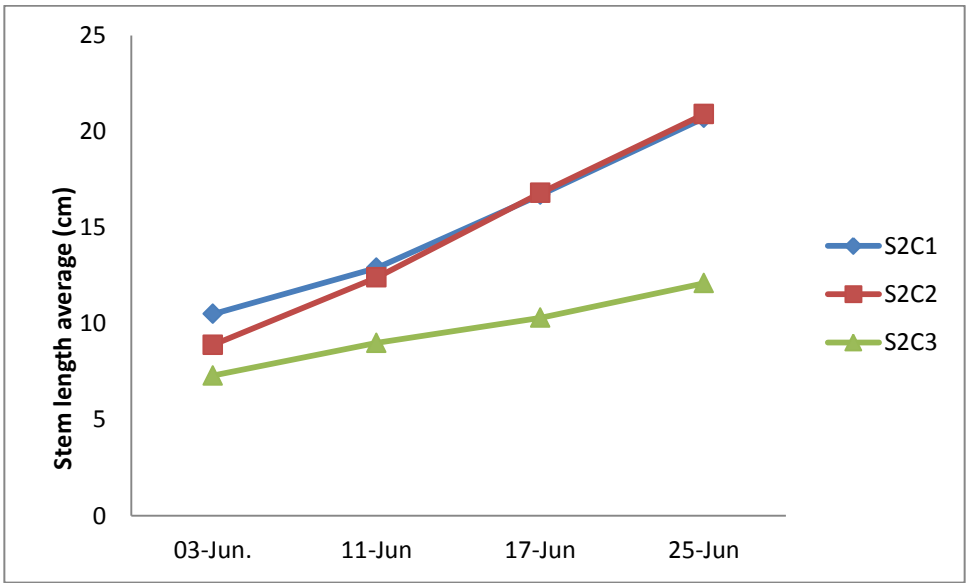


Figure (4. 12): Stem length averages for salinity two treatment, versus time before addition.

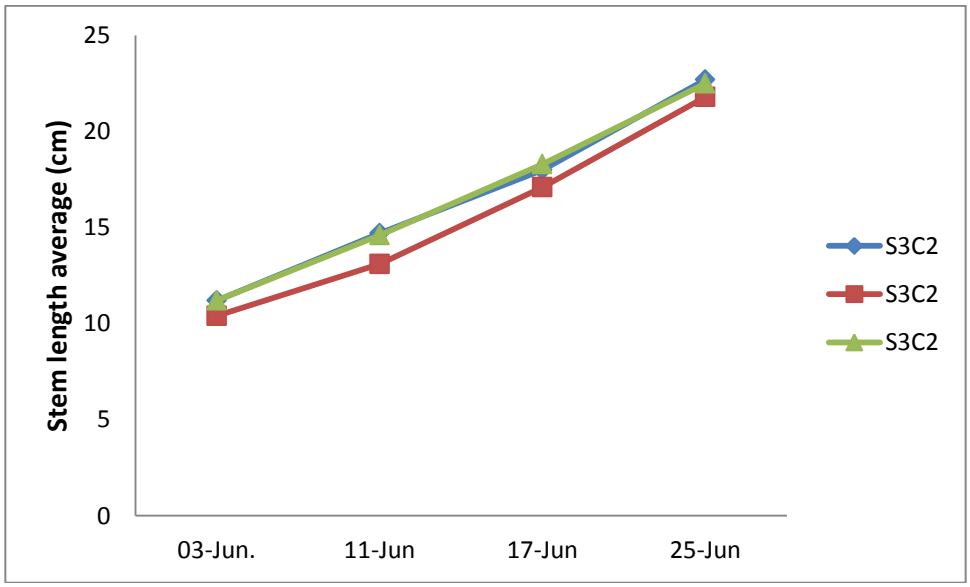


Figure (4.13): Stem length averages for salinity three treatment, versus time before addition.

And comparing growth rate of stem according to blank sample it's found that the growth for seedlings were lower, but very close to that of containers of treatment one, (before adding solution) and with the blank one, and nearly equaled with containers of treatment two; except the third container, which represents the lower growth rate of stems among other containers, and very close to the third treatment containers, which were very near to each other, and to the blank.

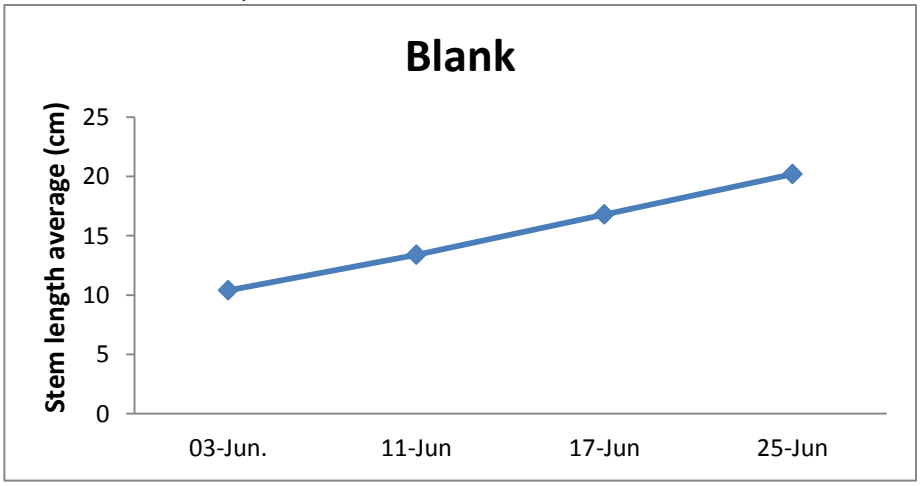


Figure (4.14): Stem length averages for blank, versus time before addition.

4.1.2.2.2. Results of stem after salinity solution addition

Looking to figure (4.15), below it is noted that the beginning of stem growth is affected clearly after solution addition when compared with results of stem growth before salinity addition , it is found that the growth rate was very close to the first treatment containers, but they began to be different from each other after addition, to give averages of height varying from each other. This appears in the first container which was affected directly by salinity one solution, the lower growth rate of the stem, which means that the stem is directly affected by increasing salinity concentrations, then become the second container with little more concentration of salinity, then the third container with higher stem elongation rate, at the end of July which is also the closest one to the rate in blank sample.

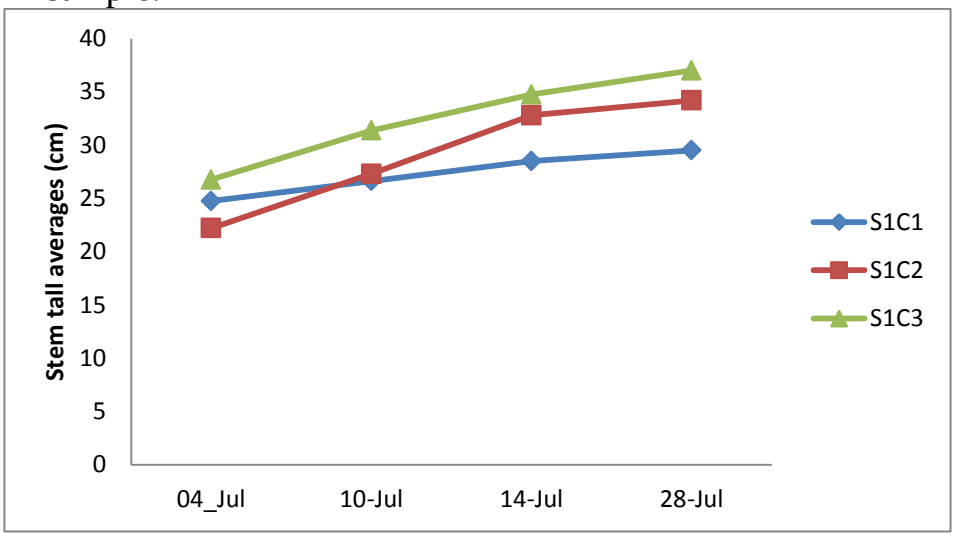


Figure (4.15): Stem length averages for salinity one treatment, versus time after addition.

When comparing results of second treatment before and after solution addition, it is clear that the growth rate was originally close to each other,

and this still appears at the beginning of July when stem height averages' rates became to be more in the middle of July. Then it remained to be stable at the end month for the first container, with higher salinity concentration of this treatment, while stem length being very close to each other and it's increasing was slow in the second container, and being linear in the third container. This means that stem growth was affected clearly by salinity, but with concentrations of values near sea water salts concentration (second treatment), Peppers stem showed some tolerance and adaptation with salinity, and began to grow again. However then the growth stopped and showed some stability, and growth rates began to slow down, but this appears to be impossible for pepper at doubling concentration to be more than sea water salts concentration. The third treatment of 7000 ppm shows very clear effects on peppers' stem length despite the fact that growth rates of stem before adding solution, were very closed to each other.

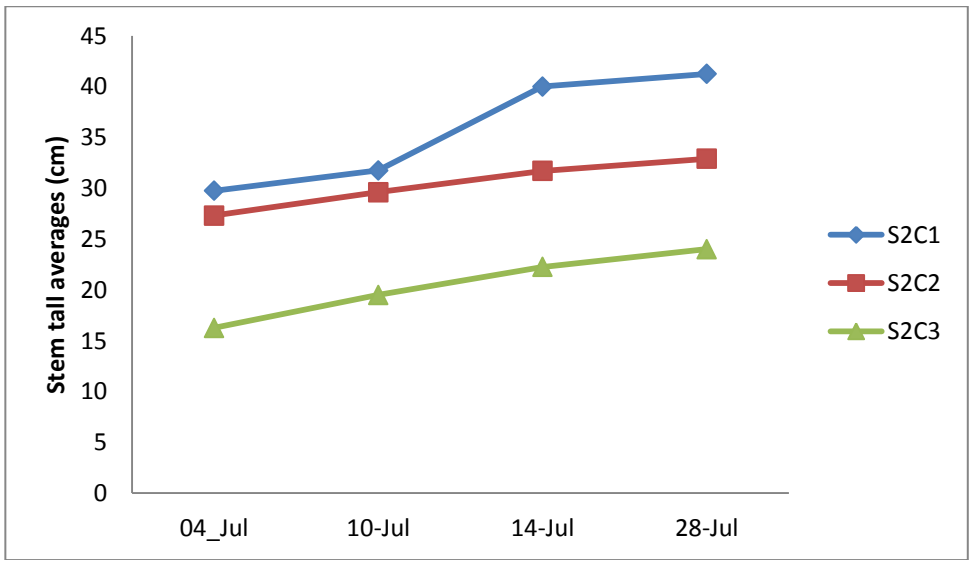


Figure (4.16): Stem length averages for salinity two treatment, versus time after addition.

As third treatment, it appears very clear that the stem growth was affected too much by salinity increase, the growth rate had dropped, to be very closed for the first container, with the highest concentration, and the second container, with little salinity concentration, see table (4.1), while stems length reach their best growth and elongation in the third container with lower salinity values. Shrinkage of cells due to salinity, appeared clearly. In salinity three treatment, and elongation rate became slow which reflects that cells shrink due to osmotic stress. This corresponds with what has been reached, by (Pascale, et al, 2003).

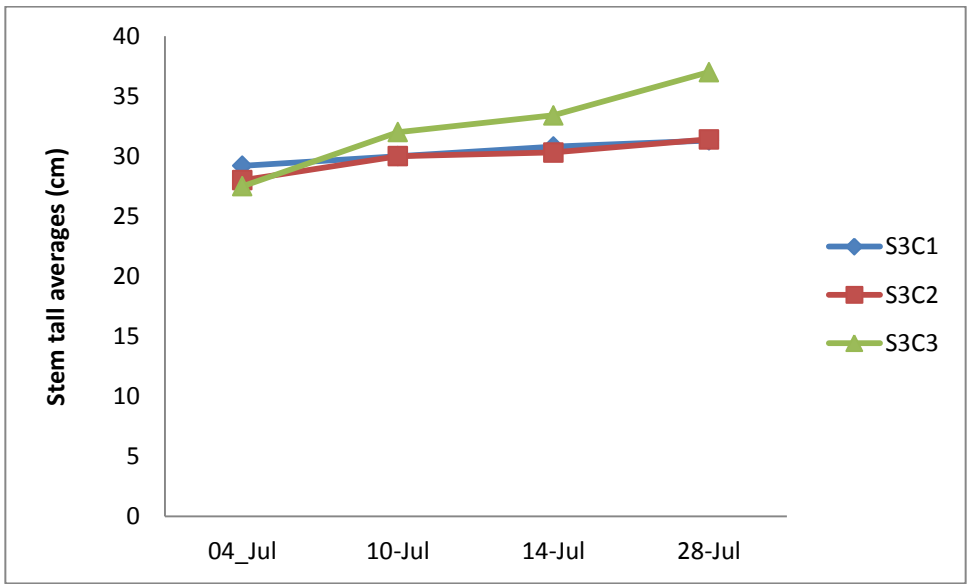


Figure (4.17): Stem length averages for salinity three treatment, versus time after addition.

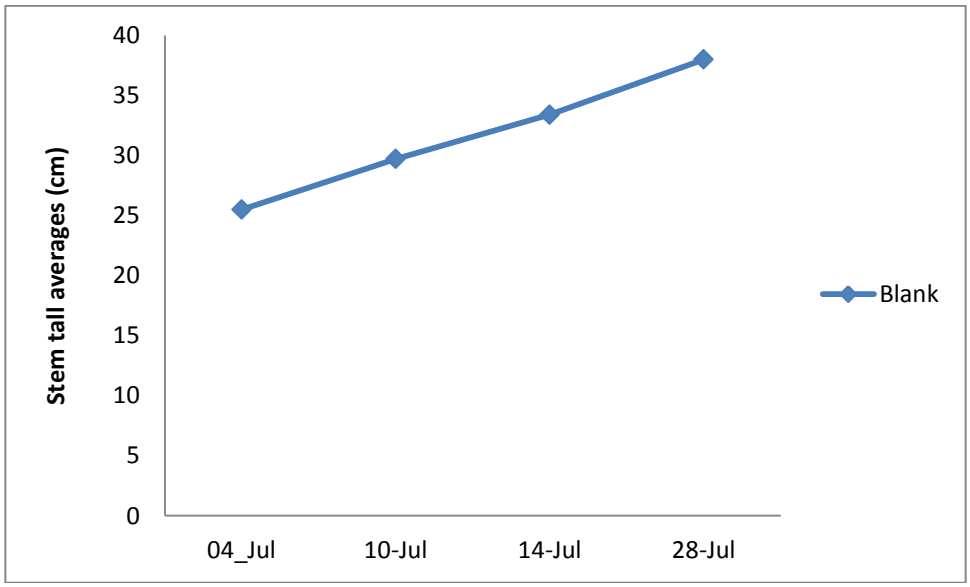


Figure (4.18): Stem length averages for blank, versus time after addition.

4.1.3. Yield evaluation of Bell Pepper

Yield was evaluated by counting the number of fruits per pepper plant. By looking at number of fruits of pepper plant. It can be noted that not all plants yield or produced fruits, and by comparing results of fruit number average before and after solution addition, it can noticed that some plants yielded before no more fruits appear then, while some other plants did not yield before and appear to yield after addition of salinity solution. This lead to think that number of fruits was not affected by salinity, but looking at the dry weights of fruit samples it can be noticed that dry weight of samples after removing plant for analysis, after application of saline solutions of three different concentrations, corresponds to a study on bell pepper but in soil cultivation media, by (Kurunc, et al, 2011), in which it was found that yield of bell pepper was affected by decreasing the averages fruits weight.

4.1.4. Growth parameters evaluation by means of dry weight and EC values

Results here are divided according to treatment containers by tables that representing dry weight and EC values of burned dried samples, to check the effect of salinity on bell pepper growth parameters. All EC values in all tables were measured by micro semins (µs), and total dry weight by grams (g).

4.1.4.1. Leaves

For treatment number one of salinity 1000 ppm, figure 20 represents the results for leaves.

It seems that leaves' productivity was a bit different from the rest of bell pepper parts. Many of the plants maintained shoot part, the root, and even one fruit at least, but t productivity of leaves was lost and this confirms that the leaves were one of parts of the pepper most affected by salinity, where it began at the beginning of solution addition, especially for high concentrations, they seem that they lost their association with shoot and fall down, and this was directly observed after the first addition. It was also noted that leaves of container one with very high concentration were affected directly from the beginning, and also for container one of salinity two treatment, where the leaves fell down but less than first container of the third treatment, but it has been obviously visible after the second addition of solution.

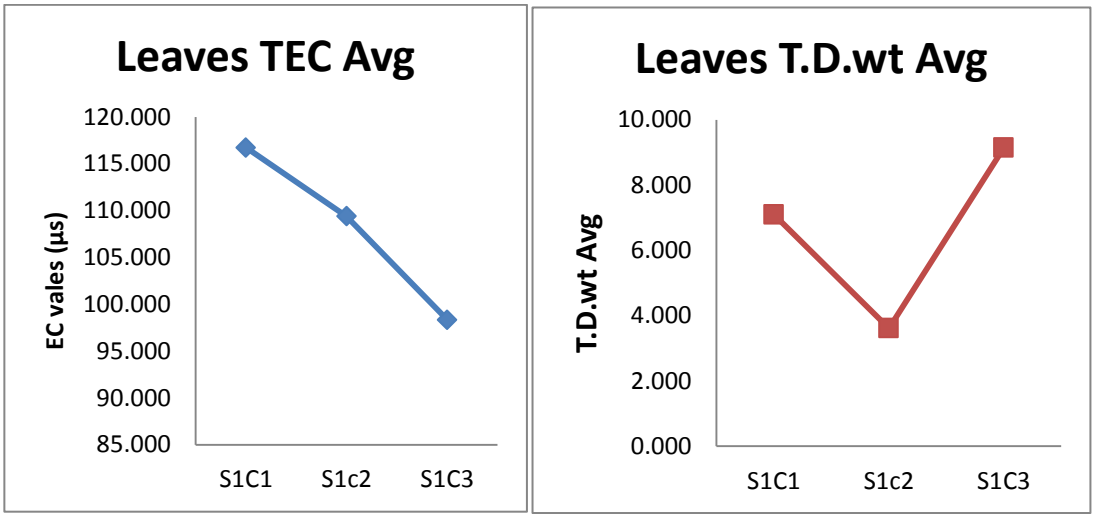


Figure (4. 19): Response of total dry weight (TD wt); to salinity of leaves for treatment One (1000 ppm).

It is noted that dry weight of leaves decreased sharply, from 7.09 to 3 g, in the second container, then retained to increase again in the third container. This does not necessarily mean that leaves' productivity decreased with decreasing of EC values. If refer to tables of leaves' number before and after addition of solution it can be observed that there were differences among the three containers, and that leaves decreased (fell down), at the end of July this is observed more in the second container than the first and third. ,Noting that leaves number in the third container were just for three plants, (plant number 3, and 5) in the second container of the first treatment dried and died. See table 3, from appendix. This averages that the weight of plants before solutions addition originally for container two of treatment one was smaller than plants of other containers. It also seems that if considering that plants were small (2, and 5 of container two for treatment one salinity), then evaluate the average, its noticed that the value

will rise, to be nearer to the other values, decreasing the difference. But if we look to salinity values, we can see that it decreased as expected.

And looking at the values of wet weight of leaves, we notice that wet weight of the same container (second of the first treatment), is far from other weights, and going back to the values of stem weights, we notice that it is smaller for the plant 5, than other stems, while plant number 2, is considered close to the values for average of wet weight.

And going back to table 7 of leaves' number after adding solution, it's noted here that in time after solution was added there was increase in the average of leaves number for the first container, but at the end of Jul. It is noted that there was some decreasing in the average number of leaves, and if compared with blank result in, figure (4.6), it's noticed that the increase in leaves number was not steady as for the blank container, where leaves production increased by time, which reflects the effects of salinity pressure on bell pepper. And the fact that leaves' number was originally lower in the second container from the beginning, than the first and third containers. This may explain the decrease in average of dry weight of plant leaves for second container than the first and third one. See figure (4.2).

Generally, the average of leaves number decreased when salinity concentration increases, and this is reflected in the means of dry weight. When compared with the containers one and three, it will be clear that the dry weight of container three samples larger than dry weight of container one for the same treatment of salinity(1000 ppm). But it was also noticed

that the number of leaves increased but slowly (that increasing values were very closed to each other. this may be because the 1000 ppm salinity is considered not high salinity concentration, (Ibrahim, 2011), Agricultural departments ,and (James, 2014).

And when we compare salinity values of third container (98.350 µs) of treatment one (salinity 1000 ppm), with values of blank (93.8 µs), it's clear that they are close to each other.

Table (4.2): Comparing T.dry wt. and T EC values for leaves among S1 treatment containers.

1000 ppm	Experiment					F	Sig. *
T.dry.wt (g)	containers plants no.	C1 (3)	C2 (5)	C3 (4)	Total (12)	2.564	0.131
	Mean	7.0981	3.6147	9.1450	6.3290		
	Standard deviation	4.15398	4.07988	2.72789	4.19685		
T. EC (µ S)	containers plants no.	C1 (3)	C2 (5)	C3 (4)	Total (12)	2.494	0.137
	Mean	116.7333	109.4000	98.3500	107.5500		
	Standard deviation	11.90014	14.14355	2.22935	12.45709		

One Way ANOVA test for salinity one treatment containers shows no statistically significant differences at (α =0.05) level on the concentration 1000 ppm due to containers in (T.dry .wt and T. EC .

Moving to salinity two treatment results we can note that dry weight adversely affected by salinity increasing among containers of salinity two treatment.

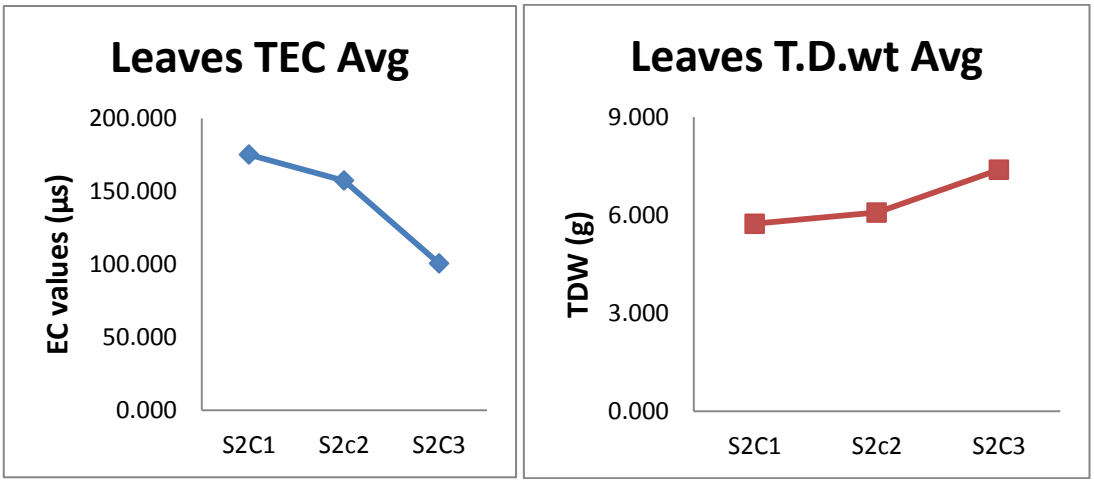


Figure (4.20): Response of total dry weight (TD wt); to salinity of leaves for treatment two (3000 ppm).

It was noticed that number of leaves and its dry weight average proportional with the salinity increase, and figure (4.20) shows that dry weight average increased with the decrease of salinity from first to second and third containers.

Table (4.3): Comparing T.dry wt. and T EC values for leaves among S2 treatment containers.

3000 ppm	Experiment					F	Sig. *
T.dry.wT (g)	Containers Plants no.	C1 (4)	C2 (5)	C3 (3)	Total (12)	0.112	0.895
	Mean	5.7359	6.0776	7.3910	6.2921		
	Standard deviation	3.87361	2.15255	8.39425	4.36479		
T. EC (µ S)	NO.	C1 (4)	C2 (5)	C3 (3)	Total (12)	3.862	0.062
	Mean	175.0500	157.2400	100.5333	149.0000		
	Standard deviation	45.41787	13.20030	49.41673	44.58936		

One Way ANOVA test shows no statistically significant differences at (α =0.05) level on the concentration 3000 ppm due to containers in (T.dry .wt and T. EC.

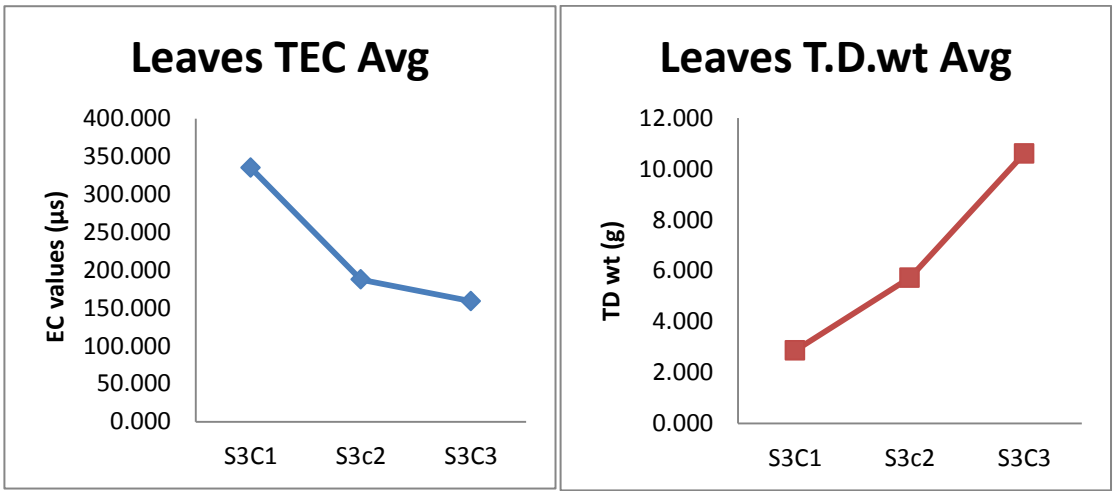


Figure (4. 21): Response of total dry weight (TD wt); to salinity of leaves for treatment three (7000 ppm).

From figure (4.21) it's noticed that there was a sharp decrease in salinity value moving from first to the second, but it seems to be gradual between second and third containers of salinity three treatment. This explains the increase in the dry weight of second container than the first of the same treatment which represents a very high concentration, also the weight differs between container two and three were very visible (from 5-10 g).

Table (4.4): Comparing T.dry wt. and T EC values for leaves among S3 treatment containers.

7000 ppm	Experiment					F	Sig. *
T.dry. wT (g)	Containers Plants no.	C1 (5)	C2 (4)	C3 (2)	Total (11)	9.523	0.008*
	Mean	2.8665	5.7232	10.6097	5.3132		
	Standard deviation	2.03321	2.54354	0.69180	3.50904		
T. EC (µ S)	Containers Plants no.	C1 (5)	C2 (4)	C3 (2)	Total (11)	3.967	0.064
	Mean	334.9600	187.6050	159.0000	249.3836		
	Standard deviation	123.93042	47.88639	21.77889	117.05127		

One way ANOVA test here shows statistically significant differences at (α =0.05) level on the concentration 7000 ppm due to containers in (T.dry .WT). On the contrary, it shows no statistically significant differences at (α =0.05) level on the concentration 7000 ppm due to containers in T. EC, in order to clarify, these differences, LSD Test has been used.

Table (4.5): Determining the differences between the measurements of T.dry wt.

Measurement		C1	C2
C3	Mean differences	7.74320*	4.88646*
	Sig.	0.002*	0.030*

LSD Test determine the differences among the containers of salinity three treatment in T.dry .wt, that there are differences between (C3) and (C1, C2) for the (C3), which represent the lowest concentration of irrigation water.

Table (4.6): Comparing T.dry wt. and T EC for leaves among three salinity treatments

Concentrations							F	Sig. *
T.dry .wT (g)	Salinity Plant no.	1000ppm (12)	3000ppm (12)	7000ppm (11)	Blank (4)	Total (39)	2.717	0.059
	Mean	6.3290	6.2921	5.3132	12.5054	6.6646		
	Standard deviation	4.19685	4.36479	3.50904	7.27431	4.71493		
T.EC (µS)	Salinity Plant no.	1000ppm (12)	3000ppm (12)	7000ppm (11)	Blank. (4)	Total (39)	10.138	0.000*
	Mean	107.550	149.0000	249.3836	93.8000	158.8979		
	Standard deviation	12.45709	44.58936	117.05127	10.54893	88.96353		

One way ANOVA test here shows statistically significant differences at (α =0.05) level on the concentrations in T. EC, but shows no statistically significant differences at (α =0.05) level on the concentration 7000 ppm due to containers for T.dry .wt.

able (4.7): Determining the differences among the concentrations T.EC for leaves

Concentration		1000ppm	3000ppm	Blank
7000ppm	Mean differences	141.83364*	100.38364*	155.58364*
	Sig.	0.000*	0.001*	0.000*

Using LSD Test shows that there are differences between (7000ppm) and (1000ppm, 3000ppm and blank) for the (7000pmm), representing the highest concentration.

4.1.4.2. Stem

From the following tables and figures; it's noticed that there is a decrease in salinity values (EC by µs) for stem, when moved among containers. On the other hand there was increase in dry weight averages, and this confirms the adverse effects on pepper stem elongation or growth. Also if we look at the salinity average value of the first treatment of 1000 ppm, we can see that EC values of stem of the third container are very close to EC average values of blank treatment. So the salinity of the stem sample for the third container became close to that irrigated with no saline water (blank), and salinity of first and second containers were not so far from blank sample.

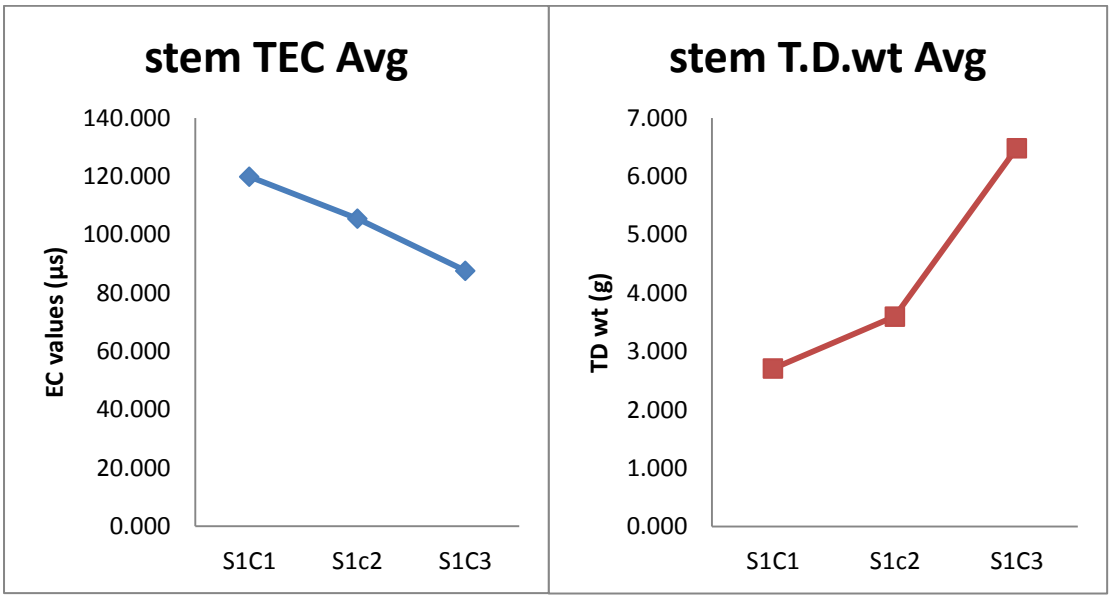


Figure (4.22): Response of total dry weight (TD wt); to salinity of stem for treatment one (1000 ppm).

Table (4.8): Comparing T.dry wt. and T.EC values for stem among S1 treatment containers.

1000 ppm	Experiment					F	Sig. *
T.dry.wT (g)	containers plants no.	C1 (3)	C2. (5)	C3 (4)	Total (12)	2.818	0.112
	Mean	2.7051	3.5983	6.4804	4.3357		
	Standard deviation	1.30704	1.45949	3.39196	2.62068		
T. EC (µS)	containers plants no.	C1 (3)	C2 (5)	C3 (4)	Total (12)	1.714	0.234
	Mean	119.8667	105.4800	87.5500	103.1000		
	Standard deviation	16.52917	22.35916	27.58375	24.62010		

Table (4.8) One Way ANOVA test shows no statistically significant differences at (α =0.05) level on the concentration 1000 ppm due to containers in (T.dry .wt and T.EC (µS).

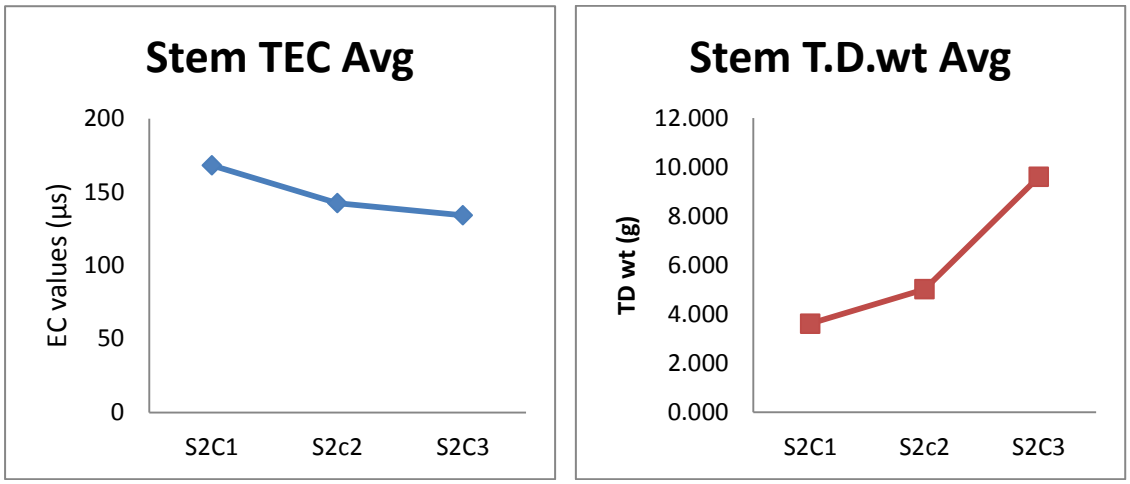


Figure (4.23): Response of total dry weight (TD wt); to salinity of stem for treatment two (3000 ppm).

For the second treatment figure(4.23), it seems clear that there was decrease in salinity values when moving from container S2C1, to S2C2, then to S2C3, for S2 treatment, which represent a very close value to that of sea water, with about 35000 ppm (Way, and Beaverton, 2006). But bell pepper stem still alive within this salinity values. The values had averages which gradually decreased. In the first container of this treatment it is 168.1 µs, then, decreased to 142.32 µs in the second container, then to 134.067 µs, We can see also a gradual increasing in the stem dry weights with salinity values decreasing to (3, 5, then 9) respectively. Which proves the bad effect on bell pepper stem under saline conditions. Thus, stem growth was affected by salinity which is compatible with the study by (Lolaei,et al, 2012), who found that shoot growth was reducedv50mg/L NaCl.

But looking at the total dry weight and comparing it to that of salinity one treatment, it seems that they were larger for treatment two. This does not

mean that growth and elongation of stem were much better under saline conditions, because saline solutions had been added after a period of growth time, and bell pepper began to produce some buds and there were growth variances. If retain we have a look to figures (4.11) and (4.12), of the stem length measured before solution addition, it will be noted that the averages of stem length for second treatment is more than those of salinity one treatment, and if we look at the values, it can be seen that at the beginning of Jun. stems length averages for S2C1, S2C2, S2C3, were (10.5, 8.9, then 7.3) cm, respectively, while for treatment one they were for S1C1, S1C2, and S1C3, (7.9, 9.375, and 9.7) cm, respectively. At the end of Jun. specifically on 25 of Jun., they were (20.7, 20.9, and 12.1) cm, for; S2C1, S2C2, S2C3 respectively, while (19.1, 17.875, and 18.5) cm for S1C1,S1C2 S1C3, respectively, This it is concluded that stems growth rate were more for when salinity two is applied, than that of salinity one treatment from the beginning. Because of that, stem average values of stem dry weight were larger for salinity two treatment, and not because the growth under salinity two is better than growth under salinity one conditions.

To find out if this represent statistical significant, one way ANOVA test is used.

Table (4.9): Comparing T.dry wt. and T.EC values for stem among S2 treatment containers.

3000 ppm	Experiment					F	Sig. *
T.dry.wt (g)	Containers Plants no.	C1 (4)	C2 (5)	C3 (3)	Total (12)	2.178	0.169
	Mean	3.6118	5.0178	9.5954	5.6935		
	Standard deviation	0.57701	2.45437	7.40941	4.26597		
T. EC (µ S)	Containers Plants no.	C1 (4)	C2 (5)	C3 (3)	Total (12)	0.985	0.410
	Mean	168.1000	142.3200	134.0667	148.8500		
	Standard deviation	40.71448	11.30020	49.61437	43.8536		

Table (4.9) by One way ANOVA test shows no statistically significant differences at (α =0.05) level on the concentration 3000 ppm due to containers in (T.dry .wt and T. EC (µ S)).

Moving to salinity three which represented by the following figure, It's noted that there were inverse proportions between stem growth,

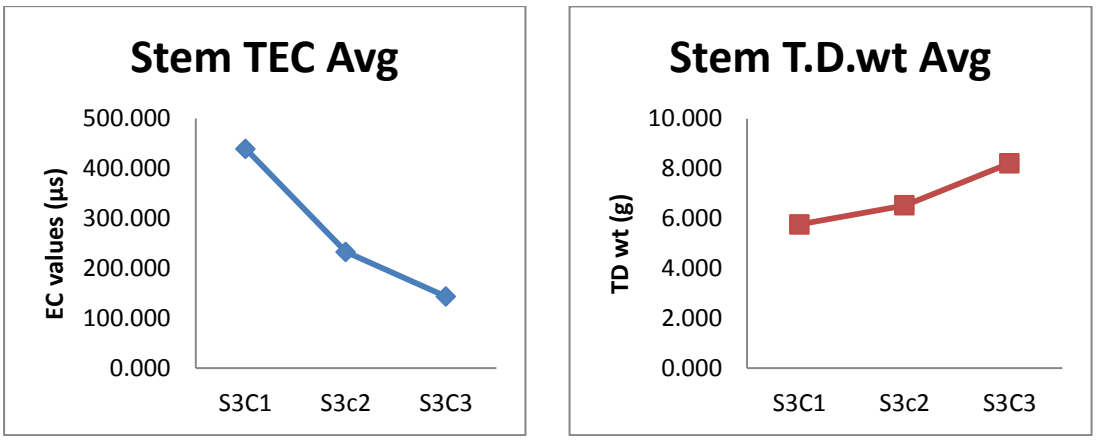


Figure (4.24): Response of total dry weight (TD wt); to salinity of stem for treatment three (7000 ppm).

which represented by dry weight, and salinity values increase, that averages of dry weight was smaller in the first container on which treatment three was applied. That represents a duplicate value of sea water

salinity values (7000 ppm, of salinity three, and 3500 ppm for sea water salinity concentrations). And the effect of saline solution addition was very clear on the stem dry weights, as increased to (5, 6, then 8)g, with salinity (EC) values decreasing. There was also decrease in EC averages in different ways for salinity one and two treatments. It was gradual decrease for them. But for salinity three, the decrease seems to be sharp between the first and second containers. Then retained to be gradual between the second and third containers.

Table (4.10): Comparing T.dry wt. and T.EC values for stem among S3 treatment containers.

7000 ppm	Experiment					F	Sig. *
T.dry wt. (g)	containers plants no.	C1 (no. 3)	C2 (no. 4)	C3 (no. 3)	Total (10)	0.397	0.687
	Mean	5.7622	6.5206	8.2074	6.7991		
	Standard deviation	1.70119	2.26712	5.58914	3.21748		
T. EC (µ S)	containers plants no	C1 (no. 3)	C2 (no. 4)	C3 (no. 3)	Total (10)	12.089	0.005*
	Mean	438.6667	232.4000	143.1333	267.5000		
	Standard deviation	49.32883	105.68343	31.09491	141.23689		

One way ANOVA test show no statistically significant differences at (α =0.05) level on the concentration7000pmm in (T.dry wt). On the contrary, it shows statistically significant differences at (α =0.05) level on the concentration 7000 ppm due to containers in T. EC

Table (4.11): The differences in T. EC values among S3 containers stems

Measurement		C2	C3
C1	Mean differences	206.26667*	295.53333*
	Sig.	0.009	0.002

Table (4.11) using LSD test for determining shows that there are differences between C2 and C3ppm) and C1) for the (C1).

The researcher due this fact to that container one was the container where salinity added for all concentrations.

Table (4.12): Comparing T.dry wt. and T EC for stem among three salinity treatments.

Concentrations							F	Sig. *
T.dry. wt (g)	Salinity plant no.	1000ppm (12)	3000ppm (12)	7000ppm (10)	Blank (4)	Total (38)	0.928	0.438
	Mean	4.3357	5.6935	6.7991	4.6934	5.4504		
	Standard deviation	2.62068	4.26597	3.21748	4.89477	3.59008		
T. EC (µ S)	Salinity plant no.	1000ppm (12)	3000ppm (12)	7000ppm (10)	Blank (4)	Total (38)	10.098	0.000*
	Mean	103.1000	148.8500	267.5000	85.0500	158.9105		
	Standard deviation	24.62010	34.49797	141.23689	16.94570	101.13968		

Table (4.12) using one way ANOVA test shows no statistically significant differences at (α =0.05) level on the concentrations in T.dry wt, but, it shows statistically significant differences at (α =0.05) level on the concentration 7000 ppm due to containers in. T. EC

Table (4.13): Determining the differences in T. dry wt. among the concentrations for stem.

Concentration		1000ppm	3000ppm	Blank
7000ppm	Mean differences	164.40000*	118.65000*	182.45000*
	Sig.	0.000*	0.001*	0.000*

This table shows that there are differences between 7000ppm and (1000 ppm, 3000ppm and Blank for the (7000ppm) by LSD Test.

Which were expected because salinity three treatment represent a very high concentration so EC values showed significant difference.

4.1.4.3. Roots

Looking at the results of treatment one concentration it can be seen that;

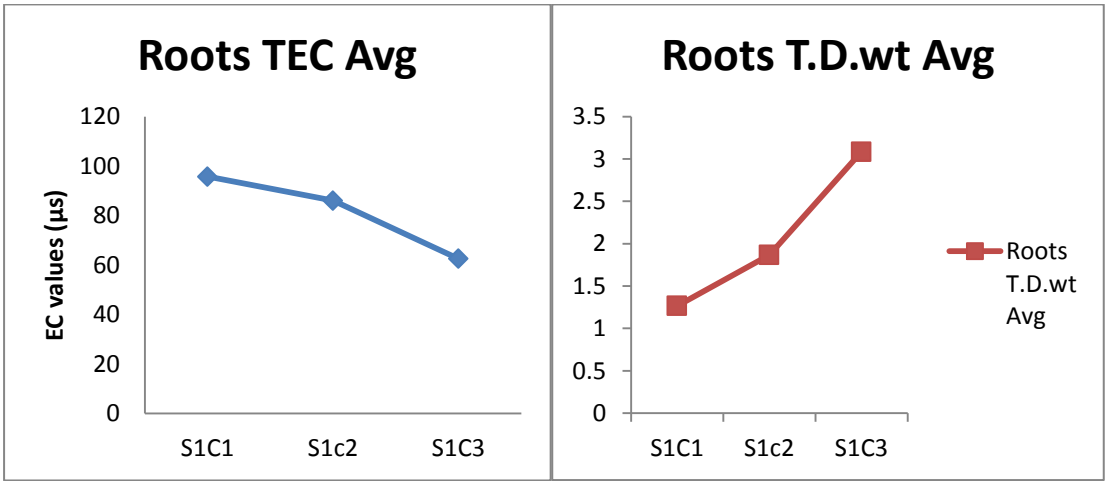


Figure (4.25): Response of total dry weight (TD wt); to salinity of roots for treatment one (1000 ppm).

Table (4.14): Comparing T.dry wt. and T EC values for roots among S1 treatment containers.

1000 ppm	Experiment					F	Sig. *
T.dry.wt (g)	Containers Plants no.	C1 (3)	C2 (5)	C3 (4)	Total (12)	3.651	0.069
	Mean	1.2664	1.8677	3.0857	2.1234		
	Standard deviation	0.26694	0.68496	1.37415	1.12487		
T. EC (µS)	Containers Plants no.	C1 (3)	C2 (5)	C3 (4)	Total (12)	2.709	0.120
	Mean	95.7333	86.0000	62.5350	80.6117		
	Standard deviation	19.20555	18.41847	22.04295	22.74477		

This table shows no statistically significant differences at (α =0.05) level on the concentration 1000 ppm due to containers in (T.dry .wt and T. EC (µS)). By using one way ANOVA test.

Roots after being removed from the first treatment, showed decrease in the dry weight with salinity increase, despite that , the difference among the containers roots wet weight is small with values of about; 8.6 g, for the container number one, 7.47g, for second container, and 9.136 for the third. **See table 2 of wet and dry weights in appendix**.

But its noted that there is decrease in the dry weight from the first, second then the third container with the larger dry weight. This means that the dry weight increased with decreasing salinity values. If we compare results of salinity values for roots of container one of salinity one treatment with blank sample, it is noted that salinity values are very near to each other. See blank result in table 28. It reaches in S1C3, 62.535 µs, and 55.705 µs, for blank sample but it is still superior in value. The dry weight average for the blank was 2.482 g, with lower salinity values of container three of salinity one treatment. Where dry weight reaches 3.08 g, this may related to that. The wet weight of roots before being dried, was originally larger for S1C3 than in blank, where no salinity concentrations was applied. And if we retain to the stem weights of S1C3 samples and for the blank, to know how much the vegetative structure, it's found that stems also of S1C3 elevated for blank stems, which led to know that the transplants were grown in a higher rate for that containers plant than blanks. Seedlings were close in age were grown in the same period, but they varying in length. For example, if retaining to average wet weight of stems in S1C3,

it is 19.284 g, and dry weight; 6.4804 g, while average wet weight of blank is 9.467 g, and dry weight average is 4.5631g, **see table 3 In appendix**. This reveals that bell pepper stems were larger for S1C3 than blank, since the beginning, and retaining to the weight at the beginning and end of Jun. It can be noted that the stem length average was larger in the blank than in S1C3.This may reveal that the branching from stems of S1C3, was more than those of blank stems which gave a larger weight than the blank.

And moving to salinity two treatments containers, it is noted that salinity increase adversely effects the dry average weight, of roots.

And comparing it with the dry average weight of S1C1, with those of S2C1 it is noted that the average weights are larger. This might be as the plant net volume from beginning before solution addition was more in the third container of treatment two salinity (S2C3), So there was increase in the dry weight in the third container and even larger than that of blank, but this does not necessarily mean that the increase of EC values in S1C3 from blank, is the reason of increasing of weights of roots, but it indicates that plant volume was larger in S1C3 than the blank one. As mentioned previously, that will not cancel the adverse effects of salinity on roots of bell pepper.

And looking at the treatment of two containers, it is seen that salinity decrease a little from the first container and the second, then sharply from the second to the third of the same treatment two salinity, but it is still higher than EC values of salinity one container three,S1C3, which reaches 98.3 µs, and if we have a look at the roots dry weight averages, it seems

that there was a gradual increase in weight, but not a very clear change, which means that roots were affected by salinity but may not be as other parts of bell pepper, which also appears for EC values of no salinity treatment, of blank sample, where EC reaches 55.705 µs.

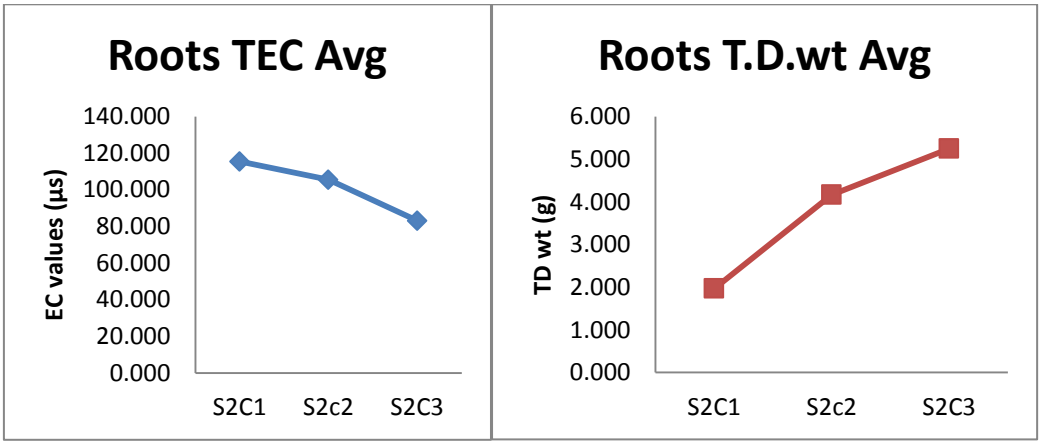


Figure (4.26): Response of total dry weight (TD wt); to salinity of roots for treatment two (3000 ppm).

Table (4.15): Comparing T.dry wt. and T EC values for roots among S2 treatment containers.

3000 ppm	Experiment					F	Sig. *
T.dry .wt (g)	Containers Plants no.	C1 (4)	C2 (5)	C3 (3)	Total (12)	0.720	0.513
	Mean	1.9719	4.1678	5.2497	3.7063		
	Standard deviation	0.92549	5.09957	3.15078	3.65179		
T. EC (µ S)	Containers Plants no.	C1 (4)	C2 (5)	C3 (3)	Total (12)	0.398	0.683
	Mean	115.4000	115.4000	83.1333	103.1833		
	Standard deviation	77.29373	22.60947	18.89056	45.23663		

One way ANOVA shows no statistically significant differences at (α =0.05) level on the concentration 3000 ppm due to containers in T.dry wt and T. EC

As for other treatments, salinity three treatment for its containers show a clear effect, that the decrease in EC values were gradual, (126, 105, then 96 µs), but the increase in the dry average weight of bell pepper roots, were very obvious, (from 0.2, to 4, then to 14 g), and especially between container two and three, see table 27, which confirms that roots are adversely affected by salinity solution application, where the dry weight increased with decreasing salinity EC values.

And for the large difference between the dry weight average of container three of treatment three, (S3C3), and the blank sample, where salinity EC value was about 62 µs, this refers to the original plant net volume, that if we refer to tables of dry weight averages of stem, from the beginning of solution addition, we find that weight averages of stem for salinity three treatment , container three, (S3C3), was 34.98129 g, but for the blank, it reached 9.467 g, and the dry weight average for S3C3, was 6.520 g, and for the blank, it is 4.563157 g, see table 4 in appendix. And we refer to stem length results before solution addition , It seems that at the beginning of Jun, the stem length was 11.2 cm, for S3C3, but it was 10.4 cm for blank. While at the end of Jun. The length of stem was 22.5 cm for S3C3, and 20.2 cm, for blank. Knowing that plant number one of blank sample had dry stem without leaves, or fruits, but it had some roots, for that has not been ignored from stems and roots, and seems the reason of increase in weight for S3C3 from blank sample, where the plants before adding solution were larger from that of the blank, And after addition there was a decrease in the dry weight, and if we refer to the tables of plants length from beginning of Jul. It is noted that the length of transplant number 4 and 5, increased but without leaves or bud production, which may mean

that there is competition among roots for water and nutrients within cultivation media, which led to decrease in roots dry weight for these transplants, (4&5), which died at the end of Jul, but their stem length, and then dry stem weights and also roots after removing them, may this competition cause the increasing in the dry weights of plants (1, 2, and 3). **See tables 1 and 4 in the appendix.**

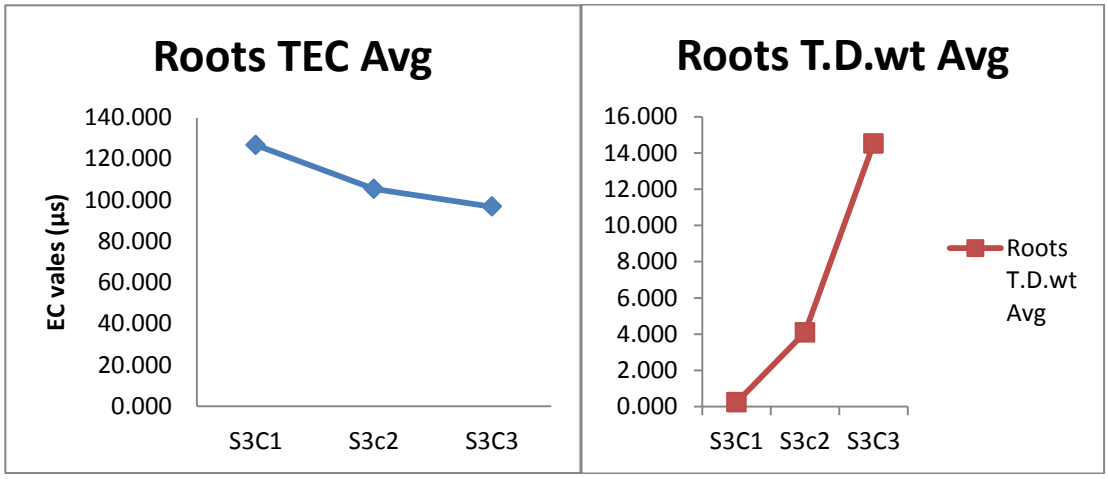


Figure (4.27): Response of total dry weight (TD wt); to salinity of roots for treatment three (7000 ppm).

Table (4.16): Comparing T.dry wt. and T EC values for roots among S3 treatment containers.

7000 ppm	Experiment					F	Sig. *
T.dry. wt (g)	Containers Plants no.	C1 (5)	C2 (4)	C3 (3)	Total (12)	6.477	0.018*
	Mean	0.2406	4.1011	14.5121	5.0953		
	Standard deviation	0.21050	2.45644	11.20656	7.72994		
T. EC (µ S)	Containers Plants no.	C1 (5)	C2 (4)	C3 (3)	Total (12)	2.354	0.151
	Mean	126.6800	105.4500	96.8000	112.1333		
	Standard deviation	28.88827	5.03157	12.20000	22.67114		

Table (4.16) shows statistically significant differences at (α =0.05) level, by one way ANOVA test on the concentrations in T.dry .wt, while shows

no statistically significant differences at (α =0.05) level on the concentration 7000 ppm due to containers in T. EC. That roots highly affected by salinity even for second and third container where concentration decreased gradually.

Table (4.17): Determining the differences in T. dry wt. values among S3 containers roots

Measurement		C1	C2
C3	Mean differences	14.27142*	10.41097*
	Sig.	0.006*	0.034*

LSD Test in this table shows that there are differences between (C1 and C2) and (C3) for the (C3 ppm).

Third container represents the lowest concentration of irrigation water so this reflected by increasing on T. dry wt. of roots.

Table (4.18): Comparing T.dry wt. and T EC for roots among three salinity treatments.

Treatments Concentrations							F	Sig. *
T.dry. wt. (g)	Salinity plant no.	1000ppm. (12)	3000ppm (12)	7000ppm (12)	Blank (4)	Total (40)	0.834	0.484
	Mean	2.1234	3.7063	5.0953	2.5584	3.5333		
	Standard deviation	1.12487	3.65179	7.72994	1.45708	4.75434		
T. EC (µ S)	Salinity plant no.	1000ppm. (12)	3000ppm (12)	7000ppm (12)	Blank (4)	Total (40)	4.370	0.010*
	Mean	80.6117	103.1833	112.1333	55.7050	94.3490		
	Standard Deviation	22.74477	45.23663	22.67114	24.25369	35.29687		

This table shows one way ANOVA test, there were no statistically significant differences at (α =0.05) level on the concentrations in T.dry .WT and statistically significant differences at (α =0.05) level on the concentration 7000 ppm due to containers in T. EC

Table (4.19): Determining the differences in T. EC values among the concentrations for roots

Concentration		3000ppm	7000ppm
Blank	Mean differences	-47.47833-*	-56.42833-*
	Sig.	0.013*	0.004*

Using LSD Test there are differences between (3000ppm and 7000ppm) and (Blank) for the (3000ppm and 7000ppm), to clarify this difference LSD test is used.

Table (4.20): Determining the differences in T. EC between S1 and S3

Concentration		7000ppm
1000ppm	Mean differences	-31.52167*
	Sig.	0.019*

In this Table (4.20) using LSD Test for determining the differences between the concentrations shows that there are differences between (1000ppm) and (7000ppm) for the (7000ppm).

4.1.5. Yield parameter evaluation by means of dry weight and EC values

Fruits results take different shapes from other peppers parts. If having a look for tables (4.29, 30, 31, and 4.32) it seems that there is an adverse effect of salinity on the fruit, which appear by the decrease of dry weight with salinity increasing, but it is noticed that fruit number is not affected, like dry weight which sometimes increase and sometimes decrease. That does not mean that with increase of salinity effects fruit yields more. For example, for salinity one treatment of the first container (S1C1), there were 6 fruits as final account of fruits of all pepper plants in the container, this number decreased for the second container to 3 fruits, and increased again in the third container to 7 fruits, and by looking at salinity two treatment, There were 4 fruits, but there were 7 fruits in the second, then

decreased to 6 fruits in the third container (S2C3). Here it must be noted that some pepper plants before salinity solution addition, produced fruits with small size, and these fruits remained after solutions addition, which may increase the fruit numbers after addition, This means that the number of fruits did not decrease clearly with salinity concentrations increase, but it means that fruit yielding increased with salinity increase, and the number increased because pepper plants already differ in growth and fruit formation from the beginning,(before solutions addition).

By having a look at tables of fruits number at the beginning of Jul. it's noted that fruit numbers for the three treatments containers were as follows:

Table (4.21): Fruits number of each container after salinity addition.

	Salinity 1	**Salinity 2**	**Salinity 3**
Container 1	7	6	7
Container 2	4	6	7
Container 3	7	4	3

And at the end of Jul. it is noted that some fruits were lost by salinity treatment and the others remained.

So fruits either increased, decreased, or remained stable, as its seen fruits increased for containers of low concentration (the second and third of each treatments), this appear in S3C3 fruits number increased from 7 to 11, that with salinity concentration, the yield increased and this was expected, for other samples fruits number decreased with concentration increasing, as in S1C1, where it was 7, then decreased to 6, a fruit died and fell due to salinity.

Taking every treatment alone, it is found that for salinity one (S1), fruit numbers decreased with salinity concentration increasing for the first container with higher salinity values, and remained stable for the second and third, because fruits appeared already at the beginning of July.

And it can be seen that there was increasing in dry weight with salinity concentration decreasing for treatment one, with no consideration of fruits number.

Looking at the figures below, we note that, EC values decreased linearly with adverse effects on dry weight that dry weight decreased with EC values decreasing among containers of the same treatment.

EC values of first and second container were very close to each other, then the difference in dry weight decrease was low.

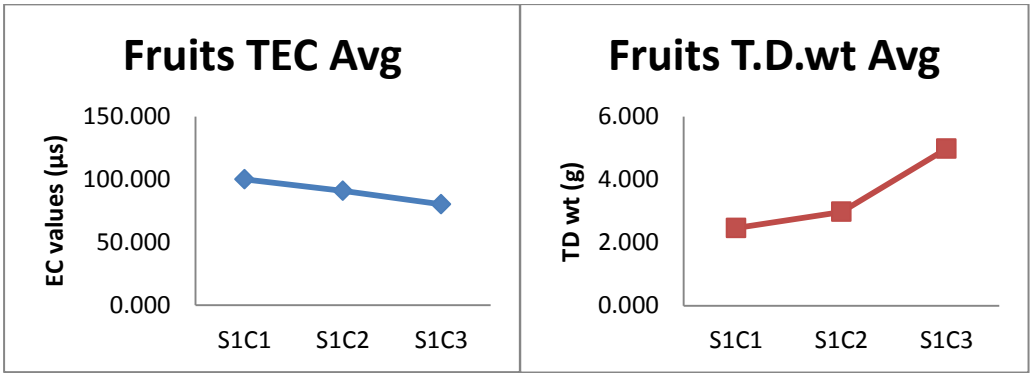


Figure (4.28): Response of total dry weight (TD wt); to salinity of fruits for treatment one (1000 ppm).

As for salinity two treatment, fruit numbers remained stable for the first container (on which salinity two solution applied), and the third container which represents the lowest concentration, while fruit numbers increased at slow rates, (one fruit). This fruit might have already grown at the beginning of July but was very small, so it was counted by buds instead of

fruit, so the number of fruits even in the second container was originally stable.

Table (4.22): Comparing T.dry wt. and T EC values for fruits among S1 treatment containers

1000 ppm	Experiment					F	Sig. *
T.dry. wt (g)	Containers Plants no.	C1 (6)	C2 (3)	C3 (7)	Total (16)	3.621	0.054
	Mean	2.4393	2.9769	4.9802	3.5804		
	Standard deviation	0.69306	1.07478	2.61601	2.09429		
T. EC (µS)	Containers Plants no	C1 (6)	C2 (3)	C3 (7)	Total (16)	4.925	0.024*
	Mean	106.4857	90.8667	80.2000	92.9059		
	Standard deviation	15.41249	13.58578	16.65573	19.19038		

Table (4.22) shows no statistically significant differences at (α =0.05) level on the concentration 1000 ppm due to containers in (T.dry .WT).using one way ANOVA On the contrary, it shows statistically significant differences at (α =0.05) level on the concentration 1000 ppm due to containers in (T. EC (µS).

In order to clarify, these differences, LSD Test has been used.

Table (4.23): Determining the differences in T. EC among S1 containers fruits

Measurement		C3
C1	Mean differences	26.28571*
	Sig.	0.007

Table (4.23) shows that there are differences between (C1) and (C3) for the (C1)

EC values gradually decreased but also reflect the adverse effect of salinity on dry weights of fruits.

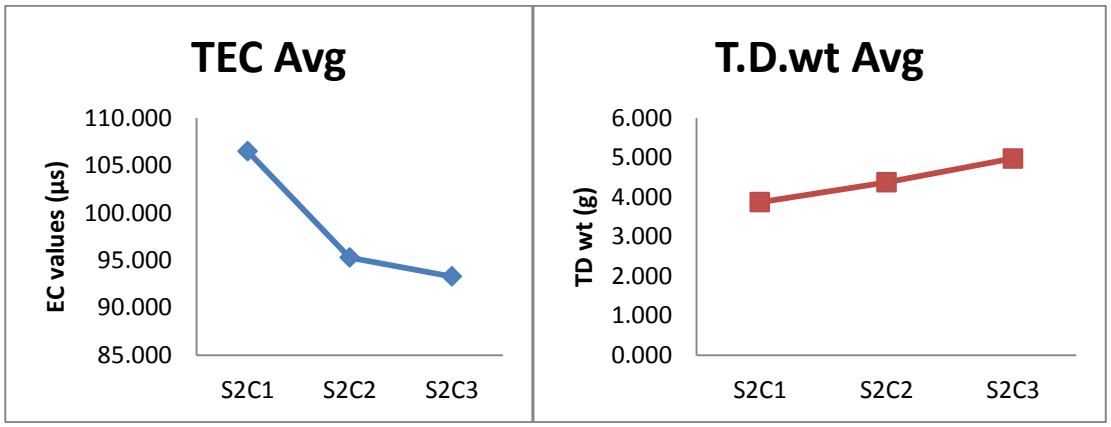


Figure (4. 29): Response of total dry weight (TD wt); to salinity of fruits for treatment two (3000 ppm).

For salinity three treatment it is noted that for the container that salinity solution applied for (S3C1), by time, it loses fruit because of high salinity. While it remained stable for the second and increased clearly in the third container. When concentration decreased with EC values of 95.578µs, we had 11 fruits. This number was the highest among all containers for all salinity treatments, even for the blank sample with 9 fruits. This may reflect the response of pepper to the salinity decreasing from one value to another. Also the bud ages for salinity three third container (S3C3), seemed to be older than those of the blank sample, so some small fruits might have been counted. But some buds in the blank sample, were really fruit but counted as buds, produced fruit. This made a slight difference in the numbers of fruit.

Table (4.24): Comparing T.dry wt. and T EC values for fruits among S2 treatment containers.

3000 ppm	Experiment					F	Sig. *
T.dry.wt (g)	Containers Plants no.	C1 (4)	C2 (7)	C3 (6)	Total (17)	0.616	0.554
	Mean	3.8699	4.3685	4.9755	4.4654		
	Standard deviation	1.91016	1.42179	1.51875	1.53407		
T. EC (µ S)	Containers Plants no.	C1 (4)	C2 (7)	C3 (6)	Total .(17)	2.678	0.104
	Mean	106.5000	95.2857	95.2857	97.2176		
	Standard deviation	3.95474	4.66741	14.38199	10.23317		

Here one way ANOVA test shows that there where no statistically significant differences at (α =0.05) level on the concentration 3000 ppm due to containers in T.dry wt and T. EC

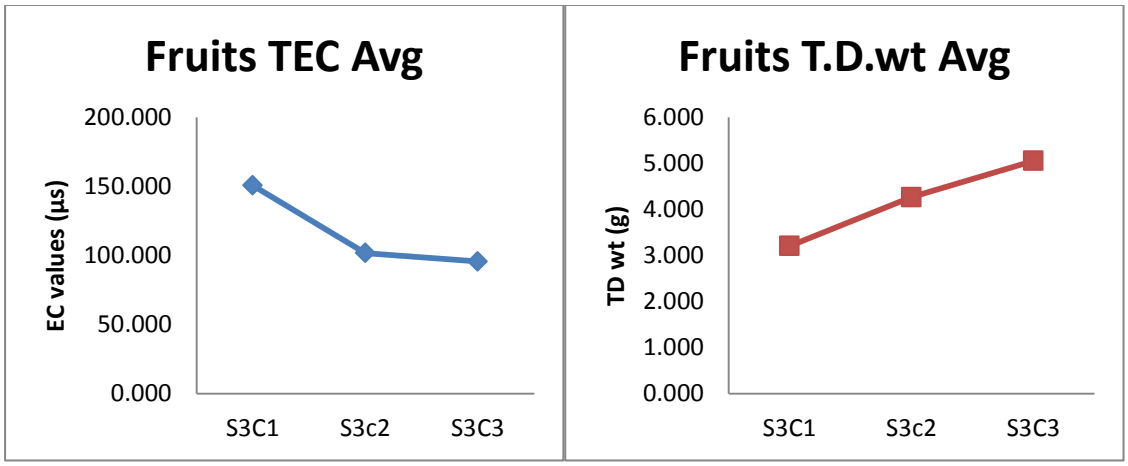


Figure (4.30): Response of total dry weight (TD wt); to salinity of fruits for treatment three (7000 ppm).

Here there is a sharp decrease in EC values for container one and two, but gradual increase in dry weight among the three containers, and in the S3C3, we note that EC values are still more than container three of salinity one,(S1C3, 80.2µs), which means that salinity is still high and fruit is affected by salinity.

Table (4.25): Comparing T.dry wt. and T EC values for roots among S3 treatment containers.

7000 ppm	Experiment					F	Sig. *
T.dry .wt (g)	Containers Plants no.	C1 (no. 4)	C2 (no. 7)	C3 (no. 11)	Total (22)	2.613	0.099
	Mean	3.2058	4.2641	5.0532	4.4662		
	Standard deviation	1.78911	1.56921	1.16410	1.51751		
T. EC (µ S)	Containers Plants no.	C1 (no. 4)	C2 (no. 7)	C3 (no. 11)	Total (22)	2.956	0.076
	Mean	150.7000	101.7829	95.5782	107.5745		
	Standard deviation	95.29134	13.09152	12.17691	43.09982		

Table (4.25) with one way ANOVA shows no statistically significant differences at (α =0.05) level on the concentration 7000 ppm due to containers in (T.dry .wt and T. EC).

Referring to treatment one containers, which had EC values close to EC values of the blank for fruits, we see that the difference in the number of fruits was low, and not far from the blank in S1C3, which had the nearest EC value to the blank. As for number of its fruits, some error might have occurred during the experiment, especially as fruits were counted manually, depending on the senses, so some fruit might have been counted as buds, then dry weight will be more representative for salinity effects on pepper, in the three treatments.

Looking to the figures, it is noted that dry weight decreased with salinity and increased with salinity decreasing, which means that nutrient storage in fruits and fruits formation were better when salinity decreased without consideration of number. So fruit volumes were larger when salinity was low, this is similar to what (Kurunc, et al, 2011), and (Chartzoulakis, and

Kalpaki, 2000), found in their studies, that decreasing yield of bell pepper was not due to decrease in fruit numbers, but in their mean dry weight.

As for blank sample, we notice that EC values are relatively high, as it was more than those of roots of the same sample, but less than those of leaves number. This means that the fruit is more affected by salinity. This might be because it represents the storage part of nutrients.

Comparing results with the blank sample, salinity one treatment EC and dry weight were the nearest one to the blank. EC values were very close to that of blank, 80.2µs for S1C3, and 76.8 µs for the blank sample, and dry weight average was very close to blank, 4.981g for S1C3, and 5.336g for the blank sample.

Comparing between containers of salinity one treatment it was noted that in container two there was less fruit, but looking to their dry weights, it seems that, dry weight was larger for the second container than in the first one. This proves what has been discussed previously, that the effects on fruits are represented by the dry weight, not by the fruit numbers.

And looking back to salinity three treatment, in the third container, plant number 5 had no stem or root samples, This reflects that those plants appeared before salinity addition and disappeared an after solution addition, when plant dried and died.

And also for the same container (S3C3), the number of fruits represents the highest one among all containers, and the highest dry weight of treatment three container. It also represents the nearest dry weight to the blank sample, more than those of treatment one containers. This might be the same of what was mentioned before that fruit weights before solution

addition were larger for salinity three third container S3C3. Then dry weights were affected by salinity reflecting that fruits size, which is compatible with the study by (Lolaei,et al, 2012), that annual and accumulated yield, fruit size and vegetative growth ratio are affected by salts.

Table (4.26): Comparing T.dry wt and T. EC for fruits among three salinity treatments.

Concentrations							F	Sig. *
T.dry.wt (g)	Salinity Fruits no.	1000ppm (16)	3000ppm (17)	7000ppm (22)	Blank (9)	Total (64)	1.542	0.213
	Mean	3.6921	4.4654	4.4662	5.3362	4.3948		
	Standard deviation	2.10998	1.53407	1.51751	2.63918	1.88809		
T.EC (µS)	Salinity Fruits no.	1000ppm (16)	3000ppm (17)	7000ppm (22)	Blank (9)	Total (64)	2.648	0.057
	Mean	91.6875	97.2176	107.5745	77.9111	96.6803		
	Standard deviation	19.12861	10.23317	43.09982	8.30729	28.98028		

This table shows no statistically significant differences at (α =0.05) level on the concentrations in (T.dry .wt and T. EC), by one way ANOVA test.

4.1.6. Electrical Conductivity averages for all bell pepper parts

Table (4.27): Electrical conductivity averages, for all bell pepper part of blank.

Blank container plant parts	Average EC (µs)
Stem	85.050
Root	55.705
Leaves	93.800
Fruits	76.800

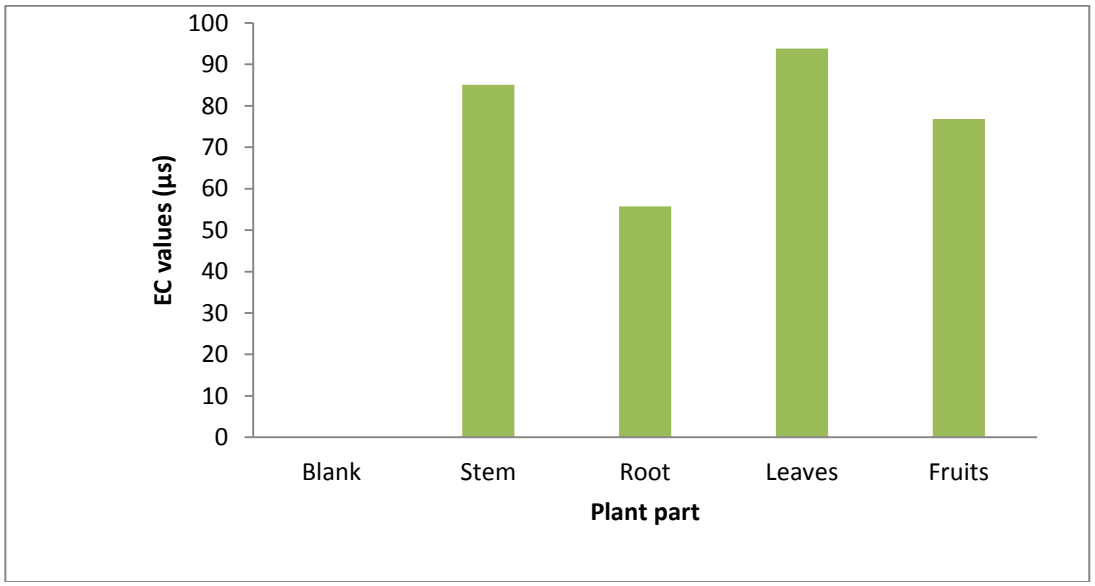


Figure (4.31): Average total Electrical conductivity values, for all bell pepper parts of blank sample.

4.1.6.1. Tables Summary of EC averages values in bell pepper parts

Table (4.28): Electrical conductivity averages, for all bell pepper part of salinity one containers.

Plant part	Average EC (µs) S1C1	Average EC (µs) S1C2	Average EC (µs) S1C3
Stem	119.867	105.480	87.550
Root	95.733	86.000	62.535
Leaves	116.733	109.400	98.350
Fruits	100.100	90.870	80.200

Table (4.29): Electrical conductivity averages, for all bell pepper part of salinity two containers.

Plant part	Average EC (µs) S2C1	Average EC (µs) S2C2	Average EC (µs) S2C3
Stem	168.100	142.320	134.067
Root	115.400	105.440	83.133
Leaves	175.050	157.200	100.533
Fruits	106.500	95.290	93.300

Table (4.30): Electrical conductivity averages, for all bell pepper part of salinity three containers.

Plant part	Average EC (µs) S3C1	Average EC (µs) S3C2	Average EC (µs) S3C3
Stem	438.667	232.400	143.133
Root	126.680	105.450	96.800
Leaves	334.960	183.004	159.000
Fruits	150.700	101.800	95.578

4.1.6.2. Figures summary of EC averages values in bell pepper parts

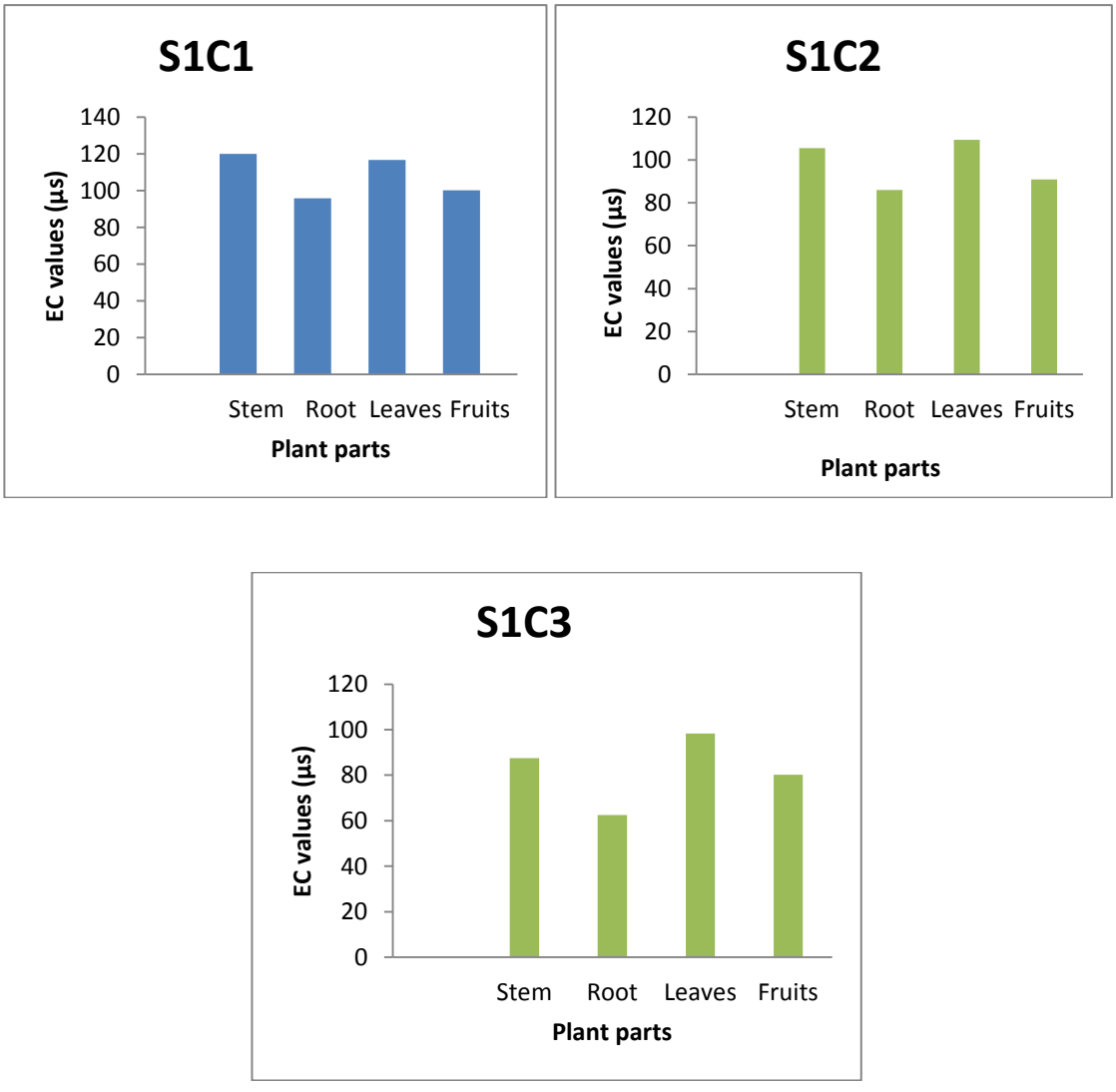
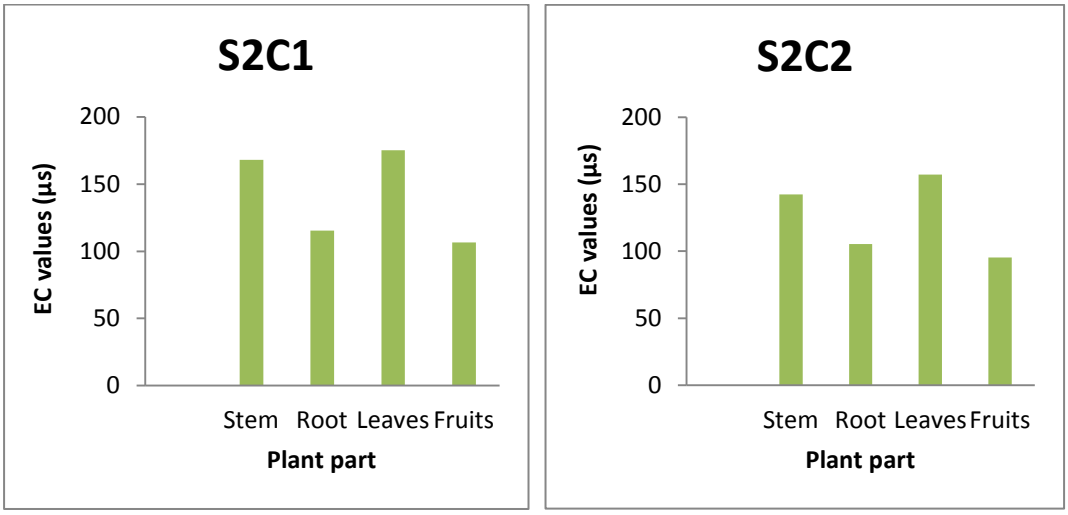


Figure (4.32): EC values for Salinity one containers



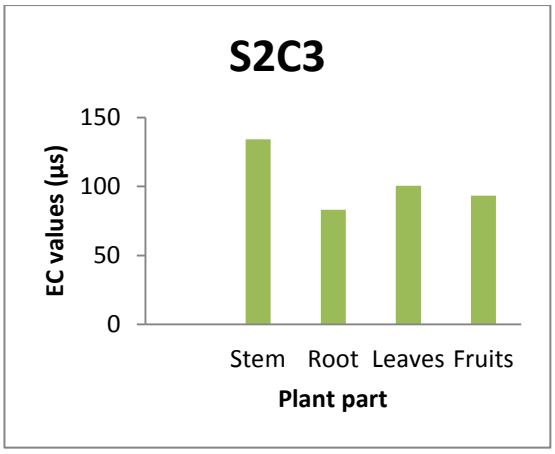


Figure (4.33): Salinity two containers EC values.

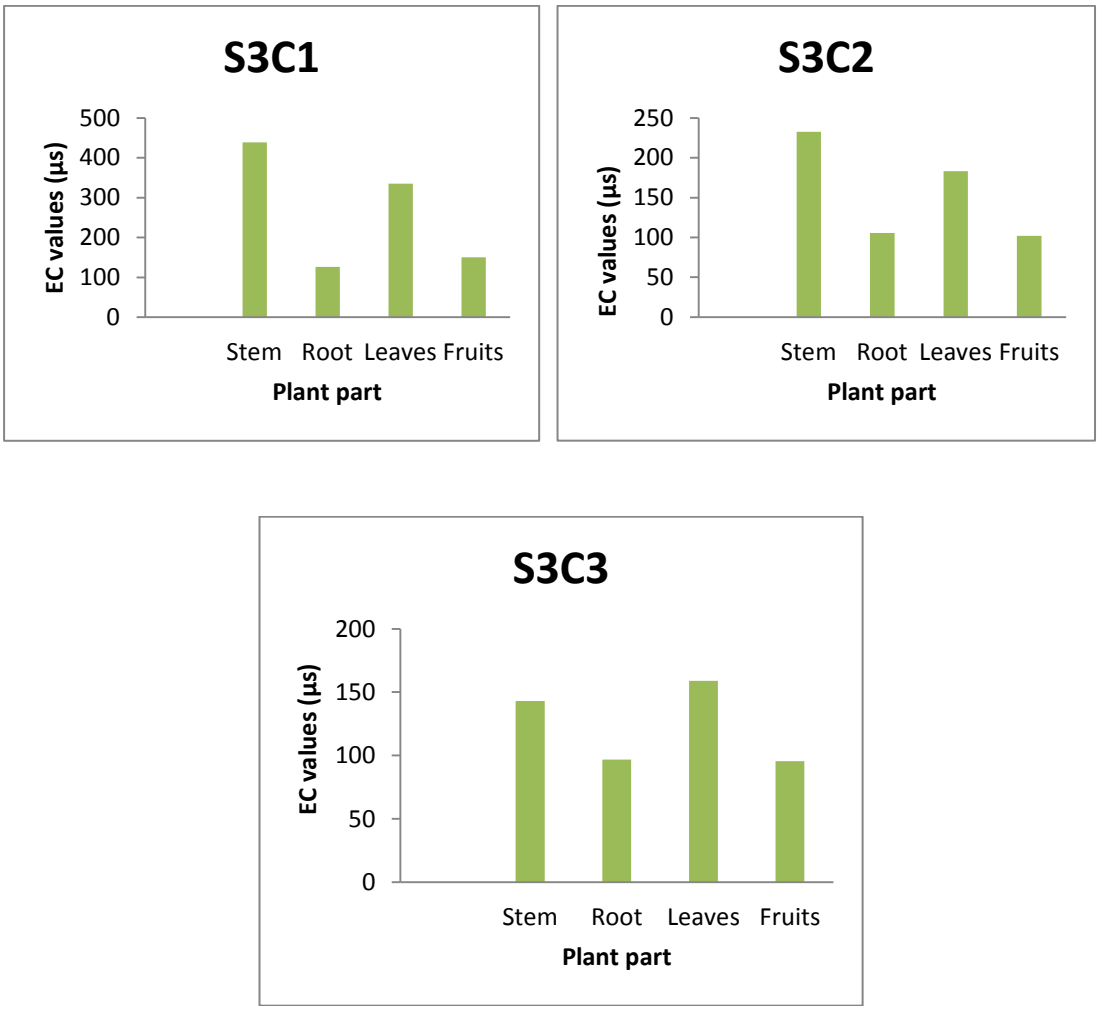


Figure (4.34): Salinity three containers EC values.

From the figure which shows EC values for pepper parts, it is noted that values arranged ascending as root, fruit, stem, then leaves with the higher value, and if they are compared to those of the first treatment containers, (Salinity one), shown in the previous tables (4.27) and figures (4.31).

It can be seen that for the three containers with the same arrangement of the blank, that leaves have the highest EC values, but the first container differs, the stem with highest values, which shows that stem is affected clearly, then comes the leaves, fruits, and finally the roots for the same container.

For elevating EC values of leaves, this seems to be logical, because leaves are considered to be the plant food factory, and also as a storage of many nutrients, and leaves responsible for evapotranspiration and photosynthesis, but after the solution addition stem affected clearly and takes values higher than leaves, but with little difference (119.867 µs for stem), and (116.733 µs for leaves). And with salinity decreasing from container two to three, arrangement of EC values remained to be as in the blank with small elevating of EC values for leaves and stem in the second container, which reflects that stem is affected clearly with salinity.

For salinity two treatment, the table (4.28) and figure (4.32) represent the arrangement of EC values for pepper parts. In this treatment we notice that the arrangement remained as in the blank with little difference between leaves and stem, and higher than those of the blank, which reflects that all plant part are affected by high salinity concentrations, but the EC values remain as in the blank.

As it seems in the following table and figure, the arrangement remained to be as in blank for plant parts EC values, which reflect that all plant parts are affected by high salinity.

For salinity two container three treatment, and with salinity concentration decreasing, it is clear that the highest EC values were for the stem, that EC values decreased for leaves, fruits, and roots, but not noticeable, that it was (142.320 µs) for the second container, and (134.067 µs) for the third container, which represents small difference. It is noticed that the stem was the part that store salt more than all other parts, as response to salinity increase, this also appears when salinity concentration decreased, that when salinity was high, the effects appear in all plant parts but with

salinity decreasing between containers. The stem has the highest values, because it might be stems represent the transmission channel of water and salts (contain wood) and prepared food (contain bark).

For salinity three treatment the table (4.29) and figure (4.33) represents the arrangement of pepper plant parts, and it is noted that with salinity increasing to 7000 ppm, the stem stores more salts and had high value of EC, which makes a difference among second salinity treatment that stem took the highest value from the beginning which is related to the increase in salinity of water carried by stem. Here it should be noted that bell pepper has green stem, which means that it makes photosynthesis. This effect is made more as the stem by salinity, so it had highest value, then the leaves where photosynthesis occurred, then fruits where food is stored, and finally roots with lowest EC values, as in the blank.

From the table(4.30), and figure(4.34) of salinity three treatment, second container, the stem still had the highest EC values which means that salinity concentration is still high, that stem carries large amount of salts, which led to high EC values, more than the other parts of pepper. Then leaves where photosynthesis and transpiration occur come next, the roots had higher EC values than fruits, but with little difference, 105.450µs for roots, and 101.800 µs for fruits, which might be due to the decrease in fruits tissue with salinity increased. This may cause decrease in EC values that may be stored within. While roots had higher EC values than fruits. In the third container, we notice there is salinity decrease as shown in table (4.30), figures (4.34), it is noted that EC values of leaves rose again as for the blank sample, then decrease again in the stem and leaves to be the same the arrangement of the blank with little difference, 143.133 µs for

stem, and 159.000 µs, for leaves, which proves that all pepper plant parts are affected by salinity. As it is noted in the second treatment, where it was not clear which part salinity affects more than others, still dilution by treating water when we reach the third container of second salinity treatment, where stem took the highest EC values but with salinity increasing we notice that the stem still has the highest EC values, copared with other parts. And with dilution at the end of treatment in the third container the arrangement returned as in the blank with little difference, that stem EC values remained high.

4.1.7. Comparison of bell peppers parts among each salinity containers

A statistical comparison among bell pepper parts among containers of each salinity treatment using one way ANOVA and LSD tests.

Table (4.31): Comparing plant parts evaluation among containers for S1 treatment.

1000 ppm	Description					F	Sig. *
Stem	Containers Plants no.	C1 (20)	C2 (20)	C3 (16)	Total (56)	3.660	0.032*
	Mean of stem length	22.6500	30.0250	32.4688	28.0893		
	Standard deviation	14.20165	8.75917	10.82662	12.07669		
Leaves	Containers Plants no.	C1 (20)	C2 (20)	C3 (16)	Total (56)	3.431	0.040*
	Mean of leaves no.	33.6000	34.6000	50.5625	38.8036		
	Standard deviation	28.19182	10.84532	21.08070	22.20108		
Fruits	Containers Plants no.	C1 (20)	C2 (20)	C3 (16)	Total (56)	3.430	.040*
	Mean of fruits no.	1.2000	4.0500	2.8125	2.6786		
	Standard deviation	0.95145	4.75145	3.50654	3.59852		

Here one way ANOVA test shows statistically significant differences at (α =0.05) level on the concentration 1000 ppm due to containers in (number of leaves, stem length and fruit number). In order to clarify, these differences, LSD Test has been used.

Table (4.32): Determining the differences among containers of S1 treatment plant parts

Measurement			C2	C3
Stem	C1	Mean differences	-7.37500*	-9.81875*
		Sig.	0.048	0.014
Leaves	C3		C1	C2
		Mean differences	16.96250*	15.96250*
		Sig.	0.021	0.030
Fruit nu.	C1		C3	
		Mean differences	-2.85000*	
		Sig.	0.012	

This table shows that there are differences the following domains:

Stem: Between (C1) and (C2 and C3) for the (C2 and C3).

Leaves: Between (C3) and (C1 and C2) for the (C3)

Fruit: Between (C1) and (C3) for the (C3).

Table (4.33): Comparing plant parts evaluation among containers for S2 treatment.

3000 ppm	Description					F	Sig. *
Stem	Containers Plants no.	C1 (20)	C2 (20)	C3 (16)	Total (56)	1.481	0.236
	Mean of stem length	29.1500	30.3750	23.4500	27.6583		
	Standard deviation	14.68359	8.64790	16.21719	13.69198		
Leaves	Containers Plants no.	C1 (20)	C2 (20)	C3 (16)	Total (56)	1.640	0.203
	Mean of leaves no.	47.5000	46.3000	34.2500	42.6833		
	Standard deviation	24.69498	22.44783	29.16356	25.86437		

Fruit	Containers Plants no.	C1 (20)	C2 (20)	C3 (16)	Total (56)	1.140	0.327
	Mean of fruits no.	1.0500	1.5000	1.3500	1.3000		
	Standard deviation	0.75915	1.00000	1.08942	0.96199		

From this table it's appear that there were no statistically significant differences at (α =0.05) level on the concentration 3000 ppm due to containers in (leaves number, stem length and Fruit number).

Table (4.34): Comparing plant parts evaluation among containers for S3 treatment.

7000 ppm	Description					F	Sig. *
Stem	Containers Plants no.	C1 (20)	C2 (20)	C3 (16)	Total (56)	0.612	0.546
	Mean of stem length	30.3250	29.9250	32.3750	30.8750		
	Standard deviation	2.44021	7.27337	10.51174	7.46383		
Leaves	Containers Plants no.	C1 (20)	C2 (20)	C (16)	Total (56)	2.221	0.118
	Mean of leaves no.	40.7500	44.8000	61.8500	49.1333		
	Standard deviation	27.52391	22.03251	46.31162	34.29259		
Fruit	Containers Plants no.	C1 (20)	C2 (20)	C3 (16)	Total (56)	6.719	0.002*
	Mean of fruits no.	0.7000	2.3500	1.9500	1.6667		
	Standard deviation	0.65695	1.92696	1.57196	1.62258		

Here one way ANOVA shows no statistically significant differences at (α =0.05) level on the concentration 7000 ppm due to containers in (Leaves number and Stem length). But there are statistically significant differences at (α =0.05) level on the concentration 7000 ppm due to containers in

(Fruit number). And in order to clarify these differences, LSD Test has been used in the following table.

Table (4.35): Determining the differences among containers of S3 treatment plant parts

Measurement			C2	C3
Fruit	C1	Mean differences	-1.65000-*	-1.25000-*
		Sig.	0.001*	0.010*

From this table there were differences in fruit, between (C1) and (C2 and C3) for the (C2 and C3) fruits. Where concentration decreased.

4.2. Trace Metal (TM) experiment

4.2.1. Growth parameter evaluation by number of leaves, and stem length

4.2.1.1. Leaves results

Results of leaves number are arranged in the tables and figures, and divided to results before and after solution addition.

4.2.1.1.1. Leaves number results before trace metal solution addition

It can be noted from the table that all containers represent increase in leaves number, but the blank sample represents the highest number of leaves, knowing that no trace heavy metal was added till 25-Jun. This must be taken into account when comparing containers after TM addition. The following figures represents the comparison between TM treatment containers, TM1, TM2, and TM3.

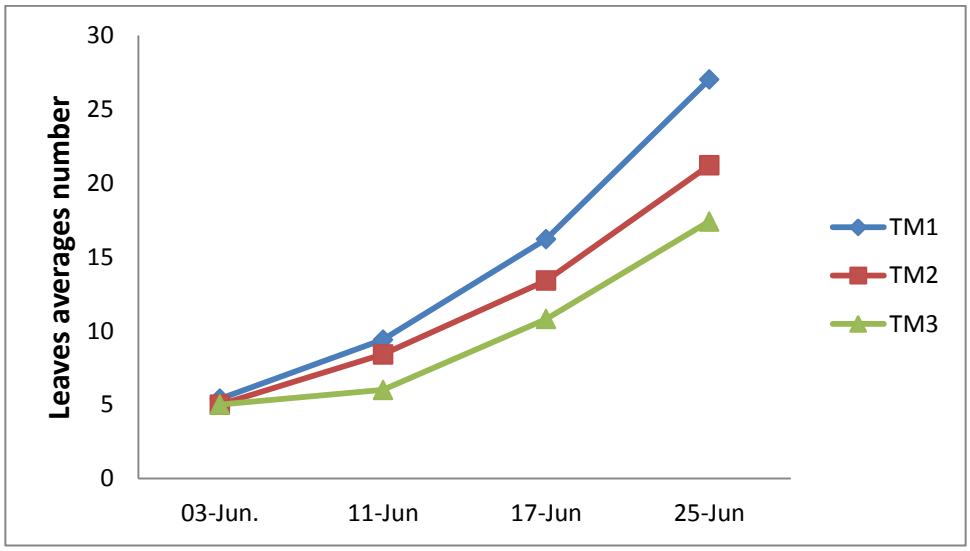


Figure (4.35): Leaves average number before Trace Metal (TM) addition versus time.

Leaves here were still increase in number, and it seems that there are differences among containers in leaves number, container one represents the highest number (which is near to the blank container), then the second, and the third had the least number of leaves but the increase was linear. But after adding trace metals, it can be noted that there are the differences in leaves number, as shown in the following table and figure.

4.2.1.1.2. Leaves number results after trace metal solution addition

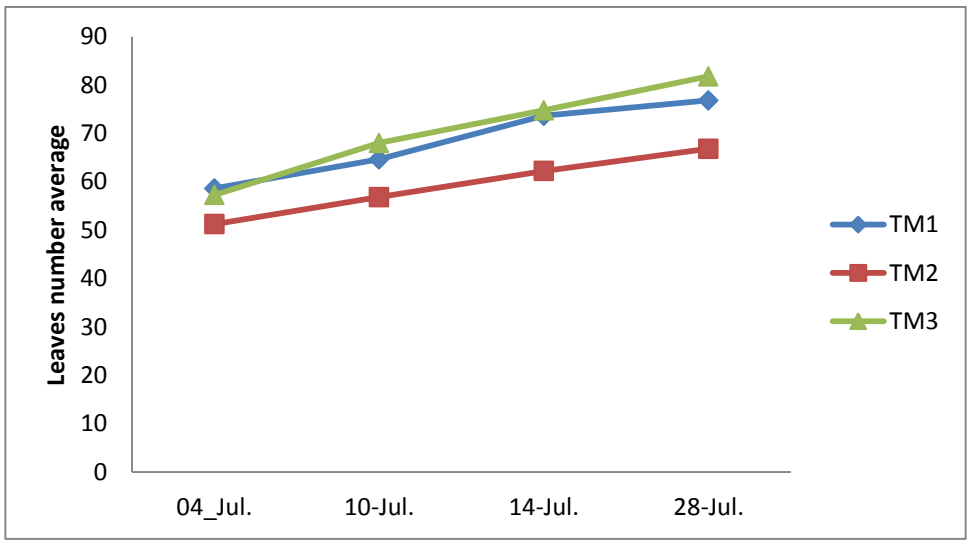


Figure (4.36): Leaves average number after Trace Metal (TM) addition versus time.

The first container here is affected very clearly with the decrease in leaves number. Here the order of the container changes. The third container had the highest number of leaves, then the second, and the first has the least. This reflects the effect of adding trace metals on the leaves number that the third container is expected to have the lowest trace metals concentration.

4.2.1.2. Stem results

Stems results were also, as that of leaves, arranged in tables and figures before and after solution addition.

4.2.1.2.1. Stem Length results before trace metal solution addition

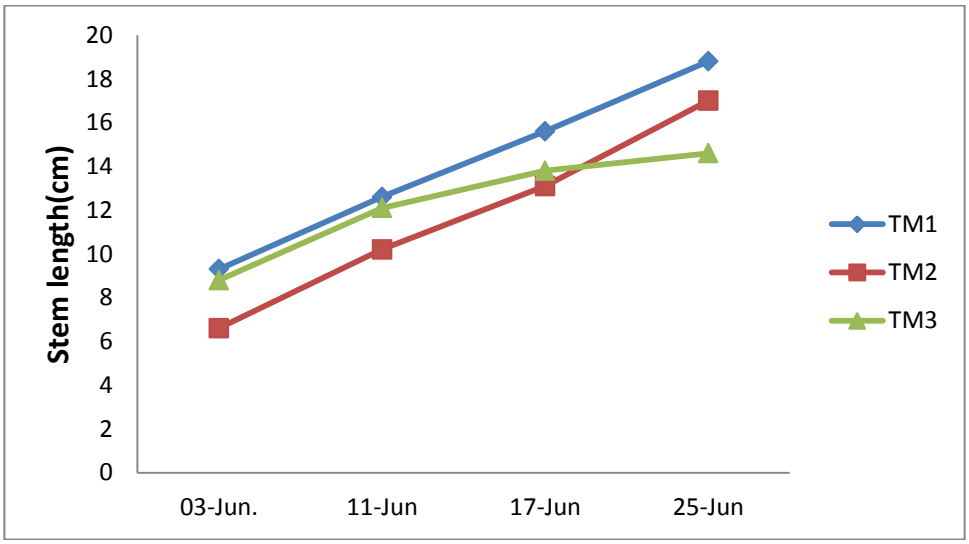


Figure (4.37): Stem averages length before TM addition versus time.

The growth was linear before TM addition for the three containers, and seems to be very close in containers one and three till 17- Jun. where container three showed some stability, but the highest stems were for container one to which TM would be added, this must be taken into account after TM addition.

4.2.1.2.2. Stem length results after trace metal solution addition

Table (4.36): Stems length averages after TM addition.

Container	Stem length average			
	4-Jul.	10-Jul.	14-Jul.	28-Jul.
TM1	23.6	24.6	31	31.9
TM2	24.6	29.4	33.2	37.8
TM3	24.5	31.5	38.75	44.25

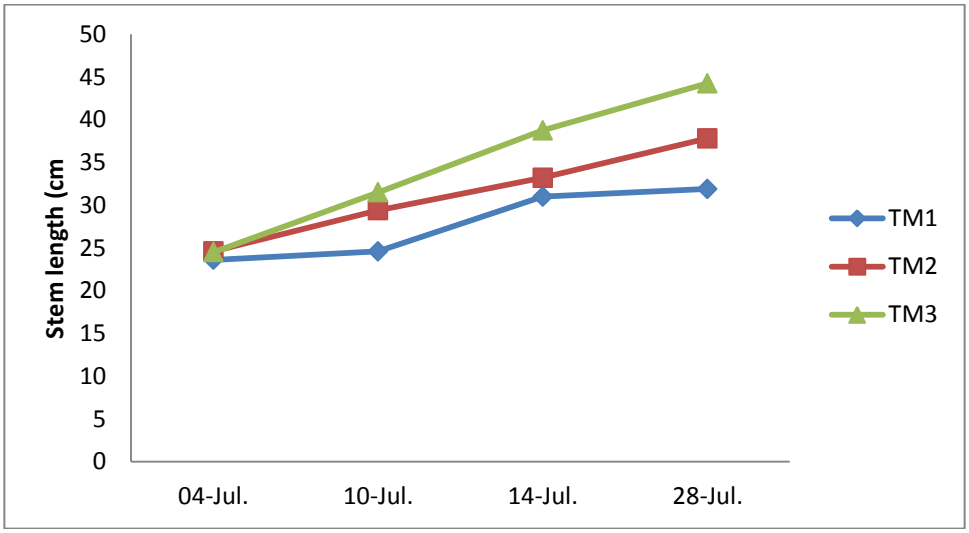


Figure (4.38): Stem averages length before TM addition versus time.

Here it can be noted that the third container (TM3), represents the highest values of stem length and reflect the effect of adding trace metal on stem, with a little increase, The order of containers for stem length was container three (TM3); which is expected that container two (TM2) would have the lowest trace metals concentration, and then the first container for which the trace metals was applied.

4.2.2. Growth evaluation by means of dry weights for bell pepper parameters

The table below summarizes, the dry weight of bell pepper parts for the three containers of trace metal containers compared with the blank container.

Table (4.37): Averages dry weight of leaves, stem, and roots after trace metals addition in grams.

Container treatment (TM)	Leaves dry weight (g) of all treatment plants	Stem dry weight (g) of all treatment plants	Roots dry weight (g) of all treatment plants
Trace metal treatment one (TM 1)	1.8716	4.7645	9.1780
Trace metal treatment two (TM 2)	2.1460	4.8065	23.7477
Trace metal treatment 3 (TM 3)	2.0547	4.7174	11.1386
Blank	12.5	4.5630	2.5580

4.2.3. Yield parameter evaluation

Fruits were used as yield parameter evaluation, and were estimated before and after the addition of trace metal solution.

4.2.3.1. Yield evaluation by number of fruits

Fruits were counted manually for the salinity experiment, and counting was done twice, before and after.

4.2.3.1.1. Number of fruits before trace metal solution addition

Fruits did not appear from period (3 Jun. to 25 Jun.) for plants of trace metal experiment containers but after solution addition, small fruits appeared and remained stable in number for each container.

4.2.3.1.2. Number of fruits after trace metal solution addition

Table (4.38): Number of fruits after trace metal solution addition

	Fruits number			
Container	4-Jul.	10-Jul.	14-Jul.	28-Jul.
TM1	4	4	4	4
TM2	3	3	3	3
TM3	1	1	1	1

So from 4 Jul. to 28 Jul. fruit numbers for each container remained stable, for trace metal treatment one there were 4 fruits (from four different plants), for trace metal two treatment there were three fruits (from three different plants), and for trace metal treatment three were six (three for different plants and three from plant four of the same container).

4.2.3.2. Yield evaluation by means of fruits dry weight

Table (4.39): Averages dry weight of fruits after trace metals addition in grams.

Container treatment (TM)	Fruits dry weight (g), of all treatment plants
Trace metal treatment one (TM 1)	3.785
Trace metal treatment two (TM 2)	3.997
Trace metal treatment three(TM 3)	4.257
Blank	5.336

It is noted from dry weight of fruits for trace metals that the results were not so far from blank sample, the dry weight of fruits was not too much affected by adding trace metals and they were near to each other and to the blank in fruit formation but the effect is represented in plant metabolisms such as photosynthesis. (Kupper, and Kroneck, 2005)

4.2.4. The evaluation Trace metal concentration using ICPMS

Results here are arranged in tables that represent concentrations of our desired trace metals which are (Cu, Cd, Cr, and Zn).

4.2.4.1. The evaluation Trace metal concentration evaluation using ICPMS of collected water

Our tested trace metals were evaluated also through collected water from each container, twice, after the second and final solution addition, and are arranged in the following tables.

Table (4.40): Concentrations averages of analyzed trace metals in collected water sample after first TM addition to irrigation water.

Analyzed TM of collected water 1	Concentration mean (ppb)		
	TM treatment 1	TM treatment 2	TM treatment 3
Cd	2.334	0.495	0.059
Cr	23.782	8.882	5.552
Cu	2.458	6.078	1.671
Zn	-23.238	-23.297	-17.299

Cd, and Cr, concentration decreased, when moving from container one , two, then to the third container, but with some differences. Zn had negative values and near to each other, which reflects how much it decreased from the standard instrument, reflecting that most of Zn absorbed by plant or added to the cultivation media. The increase of Cu concentration reflects that there was Cu added to the media and diluted with water, then retain to decrease again which reflect that plant parts absorb some of it.

Table (4.41): Concentrations averages of analyzed trace metals in collected water sample after final TM addition to irrigation water.

Analyzed TM of collected water 2	Concentration mean (ppb)		
	TM treatment 1	TM treatment 2	TM treatment 3
Cd	1.054	0.167	0.111
Cr	28.263	3.714	6.018
Cu	1.658	3.454	1.774
Zn	-18.477	-17.534	-16.546

If we compare the concentration of trace metal in the first container for both collected water samples in the previous tables, we notice that some metals were increased while others decreased. This may reflects trace metals which decreased in collected water, many of the elements or metals

either stuck in the media or were absorbed by plant (enter plant tissue), and for those which increased reflect that small quantities of metals were absorbed by the plant and little stuck in planting media most of them percolated with water (accumulated in water).

4.2.4.2. Trace metal concentration evaluation using ICPMS of pepper parts samples

Results of trace metals of collected parts were arranged in tables with a column for comparison of blank sample. Here the trace metals will be distributed and absorbed by pepper parts and in different ways for each part, then there is different accumulation and deposition.

4.2.4.2.1. Trace metal concentration evaluation using ICPMS of peppers roots

Table (4.42): Concentration of analyzed trace metal in roots compared with blank.

Analyzed TM of roots	Concentration mean (ppb)			
	Blank	TM1	TM2	TM3
Cd	3.035	5.326	1.912	0.826
Cr	29.121	36.169	23.365	21.587
Cu	33.904	28.688	24.749	16.341
Zn	53.697	49.451	47.057	43.160

From this table it can be noted that Zn has the highest concentration in pepper roots, which complies with study by, (Kupper, and Kroneck, 2005), that Zn proteins expressed mainly in roots and also in shoots.

For each trace metal, it can be noted that, all decreased by moving from container one, two, then the third container, and also decreased in blank container.

4.2.4.2.2. Trace metal concentration evaluation using ICPMS of peppers stem

Table (4.43): Concentration of analyzed trace metal in stem compared with blank.

Analyzed TM of stem	Concentration mean (ppb)			
	Blank	TM1	TM2	TM3
Cd	2.014	1.663	1.280	0.281
Cr	24.150	27.787	10.436	7.253
Cu	13.503	10.478	8.145	2.332
Zn	52.245	54.460	7.550	15.488

From this table it is noted that all trace metals decreased, moving from first, second, and then to the third container, except Zn which increased in the third container about a double. This was related to the decrease in Cd concentration, due to antagonistic relationship between Zn and Cd.(Dar, et al, 2011).

4.2.4.2.3. Trace metal concentration evaluation using ICPMS of peppers leaves

Table (4.44): Concentration of analyzed trace metal in leaves compared with blank.

Analyzed TM of leaves	Concentration mean (ppb)			
	Blank	TM1	TM2	TM3
Cd	1.782	4.105	2.003	0.729
Cr	22.402	15.954	14.661	11.588
Cu	25.035	14.819	14.189	10.698
Zn	122.219	122.580	71.246	66.223

For Cd concentration in leaves, it was noted that it is decreased, and the first container was elevated from blank container, and the concentration is close to the blank in the second container, but decreased for the third container, this reflects that some of it stoked in the cultivation media and

absorbed by other parts. This corresponds with studies of Kinetics of trace element uptake and release by particles in estuarine water: effects of PH, Salinity, and Particle loading (Hatje et al, 2003). Others finding was that adsorption onto suspended particulate matter and bottom sediments is an important process controlling dissolved metal concentration, bioavailability, and toxicity to biota and both fate and transport of trace metals. (Jannasch et al, 1988), (Comber et al, 1996).

Cu concentration seems to be stable in the second and third containers, but decreased in the third container. Cr also decreased but slowly, Zn concentration in blank and first containers seems to be close to each other in leaves, but it is noted that trace metals concentrations seem to be higher for the blank. This may be related to the presence of some trace metals in the cultivation media, that may have stoked in the gravels. It is also noted that irrigation water uptake and metabolisms of many trace metals are complex and not clearly understood. (Kupper, and Kroneck, 2005).

4.2.4.2.4. Trace metal concentration evaluation using ICPMS of peppers Fruits

Table (4.45): Concentration of analyzed trace metal in fruits compared with blank.

Analyzed TM of fruits	Concentration mean (ppb)			
	Blank	TM1	TM2	TM3
Cd	1.025	1.545	1.162	0.650
Cr	11.817	13.295	10.350	6.680
Cu	0.057	25.839	17.730	10.562
Zn	79.924	81.801	53.997	31.951

It was noted that all trace metals' concentration decreased moving from the first container, to the second, then to the third. Noting that the metabolisms of trace metals antagonistic relationships, effects of salinity on the media and other environmental conditions affecting trace metals uptake, absorption, and accumulation in plant parts. (Kupper, and Kroneck, 2005).

4.2.4.3. Concentration of analyzed trace metals in plant parts for each container

Each trace metal for each container was compared with bell pepper parts, the following figures is classified for each analyzed trace metal for each plant part.

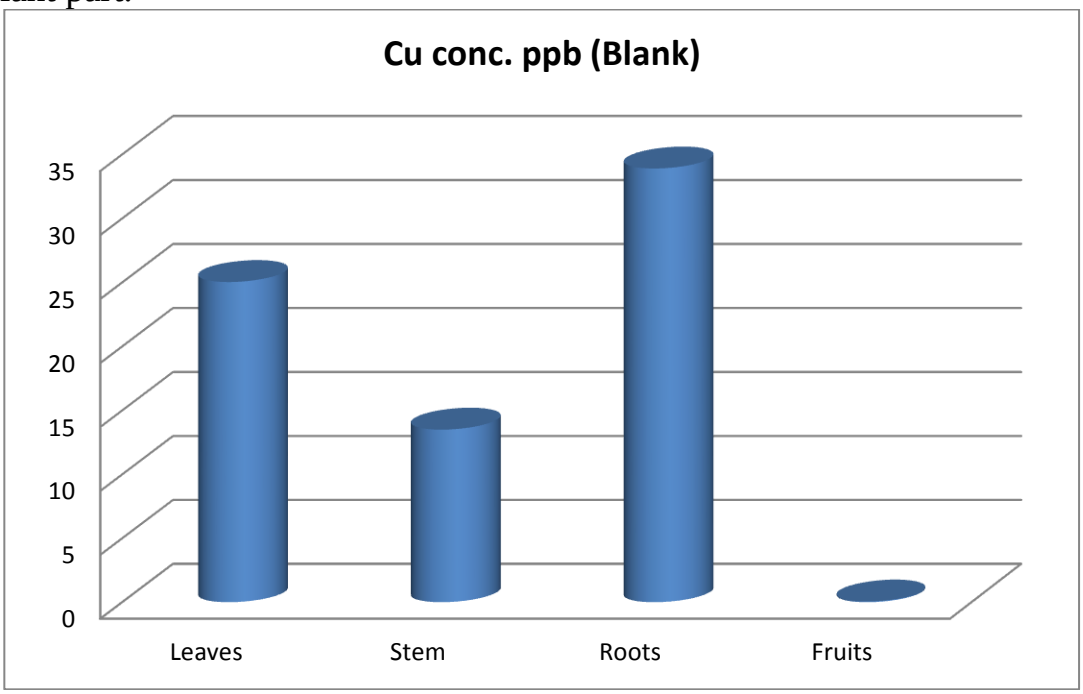


Figure (4.39): Copper concentration of bell pepper parts for blank container.

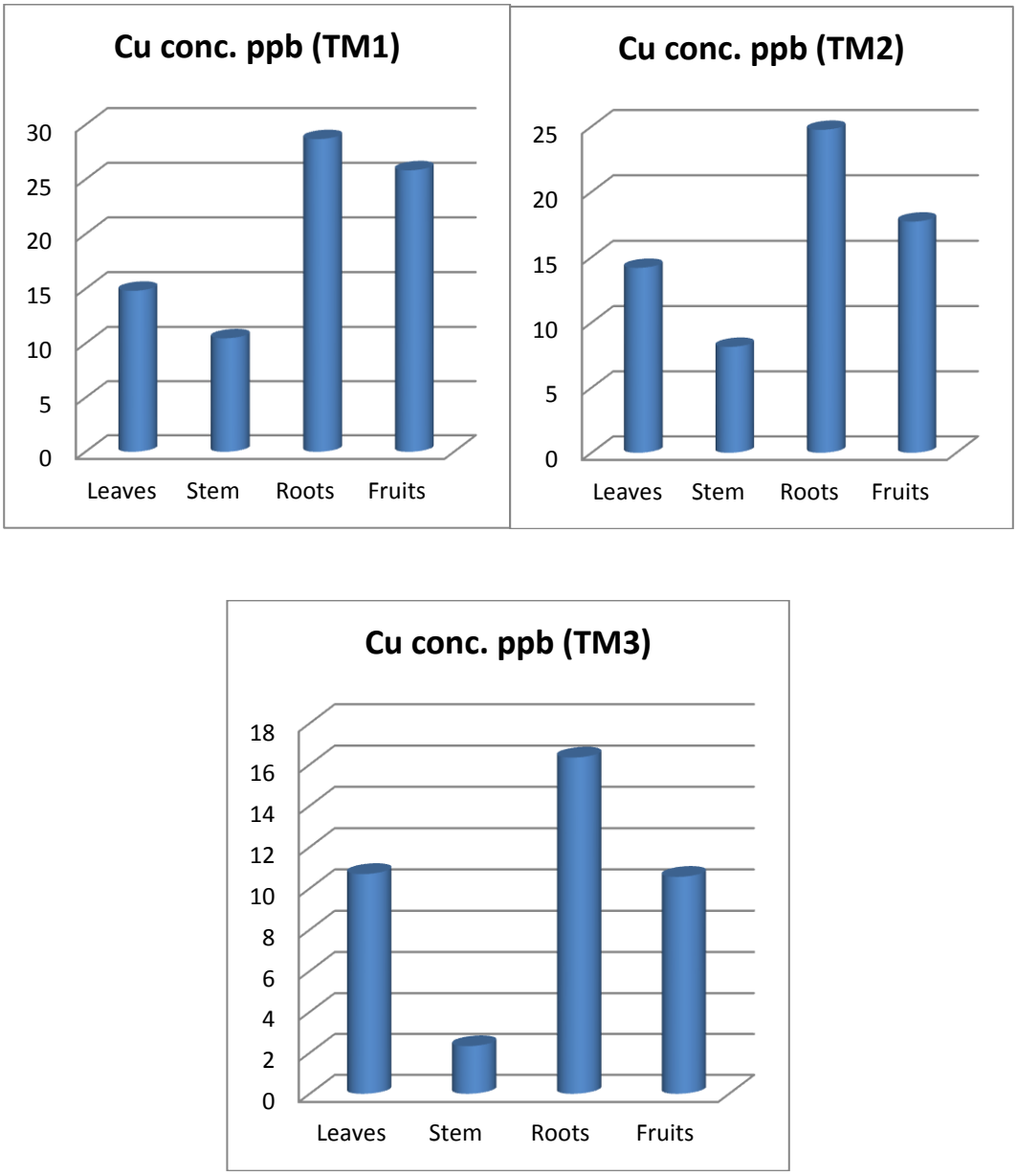


Figure (4.40): Copper concentration of bell pepper parts for first, second, and third TM treatment container.

Cu concentrated in roots, fruits, leaves, then stem, in the first container (TM1). The second and third containers (TM2, TM3), also have the same order with different concentrations, and if compared with the blank it can be noted that fruits are too much affected and high concentration of Cu accumulated within fruits.

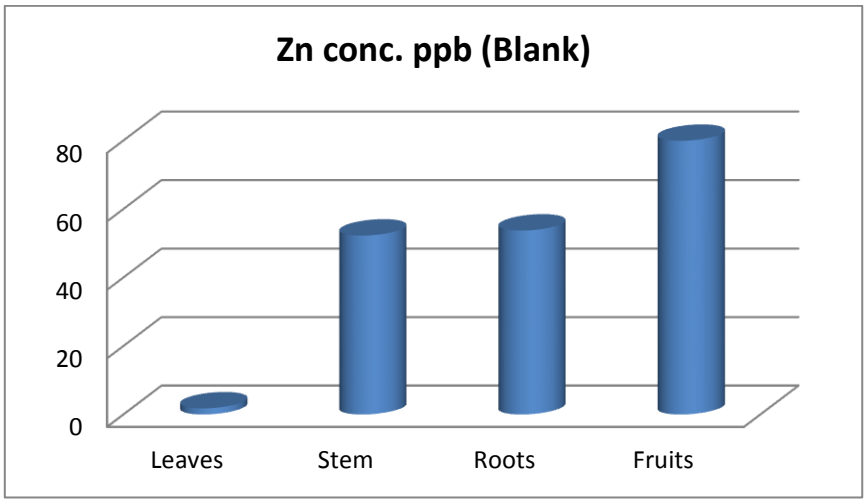


Figure (4.41): Zinc concentration of bell pepper parts for blank container.

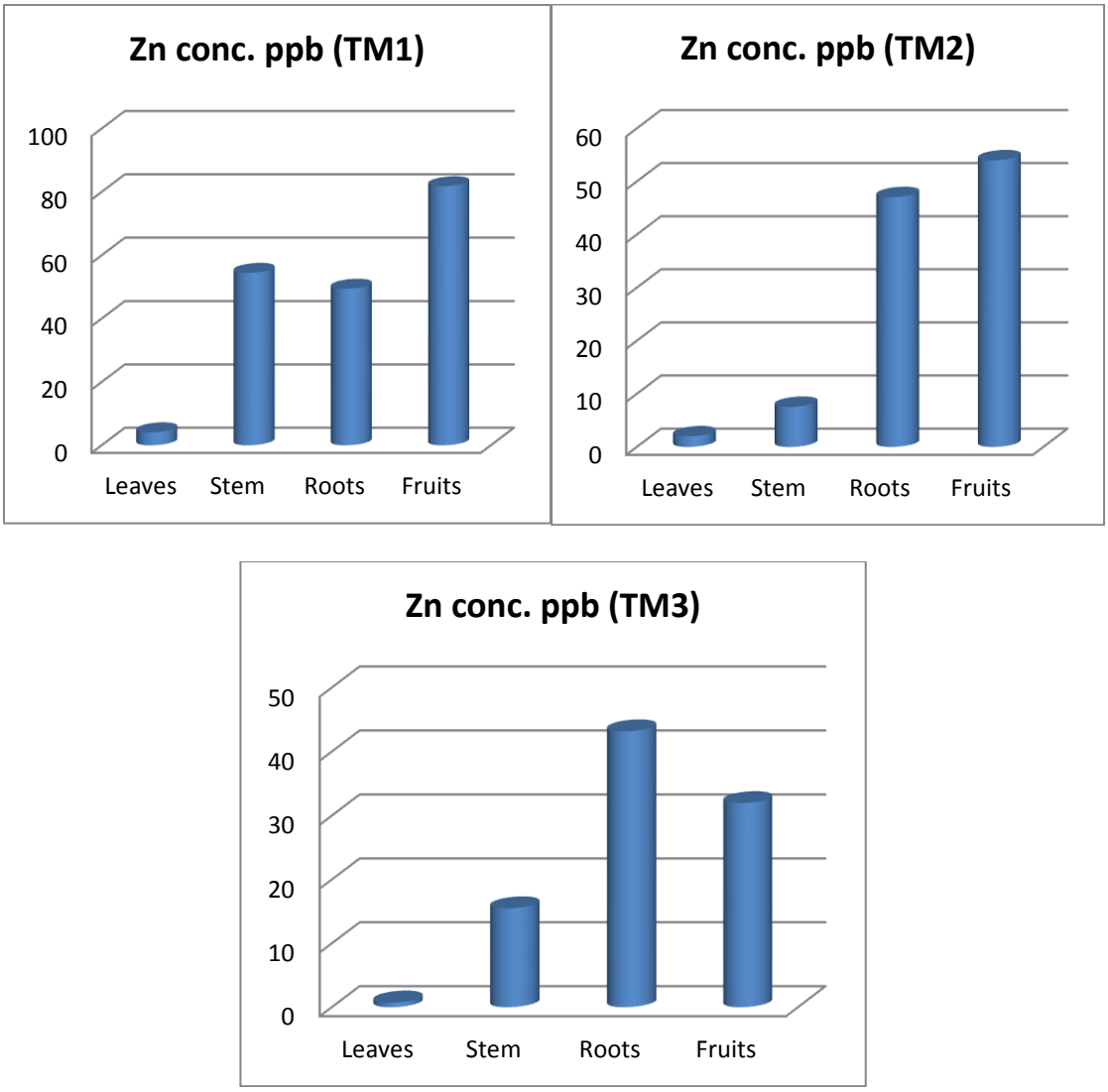


Figure (4.42): Zinc concentration of bell pepper parts for first, second, and third TM treatment container.

Zn concentrated in fruits in the first and second container by decreasing to less than it is roots in the third container; leaves have the lowest Zn concentrations. Roots and stems for blank were much close to each other and roots values had near to each other for the three containers.

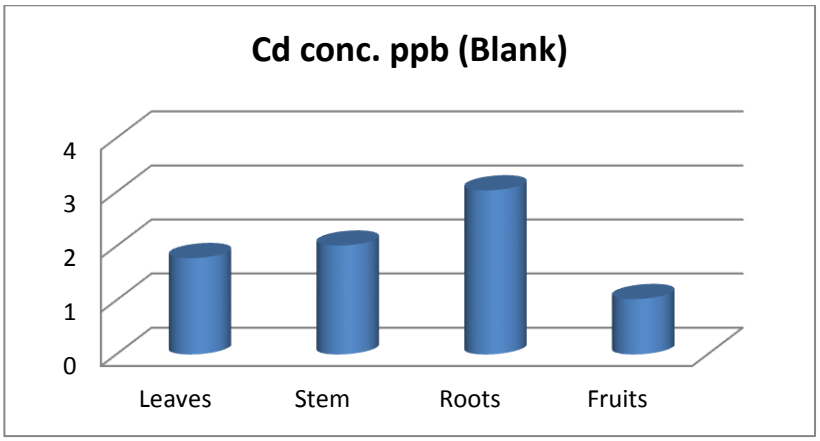


Figure (4.43): Cadmium concentration of bell pepper parts for blank container.

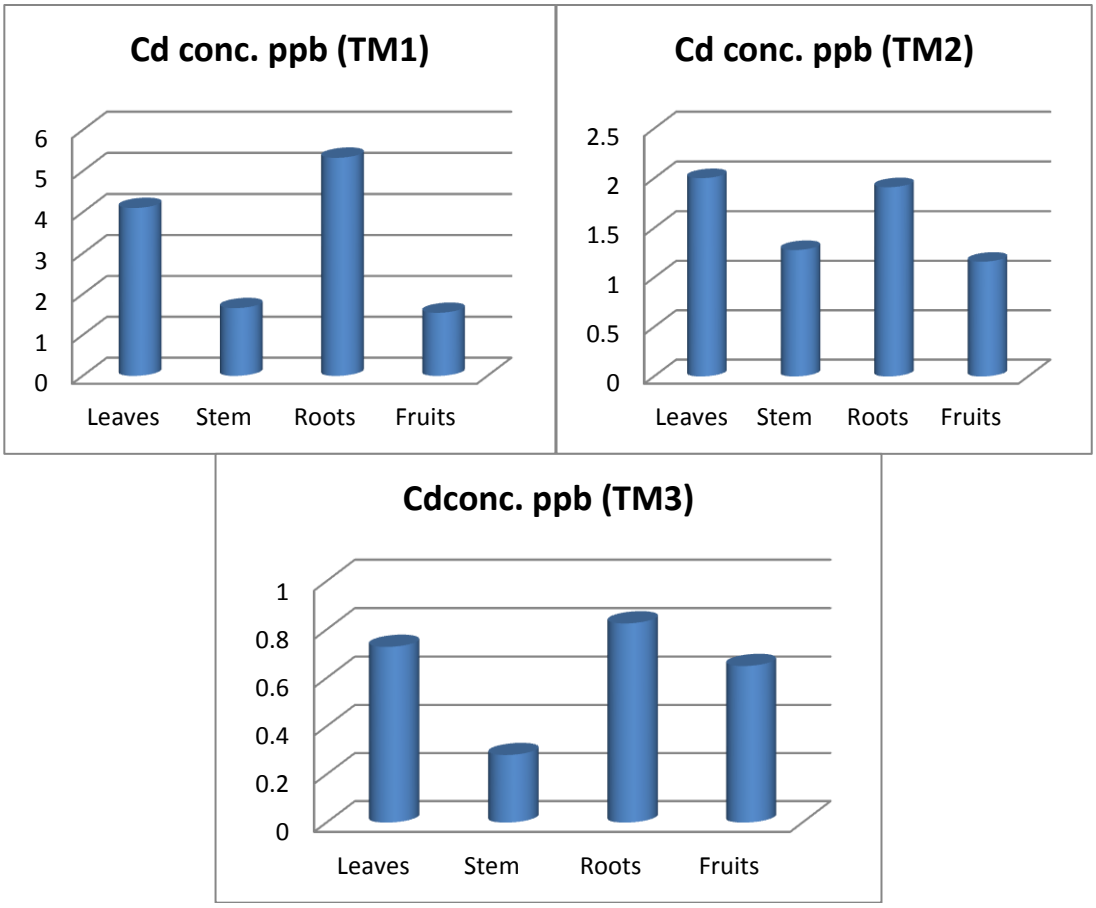


Figure (4.44): Cadmium concentration of bell pepper parts for first, second, and third TM treatment container.

Cd order differs in the three containers and also differs from the blank, but the highest concentrations appear to be in leaves, roots, fruits then stem. Having a look at the blank samples it is noted that Cd concentrations are in roots, stem, leaves, and then fruits.

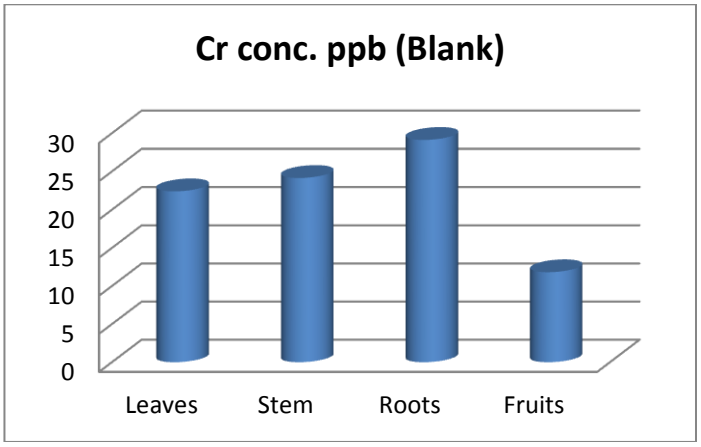


Figure (4.45): Chrome concentration of bell pepper parts for blank container.

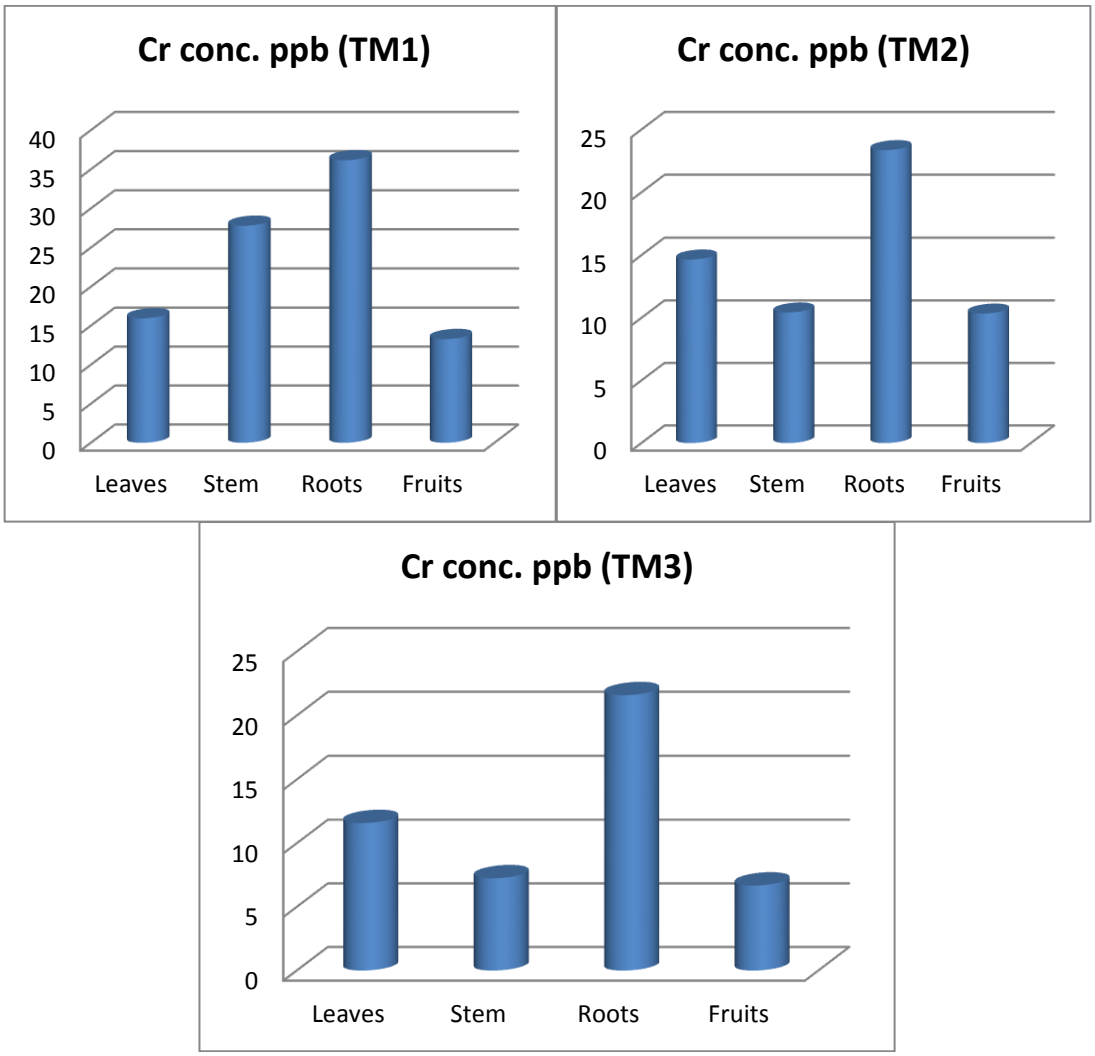


Figure (4.46): Chrome concentration of bell pepper parts for first, second, and third TM treatment container.

Roots have the highest Cr concentration of all bell pepper parts in all containers, even for blank, but the other parts have different orders, and Cr is noted to be concentrated in all plant parts, with lower values of fruits.

Table (4.46): Evaluation of bell pepper parts after adding selected TM.

Experiment containers	Bell pepper parts evaluation after addition of TM					F	Sig. *
Blank	Plant part	Roots	Stem	Leaves	Fruits	0.989	0.431
	Mean TM	92.1893	22.9780	1849.1883	55.7058		
	Standard deviation	140.99263	21.50346	3601.15856	95.80809		
TM1	Plant part.	Roots	Stem	Leaves	Fruit	1.199	0.352
	Mean TM	27.4718	13.1750	72.5843	57.9970		
	Standard deviation	19.32130	11.33803	76.32865	59.97465		
TM 2	Plant part	Roots	Stem	Leaves	Fruit	1.083	0.394
	Mean TM	20.4785	2.4665	23.0275	12.4608		
	Standard deviation	17.50256	3.35602	27.65576	13.61844		
TM 3	Plant part	Roots	Stem	Leaves	Fruit	0.067	0.976
	Mean TM	26.7075	19.2593	23.9505	22.9328		
	Standard deviation	18.16159	23.83052	28.91242	23.01590		

One way ANOVA test in this table shows no statistically significant differences at (α =0.05) on analyzed trace metal in (Root, Stem, Leaves and Fruit) Comparing them with Blank. P values > 0.05.

Table (4.47): Comparison among selected trace metals in bell pepper parts within experiment containers and blank

Experiment containers	Analyzed TM in bell pepper parts					F	Sig. *
Blank	Metal in plant parts	Cd	Cr	Cu	Zn	0.952	0.447
	Mean	2.9640	23.6225	1824.4535	169.0213		
	Standard deviation	1.47788	4.28541	3617.29110	107.37865		
TM 1	Metal in plant parts	Cd	Cr	Cu	Zn	4.175	0.031*
	Mean	2.1148	87.0513	15.3305	66.7315		
	Standard deviation	1.36708	64.29603	7.47345	46.04030		
TM 2	Metal in plant parts	Cd	Cr	Cu	Zn	4.099	0.032*
	Mean	0.9400	11.7770	11.0135	34.7028		
	Standard deviation	0.74417	6.89729	6.28322	26.60964		
TM 3	Metal in plant parts	Cd	Cr	Cu	Zn	49.894	0.000*
	Mean	2.3158	14.7030	19.7985	56.0328		
	Standard deviation	2.04935	6.11522	6.11522	7.15957		

Table (4.47) using one way ANOVA test shows no statistically significant differences at (α =0.05) on analyzed trace metal in (Root, Stem, Leaves and Fruit) Comparing them with Blank for (metals) at P values > 0.05. On the other hand, it shows statistically significant differences at (α =0.05) on analyzed trace metal in (root, stem, leaves and fruit) Comparing them with Blank in (TM 1, TM 2 and TM3) at P value< 0.05. And in order to clarify, these differences, LSD test has been used.

Table (4.48): Determining the differences among the three containers for selected TM.

TM 1	Metal		Cr		Zn
	Cd	Mean differences	-84.93650*		-64.61675
		Sig.	0.011*		0.040*
	Metal		Cd		Cu
	Cr	Mean differences	84.93650*		71.72075*
		Sig.	0.011*		0.025*
TM 2	Metal		Cd	Cr	Cu
	Zn	Mean differences	33.76275*	22.92575*	23.68925*
		Sig.	0.005*	0.040*	0.035*
TM3	Metal		Cd	Cr	Cu
	Zn	Mean differences	53.71700*	41.32975*	36.23425*
		Sig.	0.000*	0.000*	0.000*
	Metal		Cr		Cu
	Cd	Mean differences	-12.38725*		-17.48275*
		Sig.	0.000*		0.000*

LSD test shows that there are differences among the following :

TM 1 container: between (Cd) and (Cr and Zn) for (Cr and Zn) and between (Cr) and (Cu) for (Cr).

TM 2 container: between (Zn) and (Cd, Cr and Cu) for (Zn).

TM 3 container: between (Zn) and (Cd, Cr and Cu) for (Zn) and between (Cd) and (Cr and Cu) for (Cr and Cu).

Table (4.49): Comparison between first and final TM addition in collected water for each container

Treatment		N	Mean	S. deviation	F	Sig. *
TM 1	**First TM addition to irrigation water**	4	12.9530	12.19230	0.065	0.950
	Final TM addition to irrigation water	4	12.3630	13.32518		
TM 2	**First TM addition to irrigation water**	4	9.6880	9.71936	0.853	0.426
	Final TM addition to irrigation water	4	4.9673	5.29650		
TM 3	**First TM addition to irrigation water**	4	11.8953	13.55581	0.749	0.482
	Final TM addition to irrigation water	4	6.1122	7.38709		

T-test independent samples of selected trace metals in collected water sample of first and final TM addition to irrigation water in this table shows no statistical significant differences at (α =0.05) on the of analyzed trace metal in collected water sample after the first and final TM addition to irrigation water.

Table (4.50): Evaluation of selected trace metal in collected water sample of each container

TM addition	Analyzed TM in collected water					F	Sig. *
TM 1	Selected TM	Cd	Cr	Cu	Zn	56.669	0.001*
	Mean	1.6940	26.0225	2.0580	20.8575		
	Standard deviation	0.90510	3.16855	0.56569	3.36654		
TM 2	Selected TM	Cd	Cr	Cu	Zn	6.016	0.058
	Mean	0.3310	6.2980	4.7660	17.9155		
	Standard deviation	0.23193	3.65433	1.85545	7.61059		
TM 3	Selected TM	Cd	Cr	Cu	Zn	2.768	0.175
	Mean	0.0850	17.2850	1.7225	16.9225		
	Standard deviation	0.03677	15.93394	0.07283	0.53245		

One Way ANOVA test shows no statistically significant differences at (α =0.05) on analyzed trace metal in collected water sample in (TM2 and TM3). On the contrary, it shows statistically significant differences at (α =0.05) level on analyzed trace metal in collected water sample in (TM2 and TM3).In order to clarify, these differences, LSD Test has been used.

Table (4.51): Determining the differences among the selected TM for collected water

Metal		Cd	Cu
Zn	Mean differences	19.16350*	18.79950*
	Sig.	0.001*	0.001*
Metal		Cd	Cu
Cr	Mean differences	24.32850*	23.96450*
	Sig.	0.001*	0.001*

From LSD Test it appears that there are differences between (Zn) and (Cd and Cu) for the (Zn). Also, it shows that there are differences among (Cr) and (Cd and Cu) for the (Cr).

Chapter Five

5. Conclusions and recommendations

Based on the results observed in this study, the following concluding remarks were observed:

1. For salinity, it is investigated that the growth is affected rapidly by adding salt to the plant. The plant adverse effects appeared in leaves and the yellowish color of stem and leaves, and the drought of fruits
2. It seems that drought due to the decrease in water irrigation have the same effects of salinity condition for pepper plant, as for other crops like corn and pea in traditional soil agricultural conditions.(Kurunc, et al, 2011).
3. Leaves are directly affected by salinity addition which led to the leaves fall down after the first addition of salinity of high concentration (7000 ppm) of salinity three treatment.
4. Saline water is suitable to irrigate bell pepper plant under special conditions and concentrations. Particularly, under high concentration, represented in the experiment by salinity three treatments, with 7000 ppm, the plant died. But with slightly near to sea water salinity concentration, bell pepper tolerated salinity, survived and yielded, so sea water with hydroponic system can be used to irrigate this crop.
5. Bell pepper can grow and give yield under low and moderate salinity concentrations, under hydroponic system which can solve the problem of soil salinity in many parts at Palestine.

6. Fruit numbers were not affected by the experimental conditions, but it is noted that total dry weight is affected. The number of fruits of high salinity did not decrease, but their dry weight decreased.
7. Salinity affects nutrients' uptake and that is reflected in pepper parts as each plant part will be affected according to its way.
8. It was found that roots and shoots growth are inhibited by salinity, and reproduction development is considered less sensitive to salt stress than vegetative growth.
9. For the trace element, the effect appeared slowly, for the length and the number of leaves, but fruit numbers appeared not to be affected, however the color become more yellow than at the beginning of the growing fruit.
10. Trace metals effects on bell pepper represented by decreasing stem elongation rate, leaves surface, color, and edges show some differences, but generally no other exterior differences appear.
11. Accumulation of trace metals appear to concentrate in different parts of bell pepper but the most serious one is their accumulation in the edible part (fruits), which will affect human health.
12. Hydroponic system represents a very usable system which can be used in Palestine; in case it is suffering from availability of low water resources since low irrigation water quantity can be used.

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Appendix

Table 1:

Container	Plant. No	Fruit				
		Wet	Dry 10g	T.dry.WT	EC (0.5g d wt)	T.EC(µs)
S1 C1	1	31.689	0.5634	1.785358	0.652	130.4
		28.714	0.6127	1.759307	0.395	79
	2	43.274	0.7976	3.451534	0.528	105.6
		43.411	0.7277	3.159018	0.498	99.6
	4	38.02	0.6743	2.563689	0.546	109.2
		40.568	0.5095	2.06694	0.384	76.8
	AvG	**37.61267**	**0.647533**	**2.464308**	**0.5005**	**100.1**
S1 C2	1	25.298	0.7406	1.87357	0.425	85
		37.067	1.0847	4.020657	0.406	81.2
	3	46.026	0.6597	3.036335	0.532	106.4
	AvG	**36.13033**	**0.828333**	**2.976854**	**0.454333333**	**90.86667**
S1C3	1	79.161	1.21	9.578481	0.452	90.4
	2	46.184	1.2878	5.947576	0.295	59
		41.632	0.6732	2.802666	0.492	98.4
	3	89.665	0.6548	5.871264	0.421	84.2
		31.501	0.4924	1.551109	0.304	60.8
		84.691	0.6338	5.367716	0.355	71
	4	109.96	0.3408	3.747437	0.488	97.6
	AvG	**68.97057**	**0.756114**	**4.980893**	**0.401**	**80.2**
S2 C1	1	14.962	1.198	1.792448	0.562	112.4
	2	44.432	1.234	5.482909	0.52	104
		49.449	1.1127	5.50219	0.525	105
	5	29.305	0.922	2.701921	0.523	104.6
	AvG	**34.537**	**1.116675**	**3.869867**	**0.5325**	**106.5**
S2 C2	1	33.897	0.928	3.145642	0.523	104.6
	2	54.398	1.154	6.277529	0.485	97
		42.045	0.99	4.162455	0.478	95.6
	3	53.641	1.13	6.061433	0.457	91.4
		58.685	0.8431	4.947732	0.454	90.8
	4	41.349	0.7621	3.151207	0.465	93
		36.344	0.7846	2.85155	0.473	94.6
	AvG	**45.76557**	**0.941686**	**4.371078**	**0.476428571**	**95.28571**
S2C3	2	51.692	0.9641	4.983626	0.433	86.6
		48.39	0.7509	3.633605	0.553	110.6
	4	83.607	0.6889	5.759686	0.439	87.8
	5	43.697	0.7074	3.091126	0.558	111.6
		60.403	0.8363	5.051503	0.383	76.6
		79.939	0.9174	7.333604	0.433	86.6

	AvG	**61.288**	**0.810833**	**4.975525**	**0.4665**	**93.3**
S3 C1	1	16.4633	2.3266	3.830351	0.559	111.8
	2	7.3197	3.0694	2.246709	0.556	111.2
		7.57	1.7751	1.343751	1.463	292.6
	3	17.9725	3.006	5.402534	0.436	87.2
	AvG	**12.33138**	**2.544275**	**3.205836**	**0.7535**	**150.7**
S3 C2	1	19.4814	1.2305	2.397186	0.5617	112.34
		30.404	1.828	5.557851	0.5341	106.82
		23.6102	1.1134	2.62876	0.5412	108.24
	2	31.6505	1.8983	6.008214	0.4811	96.22
		31.213	1.3267	4.141029	0.4184	83.68
	3	36.005	0.8875	3.195444	0.4347	86.94
	5	35.037	1.6908	5.924056	0.5912	118.24
	AvG	**29.62873**	**1.425029**	**4.264649**	**0.508914286**	**101.7829**
S3 C3	1	35.2185	1.8871	6.646083	0.466	93.2
		32.788	1.2031	3.944724	0.442	88.4
		38.1991	1.3008	4.968939	0.552	110.4
	2	52.4462	1.405	7.368691	0.56	112
		25.7876	2.0024	5.163709	0.532	106.4
		53.6347	0.9488	5.08886	0.5168	103.36
		30.7041	1.5481	4.753302	0.373	74.6
		53.798	0.9206	4.952644	0.396	79.2
	3	32.075	1.0261	3.291216	0.445	89
	5	46.5611	0.8622	4.014498	0.485	97
		35.6973	1.5117	5.396361	0.489	97.8
	AvG	**39.71905**	**1.328718**	**5.053548**	**0.477890909**	**95.57818**
blank	2	95.579	0.4516	4.316348	0.416	83.2
		105.541	0.5554	5.861747	0.364	72.8
		91.388	0.598	5.465002	0.424	84.8
	3	81.517	0.5668	4.620384	0.391	78.2
		107.101	1.029	11.02069	0.319	63.8
		87.344	0.8683	7.58408	0.404	80.8
	4	30.913	0.8222	2.541667	0.396	79.2
		39.487	0.9621	3.799044	0.361	72.2
	5	58.074	0.4854	2.818912	0.381	76.2
	AvG	**77.43822**	**0.704311**	**5.336431**	**0.384**	**76.8**

Table 2:

Container	Plant. No	Root				
		Wet	Dry 10g	T.dry.WT	EC (0.5g dwt)	T.EC(µs)
S1 C1	1	6.398	1.5266	0.976719	0.584	116.8
	2	9.888	1.3349	1.319949	0.396	79.2
	4	9.699	1.5491	1.502472	0.456	91.2
	avg.	**8.661667**	**1.4702**	**1.26638**	**0.478666667**	**95.73333**
S1 C2	1	5.991	2.5572	1.532019	0.415	83
	2	12.757	2.4164	3.082601	0.305	61
	3	5.928	2.8013	1.660611	0.518	103.6
	4	6.282	2.2822	1.433678	0.389	77.8
	5	6.435	2.5322	1.629471	0.523	104.6
	avg.	**7.4786**	**2.51786**	**1.867676**	**0.43**	**86**
S1C3	1	11.32	3.6599	4.143007	0.205	41
	2	9.457	2.8216	2.668387	0.399	79.8
	3	11.247	3.7426	4.209302	0.2307	46.14
	4	4.519	2.9256	1.322079	0.416	83.2
	avg.	**9.13575**	**3.287425**	**3.085694**	**0.33614**	**62.535**
S2 C1	1	7.258	1.3217	0.95929	0.726	145.2
	2	13.216	2.4016	3.173955		0
	4	16.194	1.2837	2.078824	0.817	163.4
	5	9.036	1.8543	1.675545	0.765	153
	avg.	**11.426**	**1.715325**	**1.971903**	**0.577**	**115.4**
S2 C2	1	14.339	2.4734	3.546608	0.589	117.8
	2	8.818	1.3601	1.199336	0.47	94
	3	22.042	5.8639	12.92521	0.59	118
	4	1.202	0.3161	0.037995	0.631	126.2
	5	13.627	2.2968	3.129849	0.356	71.2
	avg.	**12.0056**	**2.46206**	**4.167799**	**0.5272**	105.44
S2C3	2	48.831	1.28931	6.29583	0.327	65.4
	4	8.507	2.0089	1.708971	0.405	81
	5	48.285	1.6039	7.744431	0.515	103
	avg.	**35.20767**	**1.634037**	**5.249744**	**0.415666667**	**83.13333**
S3 C1	1	1.612	0.6227	0.100379	0.685	137
	2	3.1301	1.131	0.354014	0.62	124
	3	5.321	1.0523	0.559929	0.437	87.4
	4	1.3321	0.7419	0.098828	0.591	118.2
	5	1.3299	0.6774	0.090087	0.834	166.8
	avg.	**2.54502**	**0.84506**	**0.240648**	**0.6334**	**126.68**
S3 C2	1	10.3697	2.8175	2.921663	0.49	98
	2	16.0452	4.8235	7.739402	0.543	108.6
	3	8.7753	2.7313	2.396798	0.542	108.4

	4	9.1201	3.6694	3.346529	0.534	106.8
	avg.	**11.07758**	**3.510425**	**4.101098**	**0.52725**	**105.45**
S3 C3	1	20.611	7.9445	16.37441	0.484	96.8
	2	26.6041	9.2733	24.67078	0.545	109
	3	10.531	2.3654	2.491003	0.423	84.6
	avg.	**19.2487**	**6.527733**	**14.51206**	**0.484**	**96.8**
Blank	2	8.24	5.059	4.168616	0.1441	28.82
	3	6.811	3.893	2.651522	0.237	47.4
	4	7.093	3.9238	2.783151	0.3	60
	5	6.199	1.0169	0.630376	0.433	86.6
	avg.	**7.08575**	**3.473175**	**2.558416**	**0.278525**	**55.705**

Table 3:

Container	Plant. No	Leaves				
		Wet	Dry 10g	T.dry.WT	EC (0.5g dwt)	T.EC(µs)
S1 C1	1	25.795	1.7867	4.608793	0.535	107
	2	61.247	1.9419	11.89355	0.65	130
	4	26.173	1.8309	4.792015	0.566	113.2
	avg.	**37.73833**	**1.853167**	**7.098121**	**0.583667**	**116.7333**
S1 C2	1	37.689	2.7782	10.47076	0.582	116.4
	2	6.511	0.8662	0.563983	0.574	114.8
	3	12.252	1.8391	2.253265	0.448	89.6
	4	20.744	1.9477	4.040309	0.627	125.4
	5	7.074	1.0533	0.745104	0.504	100.8
	avg.	**16.854**	**1.6969**	**3.614684**	**0.547**	**109.4**
S1C3	1	45.147	2.5287	11.41632	0.492	98.4
	2	25.012	2.7648	6.915318	0.501	100.2
	3	55.729	2.0803	11.5933	0.476	95.2
	4	23.904	2.7841	6.655113	0.498	99.6
	avg.	**37.448**	**2.539475**	**9.145014**	**0.49175**	**98.35**
S2 C1	1	25.977	1.2177	3.163219	0.766	153.2
	2	40.005	2.8156	11.26381	0.725	145
	4	24.503	1.2002	2.94085	0.797	159.4
	5	37.501	1.4868	5.575649	1.213	242.6
	avg.	**31.9965**	**1.680075**	**5.735881**	**0.87525**	**175.05**
S2 C2	1	29.71	2.22694	6.616239	0.735	147
	2	19.383	1.9491	3.777941	0.886	177.2
	3	37.027	2.3857	8.833531	0.768	153.6
	4	32.497	2.1981	7.143166	0.816	163.2
	5	15.385	2.6137	4.021177	0.726	145.2
	avg.	**26.8004**	**2.274708**	**6.078411**	**0.7862**	**157.24**
S2C3	2	1.801	0.1042	0.018766	0.224	44.8
	4	19.129	2.9417	5.627178	0.589	117.8
	5	85.752	1.9273	16.52698	0.695	139
	avg.	**35.56067**	**1.657733**	**7.390976**	**0.502667**	**100.5333**
S3 C1	1	12.0252	1.108	1.332392	2.12	424
	2	20.8121	0.9701	2.018982	2.335	467
	3	20.5432	1.6198	3.327588	1.835	367
	4	9.9451	1.4465	1.438559	0.848	169.6
	5	46.1121	1.3478	6.214989	1.236	247.2
	avg.	**21.88754**	**1.29844**	**2.866502**	**1.6748**	**334.96**
S3 C2	1	29.885	1.7431	5.209254	0.7431	148.62
	2	31.4591	1.4125	4.443598	0.848	169.6
	3	41.753	2.2608	9.439518	0.874	174.8

	4	30.591	1.2424	3.800626	1.287	257.4
	avg.	**33.42203**	**1.6647**	**5.723249**	**0.938025**	**187.605**
S3 C3	1	55.93	1.8095	10.12053	0.718	143.6
	2	59.153	1.8763	11.09888	0.872	174.4
	avg.	**57.5415**	**1.8429**	**10.60971**	**0.795**	**159**
Blank	5	62.813	3.1897	20.03546	0.456	91.2
	2	52.291	1.9998	10.45715	0.447	89.4
	3	49.907	3.246	16.19981	0.546	109.2
	4	20.56	1.6193	3.329281	0.427	85.4
	avg.	**46.39275**	**2.5137**	**12.50543**	**0.469**	**93.8**

Table 4:

Container	Plant. No	Stem				
		Wet	Dry 10g	T.dry.WT	EC (0.5g dwt)	T.EC(µs)
S1 C1	1	13.127	0.9179	1.204927	0.514	102.8
	2	22.331	1.6112	3.597971	0.679	135.8
	4	18.877	1.7548	3.312536	0.605	121
	avg.	**18.11167**	**1.427967**	**2.705145**	**0.599333333**	**119.8667**
S1 C2	1	19.354	1.6801	3.251666	0.478	95.6
	2	13.433	2.9039	3.900809	0.679	135.8
	3	22.862	2.594	5.930403	0.469	93.8
	4	11.936	2.3382	2.790876	0.606	121.2
	5	9.827	2.1476	2.110447	0.405	81
	avg.	**15.4824**	**2.33276**	**3.59684**	**0.5274**	**105.48**
S1C3	1	23.085	3.2648	7.536791	0.558	111.6
	2	13.178	2.9871	3.9364	0.309	61.8
	3	29.8411	3.625	10.8174	0.556	111.2
	4	11.033	3.2911	3.631071	0.328	65.6
	avg.	**19.28428**	**3.292**	**6.480415**	**0.43775**	**87.55**
S2 C1	1	17.211	2.0625	3.549769	0.907	181.4
	2	27.74	1.3438	3.727701	0.589	117.8
	4	17.66	1.6335	2.884761	1.195	239
	5	26.632	1.6089	4.284822	0.671	134.2
	avg.	**22.31075**	**1.662175**	**3.611763**	**0.8405**	**168.1**
S2 C2	1	26.437	1.7925	4.738832	0.657	131.4
	2	14.27	2.1329	3.043648	0.825	165
	3	28.715	3.0698	8.814931	0.822	164.4
	4	27.625	2.0806	5.747658	0.602	120.4
	5	25.672	1.0689	2.74408	0.652	130.4
	avg.	**24.5438**	**2.02894**	**5.01783**	**0.7116**	**142.32**
S2C3	2	53.095	2.0996	11.14783	0.689	137.8
	4	11.037	1.3887	1.532708	0.695	139
	5	89.98	1.7899	16.10552	0.627	125.4
	avg.	**51.37067**	**1.7594**	**9.595352**	**0.670333333**	**134.0667**
S3C1	1	20.0341	2.5826	5.174007	1.91	382
	2	21.2248	2.0887	4.433224	2.36	472
	3	15.9494	4.8149	7.679477	2.31	462
	avg.	**19.06943**	**3.162067**	**5.762236**	**2.193333333**	**438.6667**
S3 C2	1	34.9048	2.3049	8.045207	0.907	181.4
	2	35.3079	1.8981	6.701792	1.95	390
	3	22.0092	1.4806	3.258682	0.826	165.2
	4	25.4913	3.1685	8.076918	0.965	193
	avg.	**29.4283**	**2.213025**	**6.52065**	**1.162**	**232.4**

S3 C3	1	49.08726	2.7262	13.38217	0.756	151.2
	2	44.8105	1.9995	8.959859	0.544	108.8
	3	11.0461	2.0642	2.280136	0.847	169.4
	avg.	**34.98129**	**2.2633**	**8.207388**	**0.715666667**	**143.1333**
Blank	2	22.006	5.306	11.67638	0.347	69.4
	3	10.385	4.0715	4.228253	0.357	71.4
	4	5.477	4.287	2.34799	0.502	100.4
	5	4.23	1.2393	0.524224	0.495	99
	avg.	**9.467**	**3.416125**	**4.563157**	**0.3015**	**85.05**

Table 5:

Container	Plant. No	03-Jun			11-Jun			17-Jun			25-Jun		
		Stem tall	Leaves no.	Buds no.	Stem tall	Leaves no.	Buds no.	Stem tall	Leaves no.	Buds no.	Stem tall	Leaves no.	Buds no.
S1 C1	1	9.5	5		14	10		17.5	15	3	23.5	23	10
	2	6	4		10	10		16.5	14	3	23.5	26	8
	3	9	6		12.5	5		14	5	1	16.5	5	
	4	9	7		12.5	8		15	11	1	20	17	6
	5	6	5		11.5	5		11.5	5		12	5	
S1 C2	1	10.5	6		12	8		14	10		16.5	15	5
	2	7	6		10	9		13	11		16	14	3
	3	9	5		11	10		13	13	2	15	17	4
	4	11	6		14	10		17	15	1	24	24	6
	5												
s1 c3	1	14	6		17	14	1	21	18	3	26	21	9
	2	10	5		12	4		13	6		14	8	2
	3	7	6		9	7		12	9		13.5	11	3
	4	9.5	6		13.5	12	1	18	14	5	23	27	11
	5	8	7		9	8		13	11	1	16	15	4
S2 C1	1	10.5	5		13.5	9	1	15.5	10	3	20.5	15	7
	2	10	6		12	10	1	20	15	6	25	30	14
	3	8	6		10	9		11	9		12	9	
	4	12	9		15	13	3	20	15	4	24	24	8
	5	12	8		14	13		17	19	3	22	26	6
S2 C2	1	8.5	4		12	7		17	11	3	20.5	23	9
	2	7.5	6		12	11		16.5	17	5	23	25	9
	3	8	7		11	11	1	20	21	8	25	46	16
	4	9	4		12	6	1	14	10		14	11	1
	5	11.5	7		15	13	1	16.5	17	4	22	30	11
S2 C3	1	9	2		10	3		10	جافة7		10	7	
	2	9	5		11	10		17.5	13	2	23.5	22	10
	3	10	5		14	8		12	5		12	6	
	4	8.5	5		10	4		12	10	1	15	13	4
	5	7 7	5 4		9 9	8 7		11.5 11.5	10 10	3 3	17 17	14 14	4 3
S3 C1	1	11	6		15	12	1	19	18	5	24.5	34	13
	2	10	7		14	15	1	17	18	5	21.5	27	12
	3	11	7		15.5	13	1	19.5	17	8	24.5	27	7
	4	11	6		13	12	1	16	15	3	20.5	25	10
	5	13	7		16	14	1	18.5	20	5	22.5	29	10
S3 C2	1	9	5		11.5	9	1	16	13	2	18	21	8
	2	10	6		13	12	1	17.5	18	4	24	26	11

	3	13.5	10		16	17	4	18	17	4	25	31	12
	4	10	4		13	7		14	10	1	15	12	6
	5	9.5	5		12	13	1	20	19	6	27	27	12
S3 C3	1	13	10		17	24	2	24	39	13	32	64	29
	2	10	8		13.5	13	1	20	20	5	26	34	16
	3	12	7		15	13	1	19	17	4	21.5	22	8
	4	9	5		11	3		12	4		11.5	5	1
	5	12	5		16.5	8	1	16.5	13	4	21.5	18	7
Trace metals 1	1	10	5		13	9	1	17.5	19	4	22	35	11
	2	9	5		12	8		13	13	1	16	26	5
	3	10.5	6		13.5	11	3	17	19	9	19	28	15
	4	7	5		12	11	1	16	17	4	20	29	10
	5	10	6		12.5	8	1	14.5	13	2	17	17	7
trace metals2	1	6	5		11	9		13	11	1	13	16	4
	2	10	6		13	9	1	15	13	3	20	23	7
	3	6	4		10	9		14.5	18	1	18.5	24	4
	4	4	4		6	6		9	12	1	14.5	18	4
	5	7	6		11	9		14	13	3	19	25	10
trace metals3	1	8	5		12	6	1	15	17	4	17	13	4
	2	9	5		12	8	1	14	11	1	18	20	6
	3	9	6		12	10		13	11	1	21	29	11
	4	7	4		12	6		15	15	4	17	20	7
	5	11	5		12.5	5جافة		12	6جافة		13.5 جافة	5	
blank	1	10		بدون اوراق	10	بدون اوراق		10	6		10	7	
	2	9	10		13.5	15	1	20	25	10	25	34	19
	3	11	10		15	16	2	18.5	23	6	23.5	41	17
	4	10	8		13.5	14	1	19.5	30	9	22.5	60	17
	5	12	5		15	8	1	16	14	4	20	22	8

Table 6 :

container	Plant. No	04-Jul			10-Jul			14-Jul			28-Jul		
		Stem tall	Leaves no.	Buds no.	Stem tall	Leaves no.	Buds no.	Stem tall	Leaves no.	Buds no.	Stem tall	Leaves no.	Fruits no.
S1 C1	1	27	37	15+2f	30	40	15+f2	32	48	15+2f	32	15	2
	2	34	69	30+f	37	73	33+f2	40	79	31+2f	41	60	2
	3	dry											
	4	26	46	15+2f	27.5	49	16+f2	30	54	16+2f	33	49	2
	5	12	4	1	12	3		12			12		
S1 C2	1	18	19	5+2f	20.5	26	7+f2	23	30	7+2f	25	19	2
	2	18.5	21	8	23	27	8	29	36	11	30	20	
	3	23	32	9+f	29	37	12+f	35	44	12+f	35	41	1
	4	28.5	39	12	34	46	12	42	52	14	46	45	
	5	23	26	17+f	30	35	8+f	35	40	7+f	35	45	1
s1 c3	1	34	48	25+f	41	60	25+f	44	64	25+f	46	58	1
	2	19.5	19	6	20.5	29	10	24	35	12	29	38	
	3	20.5	25	9+f	22	36	13+f2	23	41	15+2f	25	42	2
	4	33	64	22+f3	42	79	27+f3	48	83	30+f3	48	88	3
S2 C1	1	28	44	17+f	30	54	16+f	37	51	14+f	38	53	1
	2	34	74	30+f	39	80	30+2f	44	75	28+2f	46	66	2
	3	12	12		12	10		Dry died					
	4	27	54	19+2f	27	59	19	39	60	18	41	55	
	5	30	49	19+f	31	60	23+f	40	55	24+2fff	40	49	1
S2 C2	1	28	59	18+f	32	55	20+f	35	56	35+f	36	51	1
	2	28	36	11+f	30	40	11+2f	33	39	33+2f	36	43	2
	3	34	73	28+2f	39	76	28+2f	41.5	77	25+2f	42	80	2
	4	15	15	3	15	11	3	15	7	3	15.5	8	
	5	31.5	51	16+2f	32	55	16	34	46	14	35	48	
S2 C3	1	dry											
	2	31	71	28+2f	39	77	30+2f	45	86	35+2f	48	92	2
	3	12	7	1	12	8	1	12	19	1	12	26	
	4	22	24	7+f	27	30	13+f	32	40	16+f	36	42	1
	5	27 27	31 28	11 6 +3f	35 35	42 38	14 8+f	39 40	46 44	14 11+3f	40 42	48 46	3
S3 C1	1	33	108	29+f	34	99	19+f	34	40	6+f	34	20	1
	2	29	58	27+f	29	51	15+f	29	20	5+2f	30	11	2
	3	26	48	16+f	28	40	13+f	28	19	2+f	28	10	1
	4	28	58	23	29	50	19	30	25	11	31	9	
	5	30	57	20	30	49	15	33	30	11	33.5	13	
S3 C2	1	26	55	25+3f	28	51	23+f3	28	5	17+f3	28	7	3
	2	32	69	+ت2	35	60	26+f2	36	60	24+2f	38	49	2

				26									
	3	31	70	20+f	34	65	18+f	34	64	18+f	35	60	1
	4	17	17	7	17	17	6	17.5	16	6	18	19	
	5	34	59	22+f	36	51	21+f	36	50	19+f	38	52	1
S3 C3	1	40	117	46+f3	45	121	46+f3	45	122	47+f3	48	126	3
	2	34	93	40+f	39	100	37+f5	40	111	37+f5	44	119	5
	3	25	33	12+f	30	39	12+f	31	31	14+f	35	36	1
	4	13.5	8	1	14	8	1	17	8	1	20	6	
	5	25	34	13+2f	32	39	14+f	34	14	14+f2	38	15	2
Trace metals 1	1	26	64	20+f	27	67	19+f	32	71	20+f	32	70	1
	2	25	59	20+f	25	66	20+f	30	75	20+f	31.5	80	1
	3	21	50	17+f	22	61	16+f	29	79	18+f	31	82	1
	4	23	69	25+f	26	77	27+f	33	83	20+f	33	86	1
	5	23	51	16	23	52	16	31	60	16	32	66	
trace metals2	1	22	46	16	27	50	18	29	56	18	32	59	
	2	24	53	22+f	27	59	23+f	31	63	23+f	35	66	1
	3	27	57	27+f	33	63	27+f	36	70	29+f	40	74	1
	4	23	51	18	29	59	18	33	65	18	37	72	
	5	27	49	15+f	31	53	16+f	37	57	15+f	45	63	1
trace metals3	1	21	23	8+f	27	30	8+f	35	39	7+f	40	49	1
	2	22	53	18+f	28	60	20+f	39	70	22+f	45	76	1
	3	29	90	34+f	35	111	35+f	40	115	35+f	47	120	1
	4	26	63	20+3f	36	71	20+f3	41	75	22+f	45	82	3
	5	dry											
Blank	1	10.5	7		10.5	7		11	7		11	5	
	2	31	78	30+f	37	98	29+f3	43	106	29+f3	49	110	3
	3	28	84	30+f	33	114	32+f3	35	123	33+f3	41	130	3
	4	28	100	28+2f	35	137	28+2f	37	141	29+2f	40	151	2
	5	30	34	9+f	33	47	14+f	41	53	14+f	49	60	1

جامعة النجاح الوطنية

كلية الدراسات العليا

تقييم تأثير العناصر الخفيفة المختارة والملوحة على نمو وعطاء وامتصاص الفلفل المزروع بنظام مائي عمودي ومتدرج

إعداد

نور (لطفي محمد) حسان الحسين

إشراف

أ.د مروان حداد

قدمت هذه الاطروحة استكمالا لمتطلبات الحصول على درجة الماجستير في العلوم البيئية بكلية الدراسات العليا في جامعة النجاح الوطنية في نابلس ، فلسطين

2014

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الملخص

تهدف هذه الدراسة الى تقييم نمو وانتاجية الفليفلة الحلوة تحت ظروف خاصة في تجربتين، الاولى مع ثلاثة معاملات ملوحة بتراكيز مختلفة من كلوريد الصوديوم، والثانية باستخدام بعض المعادن الثقيلة المختارة وهي (النحاس، الكروم، الكادميوم، والخارصين)، وكلاهما تحت نظام زراعة مائي عمودي ومتدرج.

شيدت التجربة باستخدام 26 وعاء، رتبو على شكل ازواج واحد لزراعة الفليفلة والاخر اجمع المياه المتسربة، ورتبت على شكل صفوف بحيث يمثل كل صف نوع معاملة مختلفة، وترك الصف الخامس بزوج واحد من الاوعية لعينات المرجع.

كانت المياه المجمعة من ري النبات من الوعاء الاول في كل صف تستعمل لري الوعاء اللاحق لنفس الصف، عومل الصف الاول بمعاملة الملوحة الاولى (S1) بتركيز 1000 ppm ، والصف الثاني بمعاملة الملوحة الثانية (S2) بتركيز 3000 ppm ، والصف الثالث بمعاملة الملوحة الثالثة (S3) بتركيز 7000 ppm ، بينما عومل الصف الرابع بالمعادن الثقيلة المختارة وبتركيز ppm 0.2 لكل عنصر.

كانت المياه نحرك يوميا بشكل يدوي وتم احصاء عدد الاوراق والبراعم والثمار وأطوال السيقان قبل وبعد اضافة محاليل الملوحة والمعادن الثقيلة.

قيست الملوحة بجهاز قياس الايصالية الكهربائية (EC) بوحدة (µs) بينما فحصت تراكيز المعادن الثقيلة المختارة باستخدام جهاز (ICPMS). ظهرزيادة مضطردة لاجزاء الفليفلة الحلوة الى حين

اضافة المحاليل حيث بدأت أجزاء النبات بالتأثر باضافة المحاليل وظهر ذلك من خلال تأثر الاوراق الذي بدى واضحا من خلال تساقطها وفقد الارتباط مع الساق، وظهرت فروق احصائية عند (α =0.05) على تراكيز الملوحة العالية الممثلة بمعاملة الملوحة الثالثة (S3) وكذلك الامر للساق والجذور بينما ظهرت الفروق الاحصائية على الثمار لمعاملة الملوحة الاولى (S1) وبالذات للوعاء الاول ، ولكنها لم تظهر أي فروق احصائية عند المقارنة مع تراكيز المعاملات مجتمعة مما يدل على عدم تأثر عدد الثمار بالملوحة بشكل واضح.

أما بالنسبة لتجربة المعادن الثقيلة المختارة فقد تركز النحاس في الجذور والخارصين في الثمار أما الكادميوم فقد أعطت الجذور والاوراق اعلى تراكيز له ، وتركز الكروم بشكل أساسي في الجذور مع الاخذ بعين الاعتبار ان بعض هذه المعادن كانت ذات تأثيرات متضادة والذي انعكس على اختلاف تركيز هذه المعادن في أجزاء الفليفلة الحلوة وبدى التأثر الخارجي للنبات غير واضح وبالنسبة لنبات الفليفلة الحلوة فإن خطورة هذه المعادن تتمثل بتراكمها في الثمار التي تشكل الجزء الذي يؤكل.