An-Najah National University

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Evaluation of Salinity and Selected Trace Metals Impacts on Muskmelon Growth, Yield, and Uptake Grown in Horizontal Hydroponic System

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Dedication

To my mother with respect and love

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الإقرار

أنا الموقع/ة أدناه, الرسالة التي تحمل العنوان:

Evaluation of Salinity and Selected Trace Metals Impacts on Muskmelon Growth, Yield, and Uptake Grown in Horizontal Hydroponic System

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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.

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List of Abbreviations

NaCl	Sodium Chloride
km^2	Square kilometer
mm	millimeter
mcm	million cubic meter
$NO3^-$	Nitrate
mol/ m^3	mole per Cubic meters
Na^+	Sodium
Cl^-	Chloride
mM	millimoler
SEB	Society for Experimental Biology
K	Potassium
H	Hydrogen
SOS1	SON OF SEVENLESS PROTEIN1
Zn	Zinc
Cu	Copper
Pb	Lead
Cd	Cadmium
Ni	nickel
Fe^{3+}	ferric
Fe^{+2}	ferrous
DNA	Deoxyribonucleic acid
CO_2	Carbon dioxide
Mg^{+2}	magnesium
NDF	Neutral Detergent Fibers
FAA	Free Amino Acid
TSS	Total Soluble Solid
$CuSO_4$	Copper Sulfate
PVC	Polyvinyl Chloride
NFT	Nutrient Film Technique
ppm	Part per million
Cr	Chrome
Cm	centimeter
Ml	milliliter
H_2O_2	Hydrogen Peroxide
HNO3	Nitric Acid
ICP-MS	Inductively Coupled Plasma Mass Spectroscopy
ANOVA	Analysis of variance
SPSS	Statistical Package for the Social Sciences
LSD	Least Significant Difference
µM	Micromoler

mg/l	milligram per liter
p	probability
RFwt	Root Fresh Weight
FFwt	Fruit Fresh Weight
SDwt	Stem Plus Leaves Dry Weight
FDwt1	Fruit Dry Weight 1
FDwt2	Fruit Dry Weight 2
SFwt	Stem Plus Leaves Fresh Weight
RDwt	Root Dry Weight
gm	gram
EC	Electrical Conductivity
WREC	Electrical Conductivity for Whole Root
5g SEC	Electrical Conductivity for Five grams of stem plus leaves
5g FEC	Electrical Conductivity for Five grams of Fruit
µS	microsiemens
ppb	part per billion
mg/kg	milligram per kilogram
WHO/FAO	World Health Organization/Food and Agricultural organization
Mn	Manganese
Ca	Calcium
µg/g	Microgram per gram
DW	Dry Weight
As	Arsenic

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Abstract

Salinity and metals have a strong impact on plants. This study was conducted to evaluate the impacts of salinity and selected trace metals on muskmelon (*Cucumis melo L.*) growth, yield, and uptake grown in horizontal channels using a hydroponic system established at a model greenhouse at An-Najah National university. Plants were subjected to four salinity treatment including: 0 (control), 1000, 3000, 7000 ppm of NaCl . while three metals treatment were used including: 0, .1, .2 ppm of Cd, Cr, Cu, Zn. Data of plant height, number of leaves, and fresh and dry weight was taken. The uptake of NaCl was analyzed using electrical conductivity, and the uptake of metals was analyzed by ICP-MS.High concentrations of salt and metals cause a significant reduction on melon height and number of leaves. The weight of several melon parts was increased after salinity and metals treatment upto 3000, and .1 ppm of salt and metals, respectively, and start to decline at higher concentration this could be due to a nourishment effect up to certain level, and toxicity effect at higher concentrations. The uptake of salt and metals was increased with the increase of concentration.

Chapter One
Introduction

Chapter One

Introduction

1.1 Importance of study

Stalinization is a major problem facing the agricultural section in Palestine, there is a great need for finding solutions to this problem. A major solution for salinity is soil leaching which is not practical in our situation due to scarcity of water, thus, the need for finding alternative solutions is important. Solutions for such situation include: replacement of field crop with trees, use of tolerant plant species which can be obtained through gene manipulation, determination of plant needs and growth requirement and the use of soilless media.[1] More attention should be paid by the various governmental bodies concerned in this issue and mainly Ministry of Agriculture for the search for best solutions that may solve the problem of salinity and heavy metals in order to save this vital section of the Palestinian economy.

1.2 General back ground

Plants are entirely dependent on their environment and soil contents of water and elements are a major limiting factor of growth and survival of most plants. Many of these elements and minerals are considered as essential nutrients for plants. Salinity occurs when soluble salts mainly NaCl are raised in soil and water. Saline soils occur mainly in arid or semi-arid areas and can arise from natural processes like weathering of mineral rocks and these are called primary salinity. In these arid areas, there is often inadequate rainfall or drainage to leach the salt down through the soil so it

can leach away from plant roots. In addition to this, secondary salinity can occur from human intervention. In agricultural areas, the land is cleared of native vegetation such as perennial shrubs and trees with deep roots and replaced with shallow-rooting crop plants. This causes the underground water table to rise, moving salts up to the soil surface. Irrigation water is also often saline in these areas and adds to the level of salts that the plant must tolerate.[2] In fact millions of hectares of irrigated land in many countries such as India, Egypt, Palestine, and many others have been badly affected by salinity[3]. Soil salinity existed long before humans and agriculture, and considered a major abiotic stress in plant agriculture worldwide, this problem comes together with agricultural practices such as irrigation. Today about 20% of the world cultivated land and half of all irrigated lands are affected by salinity.[4]

Palestine is a small country located in Western Asia, the climate of Palestine can be described as warm to hot dry summers, cool to mild rainy winters, the temperature is temperate and precipitation vary with altitude. The West Bank receives annual rainfall of 700mm in the north around the city of Jenin then it start to decline to reach 80-100mm in the Dead Sea area. According to Ministry of Agriculture, 2008 there is an orographic variation in addition to this latitudinal one, this mean that the western slopes receive an annual rainfall of 500-600mm while the eastern slopes receive 45-150mm. As a result, the area of the south-eastern edge of the west bank suffers from the highest aridity about 44%; this area is located at

the south-eastern edge of the West Bank, which is lightly inhabited. This area represents good reserve agricultural land [5,6]

According to the Palestinian Water Authority (2011), the total water volume over Gaza Strip was 81mcm.[7]

The agricultural sector considers as the most important element in palestinian economy, it contributes in about 15% to 20% of the gross domestic product and 25% of the total export. According to the cultivation type in Palestine, the agriculture can be divided into rain-fed and irrigated agriculture. The West Bank total cultivated area is 1,682,062.5 dunums and the total production is 514,451.7 tons, only 6% of this area depends on irrigated agriculture and represents 52% of the total agricultural production. The total available water used for irrigation in Palestine is very small in quantity about 150mcm per year which cover the need for only 10% of cultivated land. In contrast the available water for irrigation in Israel about 1275 mcm which is extremely higher than the available water for Palestinians. Limitations in water availability are mainly due to the prevailing political situation in the area and most of water aquifers are under the control of the Israeli government.[8]

Soil is a dynamic system contains several micro-and macro-flora and fauna such as bacteria, fungi, nematodes, arthropods, crustaceans and earthworms. They serve in plant and animal degradations, nitrogen fixation, nitrification, and they benefit from the nutrients released from soli minerals [9]. The limitations in agricultural land and water availability have been increased with the intensive use of agricultural land due to the

accumulation of various ions and salts. On the other hand, uncontrolled use of fertilizers, herbicides, pesticides and fungicides badly affect soil quality and reduce the available land size for agricultural purposes[10]

Studies in this respect showed that the use of pesticides in the irrigated agriculture of the West Bank in the growing season of 1995-96 totaled 153 tons. [11]

Fertilizers used in the West Bank are divided into two types: organic representing mainly animal manure fertilizers and inorganic including various chemical fertilizers. Estimated quantity of organic fertilizers being used in 1995-1996 was between 198,900 and 265,200 tons, the irrigated water used to apply these fertilizers contains different amounts of soluble salts which increase the accumulation of soluble salts and exchangeable sodium in the soil. Excessive use of these soluble fertilizers results in increasing the salinity of soil. The problem of saline soil increased largely with low precipitation rate and high evaporation rate, or when the water used for irrigation is not enough to carry the accumulated salts away from the root zone and thus inhibit plant growth and change the properties of soil. Most of Nitrogen fertilizers are water soluble. The nitrate form (NO3) have high mobility in soil which increase their potential to leach down below the root zoon. High rate of rainfall and irrigation with these fertilizers could affect the ground water quality.

Zhangetal. (1995) investigated the pollution in groundwater by nitrogen fertilizers in north china. In most of the investigated locations, the nitrate concentration in groundwater was 50 mg/L which exceeded the allowable limit for nitrate content in drinking water. In some locations the nitrate concentration was 300 mg/L. Zhangetal.(1995) reported that doubled increase in the application of nitrogen fertilizers since eighties is one of the most responsible reasons for nitrate pollution of ground water in North China.[12]

Nitrate pollution becomes more dangerous with sandy soils because of high percolation capacity of sandy soil. So, nitrogen fertilizers must be used in moderate amounts and only during the active growing periods.

Another form of fertilizers is the phosphate form, which reacts with soil particles and form insoluble compounds which have lower mobility in soil compared with the nitrate form. In this case the possibility to percolate to the ground water decreases. However, phosphate water fertilizers move the absorbed phosphate on soil particles to the surface contributing to significant algal growth or algal bloom[13]

1.3 Study objectives

The main objectives of this research are to find the effect of various salt and metal concentrations on:

1. Musk melon growth as plant height, number of leaves, fresh and dry weight.
2. The uptake of salt and metals by musk melon.

1.4 Research question

What are the effects of salinity and trace metals on musk melon growth, uptake and yield?

Motivations

This study aims at presenting partial solutions for saline soils and can determine salt tolerance for this species and the best soil condition for its growth being one of the major vegetable types grown in the country.

Chapter Two
Literature review

Chapter Two

Literature review

2.1Salinity and plant growth

Plants differ in their sensitivity to saline rooting media ranging from very sensitive (glycophytes) which are affected by salt concentrations of less than 50 mol/ m^3 to halophytes that are able to tolerate root zone salinity levels up to 1000 mol/ m^3.[14]

There are two main mechanisms that explain how salinity interacts with growth reduction in plants. First through reducing osmotic potential at the root surface and limiting availability of water to plant. The second is due to the toxic effect of certain ions such as sodium and chloride. The effect of salinity in growth reduction is usually determined by measuring the rate of photosynthesis per leaf area and the area available for photosynthesis. These two physiological components should be measured under the same growing conditions. The effect of salinity on photosynthesis can be clarified using a variety of techniques including monitoring the rate of photosynthetic carbon dioxide uptake by leaf at specific environmental conditions such as light, temperature, humidity, and carbon dioxide concentration. Such studies showed that the primary effect of salinity on growth occurred through leaf expansion rather than through changes in the rate of photosynthesis. The expansion was through plant's total leaf surface rather than through the rate of production of new leaves. It was also found that short term root zone salinity (48 hours) resulted in decreased leaf extension rate and leaf water potential. Complete recovery was observed

with the elimination of such salinity effect. These findings indicate that growth reduction is largely mediated by changes in plant water status.[15,16]

Once inside the cell, salt can cause ionic stresses, largely as Na^+ (and Cl^-) inhibit metabolic processes including protein synthesis. Na^+ can rise to toxic levels in older leaves, causing them to die. This reduces the leaf area available for photosynthesis and so the plant cannot sustain growth or crop yield. In general, salinity is shrinking the land available for growing crops at an alarming rate, and is expected to influence food availability and production. At present, approximately 7% of the world's land area is affected by salinity and it seems that irrigated land is the most affected, often by the previously mentioned poor agricultural practices. Roughly 30% of all irrigated land and up to 50% in some countries is considered economically1 unproductive. The problem is that irrigated land has at least twice the productivity of rain-fed land and produces up to one third of the world's food.[17]

Unfortunately graminaceous crops are some of the most salt-sensitive plants and termed glycophytes compared to halophytes, which do manage to live in high salt conditions. In graminaceous crops, the main cause for ion specific damage is related with Na^+ ions. Salt tolerance is defined when plants show little growth reduction at concentrations of 300mM NaCl or more.[18]The agricultural salinity problem can be solved by improving farming practices to prevent salinization in the first place and this can be achieved through planting deep-rooted trees to lower the water table. However, the increasing demands on cultivated land also mean that crops

which are salt tolerant need to be generated, either by traditional breeding or genetic manipulation technologies.[19] Mechanisms of salt tolerance and efforts to create tolerant plants were the focus of SEB meeting (Society for Experimental Biology) in Barcelona in 2005. The meeting focused on approaches trying to integrate the research on cell biology, molecular biology and whole plant physiology. Through this, one can generate salt-tolerant crops for the increasing food demands, but like most important traits, salinity tolerance doesn't appear to be a simple one and attempts to improve salt tolerance through traditional breeding programs have very limited success. Salt tolerance is complex process both genetically and physiologically. The effects of salinity appear to be dependent on the species and the stage of the plant's development such as germination or vegetative growth. Scientists are trying to understand the mechanisms of how the halophytes survive in areas where glycophytes cannot. The aim is then to move these tolerance traits into non-tolerant crops. In this respect, there appear to be two essential elements for tolerance that halophytes are particularly managed to solve. The first is to exclude Na^+ from the roots to limit its transport to the leaves, the second is to accumulate Na^+ in the shoot and inhibit its effect on vital cellular functions. A good example is to improve salt tolerance using the above methods to avoid Na^+ effects, was reported from studies on wheat varieties where scientists managed to improve salt tolerance of durum wheat by crossing varieties with different characteristics in combination with salt tolerance.

Breadwheat has the first of these traits and barley has the second but modern durum wheat has neither. Given that pasta makers consider Australian durum wheat to be of excellent quality (and it is more valuable to farmers than bread wheat), so they start searching through a collection of wheat that had originated in the Mediterranean, which is considered a salt-affected area and found a wheat line from Iran which excluded salt, resulting in lower levels in the leaves. This line was then crossed with modern durum wheat four times to give a new salt tolerant variety.[20]

Field trials are currently running and preliminary results from wheat breeders indicate that 20% increasing in yield production on saline soil. Researchers have also developed a new molecular marker to recognize the location for genes responsible for salt tolerant trait on a particular chromosome. This will hopefully accelerate the breeding of new tolerant varieties.

Because of Na^+ adverse effects on many plants, researchers attempt to know why crop plants do not seem to have an off switch where salt is concerned and continue to accumulate Na^+ ions to reach a toxic level. Although most plant species show no nutritional requirement for Na^+, the addition of Na^+ was reported to enhance growth in some plants.[21]

Two genes code for Na^+ specific transporters were identified in the salt-sensitive model plant *Arabidopsis thalian*. The transporter proteins are membrane bound that allow Na^+ ions or other small compounds to travel into the cell and between cellular compartments. Na^+ transporters also seem to affect potassium (K^+) balance and root development. This

indicates that Na^+ may have important physiological functions under nonsaline condition. Evidence on this role is clear from a Na^+ /H^+ transporter in morning glory flowers which is located in the membranes of the cells that controls petal color through turning the anthocyanin pigments blue.[22] A vital role for Na^+ in normal membrane transport processes explain why Na^+ accumulates to such dysfunctional levels in plants not normally exposed to salinity. Professor Jose Pardoinvestigated the function of one proposed Na^+ transporters, called SOS1 aiming at finding the role of sodium transporters in Na^+ exclusion, storage of excess Na^+ in the vacuole and long distance transport of ions within the plant. This study suggested that SOS1 may have the ability to sense salinity stress which may help the plant to respond and survive such conditions.[23]

2.2 Mechanisms of tolerance to salinity in plants

Over the past ten years, scientists were investigating which genes make it possible for some plants to survive high salt and drought while others do not. Several studies attempted to find these genes using salt-sensitive species such as *Arabidopsis thaliana* and salt tolerant species using Salt cress (*Thellungiella halophila*) which seems to have similar DNA sequence. The plant does not have salt glands or other morphological alterations such those found in other halophytes. However, Microarrays studies showed that stress genes in salt cress plants are expressed at a noticeably higher basal level. These genes seem to show over-expression under stress, which may indicate that tolerant plants are constantly in a pre-

activated state. In addition to these genes, salt cress may have some other unique tolerance genes. [24]

Other studies are aiming at manipulating Na+ exclusion rout to generate more salt tolerant plants. Many components of salinity tolerance of a whole plant require particular functions in specific cells. To facilitate Na+ exclusion from the shoot, Na+ would need to be pumped out of the cells in the outer part of the root, back into the soil. Na+ would also need to be moved into cells in the inner part of the root (adjacent to the xylem), to maintain low Na+ in the xylem and thus low delivery to the shoot. Genes that encode pathways for Na+ influx are still not known. To understand the role of different root cells Tester group generated *Arabidopsis* plants whose gene expression is randomly activated in specific cell types. The research group then analyzed shoots for Na+ content to find out which genes are important for Na+ transport. Recently this group employed this approach on rice, with the hope to develop salt tolerant varieties of this important crop plant.[25]

2.3 Reaction to melon salinity

In vascular plants which form the majority of agricultural crops, water and selected solutes move against energy gradient from soil to plant tissue in response to osmotic potential. Melon (*Cucumis melo L.*) is one of the most plants that earned the attention of scientists to examine and face the salinity problem, which are the most important problems related to plant growth in dry and semi-dry regions.[26]In respect to salinity tolerance it was reported that melon plants have medium tolerance to salinity,[27,28,29,30] it has also

been reported that saline tolerance differs in melons according to genotypes, with variables ranging from sensitive to medium tolerant with regards to this characteristic .[31,32,33]

Sebnem *et al.*2007, studied the genotypic differences for salt tolerance of thirty six Cucumis sp. They reported that some genotypes have high salt sensitivity and exhibit a reduction of the plant fresh weight and inhibition on the plant growth. While other genotypes were less affected and grew equally with control plants and they showed no inhibition effects on saline growth. Other genotypes grow and survive only at 50% or even at 20% of control plants this indicates that melon plants have medium tolerance to salinity. It was also reported that the most significant reasons for growth reduction in different melon genotypes refers to the sodium ion concentration which accumulated more than necessary and reached toxic levels in plant tissues. Levels of sodium ions increased in leaves after saline application, this increase varied by genotypes, the other important and critical reason for muskmelon growth reduction is the chloride ion which shows toxic effect at high levels in the plant body. In all studied melon genotypes, levels of Cl^- ions have increased clearly in the NaCl containing medium and with very large differences in such increase rates.[34]

Tolerance to salinity can differ according to the plant growth stage. For melon plants, it was concluded that melon tolerance during germination and emergence was more than their tolerance during vegetative growth.[35] The germination process based mainly on the capacity of the seed to absorb water which is on turn based on the osmotic potential of the external

solution and the enzyme and hormone levels in the seeds, those can be altered by the toxic effects of $Na^{+}$and Cl^{-} concentrations. The effect of salinity on germination process occurs by two ways, either by inhibiting or reducing the germination process, or by causing a delay immediately after saline treatments.[36]

Botia *et al.*,1998 reported that Na+ and Cl^{-} concentrations in the shoots were significantly increased by increasing of NaCl concentrations. However, a slight increase was observed in roots at 30Mm NaCl treatments, but it remained constant with higher NaCl concentration. They also stated that salt application for melon crops may induce a reduction in Ca^{+2}, K^{+}, and Mg^{+2} concentrations in the shoots, however, in case of K^{+} ions only the reduction happened also in the roots of all varieties of melon plants.[37]The different behavior between melon fruit, leaves and stems could be explained by the ability of different tissues to compartmentalize ions which results in an effective dilution of the salt [38]. Shannon and Francois suggested that fruit size and yield were reduced by saline water so the efforts must be focused on developing appropriate management practices for saline water irrigation which attempt to minimize fruit yield losses and maintain soluble solid content this agrees with findings Botia*et al.*, 2005.[27,39]

Li Zong *et al*.2009 assessed the effects of increasing salinity on fruit yield, yield components, and several quality parameters that affect the economic value of melon crops, their results showed that there were no significant differences of mean fruit weight after saline application. However, there

was a significant decrease in fruit number they also found that total soluble solid (TSS) rose with increasing salinity. In relation to crude protein content it increased significantly after saline application. Salinity causes a decrease in the neutral detergent fiber content and an increase in amino acid content.

One of the protective responses to salt stress is the accumulation of nitrogen compounds in melon fruit, also the enrichment in essential amino acids may be considered as an advantage for human nutrition. However, this advantage is accompanied by a significant reduction in fruit yield. From an economic point of view, the reduced yield can be compensated partly by improved fruit quality which result from increasing the concentrations of antioxidants and soluble solids after saline application.[40]

2.4 Heavy metals - plant growth and tolerance

Metals and metalloids are elements that present naturally in minute trace amounts in the soil and water as a result of the weathering of rocks. These trace elements are ubiquitous, and resistant to natural degradation. They can be leached into surface water or groundwater and taken up by plants through irrigation.[41]

In small amounts, many of these trace elements (e.g., boron, zinc, copper) are essential for plant growth. However, in higher concentrations they have negative influence on plant growth. Plants react very differently to metals which may be present. The impact of metals depends largely on the concentration of metals, pH, surface area and texture of soil particles, the

presence and concentration of foreign ions, growth rate and growth conditions, and organic content.

Other trace elements such as arsenic, cadmium, lead, and mercury are disturbing primarily because of their adverse effects on soil organisms. Animals and humans will be affected by these elements after eating the contaminated plants.[42]

Metals can reach the plant tissues either by absorption from soil or by deposition from the atmosphere. Some of the higher plant species have adaptations that enable them survive and reproduce in high concentrations of Zn, Cu, Pb, Cd, and Ni. These species are divided according to their adaptation into two main groups:

A. Pseudometallophytes that can grow and survive on both metals-contaminated and non-contaminated soils.[43] Example (*Commelina communis L.*)[44]

B. Metallophytes that grow only on metal-contaminated and naturally metal-rich soils.[43]Example (*Arabidopsis halleri*)[45]

There are two main strategies for metal tolerance depending on plant species: metal exclusion and metal accumulation.[46]

The first strategy described by De Vos *et al.*, 1991 and involves blocking of metal uptake and restriction of metal transport to the plant shoots as in the case of pseudometallophytes. These plants can be used to revegetate bare soil areas, in which the lack of vegetation results from excessively high metal concentration.[47]Thesecond strategy consists of high concentration of metals in plants tissues. Plant species differ in their ability to exclude and

accumulate heavy metals. These differences also exist among plants as to whether the excluded metal is accumulated in the root or translocated to the shoot system.[48]

In addition, some metals have characteristic physiological fates as in the case of Pb which is usually accumulated in roots more than any other part of the plant; where Cu and Ni are accumulated in roots and shoots.[42]Theplants seem to continue to absorb and accumulate metals so they look like diffuse samplers.[48]The following represents some elements that affect plant photosynthesis and growth:

- **Boron** can decrease plant growth and production, like other trace elements it is found in deficient amounts in soils than to cause toxicity. Boron is considered as water soluble and sufficient leaching of the compost prior to application may eliminate the problem of toxicity. In addition, greenhouse experiments concluded that the addition of mineral fertilizers will decrease the uptake of boron by plants and as a result, fertilization could also be used to overcome boron toxicity to plants.
- **Copper** present in plants associated with plastocyanin as an essential component of the electron transport chain in the chloroplast. Thus, the deficiency of copper inhibits photo-system I electron transport due to reduction of plastocyanin.[49] It may also affect photo-system II.[50] Cu^{++} deficient plants exhibit many characteristics such as degeneration of the thylakoid membrane of chloroplasts which result in reduction of the pigment content, and

reduction of plastoquinone synthesis and lower unsaturated C18 fatty acid contents .[49,50]

- **Iron** is an essential element for chlorophyll synthesis. It is involved in the composition of redox enzyme for photosynthesis including the haem-containing cytochrome and non-haem iron-sulfur protein. [51] Iron deficiency leads to a simultaneous loss of chlorophyll structure and many plant species develop iron-acquisition mechanisms. This involves many morphological changes, such as increased formation of lateral roots, root hairs, and transfer cells, all of them responsible for iron uptake by increasing root surface. [52,53,54,55]

  However, iron is toxic when it accumulates in high levels. It can catalyze the formation of hydroxyl radicals via the Fenton reaction, which can damage lipids, proteins and DNA. [55]

- **Manganese** is required as a cofactor for a number of enzymes involved in photosynthesis, particularlydecarboxylase and dehydrogenase enzymes. Manganese, in the form of a mangano-protein, is part of the oxygen evolving complex (OEC)where it appears to be involved in the accumulation of changes during the oxidation of water. Its deficiency may cause extreme chlorosis between the leaf veins as well as discoloration and deformitiesin seeds.[51]

- **Cadmium** is considered as a toxic element for the plant. Studies on barley showed that the germination ratio and growth rate were declined after cadmium pollution. The root growth for many kinds

of crops such as wheat, pumpkin, garlic, and maize were inhibited as a result of cadmium pollution. The primary effect of cadmium was reported to be on stomatal function as it seems to cause stomatal closure in epidermal peels on detached leaves of *Helienthus annus L*. as a result of this photosynthesis and transpiration will be inhibited.[56]

It also decreases the water use efficiency this mean that the amount of CO_2 fixation in photosynthesis per mol of water transpired will be decreased.[57,58]

Rai*et al.*, 1978reported that photosynthetic pigments were reduced under the excessive concentrations of this metal. Cadmium is also known for its strong binding affinity to sulfhydryl groups which essential for enzymatic activity and protein structure.[59]

2.5 Reaction of melon to heavy metals

Fruits and vegetables contaminated with heavy metals have an adverse effects on human health. Thus, it considered as the main aspect of food quality assurance.[60]

In general, heavy metals are accumulated in different body organs as it is not a biodegradable material, leading to undesirable effects.[61]

Contents of various metals were determined in melon samples by Waqas *et.al*, 2012, the results showed that cadmium, iron, lead and zinc contents were exceeded the maximum limits given by WHO. However, chromium and nickel content were within the recommended limit.

The highest mean concentrations of copper and zinc were detected in melon compared with other selected fruits and vegetables studied by M. A. Elbagermi *et al.* 2012.[62]

Studies on melon plants showed that growth of melon was affected by iron treatment as Fe $(No_3)_3$, and resulted with increased chlorophyll concentration in leaves.[63]

Researchers have been interested in the ability of using melon seed husk, an agricultural waste in the biosorption of metals such as cadmium, lead, and zinc from an aqueous solution under several physicochemical parameters. The feasibility of biosorption was dependent on many factors including the pH of the solution, contact time, dose of the biosorbent, metal concentrations, and temperature. Studies on this respect showed that binding of metals was facilitated by the presence of ionizable groups and lone pairs. The biosorption of metals was in decreasing order as follow: Zn> Cd> Pb.

This study showed that melon seed husk has high ability for industrial effluents treatment which contains Cd, Pb and Zn metals.[64]

The bioaccumulation characteristic of heavy metals (Cd, Pb, and Zn) in human body are responsible for causing kidney and renal disorders, increasing in blood pressure, and red blood cells destruction.[65]

Boron considered as an important micronutrient for plants. Its deficiency and toxicity largely affect the productivity of cultivated plants in many regions in the world.[66]

El-Sheikh et al. (1971) stated that the vegetative growth of muskmelon (*Cucumis melo*) was decreased in 50% as the boron concentrations increased in the nutrient solutions.[67]

Boron concentration was increased in leaves of Top Mark melon with the increasing of its concentration in the soil solution, and resulted with leaf margins chlorosis and fruit yield reduction according to *Goldberg et al.* (2003) findings .[68]

Menahem et al. (2007), studied the effects of boron on the growth, yield, and uptake of grafted and nongrafted melon (*Cucmis melo L.)*. Plants were treated with different concentrations of boron ranged from 0.1 to 10.4 mg/l. The concentration of boron increased in plants proportionally with the increasing in irrigation water concentration. boron concentration was higher in old leaves, the fruits had lowest concentration, these results indicated that the transpiration was affected largely by boron accumulation in plant parts in which the leaves are the main site for transpiration.

Menahem et al.(2007) reported that boron concentration was lower in grafted compared with nongrafted melons, this could be due to the high selectivity and low absorption of boron in the roots of grafted melons. They also reported that total fruit yield, total soluble solids content of the fruits, and the dry weight of shoots and roots were significantly decreased with increasing boron concentration of the irrigation water. The reduction in the total fruit yield resulted from the reduction in the number of fruit per melon plant with the increase in boron concentration in irrigation water.[69]

Chapter Three
Materials and Methods

Chapter Three

Materials and Methods

3.1 Experimental setup

Experiments were conducted in a greenhouse at An-Najah National University new campus. Media composed of gravel, wood- saw dust, and agricultural sand 2:1:1. Media was washed with tap water to get rid of any residual salts or other contaminants. Melon plants were cultivated in horizontal channels in a hydroponic system. For this purpose, three channels were used; the first channel was divided into three sections, plants in each section were treated with a different NaCl concentration. The second channel was divided into two sections each with a different concentration of trace metal. The third channel was used as a control treated with tap water only.

The frame of the green house was made of galvanized steel and covered with thick plastic layer. The dimensions of the green house was 36 m in length, 8.5 m in width and 5.5m height. It contains three hydroponic channels, a water tank, an aeration tank, and settling tank. (Figure 1)

The hydroponic channels were divided longitudinally into two channels totalling six channels, three of them were used in this study. Channels was made of steel with length of 27 m, width of 22 cm, and height of 35 cm.

The water tank was made of steel and coated with anti corrosion layer, and used to provide the channels with fresh water. The size of the tank was 13 m^3.

The settling tank was used to collect the excessive water discharged from the end of each channel.

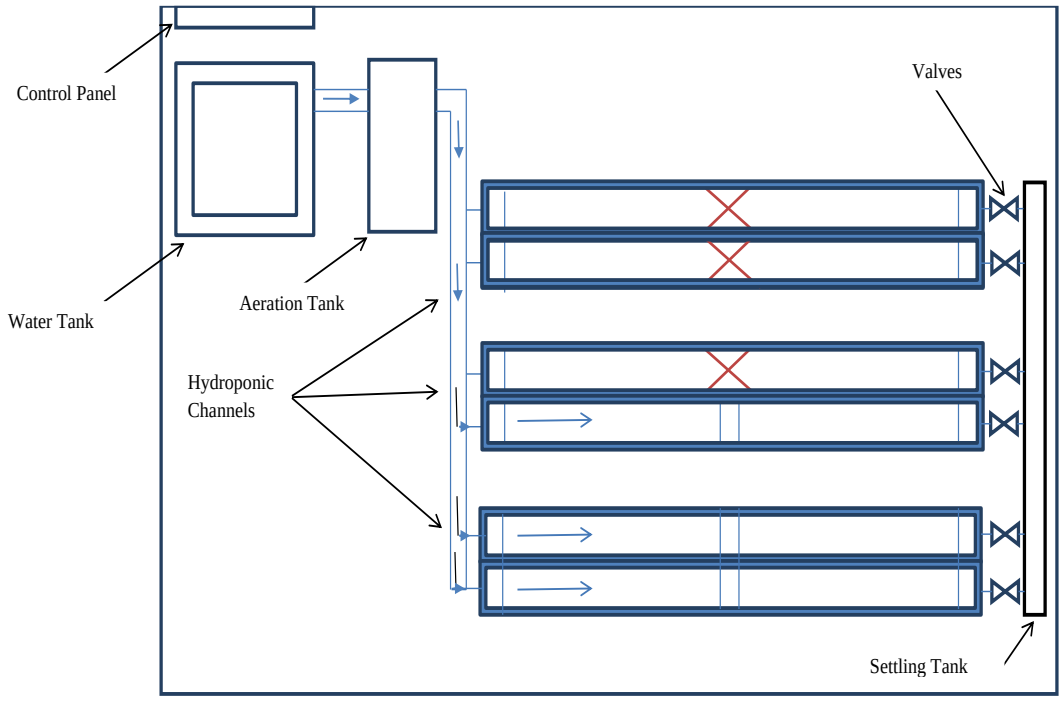

Figure 3.1 Schematic of Hydroponic System

The experiment was designed as follows:

1. The first channel was divided by chambers into three parts each 9 meter in length and contained 20 seedlings. This channel was used to study the effect of salinity on melon growth, sections were treated with 1000, 3000, 7000 ppm of NaCl salt in the first, second, third sections, respectively.
2. The second channel divided into two sections each 13.5 meters in length and contained 30 seedlings. This channel was treated with 0.1 and 0.2 ppm of(Zn, Cr, Cu and Cd) in the first and the second section, respectively.
3. The third channel was used as a control with tap water in the media. The length was 27 meters and was divided into two sections each contained 30 seedlings.

3.2Experimental program

The nutrient supplement in all of the three channels was added on a weekly basis for the growth period of the study which lasted for four months. Seedlings were left to grow on nutrient media for 45 days before administration of either salt or trace metals.

3.3 Plants

Melon seedlings were purchased from a local market nursery free from any known viral, fungal or bacterial infections. Seedlings were 11-14 cm in height and the number of leaves ranged from 8-12. Al seedlings were healthy and green in color. Melon seedlings were planted and spaced 45 cm from each other in all channels.

The following figures shows the stages of muskmelon development:

Figure 3.2 Seedlings of Muskmelon

Figure 3.3 Flowers Emergence Stage

Figure 3.4 Fruits Formation Stage

Figure 3.5 Maturation Stage

3.4 Laboratory Analysis

The plants were taken for the analysis at the end of the experiment, determination of composition was carried out as follows:

A. The weights of the stem plus leaves; fruits; and roots were obtained immediately after harvesting. For stems, leaves and fruits duplicate 5grams of wet material was taken and were dried by incubating at $150C^0$. For root system the whole root was dried as above. Dry samples were stored till further analysis for their contents of salt and trace metals. The procedure was carried out according to standard methods.[70]

B. For salt content, dried material was burned to ashes using a laboratory furnace. Ash samples were then put in 50 ml distilled water and the electrical conductivity was measured using an electrical conductivity meter .

C. For estimation of trace metal content, 0.5 g of dried samples was digested using 5 ml concentrated HNO_3 and placed in digester for 16 hours. After digestion, 1 ml of H_2O_2 was added to each sample and placed again in the digester for 40 minutes. Samples were then put in 100ml distilled water. Aliquots of 10ml of the digested material were stored till analyzed by ICP Ms instrument for their trace metal contents. The procedure was carried out as described by Chaturvedi and Sankar (2006).[71]

3.5 Data Management

Data regarding height and number of leaves was obtained and recorded for each seedling in all channels before the application of salinity or trace metals. Plant growth was monitored and data regarding height and number of leaves was recorded on a weekly basis. By the end of the study period (4 months), melon plants were harvested at maturity for further analysis on composition of trace elements and salt concentrations. Data obtained were analyzed with ANOVA using SPSS version 16 with $p < 0.05$ considered significantly different. Moreover, Least Significant Difference (LSD) test was carried out to identify the significant differences between the means.

Chapter Four
Results and discussion

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Results and discussion

4.1 Plant height

Table 1 shows that the means of plant height among all treatments during first, third and sixth week of salts and metals addition are significantly different ($p<0.05$).

Table 1. One Way ANOVA test for plant height in cm

Measure/ Group		Concentration Means						(F)	Sig.*
		Salt1000	Salt3000	Salt 7000	Metal 0.1	Metal 0.2	Control0		
Height	1st Week	55.7	54.2	52.0	52.6	50.8	66.5	45.7	0.000*
	3rd Week	80.0	75.8	75.1	79.2	75.2	92.8	42.9	0.000*
	6th Week	104.2	97.6	98.3	105.6	99.9	118.9	38.5	0.000*

The mean of control was the heights for all groups, the mean of salt and metals decreased when concentration in part per million increased.(Table1) For group one, the highest plant height was for the control (66.5 cm) followed by salt treatment of 1000 ppm (55.7 cm). the lowest was for metals treatment 0.2 ppm (50.8 cm).in group two the highest plant height was for the control(92.8 cm) followed by salt treatment of 1000 ppm (80.0 cm). the lowest was for salt treatment of 7000 ppm (75.1 cm). for group three, the highest plant height was for the control(118.9 cm) followed by metal treatment of .1 ppm (105.6 cm) the lowest was for salt treatment 3000 ppm(97.6 cm) (Figure 4.1 and 4.2).

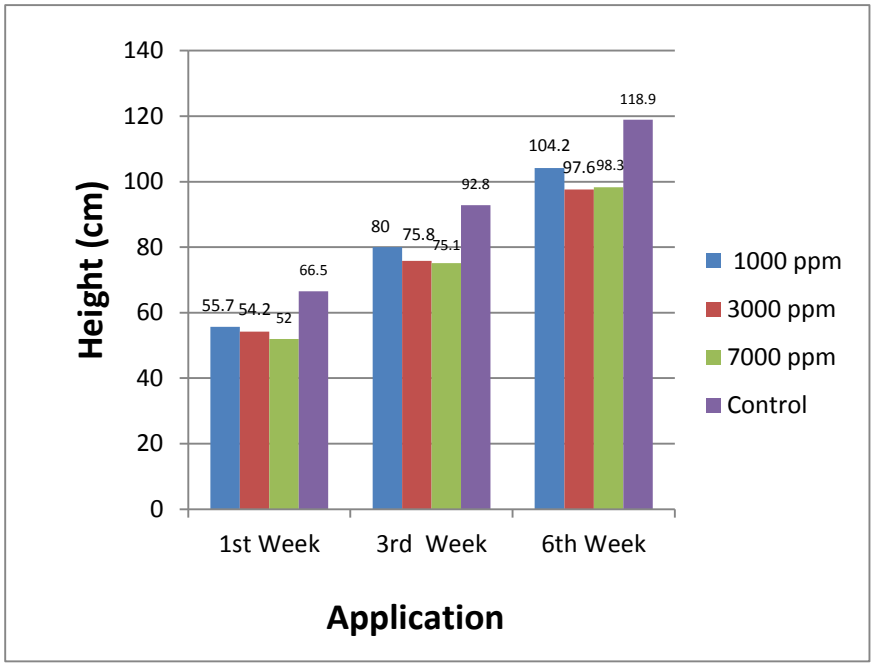

Figure 4.1: The height of melon plant during the first, third, and sixth week of different salinity treatments

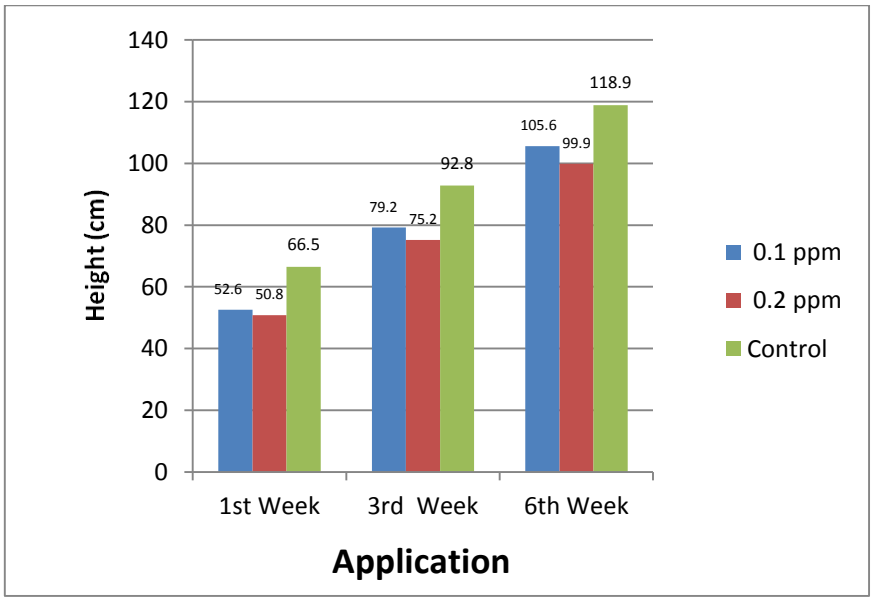

Figure 4.2: The height of melon plant during the first, third, and sixth week of differentmetals treatments

LSD test was carried out for the differences ($p<0.05$) in the treatment levels, the results show significance differences among all levels of treatments (app. 1).

Loreto *et al*.2003 reported that salinity cause reduction in cell elongation and division due to its adverse effect on different auxin synthesis, as a result, the plant remains stunted. [72]

H.O¨ .Sivritepe et al. founded that leaf and stem growth of melon cultivars Hasanbey and Kirkagac reducedsignificantlyatNaCl concentrations above9.0 dS/ m .[73]

Shoot height of wheat seedlings was significantly decreased at 10 µM Cu and Zn treatment according to the observation of Tariq et al., 2007.[74]

Studies on alfalfa plant indicated that Cuand Ni caused destructive effects at 40 ppm dose resulted in a reduction of shoot elongation by 70.0%and 58.0%, respectively. The result of this study also suggested that those metals havemicronutrient-like effects on the alfalfa plants at low concentrations. However, In the case ofZn, the resultsshow that

zinc has a positive effect on thegrowth of this plant, even at moderatelyhigh concentrations because it is an essential element.[75]

Studies on the effects of chrome on radicle and hypocotyll length of melon plants indicated that Cr caused a reduction at $p<0.001$ level.Radicle elongation significantly decreased after treated with solutions containing 2.5 to 70mg/l Cr, from 14.7 to 58.5% compared with the control.The reduction also obtained for the hypocotyll height from 11.4 to 52.7% after the same treatment.This study also concluded that higher concentrations of

chrome resulted in an adverse effect on length and fresh and dry weight of melon seedlings atp<0.001 level compared with the control.Gardea-Torresdey et al., 2004 reported that chromium concentrations of 20, 40 and 80 reduced the lengths and dry biomass of roots and shoots of *Convolvulus arvensis* plants.[76]

4.2 Number of leaves

Table (2) indicates that there are significant differences in the number of leaves among all of the groups.

Table 2. One Way ANOVA test for number of leaves

Measure/ Group		Concentration Means						(F)	Sig.*
		Salt1000	Salt3000	Salt7000	Metal0.1	Metal0.2	Control0		
Number of Leaves	1st Week	46.9	42.8	44.2	41.2	37.5	55.4	50.0	0.000*
	3rd Week	56.5	53.9	53.3	50.2	43.1	67.4	86.9	0.000*
	6th Week	66.2	65.2	62.7	59.2	48.7	79.5	136.1	0.000*

From the table above it was noticed that the control has the highest mean (55.4, 67.4, 79.5) for groups one, two, three respectively, the lowest mean was for metal treatment .2 ppm (37.5, 43.4, 48.7) forgroups one, two, three respectively.In salt and metals treatments the mean decreases with the increasing of concentrations in ppm.(Figure 4.3,4.4)

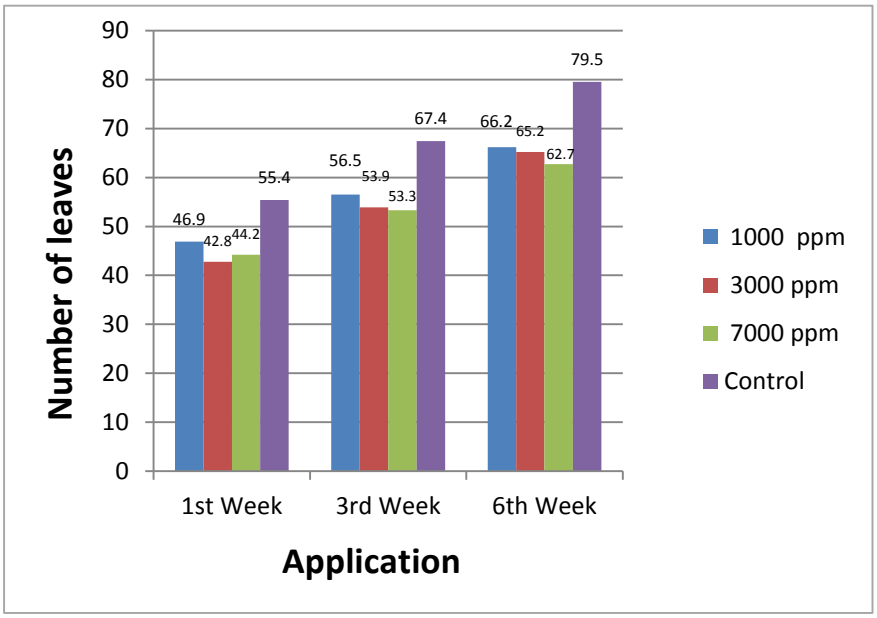

Figure 4.3. Number of leaves during first, third, and sixth week of different salinity treatments

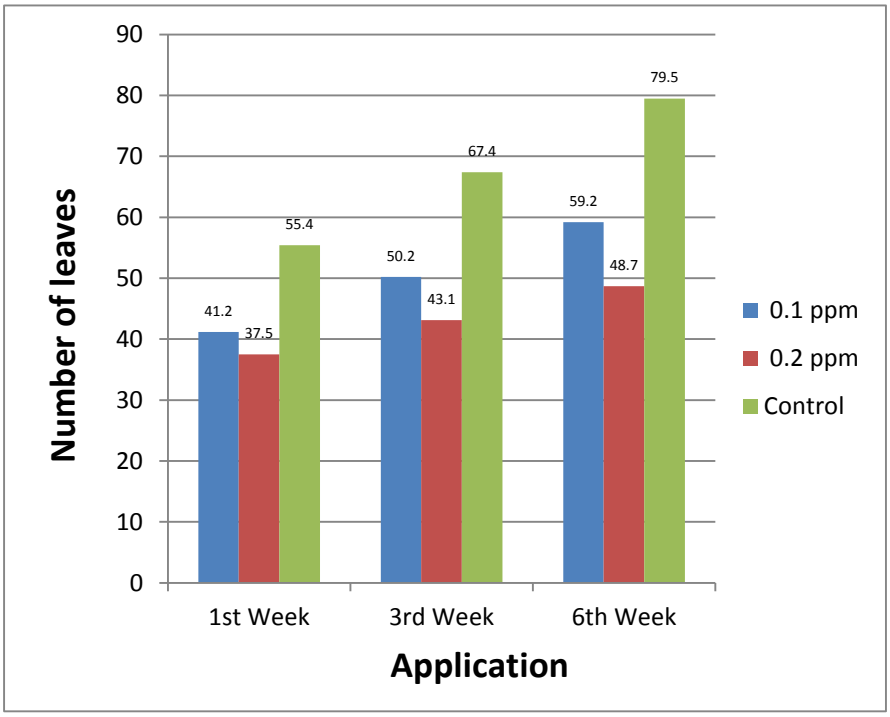

Figure 4.4. number of leaves during first, third, sixth week of different metals treatments

LSD test of number of leaves shows significant differences among all levels of treatments. (app. 2)

The result for number of leaves agrees with the findings of Munns*et al*.,2003 ; Romero Aranda*et al*,1998; Dong *et al*., 2007, who found that salinity caused areduction in growth parameters like number of leaves. [77,78]

4.3 Stem plus leaves, root, and fruit fresh and dry weight

One Way ANOVA indicated that there are significant differences at ($\alpha<0.05$) amongs groups of (RFwt, FFwt, SDwt, FDwt1, and FDwt2). On the other hand, the test indicated that there were no significant differences between groups in (SFwt, and RDwt), the significant was> 0.05. The results are similar to the findings of Tito *et al*.(2011) , who found no significant differences on the weight of the roots, but there was significant difference on the dry weight of stems after analyzing the results of increasing doses of zinc in beans.[79]

Table 3. One Way ANOVA test for stem plus leaves, root, and fruit fresh and dry weight in gm

Measure/ Group	Concentration Means						(F)	Sig.*
	Salt 1000	Salt 3000	Salt 7000	Metal 0.1	Metal 0.2	Control0		
SFwt[1]	180.0	187.2	170.6	232.2	151.2	175.2	1.4	0.223
RFwt[2]	3.6	4.2	2.9	4.6	2.7	3.2	9.7	0.000*
FFwt[3]	216.0	249.8	140.5	623.8	154.3	176.8	9.8	0.000*
SDwt[4]	0.9	0.9	0.9	1.6	0.8	1.1	6.3	0.000*
RDwt[5]	0.5	0.6	0.5	0.6	0.6	0.6	0.9	0.505
FDwt1[6]	0.5	0.4	0.3	0.5	0.4	0.3	3.0	0.034*
FDwt2[7]	0.5	0.4	0.4	0.5	0.4	0.3	3.6	0.016*

1: stem plus leaves fresh weight 2: root fresh weight 3: fruit fresh weight 4: stem plus leaves dry weight 5: root dry weight 6: fruit dry weight(the first sample) 7: fruit dry weight(the second sample)

Table (3) indicated that the mean of weight after salinity treatment increased up to 3000 ppm then it decreased at 7000 ppm, except in groups four and five (stem plus leaves dry weight and root dry weight). For metal the weight increased after metals treatment up to .1 ppm then it decreased at .2 ppm, except in group five (root dry weight). This could be due to metals and salt act as nourishment for the plant at first, then it might cause a negative effect after reaching a toxicity level of salt and metals at higher concentrations.

Berry 1986 and Baker1983 et al. had been studied the responses of plants to metals concentrations. Berry studied the responses of lettuce to nickel and copper under controlled environment, he reported that there were two phases for uptake: (a) a phase for low uptake, this happened when the concentration of metals in plant tissues is low, so the concentration will increased gradually with increasing metals dose, and (b) a phase of increased uptake, when the external concentration increased to a level above the critical value. However, with the application of higher doses to reach a lethal dose the integrity of root-shoot transport system will be damaged. Baker et al. found a similar relationships for metal uptake in the genus *Silene L.* when treated with different concentrations of copper and cobalt. [80,81]

From table (3) it can be concluded that the maximum fruit dry weight yield was at 1000 ppm concentration of salinity followed by 3000 ppm, the lowest dry yield was for control plants. S.M.Alam *et al*. (1986) founded

that maximum dry matter yield of snake melon was at 2000 ppm, and it decreased at high salinity level .[82]

Studies on cadmium effect on plants showed thatcadmium reducethe size of shoots by about16.0% compared with control group, andboth of cadmium and chrome significantlyreduce the shoot growth at 10 ppm dose.[75]

LSD test indicated that there are significant differences for all levels of treatments. (app. 3)

4.4 Electrical conductivity test for salt analysis

Table 4. One Way ANOVA test for electrical conductivity

Measure/ Group	Concentration means				(F)	Sig.*
	Salt 1000	Salt 3000	Salt 7000	Control0		
WREC[1]	.09	.10	.15	.07	16.1	0.00*
5g SEC[2]	.22	.26	.37	.19	28.0	0.00*
5g FEC[3]	.09	.10	.13	.07	15.2	0.00*

1: electrical conductivity for whole root 2: electrical conductivity for five grams of stem plus leaves 3: electrical conductivity for five grams of fruit

Table (4) shows clearly that there were significant differences under 95% level for root, stem, and fruit electrical conductivity. The results show that the mean increased with higher salt concentrations compared with control (0 ppm).(Figure 4.5) this agrees withthe findings of Edris Shabaniet al.,2012 who founded that sodium concentrated in Cherry tomato significantly more than in control plants.[83]

Bar-Tal et al. (1991) reported that sodium concentration increased in the plant by increasing the salinity level.[84]

Vinod Kumar 2013 and A.K. Chopra2009reported that the higher EC value was recorded in response of higher salt content in the plants of V. faba .[85]

As shown in table (4) it obviously clear that salt tends to be concentrated in stem and leaves rather than root and fruit.

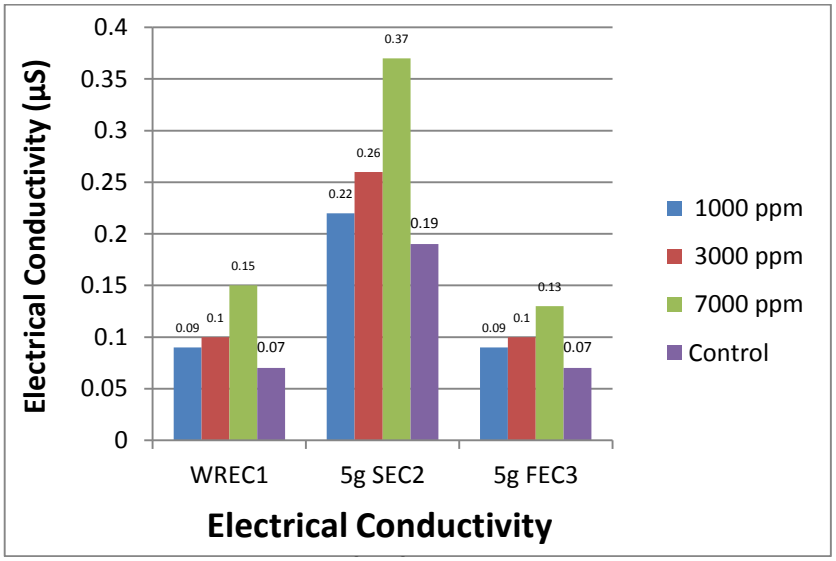

Figure 4.5: Electrical conductivity in various parts of melon plant

4.5Metals analysis

4.5.1 metals uptake, concentration in plants

The uptake of metals by plants is considered the first step of their entry into the agricultural food chain. Fate of these metals involves the followings: at first the metals move from the soil to the plant roots, then it crosses the epidermal cells membrane of the roots, after that the metals are transported from the epidermal cells to the xylem, the xylem in turn responsible in metals transportation as solution from roots to shoots, these solutions are

then moved from leaves to storage tissues by the phloem transport system, in which it accumulates and used as food in seeds, tubers, and fruit. After the plants uptake metals, it enters the food chain through herbivores and humans after its availability to them. The limiting step for metals entry to the food chain is generally from the soil to the root. Other factors may affect metals uptake rates includes: Plant species, relative abundance and availability of necessary metals. The abundance of bio available amounts of essential elements can reduce the plant uptake of non-essential but chemically similar elements .in addition, Bioavailability of some metals could be also related to the availability of other metals. Example on this is the toxicity of copper which is largely related to low abundances of zinc, iron, molybdenum and sulphate.[86]

4.5.2Cadmium uptake by root

One Way ANOVA analysis indicated that There was a significant difference ($\alpha<0.05$) among all metal treatments (control, .1 ppm, .2 ppm). The significance was .034.

Table 5. One Way ANOVA test for cadmium uptake by root

Treatment	Mean (ppb)	F	Sig.
Control	3.00	6.218	.034*
.1 ppm	5.90		
.2 ppm	6.11		

Table five show that the highest mean was for .2 ppm treatment (6.11ppb), followed by.1 ppm treatment (5.90ppb), the lowest mean was for control (3.00 ppb).

4.5.3 Cadmium uptake by stem plus leaves

One Way ANOVA analysis indicated that There was a significant difference ($\alpha<0.05$) among all metal treatments (control, .1 ppm, .2 ppm). The significance was .001.

Table 6. One Way ANOVA test for cadmium uptake by stem plus leaves

Treatment	Mean (ppb)	F	Sig.
Control	1.82	14.996	.001*
.1 ppm	5.55		
.2 ppm	5.68		

Table six show that the highest mean was for .2 ppm treatment (5.68 ppb), followed by.1 ppm treatment (5.55ppb), the lowest mean was for control (1.82ppb).

4.5.4Cadmium uptake by fruit

One Way ANOVA analysis indicated that There was a significant difference ($\alpha<0.05$) among all metal treatments (control, .1 ppm, .2 ppm). The significance was .048.

Table 7. One Way ANOVA test for cadmium uptake by fruit

Treatment	Mean (ppb)	F	Sig.
Control	1.94	4.858	.048*
.1 ppm	3.21		
.2 ppm	3.37		

Table seven show that the highest mean was for .2 ppm treatment (3.37ppb), followed by.1 ppm treatment (3.21ppb), the lowest mean was for control (1.94ppb) .

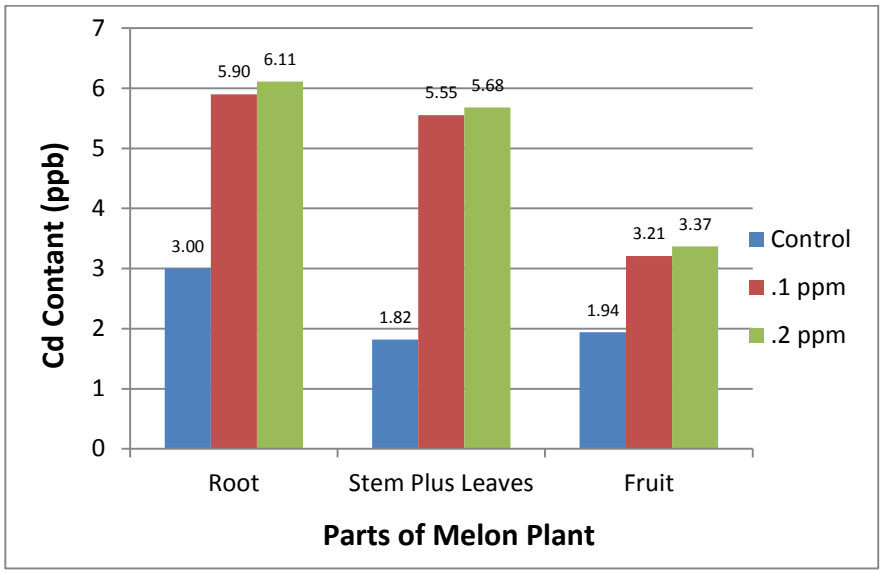

Figure 4.6: Translocation of Cd in various parts of melon

Figure six show that the ranking of Cd content for control plants was in decreasing order as follow: root> fruit> stem plus leaves. While the ranking for .1, .2 ppm treated plants was in decreasing order as follow: root> stem plus leaves> fruit.

Cadmium absorption by plants

The concentrations of cadmium which are toxic to plants are still unknown. High levels of zinc in the environment are largely related to irregular amounts of cadmium, and both of these elements may together exert a toxic effect at the same time.

Findings of Hansford T. Shacklette1972 in his book Cadmium in Plants, indicated that the uptake of Cadmium by plant increases proportionally after increasing soil Cadmium concentration.[87]

Ulrychova-Zelinkova (1959, p. 139) reported that tobacco plants (Nicotianatabacum) exhibit necrotic spots on the leaves due to increase in the inorganic phosphorus content after exposed to high doses of cadmium

greater than 160 milligrams per plant, and she also reported that cadmium ions definitely interfere with phosphorus metabolism and it considered to be more toxic to plants than zinc ions.[88]

After McMurtrey and Robinson (1938) had stated that cadmium considered as one of the very few metals that have not been reported in plants.[89], Clemente and Mendez (1940) were able to detect cadmium ions in cabbage (Brassica oleracea L.), green pepper (Capsicum frutescens L.), potato (Solanumtuberosum L.), sweet potato (Ipomeabatatas L.), lettuce (Lactuca sativa L.), and tomato (Lycopersicnmescidentum Mill.). However, they did not report the concentrations.[90]

Later analyses of metals and other plant materials using more sensitive methods leads to detecting this element in measurable concentrations in all plant tissues.

Cadmium can be absorbed by soil rooted plants easily from cadmium containing solutions applied to the soil.[87]Gordee, Porter, and Langston (1960) had studied the uptake of cadmium by peppermint plants (Menthapiperita L.) using Auto radiographic technique, the results showed that peppermint plants uptake cadmium after 24 hour of its exposure in the soil, the up taken cadmium moved gradually through the vascular system to all parts of the plant, and it accumulated largely in the lower leaves. They also stated that cadmium was not eliminated by peppermint plants and leaching of the soil.[91]

In the experiments which carried out on radish plants (Raphanussativus L.) to evaluate the effects of zinc addition on preventing or hindering cadmium

accumulation in food plants by the interactive effect between zinc and cadmium, Lagerwerff and Biersdorf (1972) combined 2, 20, and 100 ppb (parts per billion) of cadmium with 20, 100, and 400 ppb of zinc in culture solutions. The result of the experiment showed that at low concentration of cadmium, its uptake was inhibited with the increase in zinc concentration. However, at 100 ppb level of cadmium, increasing the concentration of zinc leads to increase cadmium uptake.[92]

In general the considerable reduction in crop yield due to high levels of zinc that were able to suppress cadmium absorption, combined with the inability of zinc to inhibit cadmium uptake at high levels of those elements, limits the practical possibility of decreasing cadmium uptake by plants through the application of zinc to the soil.[87] Dr. W. H. Alloway (1971) reported on his experiment that cadmium uptake by plants was not depressed by the increase of zinc levels in cultural solutions.[93]

Biological Standard Reference Materials for a variety of plants was issued by The U.S. National Bureau of Standards (Becker and LaFleur, 1972). Samples of the plants composed of dry pulverize orchard leaves from different types of fruit bearing plants. The samples were Analyzed using polarography and atomic absorption spectroscopy at the Analytical Chemistry Division of the Bureau of Standards, which indicated 0.11±0.02ppm cadmium in the dry leaves.[94] Cadmium concentrations were given in parts per million by Shirley, Benne, and Miller (1949) for some dry plant materials produced on soil containing normal levels of cadmium the results was as follows: 0.6-1.2 in dried spinach, 0.3-0.5 in dried lettuce, and 0.1-0.2 in alfalfa leaf meal.[95]

The allowable level of cadmium in most plants should be between 0.0027 and 0.663 mg/kg.[96] WHO/FAO recommended a safe value of 0.2 mg/kg for cadmium in fruit and vegetables.[97]The concentration of cadmium in the dried vegetables of pumpkin was <1 ppm.[98]

Prince (1957) studied the effect of soil type on the mineral composition of corn crops(Zea mays L.), he reported that cadmium content in the dried material of mature plants taken from four different kinds of soil ranged from 0.81 to 2.43 ppm. However, he did not give the levels of cadmium in the soils. He founded that the average values of cadmium in mature leaves of corn was 1 ppm, 0.96, 0.67 ppm in the dry grains and the husks respectively. Cadmium content in ragweed (Ambrosia artemisiifolia L.) which grown with corn was 0.46 ppm.[99]

In the experiment on several species of trees and shrubs that designed to analyze the ash of leaves and stems for cadmium using a developed semi quantitative spectrographic technique (mosier, 1972). The results of this experiment show that stem ash contains about twice as much cadmium as leaf ash. This indicated that cadmium was taken by the plant from the soil and translocated to the stem and leaves rather than being accumulated from the atmospheric fallout.[100]

Levels of cadmium, lead, zinc and copper were obtained in most plants to decline in particular parts of a plant in the following order: root - leaves-shoots - fruits and seeds, since the metals which absorbed by a plant from the soil first face a root barrier that weaken their penetration into the aerial parts of the plant.[101]

4.5.5 Chrome uptake by root

One Way ANOVA analysis indicated that there was a significant difference ($\alpha<0.05$) among all metal treatments (control, .1 ppm, .2 ppm). The significance was .027.

Table 8. One Way ANOVA test for chrome uptake by root

Treatment	Mean (ppb)	F	Sig.
Control	73.46	5.519	.027*
.1 ppm	149.51		
.2 ppm	594.47		

Table eight show that the highest mean was for .2 ppm treatment (594.47ppb), followed by.1 ppm treatment (149.51 ppb), the lowest mean was forcontrol (73.46ppb).

4.5.6 Chrome uptake by stem plus leaves

One Way ANOVA analysis indicated that There was a significant difference ($\alpha<0.05$) among all metal treatments (control, .1 ppm, .2 ppm). The significance was .007.

Table 9. One Way ANOVA test for chrome uptake by stem plus leaves

Treatment	Mean (ppb)	F	Sig.
Control	134.22	9.699	.007*
.1 ppm	269.31		
.2 ppm	633.35		

Table nine show that the highest mean was for .2 ppm treatment (633.35ppb), followed by.1 ppm treatment (269.31ppb), the lowest mean was for control (134.22ppb).

4.5.7 Chrome uptake by fruit

One Way ANOVA analysis indicated that There was a significant difference ($\alpha<0.05$) among all metal treatments (control, .1 ppm, .2 ppm). The significance was .001. (Table 10)

Table 10. One Way ANOVA test for chrome uptake by fruit

Treatment	Mean (ppb)	F	Sig.
Control	6.79	18.536	.001*
.1 ppm	7.64		
.2 ppm	8.61		

Table ten show that the highest mean was for .2 ppm treatment (8.61ppb), followed by.1 ppm treatment (7.64 ppb), the lowest mean was for control (6.79ppb).

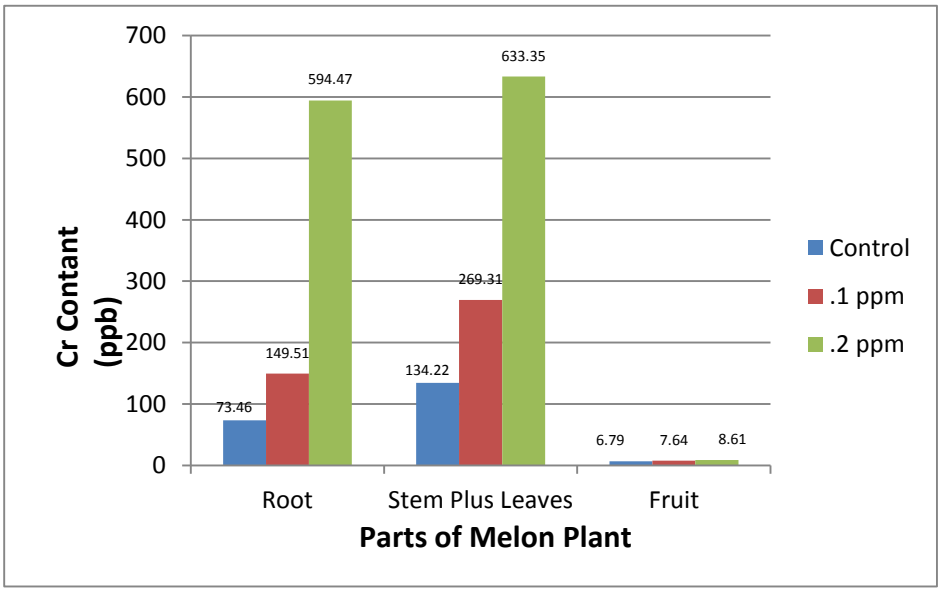

Figure 4.7: Translocation of Cr in various parts of melon

Figure seven show that the ranking Cr content for control , .1ppm and .2 ppm was in decreasing order as follow: stem plus leaves> root> fruit.

Chrome absorption by plants

Chromium (Cr) is considered as a nonessential and toxic element to plants, its normal level ranged from 10to 50 mg/kg according to the parental material.[102]

Researchers were interested in designing experiments on plants related with high concentrations of Cr. Therefore, one to five ppm of Cr found in the available form in the soil solution, either as Cr (III) of Cr (VI), set as a critical level for several plant species.the absorbed chrome by the plants grown in culture solutions, stayed mainly in the roots and poorly transported to the leaves. Concentrations of chrome in plant materials are related with toxicity symptoms and are commonly in the several hundreds of ppm range. High concentrations of chrome in plant tissues was observed before toxicity symptoms and ranged from about 5 ppm for barley, oats, corn and citrus to 175 ppm for tobacco.[103]

Irfan ErsinAkinci and SerminAkinci studied the effect of chrome on germination and seedling growth of melon (Cucumismelo L.) plants. The results of their study exhibited that increasing chromium treatment resulted in the deterioration of melon seeds. The deteriorated seeds lead to weak performance during the germination process and lower development during the early seedling stages.[76]

Jinhua Zou et al. conducted an experiment to study the effect of chromium accumulation on other minerals in sun flower (*Amaranthus viridis L*) at both contaminated and uncontaminated sites. They founded that *A. Viridis* plants grown at contaminated site accumulated chrome in ~11 times more

than those grown at the uncontaminated site. Moreover, they found that Chromium contents in *A. viridis* were as follows: leaf > root >stem. Copper was accumulated primarily in leaves and poorly in roots and it was not detected in stem in both the contaminated and uncontaminated sites. The content of zinc in leaves and stem was higher in the contaminated site than in the uncontaminated site, it accumulated mainly in roots. Concentrations of zinc in *A. viridis* from the uncontaminated site followed the order leaf > root > stem. While, in the contaminated site the order was root > leaf >stem. . Jinhua Zou et al. stated that *A. Viridis* cannot be considered as a hyperaccumulator. It can accumulate Cr, in stem and leaves, but it could not absorb and accumulate chrome in large amounts. They also concluded that chrome enhance the uptake of zinc.[104] However, some reports found that the presence of high levels of Chrome minimize the uptake of Fe, Zn and Mn in maize[105], and highly reduce the uptake of Fe, Mn, Ca, Mg, Cu, and Zn in sugar beet[106], chrome could interfere with the uptake of Ca, K, Mg, Pb, and Cu in soybean[107], and reduce the concentrations of Fe and Zn and increase the levels of Mn in bush bean[108].

According to the findings of Cunningham et al. (1975) the presence of chromium high levels will reduce the uptake of Cu, Mn and Zn in corn.[109]

Generally, researchers concluded that plants have low capacity to absorb and transport chrome (Barcelo and Poschenrieder, 1997).Studies on plants grown on soils treated with sewage sludge containing Chrome, its level was exceeded a few µg/g DW in leaves. However, plants grown on chrome rich soils, the level does not exceed 45µg/g DW.[110]

4.5.8 Copper uptake by root

One Way ANOVA analysis indicated that There was a significant difference ($\alpha<0.05$) among all metal treatments (control, .1 ppm, .2 ppm). The significance was .010. (Table 11)

Table 11. One Way ANOVA test for copper uptake by root

Treatment	Mean (ppb)	F	Sig.
Control	37.16	11.079	.010*
.1 ppm	56.13		
.2 ppm	65.81		

Table 11 show that the highest mean was for .2 ppm treatment (65.81ppb), followed by.1 ppm treatment (56.13 ppb), the lowest mean was for control (37.16ppb). This is perhaps because Cu is an essential microelement toplants.

4.5.9 Copper uptake by stem plus leaves

One Way ANOVA analysis indicated that There was no significant difference ($\alpha<0.05$) among all metal treatments (control, .1 ppm, .2 ppm). The significance was .513. (Table 12)

Table 12. One Way ANOVA test for copper uptake by stem plus leaves

Treatment	Mean (ppb)	F	Sig.
Control	46.84	.749	.513
.1 ppm	55.98		
.2 ppm	59.02		

Table 12 show that the highest mean was for .2 ppm treatment (59.02ppb), followed by.1 ppm treatment (55.98ppb), the lowest mean was for control (46.84ppb).

4.5.10 Copper uptake by fruit

One Way ANOVA analysis indicated that There was a significant difference ($\alpha<0.05$) among all metal treatments (control, .1 ppm, .2 ppm). The significance was .006. (Table13)

Table 13. One Way ANOVA test for copper uptake by fruit

Treatment	Mean (ppb)	F	Sig.
Control	30.48	13.922	.006*
.1 ppm	35.32		
.2 ppm	52.58		

Table 13 show that the highest mean was for .2 ppm treatment (52.58 ppb), followed by.1 ppm treatment (35.32 ppb), the lowest mean was for control (30.48ppb) .

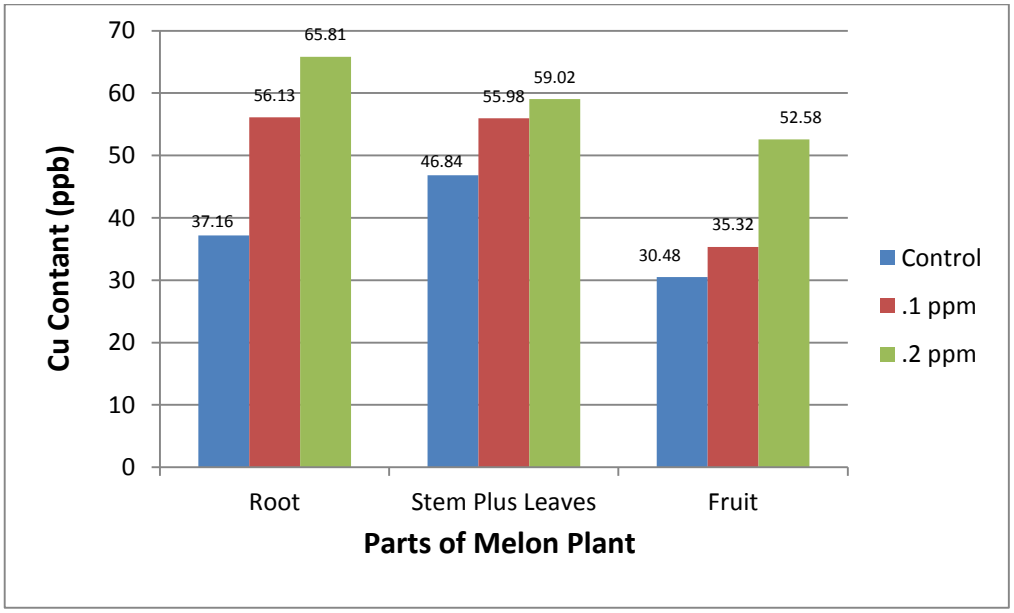

Figure 4.8: Translocation of Cu in various parts of melon

Figure eight show that the ranking of Cu content for control plants was in decreasing order as follow: stem plus leaves> root> fruit. While the ranking

for .1, .2 ppm treated plants was in decreasing order as follow: root> stem plus leaves> fruit.

4.5.11 Zinc uptake by root

One Way ANOVA analysis indicated that There was a significant difference ($\alpha<0.05$) among all metal treatments (control, .1 ppm, .2 ppm). The significance was .000. (Table 14)

Table (14) One Way ANOVA test for zinc uptake by root

Treatment	Mean (ppb)	F	Sig.
Control	123.56	53.876	.000*
.1 ppm	177.10		
.2 ppm	286.33		

Table 14 show that the highest mean was for .2 ppm treatment (286.33ppb), followed by.1 ppm treatment (177.10ppb), the lowest mean was for control (123.56ppb).

4.5.12 Zinc uptake by stem plus leaves

One Way ANOVA analysis indicated that There was a significant difference ($\alpha<0.05$) among all metal treatments (control, .1 ppm, .2 ppm). The significance was .033. (Table 15)

Table (15) One Way ANOVA test for zinc uptake by stem plus leaves

Treatment	Mean (ppb)	F	Sig.
Control	196.19	5.106	.033*
.1 ppm	274.84		
.2 ppm	379.23		

Table 15 show that the highest mean was for .2 ppm treatment (379.23 ppb), followed by.1 ppm treatment (274.84 ppb), the lowest mean was for control (196.19ppb).

4.5.13 Zinc uptake by fruit

One Way ANOVA analysis indicated that There was a significant difference ($\alpha<0.05$) among all metal treatments (control, .1 ppm, .2 ppm). The significance was .008. (Table 16)

Table 16. One Way ANOVA test for zinc uptake by fruit

Treatment	Mean (ppb)	F	Sig.
Control	191.41	8.814	.008*
.1 ppm	332.79		
.2 ppm	425.30		

Table 16 show that the highest mean was for .2 ppm treatment (425.30 ppb), followed by.1 ppm treatment (332.79 ppb), the lowest mean was for control (191.41ppb).

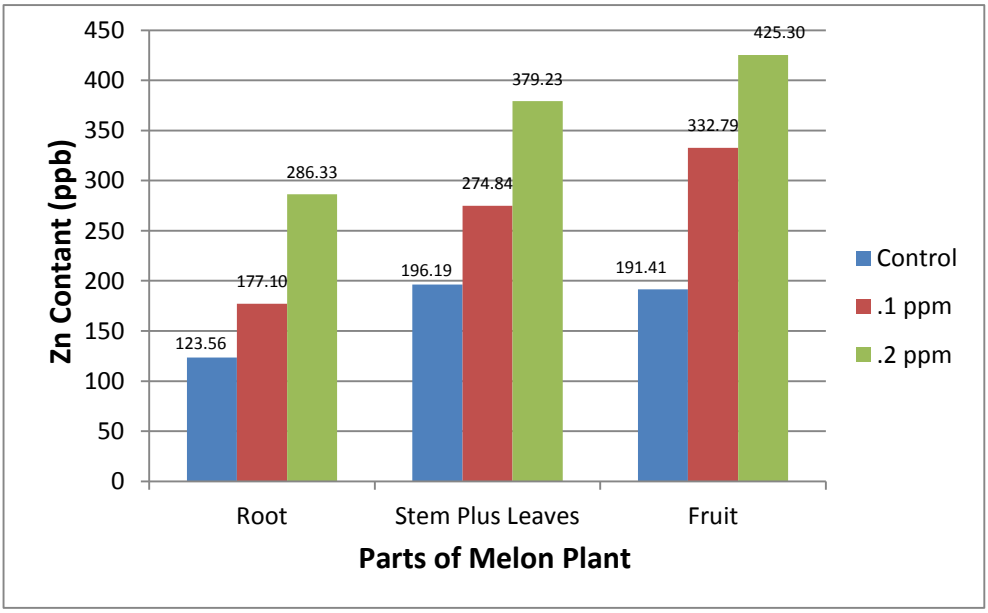

Figure 4.9: Translocation of Zn in various parts of melon

Figure nine show that the ranking of Zn content for control plants was in decreasing order as follow: stem plus leaves> fruit> root. The ranking for .1, .2 ppm treated plants was in decreasing order as follow: fruit> stem plus leaves> root.

Copper and zinc absorption by plants

Copper and zinc are considered as essential elements for plants and animals, although a small change in their concentration may cause interference with important physiological processes. The allowable level of copper in fruit and vegetables which recommended by the WHO/FAO is 40 mg/kg.[97]

Normal levels of zinc in mg/kg are 26-38 in barley, 10 in citrus pulp, 46 in potato, 25-27 in maize, 27-41 in oats, and 29-49 in wheat.[111]

Study of heavy metals in pepper (*Capsicum annuum*) and tomato (*Lycopersicon esculentum*) showed that Copper levels in the parts of Capsicum annuum plant was as follows: Shoot> Root>Fruit. While in the parts of Lycopersiconesculentumplant was as follows: Root>Shoot>Fruit. levels of zinc in the parts of Capsicum annuumplant was as follows: Shoot> Root>Fruit .its levels in the parts of Lycopersiconesculentumplant was asfollows: Root>Shoot>Fruit.The mean concentrations of copper and zinc for both weresignificantly different.Heavy metals concentrations in both shootsranking in decreasing order asfollows:Fe>Zn>Cu>As>Pb>Cd.[87]

M. A. Elbagermi et al. stated that zinc can be used toneutralize the toxicity of cadmium.The maximum content of zinc was detected in melons (8.24 mg/kg) , the lowest content was detected in mangos(0.635 mg/kg).[62]

The ranking of different heavy metals in of various plant parts of V. fabaplants were in decreasing order as follows: leaves>shoot>root> fruits for copper and zinc.[85]

Chandra et al. (2009) detected higher levels of metals (Cu, Cd, Zn ,Cr,Mn , Fe, Ni, and Pb) in wheat and mustard plants treated with different distillery and tannery effluents.[112]zincconsidered as hyperaccumulator since its concentrations ratio (shoots/roots) <1. Hyperaccumulator plants tends to accumulate metals in shoot tissues inlevels exceeding those in roots (concentration ratio> 1)[113].

According to thissome crops can be usedto remove heavy metals from the soil.Examples of these crops are: field pumpkin, red beet,chicory, commonbean, barley, white cabbage, maize, alfalfa and commonparsnip. Themost effective crop used to remove Cd, Mn, Cu, Ni, Pb, and Zn was field pumpkin, maize was effective in removing Cr, and Fe removed effectively by alfalfa crop.[114]

Gambuoestudied the capacity of several species of vegetables to uptake heavy metals. He concluded that red beet was able to accumulate copper in roots two times more than leaves. In comparison zinc distributed in plant differently. Thus, it accumulated largely in the leaves. The result of his study show that shoots/roots concentrationratio for zinc was 2.0 .[115]The content of the studied metals in pumpkin crops was as follows: copper concentrated largely in roots (25.74 mg·kg-1 d. w.). lower amounts of copper detected in stem,leaves, and fruits (average 11.05 mg·kg-1 d. w.). zinc levels in leaves 119.14 mg·kg-1 d. w.,in fruits about two times lesser,and in roots and stem about three times lesser.[116]

Conclusions

Based on the results of this study, the following can be concluded:

- As salinity and heavy metals concentrations increased, musk melon salinity and heavy metals content increased.
- Musk melon is proved to tolerate salinity as NaCl up to 3000 ppm , while it can tolerate heavy metals up to .1 ppm, this indicate that it is recommended for melon plants to grow in Al-Aghwar regionwhere salinity ranges between 2000 to 3000 ppm.
- The maximum reduction in melon height was after the treatment of 3000 ppm of salt (-17.91%) and .2 ppm of metals (-15.98%), whereas the maximum reduction in number of leaves was after the treatment of 7000ppm of salt (-21.13) and .2 ppm of metals (-38.74%). The reduction in plant size was higher in fruit fresh weight after the treatment of 7000 ppm of salt (-20.53%) and in stem dry weight after the treatment of .2 ppm of metals (-27.27%).
- Musk melon is considered as a hyper accumulator for Cr and Zn. It tends to accumulate those metals on shoot more than root.
- Cd and Zn content in the fruits of musk melon exceeded the allowable level after the treatment with .1, .2 ppm, Cu content exceeded the allowable levels in fruit when treated with .2 ppm. However Cr content in fruit was at the allowable level after both treatments.

Recommendations

- More attention should be paid by the ministry of agriculture to improve Palestine agriculture using hydroponic systems
- Experiments on other crops should be carried out to study the impacts of salinity and heavy metals
- Other parameters could be studied such as the nutritional value and the quality of musk melon fruit after thetreatment with salinity and metals
- increase farmers' awareness and introduce them to the benefits of hydroponics and their ability to solve problem of salinity in soil by the help of media, conferences and seminars.

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Appendix

Appendix (1) LSD test of plant height for the differences in the treatment levels due to the variables of Concentration .

Height during 1st week of treatment	S1	Treat.	Mean	Sig.
		S3	3.70000*	0.003*
		M1	3.05000*	0.012*
		M2	4.81765*	0.000*
		control	-10.85000-*	0.000*
	S2	M2	3.29412*	0.012*
		control	-12.37353-*	0.000*
	S3	control	1.21888	0.000*
	M1	control	-13.90000-*	0.000*
	M2	control	-15.66765-*	0.000*
Height duringthird week of treatment	S1	S2	4.18529*	0.006*
		S3	4.83889*	0.001*
		M2	4.71471*	0.002*
		control	-12.85000-*	0.000*
	S2	M1	-3.43529-*	0.024*
		control	-17.03529-*	0.000*
	S3	M1	-4.08889-*	0.006*
		control	-17.68889-*	0.000*
	M1	control	-13.60000-*	0.000*
	M2	control	-17.56471-*	0.000*
		M1	-3.96471-*	0.009*
Height duringsixth week of treatment	S1	s2	6.61176*	0.001*
		S3	5.86667*	0.002*
		M2	4.31765*	0.021*
	S2	M1	-8.06176-*	0.000*
		control	-14.70000-*	0.000*
	S3	M1	-7.31667-*	0.000*
		control	-20.56667-*	0.000*
	M1	M2	5.76765*	0.002*
		control	-13.25000-*	0.000*
	M2	control	-19.01765-*	0.000*

Appendix (2) test of number of leaves for the differences in the treatment levels due to the variables of Concentration.

No. of leaves duringfirst week of treatment	S1	s2	4.07647*	0.001*
		s3	2.67778*	0.032*
		M1	5.70000*	0.000*
		M2	9.42941*	0.000*
		control	-8.50000-*	0.000*
	S2	M2	5.35294*	0.000*
		control	-12.57647-*	0.000*
	S3	M2	6.75163*	0.000*
		control	-11.17778-*	0.000*
	M1	M2	3.72941*	0.003*
		control	-14.20000-*	0.000*
	M2	control	-17.92941-*	0.000*
No. of leaves duringthird week of treatment	S1	s2	2.55882*	0.040*
		s3	3.16667*	0.010*
		M1	6.30000*	0.000*
		M2	13.38235*	0.000*
		control	-10.95000-*	0.000*
	S2	M1	3.74118*	0.003*
		M2	10.82353*	0.000*
		control	-13.50882-*	0.000*
	S3	M1	3.13333*	0.011*
		M2	10.21569*	0.000*
		control	-14.11667-*	0.000*
	M1	M2	7.08235*	0.000*
		control	-17.25000-*	0.000*
	M2	control	-24.33235-*	0.000*
No. of leaves duringsixth week of treatment	S1	s3	3.53333*	0.004*
		M1	7.00000*	0.000*
		M2	17.49412*	0.000*
		control	-13.30000-*	0.000*
	S2	s3	2.50980*	0.048*
		M1	5.97647*	0.000*
		M2	16.47059*	0.000*
		control	-14.32353-	0.000*

			*	
	S3	M1	3.46667*	0.005*
		M2	13.96078*	0.000*
		control	-16.83333-*	0.000*
	M1	M2	10.49412*	0.000*
		control	-20.30000-*	0.000*
	M2	control	-30.79412-*	0.000*

Appendix (3) LSD test of stem plus leaves, root, and fruit fresh and dry weight for the differences in the treatment levels due to the variables of Concentration.

SFwt	M1	M2	80.92021*	0.015*
RFwt	S1	s2	-.99429-*	*0.004
		M1	-1.41402-*	*0.000
	S2	M2	1.47394*	0.000*
		control	1.26637*	0.000*
	S3	M1	-0.99579-*	0.004*
		M2	0.89788*	0.012*
		control	0.69031*	0.042*
	M1	M2	1.89367*	0.000*
		control	1.68610*	0.000*
FFwt	S1	control	-407.75000-*	.000*0
	S2	control	-483.25000*	.003*0
		control	-469.46429*	.000*0
	M1	control	-373.91667*	*0.000
	M2	control	-446.91667*	*0.000
SDwt	control	S1	0.67740*	0.000*
		S2	0.72214*	0.000*
		S3	0.70990*	0.000*
		M1	0.52815*	0.001*
		M2	0.74443*	0.000*
FDwt1	S1	control	0.14260*	0.015*
	S2	M2	-.016210-*	0.033*
	S3	control	0.12980*	0.025*
	control	M2	-0.17380-*	0.004*
FDwt2	S1	control	0.17900*	0.003*
	S3	control	0.15860*	0.007*
	M2	control	0.19780*	0.001*

جامعة النجاح الوطنية
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اشراف
أ. د. مروان حداد

قدمت هذه الأطروحة استكمالا لمتطلبات درجة الماجستير في العلوم البيئية بكلية الدراسات العليا في جامعة النجاح الوطنية, نابلس, فلسطين
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الملخص

الملوحة والمعادن لها تأثير كبير على النباتات. أجريت هذه الدراسة لتقييم تأثير الملوحة والمعادن المختارة على نمو, إنتاجية, وامتصاص نبات الشمام المزروع في نظام مائي افقيو الذيأنشئ في نموذج لبيت بلاستيكي في جامعة النجاح الوطنية. تم معالجة النبات بأربع معاملات للملوحة تضم: صفر (المرجع), 1000, 3000, 7000 جزء من المليون للملح NaCl. بينما ثلاث معاملات من المعادن تم استخدامها تضم: صفر, 0.1 , و 0.2 جزء من المليون لعناصر ال Cd, Cr, Cu, Zn . تم اخذ البيانات الخاصة بطول النبات, عدد الأوراق, والوزن الرطب والجاف. امتصاص النبات لملح ال NaCl تم تحليله باستخدام الموصلية الكهربائية , وامتصاص المعادن تم تحليله باستخدام جهاز ال ICP-MS. التراكيز المرتفعة من الملح والمعادن أدت إلى انخفاض محسوس في الطول وعدد الأوراق لنبات الشمام. الوزن لأجزاء متعددة من نبات الشمام ازداد بعد المعالجة باستخدام كل من الملح والمعادن لحد تركيز 3000, 0.1 جزء من المليون للملح والمعادن على الترتيب, ثم بدأت بالانخفاض عند تراكيز أعلى. هذا قد يكون نتيجة لتصرف المعادن والأملاح كغذاء لحد معين, وتأثيرها السمي عند تراكيز أعلى. امتصاص الأملاح والمعادن ازداد طردياً بزيادة التراكيز المضافة.