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Effect of Using Magnetized Treated Water in irrigation of Bell Pepper and Beans in AL-Jiftlik area/West Bank-Palestine

Diya'a Mohammad Da'od Radeideh

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Prepared by:

Diya’a Mohammad Da’od Radeideh

B.Sc. Al-Quds University- Palestine

Supervised by:
Dr. Amer Marei

A thesis submitted in partial fulfillment of requirements for the Degree of Master science in environmental studies, department of Applied Earth and Environmental Studies -faculty of Science and Technology, Al-Quds University.

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Thesis Approval

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Prepared by: Diya'a Mohammad Da'od Radeideh
Registration No: 20913458
Supervisor: Dr. Amer Marei

Master thesis submitted and accepted:

The names and signatures of the examining members are as follows:

1- **Head of Committee: Dr. Amer Marei Signature:**

2- **Internal Examiner: Dr. Amer Kanan Signature:**

3- **External Examiner: Dr. Mazen ALSalmman Signature:**

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Dedication

To my beloved family for their support

To my father Mohammad and my mother Fayza

To my husband Fadi and my children, Karam and Joud

To All those people who's helped me in this study

Diya'a Radeideh

Declaration:

I certify that this thesis submitted for the degree of Master is the result of my own research, except where otherwise acknowledged and that this thesis (or any part of the same) has not been submitted for a higher degree to any other University or institution.

Name: Diya’a Mohammad Da’od Radeideh

Signed: 

Date:16/4/2014

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I would like to thank my Father, Mother and husband for being very supportive and help me achieve all my goals with ease. I finally would like to dedicate all my work to my parents.

Abstract:

Agriculture sector is an essential element of national income and food security in Palestine. So there should be necessary intense work to improve and increase production. The major source of irrigation in the west bank is groundwater, where the agriculture sector consumes about 65% of this water. The increase of ground water salinity is considered as the main impediment to this sector, where the negative impact that results from increased water salinity affects soil and therefore reducing agriculture production as well as the deterioration of the economic situation.

This study was carried out at AL-Jiftlik village under greenhouse conditions grown with Bell Pepper and Beans during the growing season of 2012/2013 to investigate the effect of using magnetized treated water on the crop yield (quantity and quality) and on soil salinity. The results showed that there is a significant decrease in soil salinity when irrigated with magnetized treated water and an increase in the yield of yellow and red Bell Pepper as well as in the yield of beans of 18.4, 20.00 and 9.27 %, respectively compared to controlled samples. The dry weight of Bell Pepper plant roots was higher of about 12% by compared to the control plants. An improvement in water productivity by 15% was recorded and also an increase in the fruit weight of 11% was also recorded. The effect of using treated magnetized water caused also an increase in storage period of 7 days for Bell Pepper. The chlorophyll content of Bell Pepper leaves irrigated with treated magnetized water was 10 mg/g compared to 7.5 mg/g in control samples. The activity of nematodes pest in soil samples irrigated with magnetized treated water was less than that in controlled samples. No clear significant effects was measured on the height of the plant, number of fruits, distance between nods, thickness of walls, and sugar contents. Applying visible/near infrared (VIS/NIR)-spectroscopy test showed that it is possible to distinguish between treated and controlled Bell Pepper fruits. Multivariate data analysis method was used to test the grouping of chemical elements (Lithium (Li) , Boron (B) , Sodium (Na) , Magnesium(Mg) , Aluminum(Al), Potassium(K), Calcium(Ca), Manganese(Mn) , Iron(Fe) , Cobalt (Co), Nickel(Ni) ,Copper (Cu), Zinc (Zn) , Strontium (Sr), Molybdenum(Mo) , Silver (Ag) ,Cadmium(Cd) and Barium(Ba)) in Bell Pepper fruits, and type of was found that treated and control fruit samples are divided into two groups according to the irrigated water, one group related to the treated and the other to the controlled group). In general, the results showed benefit effect of using magnetic water especially on soil salinity, fresh yield, root weight, shelf time,

chemical constituents and nematode effect. While our findings are indicative, further testing is needed especially by involving other variables such as decreasing the volume of irrigated water, and fertilizers.

تأثير استخدام المياه المعالجة مغناطيسياً في ري الفلفل الحلو والفاصولياء في منطقة الجفتلك/ الضفة الغربية.

إعداد: ضياء محمد داود ردايدة.
إشراف: د. عامر مرعي.

الملخص

القطاع الزراعي عنصر مهم للدخل القومي والامن الغذائي ، لذلك من الضروري العمل على تحسينه لزيادة الإنتاج . المصدر الرئيسي للري في الضفة الغربيه هي المياه الجوفيه ، حيث يستهلك القطاع الزراعي 65٪ من هذه المياه، لكن زيادة ملوحة المياه الجوفيه تعتبر من العوائق الرئيسية امام هذا القطاع،حيث ان الآثار السلبية التي تنجم عن زيادة ملوحة المياه تؤثر على التربة وبالتالي الحد من الإنتاج الزراعي مما يؤدي الى تدهور الوضع الاقتصادي.

أجريت هذه الدراسة في قرية الجفتلك في بيوت بلاستيكيه ، حيث زرع الفلفل الحلو والفاصوليا الخضراء أثناء موسم النمو 2013/2012 لدراسة تأثير المعالجة المغناطيسيه للمياه على ملوحة التربة والمحصول (كما ونوعا). وقد اظهرت نتائج تحاليل نسبة الملوحة التي اجريت على عينات التربة أن هناك انخفاضا في ملوحة التربة التي رويت بالمياه المعالجه مقارنه بغير المعالجة . وهناك زيادة في محصول الفلفل الحلو والفاصوليا الخضراء حيث كانت الزيادة بنسبة 18.4 و 20٪ لمحصول الفلفل الاصفر والاحمر على التوالي و 9.27٪ لمحصول الفاصوليا الخضراء .كما أن هناك زيادة في إنتاجية مياه الري بنسبة 15٪ لنبات الفلفل الحلو. وأدت مغنطة مياه الري الى زيادة وزن ثمار الفلفل بنسبة 11% . و زيادة نسبة الكلوروفيل التي كانت 10 , 7.5 ملغ / غرام للفلفل المعالج وغير المعالج على التوالي . كان هناك زيادة في وزن جذور الفلفل بنسبة 12٪ للنبات المعالج . من ناحية أخرى، لم تكن هناك آثار واضحة على طول النبات، عدد الثمار لكل نبته، المسافة بين العقد ,عدد الفروع ، عدد الازهار , عدد الاوراق ونسبة السكر .

استخدمت الاشعة القريبة من تحت الحمراء للمقارنة بين جودة الفلفل الحلو المعالج وغير المعالج , حيث اظهرت النتائج ان هناك فرق بين النوعين وان ميزات الفلفل المعالج افضل من الغير معالج . ونتيجة تحليل العناصر الكيميائية الموجودة في عينات الفلفل المعالج وغير المعالج اظهرت النتيجة ان الفلفل المعالج يحتوي على اغلب العناصر بتراكيز اكبر من الغير معالج . واستخدام المياه الممغنطة كان

له تأثير ايجابي على تقليل النيماتودا في التربة . بشكل عام نتائج استخدام المياه الممغنطة كان ايجابيا خصوصا على ملوحة التربة ,المحصول , وزن الجذور , مدة التخزين ,التركيب الكيمائي وتأثير النيماتودا . جميع النتائج التي حصلنا عليها بحاجة الى اجراء المزيد من التجارب خصوصا باضافة متغيرات أخرى مثل تقليل كمية مياه الري والأسمدة.

List of abbreviation:

Abbreviation	Full Name
Ag	Silver
Al	Aluminum
AQU	Al-Quds University
B	Boron
Ba	Barium
Ca	Calcium
Cd	Cadmium
Cl	Chloride
cm	Centimeter
Co	Cobalt
Cu	Copper
ds/m	Decisiemens per meter
EC	Electrical Conductivity
EDR	Electrodialysis reversal
FAO	Food and Agriculture Organization of the United Nations
Fe	Iron
gm	Gram
HNO3	Nitric acid
ICP-MS	Inductivity Coupled Plasma-Mass Spectrometer
K	Potassium
Kg	Kilogram
Kg/dun	Kilogram per dunum
kg/m^3	Kilogram per cubic meter
Li	Lithium
LJV	Lower Jordan valley
m^3	Cubic meter
MCM	Million cubic meter
MD	Membrane distillation
m^3/dun	Cubic meter per dunum
mg	Milligram
Mg	Magnesium
m^3/h	Cubic meter per hour
ml	Milliliter
mm/a	Millimeter annually
Mn	Manganese

Mo	Molybdenum
mS/cm	Milli-siemens per centimeter
MVDA	Multivariate Data Analysis
MWT	Magnetic water treatment
Na	Sodium
Na%	Sodium Percent
NF	Nano filtration
Ni	Nickel
Nm	Nanometer
NPK	Nitrogen phosphorus potassium
PLS-DA	Partial Least Squares-Discrimination Analysis
RO	Reverse Osmosis
Sr	Strontium
TDS	Total Dissolved Solids
UV	Ultra violet
VIS/NIR	visible/near infrared
Zn	Zinc

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Chapter One

Introduction

1.1 Back ground:

Water source in the West Bank is mainly limited to the groundwater, where about 75% of the annual current water supply (120 MCM) covers through this source in forms of springs, and groundwater wells, where the remaining 25% is covered by the Israeli company Mekerot (Fisher, Arlosoroff et al. 2002).The agriculture sector consumes about 65% of the local water sources (palestinian water Authority 2009)**.** The Lower Jordan Valley is considered as one of the most important irrigated area in the West Bank, where 52% of the irrigated land in West Bank exists in lower Jordan valley (Da'as. 2010) where 106.056 dunums are located in the Jordan valley(LJV) as irrigated land (Arij. 2012) , because of its fertile soil, warm climate during winter months (natural green house) and availability of water. Due to the limited annual rainfall (less than 250 mm), and high evaporation rate (about 2085 mm/a), growing of crops without additional water is impossible**.** Not less than 70% of the lower Jordan valley inhabitants depend mainly on agriculture, where it is considered the second source of the national gross income, so it was necessary to work to improve and increase production.

The Shallow aquifer system in the Lower Jordan Valley is mostly used in irrigation, where water is taped from 80 to 150 meter deep boreholes. The Shallow aquifer system consists of gravel, sand, silt and marl layers of Plio-Pleistocene age. Due to the limitation of natural replenishment, and over-exploitation, water salinity has increased during the last 20 years from 1.8 mS/cm to 4 mS/cm (Amer. 2013).

Recently the critical and major problem in LJV is salinity of groundwater used for irrigation. This leads to shift the cropping pattern for more salinity tolerance, limit the crop diversity, effects on the quantity and quality of yield, soil salinity and texture, and also affects the socio-economy condition of the inhabitants. Many techniques are used to improve the level of agriculture in term of quantity and quality. The most important solutions to find new clean water resources are water desalination technologies such as (reverse osmosis (RO), electrodialysis reversal (EDR), nano filtration (NF) and membrane distillation (MD)). One of these techniques used in LJV to overcome the salinity problem is to use the R O –technology however this technology needs: a high financial investment, electricity, replacement parts, chemicals and can cause an environmental problem, when brine water is discharged in the open drainage system.

One of the new promising technologies to solve the salinity problem is to use magnetic water treatments , which requires less investment , decentralized , and mobile ; requires minimum replacement parts ; has a low maintenance cost and uses solar energy.

This magnetic technology is based on the vibration of water molecules that surround the salts ions; which splits the water molecules cluster .Therefore, the entrapped salt particles become unbound and have the ability to move outside the water clusters.

Where, these centers form platelets that avoid the formation of hard crystals residual. Converted dissolved minerals under saturated condition into a mixture of micro crystals and allow the water molecules to dissolve additional minerals through its path way , this phenomenon can be utilized for opening clogged drippers and for washing salts from the upper soil horizon .Another characteristic of treated water its low surface tension ,which allows the water to move faster within the upper soil horizon penetrating the soil quickly and reaching the plant uptake zone in a shorter period. Also, the reduction of surface tension may increase water absorption through the cell wall and thus accelerating the growth rate of the growing parts of the plant. (ALtalib, .ALsinjary, 2009)

1.2 Problem statement:

Ground water is the main source of irrigation in the LJV. The agricultural nature of this region indicates 90% of economic activity depends on agriculture sector (Arij.2012). Therefore the quality of this water is very important. Continuous rising of water salinity during the last two decades caused limitation of cropping. Figure (1.2.1) shows the salinity distribution in the study area which ranges between 2.5 ms /cm and 7ms/cm (Marie, et al.2001).

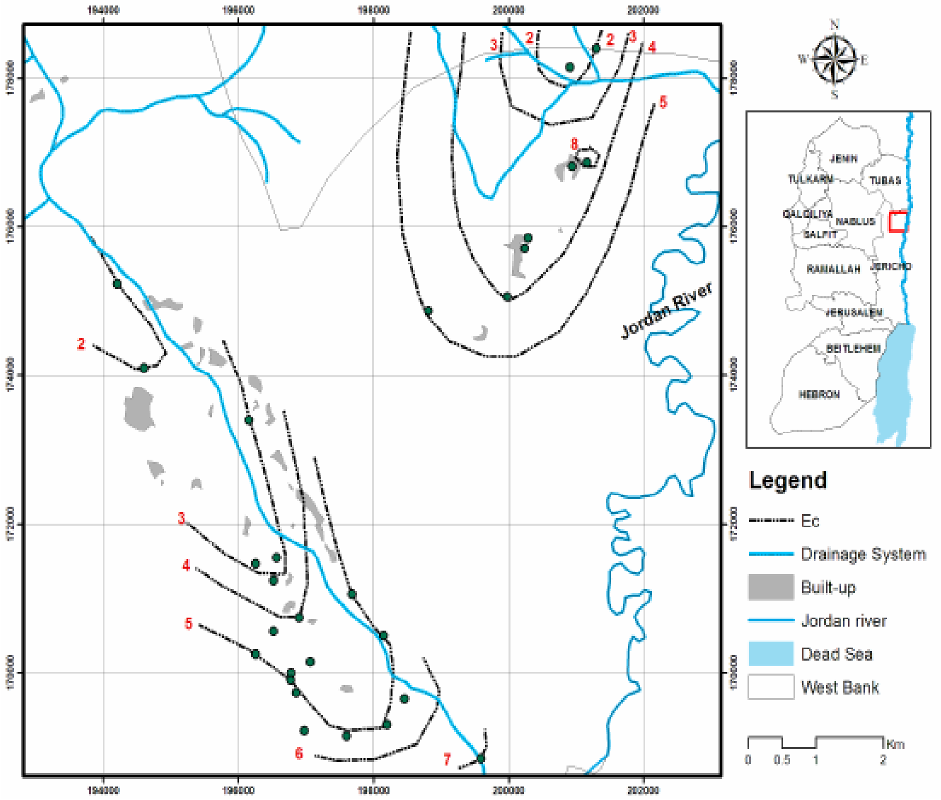

Figure1.2.1: Salinity Distribution in Al -Jiftlik Area, SMART-Project (Marei.A, et al 2011).

The agricultural sector is facing the salinity problem since more than two decades. Over irrigation is also a serious problem, where salt minerals accumulate in the upper soil layer. According to the FAO- reference paper 29.RE.1.1989-1994, Table (1.2.1) summarizes the impact of water salinity on agriculture sector.

Most of the ground water in LJV area is classified as very hard water. This causes a negative impact on the sustainability of drippers and causes clogging; also the saturation of water with calcite causes accumulation of salts and acts as a cementing material for soil. Another characteristic of ground water is the high sodium per cent ratio (Na %) where it reach close to 80% in most of the ground water boreholes (Amer.A. 2013). This salinity increase affects the soil permeability and aeration and has a toxic impact on crops.

Table 1.2.1: Negative Impact of Using Brackish Water in Agriculture (FAO.2005).

Effect on soil and water	Effect on crop diversity	Effect on socio-economy
• Changes in soil structure, decreasing permeability and soil aeration. • Increase the salinity of ground water by return flow. • Increase the consumption of water.	• Increase plant toxicity. • Low crop yield. • Low crop quality. • Less crop diversity. • Mono crop culture. • Increase pest risk.	• Low value of land price. • Low agriculture income. • Less man power. • High investment on new crops. • High risk of mono agriculture culture. • Dependence on export. • Price degradation.

To overcome the salinity problem is RO-technology in LJV can be use; this technology is still expensive and can cause environmental problem.Table (1.2.2) show the comparison between magnetic water treatment (MWT) and Reverses Osmoses (RO) technologies.

Table 1.2.2: Comparison Between Magnetic Water Treatment (MWT) and Reverses Osmoses (RO).

Name	MWT	RO
Initial Cost ($)	25000	150000
Infrastructure($)	1000-3000	10000
Energy /m^3	Solar energy	Electricity network 0.4 kw/m^3 Desalinated water
Chemicals	0.0	1L of Anti-calcinations'/ day 8$/D
Brines	0.0	20m^3 of 75m^3 water
Mobility	Yes	No
Maintenance	Doesn't need	Need
Impact on environment	Eco-friendly	Produce Brine water

1.3 Objective:

The hypothesis of this research is using Magnetic Water Technology (MWT) to overcome the effect of salinity on the agriculture sector in AL-Jiftlik. Where this usage of magnetic water in agriculture can lead to:

Leaching of salts from root zone   increasing the irrigation water infiltration to the zone of uptake and facilitating and increasing the efficiency of water absorption through the plant root.

The objectives of this study are:

1. To monitor the impact of using MWT on the quantity and quality of vegetable crops.
2. To monitor the impact of using MWT on soil salinity different depths.
3. To monitor the impact of MWT on the activities of root knot nematode (*Meloidogyne* spp.) .

Chapter Two

Literature Review

2.1 Effect of Saline Water on Soil and Plant Growth:

Plant growth is affected by environmental factors which is the most important factor. It constitutes three-fourth of plant weight, and water plays many vital roles in biological processes that occur during plant growth such as photosynthesis, respiration, cell expansion and regulation of stomata opening. So it is necessary to use good quality water for efficient growth and more production. One of the most important properties that determine the quality of water is the degree of salinity (Decoteau.1998). The source of irrigation water determines the quality of this water through the concentration of dissolved salts . Salinity of irrigation water measured by total dissolved solids (TDS) and electrical conductivity (EC) (Grattan .2002). Plant needs sixteen elements to grow , thirteen elements are obtained from the soil which is effected by water salinity and destroy soil structure and poor soil drainage, leading to inhibition of root penetration of the soil and death of root hairs and ultimately the plant death.(Hochmuth,1991). Soil salinity leads to matching between cations (such as sodium and potassium) , and anions such as chloride and nitrate- nitrogen)in the uptake sites at the roots , this leads to a decreased yield and when that happens a decrease of potassium reduces the fruits number per plant .

According to plant tolerance to salinity, the resistance is divided into three categories: low tolerance, medium and high (Veron, 2010). The classification of crop tolerance to salinity is shown in figure (2.1.1) .The increase of irrigation water salinity leads to salt stress and thus inhibits plant growth affecting plant health that may result from necrosis, abscission, and plant growth reduction.

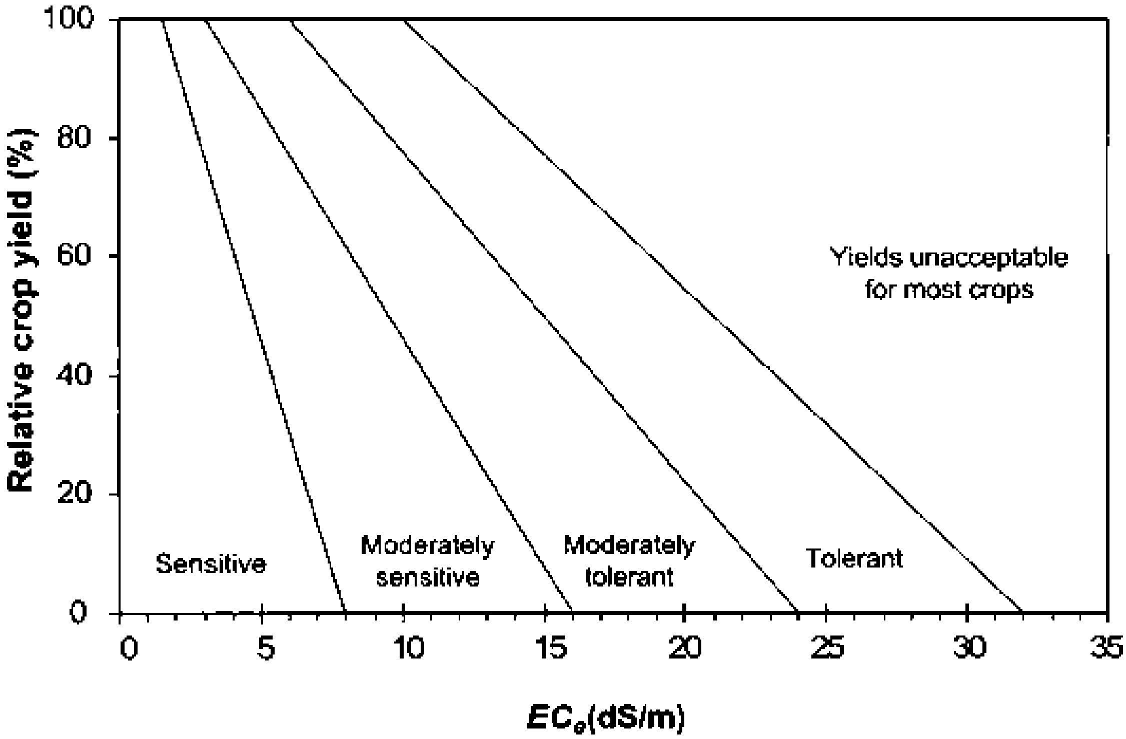

Figure 2.1.2: Classification of Crop Tolerance to Salinity (FAO, 1999)

2.2 Magnetic Water Technology (MWT):

Discovery of magnetic water back to 1803 were it was observed in the locations of natural magnetic rocks, then the first research started in 1863 by Michael Faraday and from 1980 the researches on magnetic water treatment (MWT) had increased tremendously (Mnmahon,2009). Many researchers studied this phenomenon and its influence on plants, saline waters and soil. They found that there are obvious differences between magnetic water and normal water in many properties such as pH, surface tension, viscosity. Amiri and Dadkhah 2006, measured water surface tension for MWT versus normal water and he noted a significant reduction of surface tension which positively affects the water uptake.

Selim 2008, examined the effect of magnetic technologies applied on brackish groundwater to be used for irrigation, he indicated that MWT induced changes in mobility of nutrients in root zone due to fast changes in solubility of some soil components. Also he showed the direct effect of MWT on seed germination of wheat plant seeds, where the results were showed: 100% seed germination compared to 83.86% in none magnetized water.

Water treatment products based on magnets are widespread and have been on the market in various forms for a long time. Previous studies have observed that very strong magnetic fields may cause changes in the behavior of salt ions and water molecules .When water passes through the copper water pipe it is exposed to a magnetic field (figure 2.2.2) which later called magnetic water and possesses different properties. Figure 2.2.3 shows that specific structure is directly related to hydrogen bonds between water molecules that form clusters around the foreign particles.

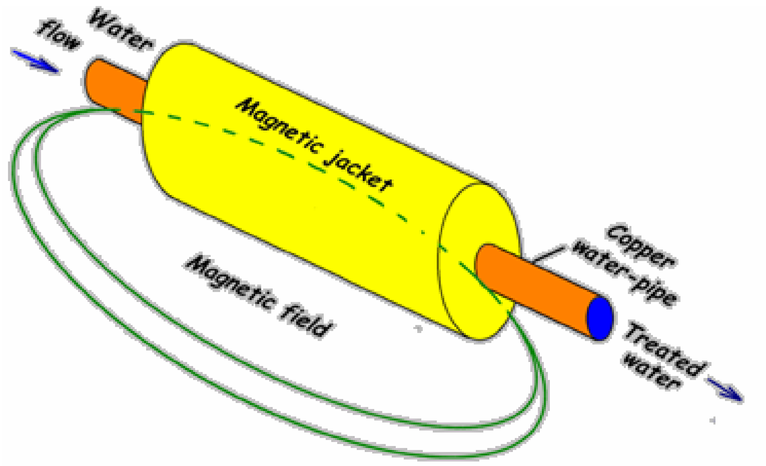

Figure 2.2.2: General Arrangement of MWT Column

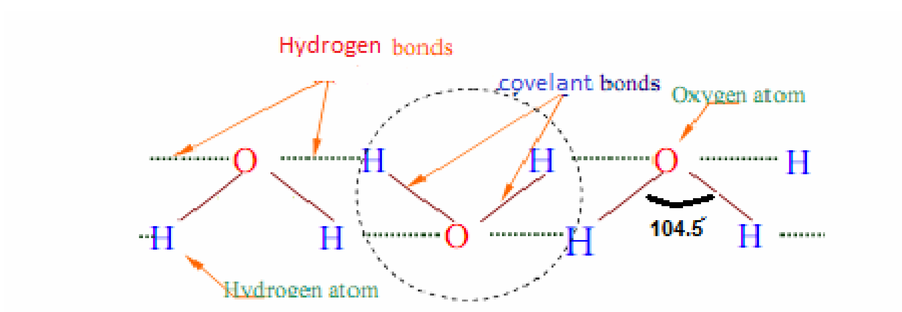

Figure2.2.3: Structure of Water Molecules and Hydrogen Bonds

The work principle of this technology is the magnetic effect on water molecules. When they pass through magnetic field where the water goes in one direction and the water molecules surround the salt ions they are cleaved and become easy to get out of the water and leached in the depths of the soil. Other properties that change the surface tension of water become low which allows the water move faster in soil and plant which leads to grow faster .(ALtalib, 2009).

The effect of the magnetic treatment depends on the force of the magnetic field that affects the water molecules leading to vibration or movement of these clusters that are formed by molecules. This leads to the split of salts particles known crystal formation into smaller molecules which are easily removed outside the water clusters .From the other perspective, the principle at work is a physical reaction between the magnetic field and mobile electric charges, when it passage of these ions through this field, there are formed a force called the power of the Lorentz that are in the opposite direction of the ions is working on a redirected leading to decrease in volumes of water clusters, increased frequency collisions between ions of different charges and form a mineral . The effect of MWT extends from 48 to 72 hours (figure 2.2.4). .

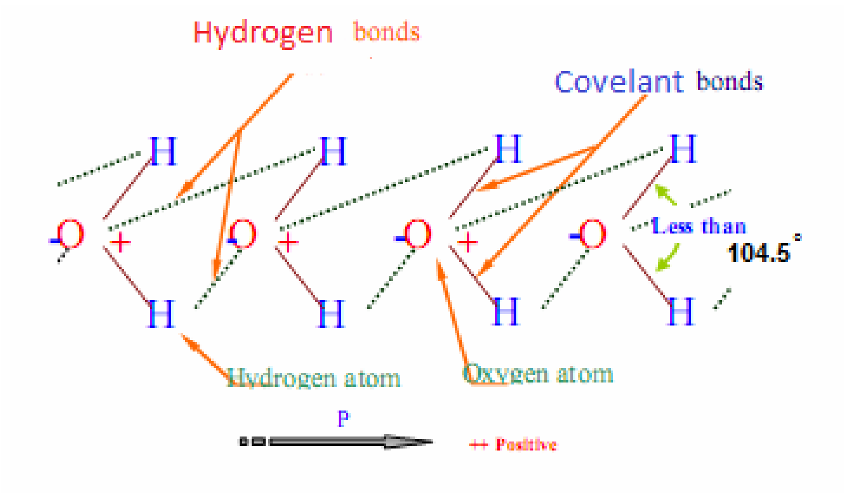

Figure 2.2.4: Water Molecules When Passes through Magnetic Field Where Water Goes on One Direction, (McMahon, 2009 and Altalib, 2009).

The success of magnetic water treatment depends on many factors such as density of magnetic field, water quality, and flow velocity of water and exposure time to magnetic field . (Ahmed, 2009).

There are many benefits of MWT such as : Prevention pollution , conserves water , length in service life of equipment that's used for water movement , save time and money and reduces energy (Banejad.2009) .

2.3 Literature Review:

There are many previous studies that examine magnetic water treatment , and the extent of impact on water properties, agriculture, and soil . In Palestine this experiment was the first time where it is a new technology wasn't implemented before and the environmental conditions are different (soil, water and crops type). Some of these studies and their results are presented below:

Lin& Yotavat ,1990 studied several factors that control the success of the agricultural sector ,whether at the level of individual farms or on all ,such equipment efficiency , water quality and the method of operation through an experiment conducted on several types of crops by using magnetic water where he found an increase in the production and an improvement in the quality of the produce .

Nasher, 2008 determined the impact of magnetic water on the growth of the chick pea seed length .He found through an experiment that the seeds irrigated with magnetic water were taller than those irrigated with non-magnetic water. The difference in length was 2.76cm and in the same experiment were examined some of the water properties such as pH, and surface tension .He found a decrease in pH and surface tension and increased dissolved oxygen concentration in water.

Tai, 2008, examined the effect of magnetic field on the crystallization of $CaCo3$ in fluidized media. He observed that the calcite growth rate in presence of magnetic field lower than in the absence of magnetic field.

Maheshwari, 2009 investigated the effect of magnetic treatment on many types of water used for irrigation and the result was an increase in the yield production.

Ameen, 2009, tested the effect of magnetic treatment on saline water with different levels of salinity to irrigate crops and the result was that there is an increase in yield and the percentage of chlorophyll in leaves were higher by using treated water.

Banejad&Abdosalehi, 2009 examined the influence of magnetic field by varied intensities on hard water and the results indicate that the magnetic field reduces the hardness of water by 90% and a reduction in the amount of calcium carbonate sediment.

Amira,2010 examined the effect of magnetic water compared with tap water on quality and quantity of lentil plant , the result was a significant increase in all growth parameters where plant height increased 21.75 % , fresh weight per plant 18.18 gm ,dry weight per plant 15.05, water content 1.37% and yield 25.82% .

Hozaynl,et al 2010, used magnetic water to study the response of growth yield , component and some chemical constitute of wheat under green house condition during winter season ,the results indicated that plants which irrigated with magnetic water increase in most vegetation growth, chemical constitute (photosynthetic pigments) over control and at harvest increased yield ,

Alkhazan, 2011 investigated the biological effect of magnetic water treatment where the results indicate that the treated water has an enhancing effect on the photosynthetic pigments compared to the control. The biomass increased in the plants irrigated with treated water as compared to the control and the essential elements increased in plants irrigated with treated water compared to their control. Thus the irrigation with treated water reduces salt accumulation in plants.

Chapter Three

Study Area

3.1 Study Area:

Al- Jiftlik is a Palestinian village in Jericho governorate located 33km north of Jericho city. Its location and borders are presented in figure 3.1.1, where the Jordan River is from the east, Marj Al Gazal village and Tubas governorate from the north, Duma, Majdal, Bani fadil ,Aqraba from the west and Alfasayil village from the south (Arij,2012).

Al-Jiftlik is located at an altitude of 189 m below sea level with a mean annual rainfall of 232mm. The average annual temperature is 22 °C and the average annual humidity is 49.2%. The total population in 2007 was 3546 (Arij, 2012).

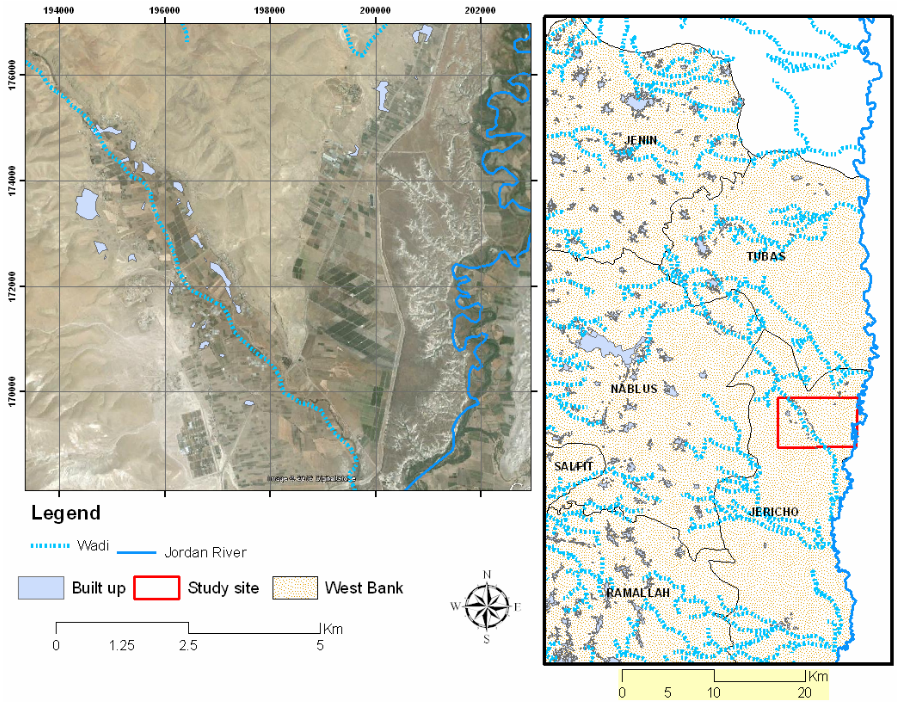

Figure 3.1.1: AL-Jiftlik location and borders.

3.2 Water Recourses:

Mekarot Israel company provide AL-Jiftlik with water. About 90% of housing units are connected to the water network and the other 10% depends on other water source. There are 23 ground water wells in AL-Jiftlik area that are used for agriculture purpose.

3.3 Economic Activity:

The economic activity in Al -Jiftlik is dependent on the agriculture sector, where 90% of the labor force works in agriculture sector. The distribution of labor by economic activity in is shown in figure 3.3.2.

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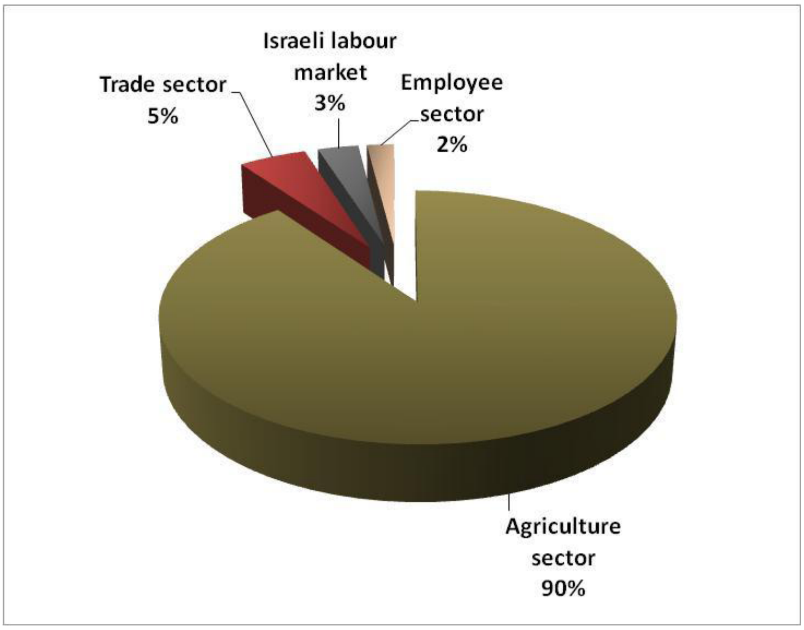

Figure3.3.2: Distribution of Work Force in Economic Activity at AL-Jiftlik (Arij, 2012).

3.4 Agricultural Activity:

The total area of Al-Jiftlik is 185,032dunums, of which 63,402 dunums are arable land and 972dunums are residential lands, (table 3.4.1). Agricultural production in Al-Jiftlik depends mostly on ground water wells. Water resources and the Mekarot Israeli Company provide Al-Jiftlik with drinking water. Table 3.4.2 summarizes the types of crops and total area of cultivated lands in Al-Jiftlik village (Arij, 2012).

The soil texture were investigated by Bahar, (2008), he found that soil consists of 28% sand, 29% silt and 43% clay.

Table 3.4.1: Land Use and Cover in AL-Jiftlik Area (ARIJ, 2012)

<table>
<tr><td>Total area / dunum</td><td colspan="2">185.032</td></tr>
<tr><td>Built up area</td><td colspan="2">972</td></tr>
<tr><td rowspan="5">Agriculture area</td><td colspan="2">63.402</td></tr>
<tr><td>Permanent crops</td><td>8.575</td></tr>
<tr><td>Green house</td><td>913</td></tr>
<tr><td>Range lands</td><td>31.195</td></tr>
<tr><td>Arable lands</td><td>22.219</td></tr>
<tr><td>Inland water</td><td colspan="2">521</td></tr>
<tr><td>Forests and Open space</td><td colspan="2">269.666</td></tr>
<tr><td>Industrial area</td><td colspan="2">77</td></tr>
<tr><td>Settlement area</td><td colspan="2">11.293</td></tr>
</table>

Table 3.4.2: Types of Crops and Area of Cultivated Lands in Al- Jiftlik Village (ARIJ, 2012)

Type of Crops	Area /dunum
Trees (Date palm, Grapes, Citrus)	1534
Vegetables	7616

Growing of Bell Pepper and Beans during winter season became common in the LJV (Palestinian Central Bureau of Statistic 2013) (Table 3.4.3, 4). Due to the increase in demand, growing of Bell Pepper and Beans under greenhouses condition raised seven folds during the last 9 years (2003 to 2012) (Palestinian Central Bureau of Statistics (PCBS). 2013).

Table 3.4.3: Bell Pepper Growing Area in the Lower Jordan Valley, (Palestinian Central Bureau of Statistics, 2013).

Cropping Year	Protected irrigated area (Dunums)	Open field irrigated area	Total irrigated area (Dunums)
2003	39	647	686
2004	135	469	604
2005	74	515	589
2006	68	530	614
2007	84	555	639
2008	180	502	682
2009	194	448	642
2011	328	303	631
2012	288	298	686

Table 3.4.4: Beans Growing Area in the Lower Jordan Valley, (Palestinian Central Bureau of Statistics, 2013).

Cropping Year	Protected irrigated area (Dunums)	Open field irrigated area	Total irrigated area (Dunums)
2003	195	1962	2157
2004	320	1830	2150
2005	133	1335	1468
2006	210	1985	2195
2007	286	1948	2234
2008	365	1586	1951
2009	381	1493	1874
2011	289	913	1202
2012	256	852	1108

Chapter Four

Methodology

4.1 Site Description:

We selected two locations in AL-Jiftlik to apply the experiment of magnetic water treatment. The sites are located in the lower part of Wadi Al- Faria area near the Adam junction, (Street 90). The source of water that is used for irrigation is the Plio-Plistocene system. The first location in B & S Company was selected to investigate the impact of MWT on soil salinity and Bell Pepper (*Capsicum annuum L.*) crop, where the total area of the farm is 18 dunum. Table (4.1.1) summarizes the characteristics of the experiment. Figure (4.1.1) shows an explanatory map of this location.

Table 4.1.1: Characteristics of the First Location.

Activity	Description	Activity	Description
Soil type	Loamy soil	Type of cover	Greenhouse with net
Water salinity	2.4 mS/cm	Growing duration	September 2012 until April 2013
Total volume of irrigated treated water/dunum	658 m^3	Total volume of irrigated non treated water/dunum	644 m^3
Irrigation method	Drip irrigation	Water salinity	2.3 mS/cm

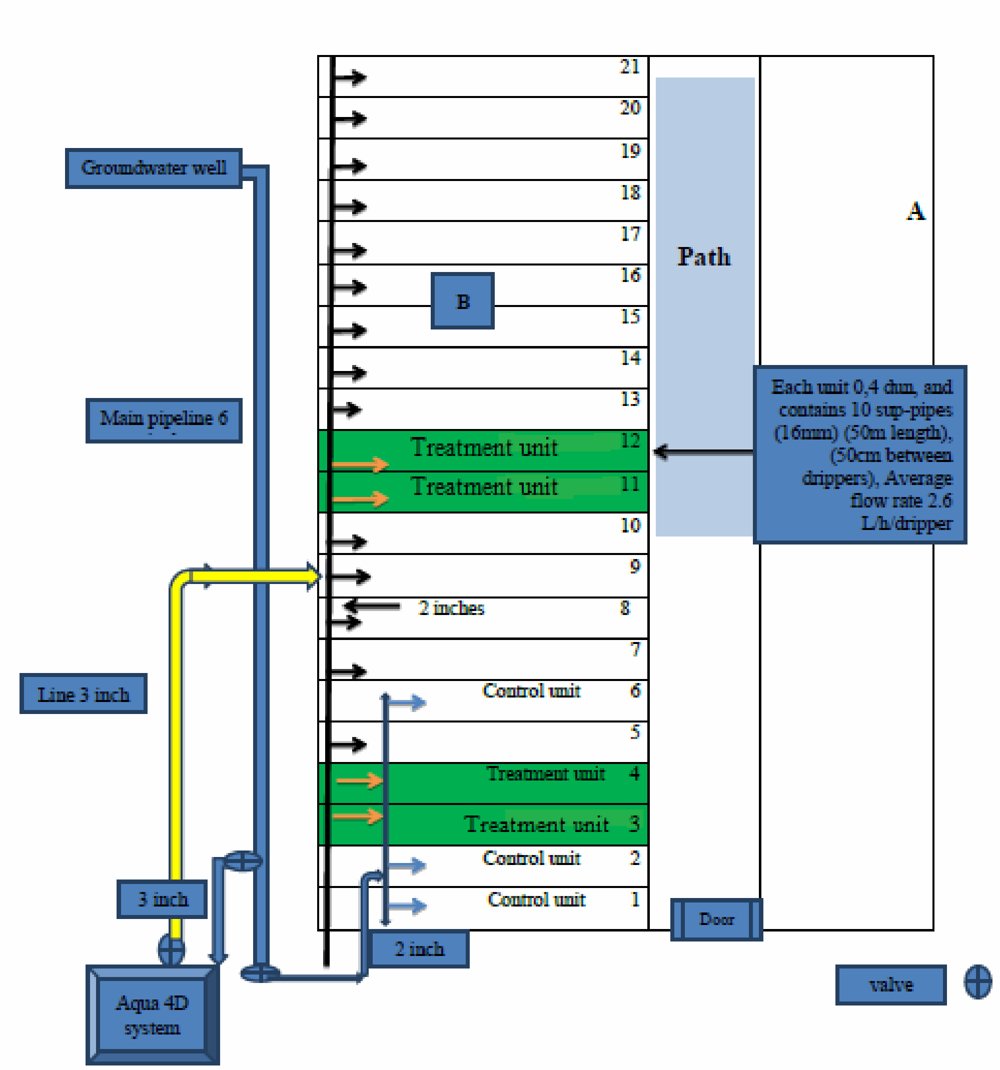

Figure 4.1.1: Explanatory Map of the First Location.

The second location, Abdul Malek Jabber farm, was selected to examine the impact of MWT on soil salinity, Beans (*Phaseolus vulgaris* L) crop and the activities of root knot nematode (*Meloidogyne*spp.) where the soil in this site is highly infected. The total farm area: 150 duns divided into 110 dunums palm trees, 24 duns grape trees and 16 dun's vegetables in green house (Cucumber, Tomato, Pepper, and Bean). The salinity of water: EC= 4.9 (mS / cm). We chased 5 dunums to apply this experiment which were divided into 2 and 3 dunums of treated and control, respectively. Table 4.1.2 summarizes the characteristics of the experiment. Figure 4.1.2shows the explanatory map of this location.

Table 4.1.2: Characteristics of the Second Location

Activity	**Description**	**Activity**	**Description**
Soil type	Loamy soil	Type of cover	Greenhouse
Water salinity	4.9 mS/cm	Growing duration	December 2012 until April 2013
Total volume of treated water/dunum	196 m^3	Total volume of non treated water/dunum	188 m^3
Irrigation method	Drip irrigation	Water salinity	4.8mS/cm

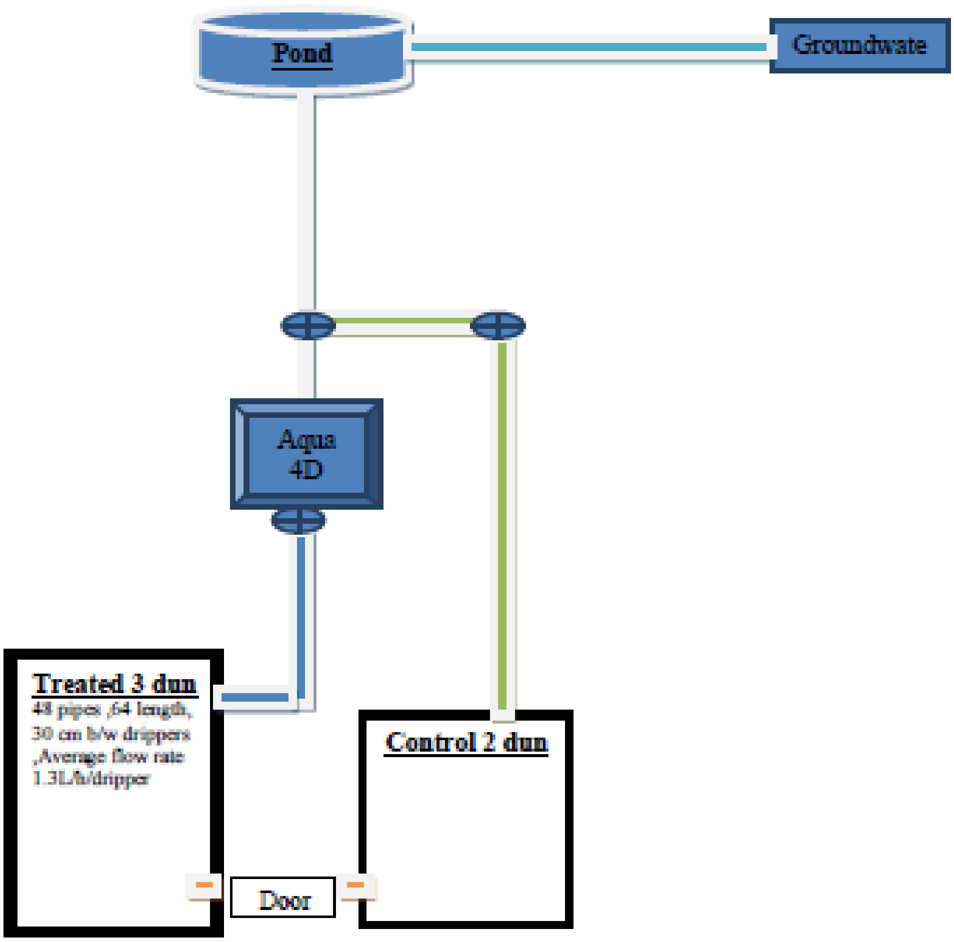

Figure 4.1.2: Explanatory Map of the Second Location.

4.2 Magnetic Treatment and Plantation:

To magnetized water, a magnetic water device called Aqua 4D (Swiss company), was used .The maximum treatment capacity for this device is 20 m³ (2 inches, output 20 m³/h) where water passes through this device. Figure (4.2.3) shows the Aqua 4D tube which can be assembled horizontally or vertically, in upward or downward flow (www.planethorizons.com).

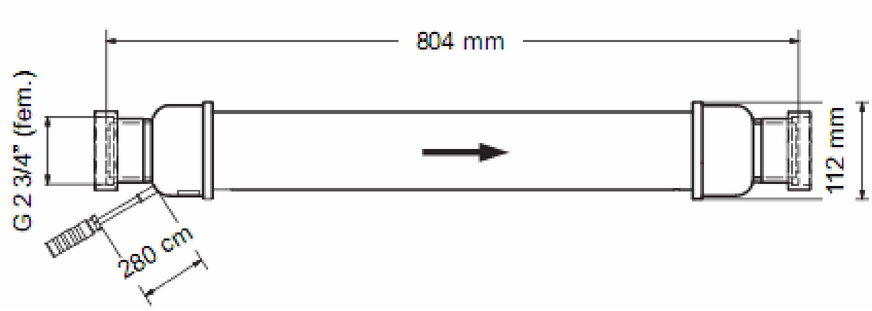

Figure 4.2.3: Tube of Aqua 4D

Before seedling, one of the blocks was irrigated with magnetic treated water. Bell Pepper and Beans in this block represent later the treated block. The plantation of Bell Pepper and Beams was conducted on the 26th of August and the 10th of December 2012. For achieving statistically valid number of representative seedling from both treated and control blocks, a random selection of the seedling within these blocks was carried out. These seedlings were traced with a plastic band, and all measurements were conducted on these marked representative seedlings during the whole time of the study period. In order to be sure that the numbers of seedlings are representative, measurements of seedling heights were carried after 20 days of plantation and the final number of marked seedling was fixed for the rest of study. We decided to accept an error of 5% for seedling height, where the flowing formula was used:

$$m = \left(\frac{Cv}{e}\right)^2$$

m =the optimum number of samples

CV = coefficient of variation.

e =5%.

4.3 Irrigation Scheduling:

Drip irrigation method was used in watering the Bell Pepper and Beans seedling. The volume of water applied per dun varied according to the stage of crop growth and was recorded**.** During the whole growing period 653, 196 m^3/dunum of treated magnetic water and 644, 188 m^3/dunum of non treated water was used to irrigate Bell Pepper and Beans respectively. Also during the same period, the same recommended NPK fertilizers were applied to both treated and controlled blocks.

4.4 Data Collection and Analysis:

The volume of water used in irrigation of controlled and treated blocks was calculated based on m^3/dun area. Water productivity was calculated based on fresh weight of bell pepper in kg/m^3 of water used. To assess the impact of the treatments on the vegetative and reproductive growth, the following parameters were recorded biweekly to Bell Pepper and Beans: plant height, number of branches, and distance between nods, leaves number, flowers number, fruit number and weight in the field. SPSS-software (Coakes and Steed 2009) was used in analyzing the collected data, where t-paired test was applied. Multivariate test was used to study the clustering of major and trace elements distribution in the bell pepper fruits.

4.5 Laboratory Work:

4.5.1 Soil:

Representative soil samples were collected during the experiment period to examine salinity and major elements such as chlorine, sodium, magnesium and calcium at different depths. Auger tool was used to collect soil samples in the field and samples were stored in dry room temperature. Soil samples were dried at room temperature and then cleaned and crushed; soil water was by 1:5 soil water ratios. 10 g of soil is placed into a suitable container, 50 ml distilled water are added, and the container is thoroughly shacked to mix the soil and water. After two hours, the electrical conductivity was examined by an electrical conductivity meter (Rhoades, 1999). Sodium, magnesium, calcium and chloride elements were measured in filtered samples.

4.5.2 Plant:

Measurements of chlorophyll content, root mass, sugar content, individual fruit mass, thickness of the walls, no. of rooms , size of the fruit , elemental composition of fruits and soil were carried out at the Environmental Research laboratory at Al-Quds University (AQU).Table (4.5.2.3) .

Table 4.5.2.3: Plant Parameters and Names of Measurement Methods

Parameter	Measurements method
Plant height, No. of branches distance between nodes Flowers No. Leaves No. No. of Fruits/plant	All these parameters were monitored in the field
Total Chlorophyll	UV Spectrophotometer at 645 and 663 nm
Sugar content	Brix Portable Refract meter Device
Height and thickness of the wall	Vernier instrument
Elemental composition of fruits	ICP-MS (Inductivity Coupled Plasma-Mass Spectrometer)
Soil water extraction	EC Meter , EC electrode
Roots weight	Electronic Balance

4.5.2.1 Bell Pepper Crop Quality:

Forty and 34 samples were randomly chosen for treated and control respectively to analyze the following:

- Weight of individual fruit, where each sample was weighted by the spring balance.
- Rooms number: As the number of rooms are quality standard, room number for each sample of the two types was registered
- Wall thickness and height of fruit have been measured for each sample by Vernier caliper.

Fruits Shelf Time:

To determine the shelf time of fruits; we stored 28 and 22 treated and control Fresh fruits respectively in special storage bags between 4 - 7 ºC.

Fruits Sugar Content:

To examine the proportion of sucrose by percent in fruits, we selected 33 treated samples and 16 control samples were washed with distilled water, cut into parts and squeezed, and a drop of juice was screened by a Portable Prix Refractometer device.

Bell Pepper Plant Roots:

Seventy two Bell Pepper plant were uprooted after the harvesting period.The aim of this activity is to compare the root development under using magnetized treated and normal water (control conditions). The stem of the plants is separated from the root and the soil particles residual were washed out in order to get the full root body, then roots were dried at room temperature (25 ºC) for 12 hours. A digital balance was used to weigh the roots.

Chlorophyll Content:

The chlorophyll content was evaluated using 10 replicates, according to Arnon, 1949, of 0.2 g pieces of Bell Pepper plant fresh leaves which were added to 10 ml acetone (80%), incubated for 30 minutes in ultrasonic bath, and followed by overnight incubation at room temperature. Second incubation was for 30 minutes in ultrasonic bath, second addition of 10 ml acetone 80%, for the third time the solution was incubated for 30 minutes in ultrasonic bath and finally incubation for 4 hours, followed by 30 minutes in ultrasonic bath. The volume of the supernatants was completed with acetone (80%) to 50 ml. Detection was carried out at 645 nm and 663 nm using spectrophotometer. Recorded numbers were applied on the following equation:

mg chlorophyll /0.2g fresh weight =20.2A645nm +8.02A663nm.

Then the values were calculated for 1 gm fresh weight by dividing them on 0.2 (Arnon, 1949).

Elemental Composition of Fruits:

Random Bell pepper fruits were selected from control and treated to determine Lithium (Li) , Boron (B) , Sodium (Na) , Magnesium (Mg) , Aluminum (Al), Potassium (K), Calcium(Ca), Manganese (Mn) , Iron(Fe) , Cobalt (Co), Nickel (Ni) , Copper (Cu), Zinc (Zn) , Strontium (Sr), Molybdenum(Mo) , Silver (Ag) , Cadmium(Cd) and Barium (Ba) ,by using the dry ashing procedure. A dried 1 g of the plant material was placed on porcelain crucibles and ashed in a cool muffle furnace at 550 °C and then cooled in desiccators. After that, the cooled ash was acidified with pure 5 ml HNO_3 mixed with a plastic rod; aliquot's volumes were brought to 50 ml using distilled water and then analyzed by ICP-MS (inductivity coupled plasma-mass spectrometer), (Donohue, Aho et al. 1992,Jones Jr, Wolf et al. 1991).

Quality Measurement of Bell Pepper Fruits by Using Visible/Near Infrared (VIS/NIR) Technology:

Visible/Near Infrared (VIS/NIR) spectroscopy was carried out at Palestine Technical University/Khadoorie. This method was applied to determine, if we can distinguish between magnetized and controlled Bell Pepper fruits by studying VIS/NIR-spectroscopy. For this part of the study sixty bell pepper fruits were investigated; half were related to the treated block and the rest to the controlled. There were no pre-treatment of fruit before measuring spectra acquisition.

A VIS/NIR spectroscopy, a USB2000+ miniature fiber optic spectrometer (Ocean Optics, USA) with Vivo light source, was used for spectra acquisition. Bell pepper fruits were placed on the top of Vivo light source and spectra were acquired in triplicates for each bell pepper around quarter. VIS/NIR spectroscopy shown in figure (4.5.2.1.4).

Figure 4.5.2.1.4: Visible/Near Infrared (VIS/NIR) spectroscopy.

The spectroscopy has a 550-1100 nm wave length and a resolution of 0.35 nm full width at half maximum (FWHM). Spectroscopy has 2-MHz analog-to-digital (A/D) converter, a 2048-element CCD-array detector, and a high-speed USB 2.0 port. The USB2000+ could be controlled by Spectra Suite software. Vivo system contains four tungsten halogen bulbs that can be turned on or off individually. The risk of overheating the sample is mitigated through active cooling. This protects the sample and ensures accuracy every time. The four halogen tungsten light sources make the Vivo a high-powered VIS/NIR source, which allows a shorter integration time than conventional methods (Ocean Optics, USA). The integration time used in this investigation was 1 ms.

Classification efficiency of leaves according to their severity using VIS/NIR spectra was carried out using MDVA. Two supervised classification methods were used, namely Partial Least Squares-Discrimination Analysis (PLS-DA) (linear method). Unscramble software was used for analysis (version 9.2, CAMO Software AS, Oslo, Norway).

PLS-DA consists of a classical partial least squared (PLS) regression, where VIS/NIR spectra represented X-data matrix, and the dependent variable (Y) is categorical and represented samples class membership (i.e. Y with values of -1 and 1, where 1 represents each sample belonging to the targeted class and -1 represents each sample belonging to the other classes)(Abu-Khalaf and Lønsmann Iversen 2007). Random cross validation, with segmentations was used.

4.5.2.2 Beans Root knot Nematodes Monitoring:

Near the root zoon, soil samples collected from fields were taken from depth 3-15 cm. The roots with node were dissected and placed in 9 cm Petridishes. To observe and monitor the nematodes, an inverted microscope was used at 40X magnification.

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Chapter Five

Results and Discussion

The impact of magnetic water treatment on soil salinity, Bell Pepper and Beans yield (quantity and quality) and root knot nematode ((*Meloidogyne* spp.) was monitored over the full growing season and the results presented here reflect this impact**.**

5.1 Water salinity:

Electrical conductivity of water isn't change because MWT affect on the behavior of water molecules' and salt particles, where the average of electrical conductivity over the season in the first location and second location respectively after and before treatment was 2.4, 4.9 mS/cm.

5.2 Soil salinity:

The effect of magnetic water on Bell Pepper and Beans crops soil salinity had slightly significant decreased.

5.2.1 Bell Pepper Experiment:

The following table (5.2.1.1) shows the result of soil salinity at a depth of 10 cm where the average soil salinity under treated condition is lower than that under controlled conditions.

Table 5.2.1.1: Electrical Conductivity (mS/cm) of Bell Pepper Crop soil (T=Treated, C= Controlled)

Sample ID	Ec in mS/cm	Sample ID	Ec in mS/cm
T1	0.27	C1	0.42
T2	0.27	C2	0.60
T3	0.27	C3	0.41
T4	0.24	C4	0.32
T5	0.27	C5	0.26
T6	0.30	C6	0.27
T7	0.25	C7	0.36
T8	0.18	C8	0.36
$\bar{x}$	**0.26**	$\bar{x}$	**0.38**

Tables 5.2.1.2 and 5.2.1.3 summarize the results of soil salinity and concentration of elements were samples collected from eight depths (<5, 10, 20, 30, 40, 50, 60 and 70 cm). The goal of this investigation is to monitor the impact of using magnetized treated water on soil salinity and the concentration of major elements at different depths. In general the soil salts contents in the upper 20 cm depth were lower than that under controlled conditions. Specifically, salts accumulate in the upper 5 cm under controlled condition where the salinity is 2.88 mS/cm, while less salts accumulate in the same depth under treated condition (0.97 mS/cm). These results show that salts move downwards below the root zone under treated condition leading to an increase in solubility of major cations and anions and plants easily take up mineral salts from soil (Mohamed, 2013).

Table 5.2.1.2: Average Soil Salinity in ms /cm (Bell Pepper)

sample ID	Depth (cm)							
	<5	10	20	30	40	50	60	70
	Ec of soil(ms/cm)							
T	$\bar{x}$=.97	$\bar{x}$=.47	$\bar{x}$=.31	$\bar{x}$=.3	$\bar{x}$=.46	$\bar{x}$=.37	$\bar{x}$=.26	$\bar{x}$=.25
	σ=.63	σ=.28	σ=.21	σ=.12	σ=.16	σ=.07	σ=.07	σ=.07
C	$\bar{x}$=2.88	$\bar{x}$=.59	$\bar{x}$=.34	$\bar{x}$=.27	$\bar{x}$=.29	$\bar{x}$=.28	$\bar{x}$=.29	$\bar{x}$=.27
	σ=2.28	σ=.45	σ=.1	σ=.07	σ=.08	σ=.09	σ=.06	σ=.08

Table 5.2.1.3: Concentration of Chloride, Sodium, Magnesium and Calcium of Bell Pepper Plant Soil in Different Depth for Treated (T) and Control (C) Water

Depth(cm)	[Cl] mg/l		[Na] mg/l		[Mg] mg/l		[Ca] mg/l	
	T	C	T	C	T	C	T	C
<5	$\bar{x}$=365	$\bar{x}$=1079	$\bar{x}$=48	$\bar{x}$=50	$\bar{x}$=38	$\bar{x}$=45	$\bar{x}$=212	$\bar{x}$=155
	σ=323	σ=862	σ=4	σ=6	σ=10	σ=11	σ=477	σ=235
10	$\bar{x}$=208	$\bar{x}$=257	$\bar{x}$=45	$\bar{x}$=44	$\bar{x}$=28	$\bar{x}$=30	$\bar{x}$=70	$\bar{x}$=644
	σ=140	σ=230	σ=5	σ=5	σ=11	σ=13	σ=105	σ=195
20	$\bar{x}$=164	$\bar{x}$=164	$\bar{x}$=44	$\bar{x}$=42	$\bar{x}$=25	$\bar{x}$=20	$\bar{x}$=89	$\bar{x}$=117
	σ=120	σ=91	σ=4	σ=3	σ=12	σ=5	σ=212	σ=229
30	$\bar{x}$=160	$\bar{x}$=97	$\bar{x}$=44	$\bar{x}$=41	$\bar{x}$=21	$\bar{x}$=15	$\bar{x}$=177	$\bar{x}$=25
	σ=227	σ=53	σ=3	σ=4	σ=13	σ=5	σ=456	σ=34

$\bar{x}$= *Mean*, σ= standard deviation

5.2.2 Beans Experiment:

Soil samples were collected from 5 to 12 cm depths and the results of soil salinity are presented in table 5.2.2.4. The average soil salinity under treated condition was lower than that under controlled condition.

Table 5.2.2.4: Electrical Conductivity (mS/cm) of Bean Crop Soil during irrigation , (T=Treated, C= controlled)

Sample ID	Ec in mS/cm	Sample ID	Ec in mS/cm
T1	0.49	C1	0.94
T2	0.71	C2	0.5
T3	0.49	C3	0.55
T4	0.38	C4	0.62
T5	0.73	C5	1.09
T6	0.71	C6	0.77
T7	1.75	C7	0.75
T8	0.62	C8	0.68
T9	0.46	C9	0.75
T10	0.59	C10	0.75
$\bar{x}$	**0.69**	$\bar{x}$	**0.74**

After the bean crop has been harvested, soil samples were collected from 10 cm depth, to investigate the impact of using magnetized treated water on soil salinity. Results of soil salinity are present in table 5.2.2.5.

Table 5.2.2.5: Average Bean Crop Soil Salinity after Harvesting

Sample ID	Ec in mS/cm	Sample ID	Ec in mS/cm
T1	0.49	C1	0.68
T2	0.62	C2	1.09
T3	0.71	C3	0.75
T4	0.38	C4	0.62
T5	0.73	C5	0.5
$\bar{x}$	**0.59**	$\bar{x}$	**0.72**

The soil salinity average under treated condition was slightly lower than that under controlled condition; this may be due to the fact that soil in this site is sandy loam which makes water percolates easier into deeper depth and salts can be transported under treated condition faster than that under controlled condition.

5.3 Field measurement:

5.3.1 Bell pepper:

Table (5.3.1.6) summarizes the results of t-paired test. There were no clear effects of magnetic treated water on field parameters of Bell pepper (plant height, number of branches, distance between branches and number of fruits).

Table 5.3.1.6: Effect of Magnetic Treated Water on Bell Pepper Growing Parameter (T= treated, C=Control)

Variables	**No. of Measurement**	**T- test range**	**Sig 0.05**
Height of Plant		0.969 -.056	Not Significant
T	240		
C	165		
No. of Branches		0.963 -0 .407	Not Significant
T	96		
C	66		
Distance b/w Nodes		0.96 - .133	Not Significant
T	96		
C	66		
Fruits No.		0.972 - 0.107	Not Significant
T	320		
C	220		

5.3.2 Beans:

Table (5.3.2.7) summarizes the results of t-paired test; there were no clear effects of magnetic treated water on field parameters of Beans (plant height, number of leaves, number of flowers and number of fruits).

Table 5.3.2.7: Effect of Magnetic Treated Water on Bell Pepper Growing Parameter (T=treated, C=control)

Variables	**No. of Measurement**	**T- test range**	**Sig 0.05**
Height of Plant		0.478 - 0.937	Not Significant
T	286		
C	295		
No. of leaves		0.200 -0 .474	Not Significant
T	286		
C	294		
No .of flowers		0.700 - 0.831	Not Significant
T	196		
C	178		
Fruits No.		0.110 - 0.879	Not Significant
T	235		
C	220		

5.4 Crop Quality of Bell Pepper:

Chlorophyll content, sugar content, number of rooms per fruit, size of the fruit, and thickness of the fruit wall, were selected for quality measurements of Bell Pepper crop according to Postharvest Technology Research & Information Center. The results of parameters analysis are as follows:

5.4.1 Influence of Magnetic Water Treatment on Chlorophyll Content:

Chlorophyll contents play an important role on the development of plant growth and plant productivity. Chlorophyll content increased significantly in treated plants compared with untreated plants, where the average chlorophyll content were 10, 7.5 mg/g respectively. This is due to the fact that magnetized water and nutrients can be absorbed easily through the roots cells, and reach the leaves quickly compared to untreated water. This clarifies the increase of yield under treated condition. This agrees with AL-khazan et al, 2011 and Amira et al, 2010.

5.4.2 Influence of Magnetic Water Treatment on *Sugar Content* (Sucrose %):

The sugar content was around 8% in both treated and control fruits and that's why no clear effects of magnetic treatment on sugar content. Based on their result, the fruits of Bell Pepper were classified as good quality according to the Refract meter measurement. Free sugars play an important role in the flavored characteristics of fruits.

5.4.3 Influence of Magnetic Water Treatment on *Thickness of the Fruit Walls*:

No noticeable difference was found in the wall thickness of both treated and controlled fruits; the average thickness was about 7.5 mm for both controlled and treated fruits.

5.4.4 Influence of Magnetic Water Treatment on *Number of Rooms (units)*:

Normally Bell Pepper plants produce fruits with three or four rooms. The form of fruit is an important factor for fruit quality. Fruits with four rooms are considered as high quality, while three room's fruits are considered as medium quality. Consequently export oriented dealers accept only high quality fruit with four room form. Bell Pepper irrigated with treated magnetic water produces 37% four rooms more than the non- treated water irrigated water.

5.4.5 Influence of Magnetic Water Treatment on Shelf Time:

The first damaging for fruit under control condition took place after 3 weeks and it took 4 weeks for treated conditions .The results showed that the shelf time for treated samples was 1 week longer than that of the controlled samples. This factor is important to be considered in case of long transportation especially for external market.

5.4.6 Influence of Magnetic Water Treatment on *Weight of Individual Bell Pepper Fruit*:

The average weight of treated and non-treated fruits was 233 grams and 211 grams respectively. This means that treated plant produce heavier fruits than the controlled plant, which influence the total weight per dunum. This result is similar to De Suza (2005) on tomato yield.

5.5 The Yield:

There was a clear positive effect of magnetic treated water on the yield of Bell Pepper and Beans crops based on the weight of fresh fruits.

5.5.1 Bell pepper:

The yield of one dunum irrigated with treated magnetic water for yellow and red Bell Pepper was 6838.75, 6307.5 kg and for non-treated it 5777.5, 5255kg respectively. So irrigation with magnetic treated water caused an increase of about 18.4, 20 % in the yellow and red Bell Pepper yield on fresh weight basis. Table 5.5.1.9 presents the yield of yellow and red bell pepper by month for treated and control water.

Table 5.5.1.8: Harvesting Yield of Yellow and Red Bell Pepper by Month for Treated and Control Water

Month	Yellow(kg/dunum)		Red (kg/dunum)	
	Treated	Control	Treated	Control
December	2852	2097.5	1897.5	1425
January	780	707.5	480	700
February	1318.75	1367.5	1587.5	1517.5
March	1603	1330	1937.5	1565
April	285	275	405	47.5
Total	6838.75	5777.5	6307.5	5255
Difference	1061.25 (18.4%)		1052.5 (20%)	

5.5.2 Beans:

The yield of one dunum of beans irrigated with treated magnetic water was 322.3kg and for non-treated 295kg. Table 5.5.2.10 shows the yield of beans by month for treated and control water, so irrigation with magnetic treated water caused an increase of about 9.27% in the Beans yield on fresh weight basis.

Table 5.5.2.9: Harvesting Yield of Beans by Month for Treated and Control Water

Month	Treated(Kg/dunum)	Control(Kg/dunum)
February	122	31.5
March	188.7	249.5
April	11.7	14
Total	322.3	295
Difference	27.3(9.27%)	

Increase production and yield indicates a good movement of ions in the root zone and an increase of the ability of the plant to absorb water and nutrients which improves the cell division. Several studies reported similar result on the impact of magnetic treatment on yield increasing for different plants. Amira, 2010 found an increased lentil yield, Hozayn, 2010 wheat yield.

5.5.3 Economic feasibility:

Growing of Bell Pepper and Beans in the LJV become more than common practices, it becomes a commercial good. The relative high market value of these crops in addition to the export possibility. Tables (5.5.3.10,11) show the financial returns (outputs) from using MWT to cultivate 30 dunums of each crop type depending on the production difference in harvesting yield .

Table 5.5.3.10: Impact of the MWT on Bell Pepper Crop Output.

	Yellow Bell Pepper	Red Bell Pepper
The average price / kilo	5 NIS	
Product increase	5*1061=5305 NIS/dunums	5*1052=5260 NIS/dunums
Treatment plant capacity	20 m^3 / hr	
Rate of Treatment plant operation /day	6 hr	
Total treated water /day	120 m^3	
Cultivated area	30 dunums	
Production increase	30*5305=159,150 NIS	30*5260=157,800 NIS

Table 5.5.2.1.11: Impact on the MWT on Beans Crop Output.

	Beans
The average price / kilo	8 NIS
Product increase	8*27.2=217.6 NIS/dunums
Treatment plant capacity	20 m^3 / hr
Rate of Treatment plant operation /day	6 hr
Total treated water /day	120 m^3
Cultivated area	30 dunums
Production increase	30*217.6=6528NIS

5.6 Water Productivity:

The total water used in irrigation of Bell Pepper during the growing season2012/2013 was 8, 7 kg/m³ for controlled crop and 10.0 kg/m³ for treated crop, so there was a clear increase in the water productivity based on the yield by applying magnetic treated water. Based on 2012 published data (Table 3.4.3) where 288 dunum of Bell Pepper were under greenhouses condition in the LJV, with an average yield of 5615 kg/dunum, the total production could be 1617 tons. According to this study an increase in the yield of about 323 tones if treated magnetic water in all location is used. This result harmonized with result found by Basant (2009) on celery plant and snow peas.

5.7 Roots Dry Weight:

Applying magnetic treated water had a positive significant impact on the root dry weight at. The arithmetic average weight of root/plant is 94 g and 73 g under treated and control conditions respectively. This had an increase of about 12% in treated Bell Pepper dry weight compared to the controlled Bell Pepper roots. Table 5.7.12summarizes the results where 33% of the control plants has a weight root between 34 and 54 gm, but where only 5% under treated condition are in this category class,39% of the treated roots have a weight range between 97 and 161 gm, where only 17% of the controlled roots due to the ability of roots to absorb water and nutrients as well as the subsequent retroactive effect on plant growth and production. This result in the current study is harmonized with the result found by Basant, 2009 on celery, de Souza, 2005 on tomato and Atak, 2003 on soybean. Figure 5.7.1 shows bell pepper plant roots for treated and control water.

Table 5.7.12: Bell Pepper Roots Weight in Gram

Classes (root weight in gm)	Number of Treated plants	Number of control plants
34-54	1-2	1-12
55-75	2-10	2-9
76-96	3-10	3-9
97-107	4-4	4-1
108-128	5-3	5-4
129-129	6-2	6-0
130-150	7-0	7-0
151-161	8-10	8-0
1->162	10-3	10-1
2-Total	3-36	12-36

Figure 5.7.1: Bell Pepper Plant Roots for Treated and Control Water.

5.8 VIS/NIR spectroscopy:

Figure 5.8.2 shows the VIS/NIR –spectroscopy data using multivariate data analysis. There are two sets of data groups, namely the treated and the magnetic one. The first principal component (PC1) explained 45% and 54% of X (Treated) and Y (Control) variation, respectively. The second principal component (PC2) explained 54% and 14% of X and Y variation, respectively. The effect of using magnetic water in irrigation of Bell Pepper could be distinguished from the controlled group by using VIS/NIR spectroscopy technology. A clear effect can be seen from the scores plot of the PLS-DA.

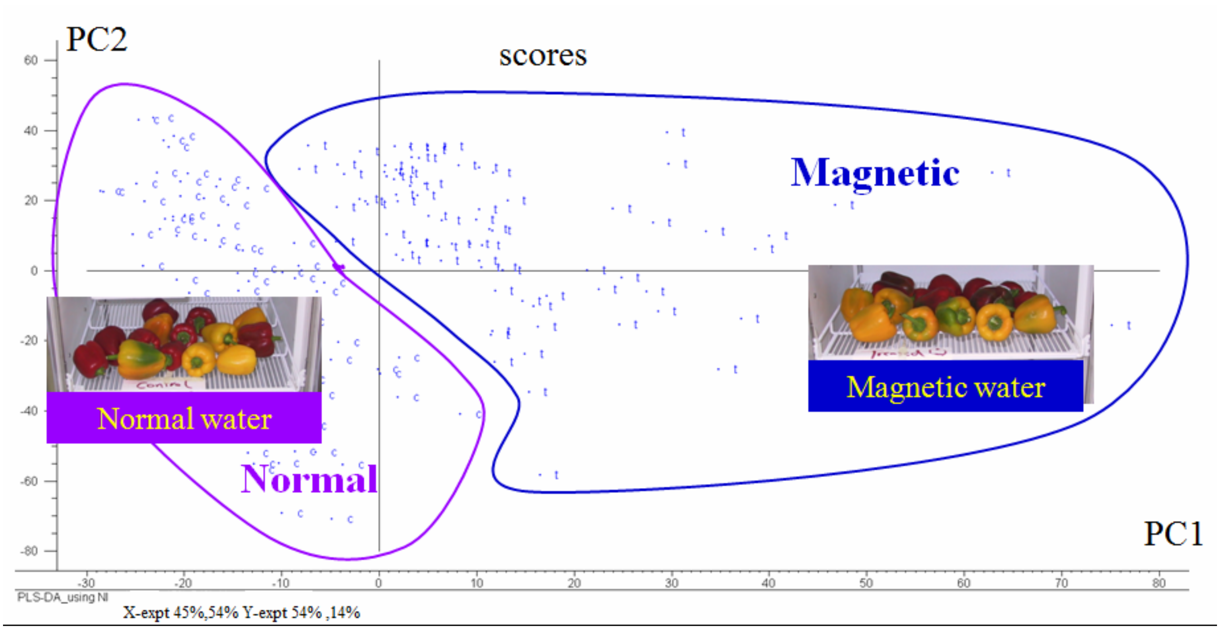

Figure 5.8.2: Scores plot of Bell Peppers Fruits irrigated from two different types of water (Treated and Control Water).

5.9 Elemental Composition of Fruits:

Table 5.9.11 shows the concentration of elements of treated and control Bell Pepper fruits. It's clear that the effect of magnetized water indicates significantly increase concentration of nutrient content. This agrees with Dimitrios, 2013 on cotton plant, Al-khazan 2011 on jojoba and Dhawi, 2009 on date palm. The positive impact of magnetic treated water on absorption and movement of elements lead to increased nutrient content and higher rates of photosynthesis processes.

Table 5.9.11: Concentration of Element for Treated and Control Bell Pepper Fruits [ppb].

ELEMENT	TREATED	CONTROL
Li	71	12
B	25	10
Na	25	21
Mg	1274	676
Al	21	6
K	74704	38930
Ca	19	15
Mn	61	34
Fe	4	2
Co	6	6
Ni	7	3
Cu	17	10
Zn	8	6
Sr	10	6
Mo	0	0
Ag	1	3
Cd	5	1
Ba	0.5	0

Relations between Samples:

Figure 5.9.3 explains the relations between samples by using multivariate data analysis program which involves observation and analysis the relations between results of treated and control samples, where it was found no correlations between samples. It looks that the most important variables of Lithium (Li) , Boron (B) , Sodium (Na) , Magnesium (Mg) , Aluminum (Al), Potassium (K), Calcium(Ca), Manganese (Mn) , Iron(Fe) , Cobalt (Co), Nickel (Ni) , Copper (Cu), Zinc (Zn) , Strontium (Sr), Molybdenum(Mo) , Silver (Ag) , Cadmium(Cd) and Barium (Ba). For getting the relation between sample.

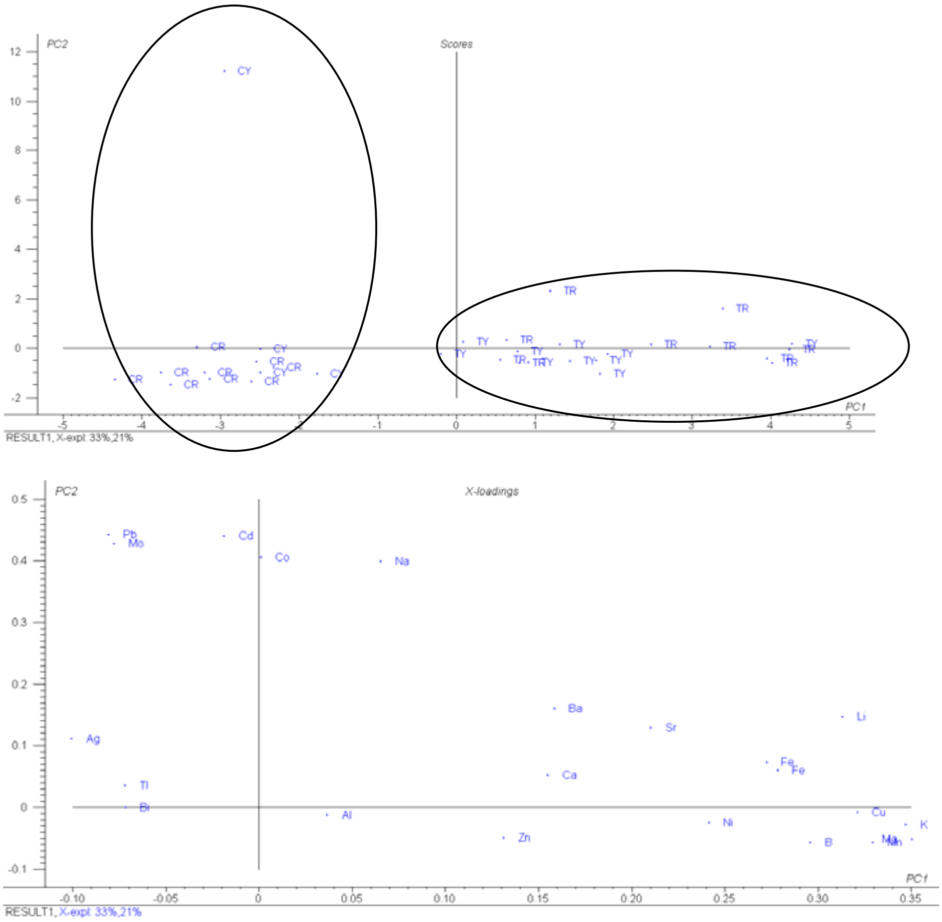

Figure 5.9.3: Variables Are Able to Separate the Samples to Two Groups: C to Left (controlled) and T to Right (treated).

5.10 Root Knot Nematodes (*Meloidogyne* spp.) activity:

Nematodes attack normally the crop roots, and as a reaction of this attack plants build nodules, so nutrient accumulate more in the roots. In normal case, farmers use chemicals to fight this pest. The problem of nematodes pest can be found in many sites in the Lower Jordan valley. It was noticed that the number of nematodes in plants irrigated with non-treated water is higher than that in the presence of magnetic water; this is because nematode adapt to the surrounding environment and by using MWT lead to change in soil water salinity thereby the salts concentration around nematodes is changing leads to a reduction in the nematode growth and activities. This result agreed with Kiewnick, 2010 on tomato.

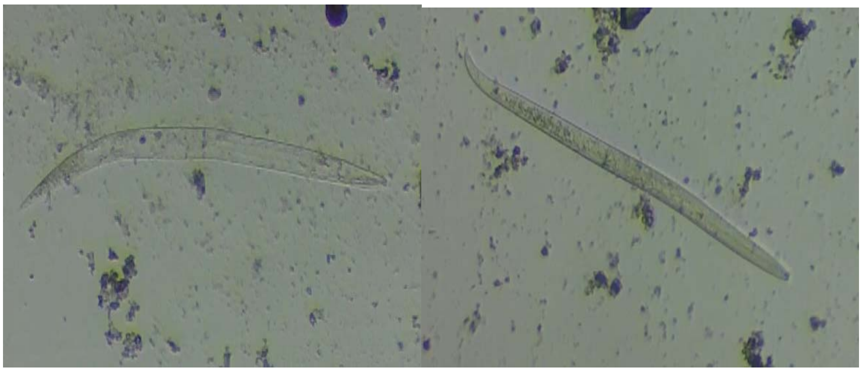

Figure 5.10.4: Dead Nematode under Treated Condition (Magnetic Water).

Figure 5.10.4: Active Nematode under Controlled Condition

Our investigation shows that the activity of soil nematodes under treated condition was weaker than those under control condition. Also, by monitoring the beans root, we found that treated plants do not have root nodules were most of the control plants show an infection with this pest (Figure 5.10.5).

Figure 5.10.6: Beans Root from Left Side, Roots with Nodules; and Treated Roots without Nodules at the Right Side

Chapter Six

Conclusion and Recommendation

Magnetic Water Treatment (MWT) is one of the new technologies utilized to solve water salinity problems. In this work the results show a positive impact on soil salinity and yield when this technology is used on irrigation water.

6.1 Conclusions:

- Soil salinity decreased by using magnetic water for irrigation and the salts move downwards under the root zone under treated condition due to increasing solubility of major cations and anions where plants can easily take up mineral salts from the soil.
- There was a clear positive effect of magnetic treated water on the yield, water productivity and on some parameters that determine the quality of Bell Pepper crops such as (chlorophyll content, weight of individual fruits, shelf time, rooms number, elemental composition and root mass).
- Magnetic water effect on soil pest especially root knot nematode where the activity of soil nematodes under treated condition was weaker than those under control condition was strong.

6.2 Recommendations:

Promising techniques like the magnetic water treatment that are used for agriculture improvements, needs more extensive research on different crops.

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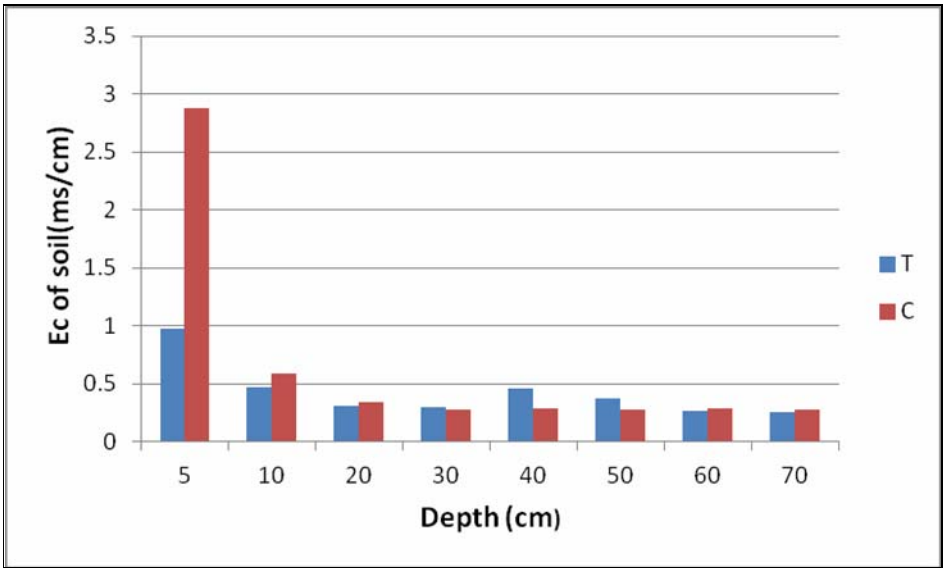
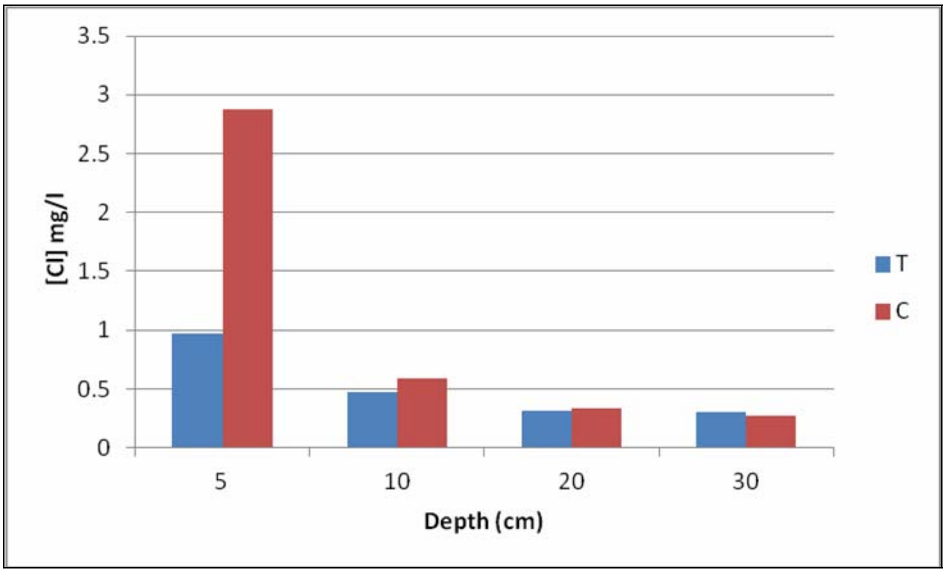
APPENDICES:

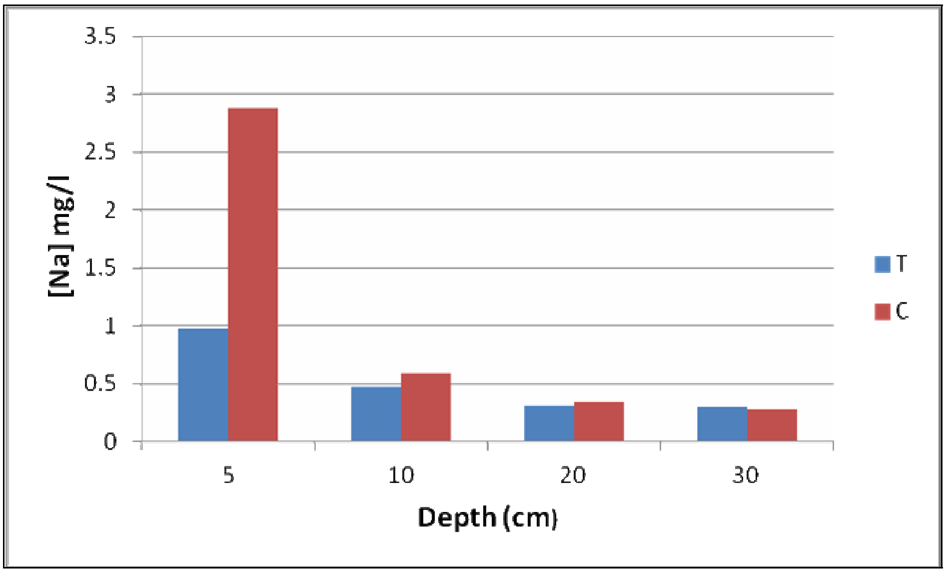
Appendix 1: Average of Soil Salinity at Different Depth for Treated (T) and Control (C) Water.



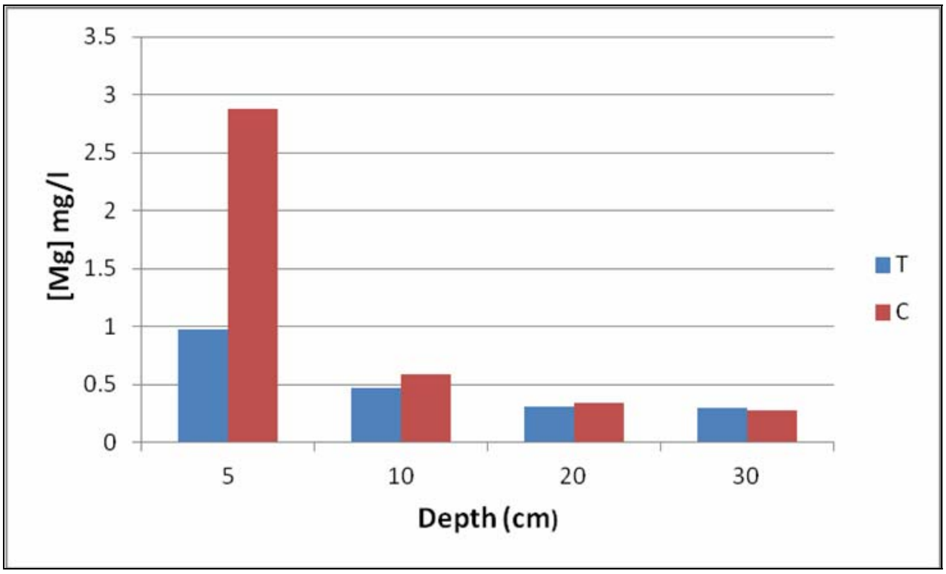
Appendix 2: Chloride Concentration of Bell Pepper Plant Soil in Different Depth for Treated (T) and Control (C) Water.



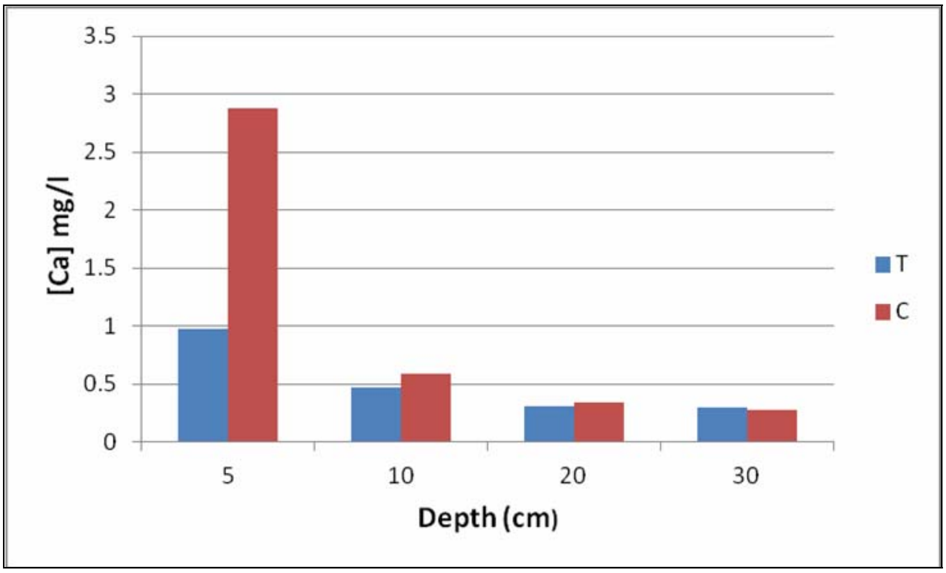
Appendix 3: Sodium Concentration of Bell Pepper Plant Soil in Different Depth for Treated (T) and Control (C) Water.



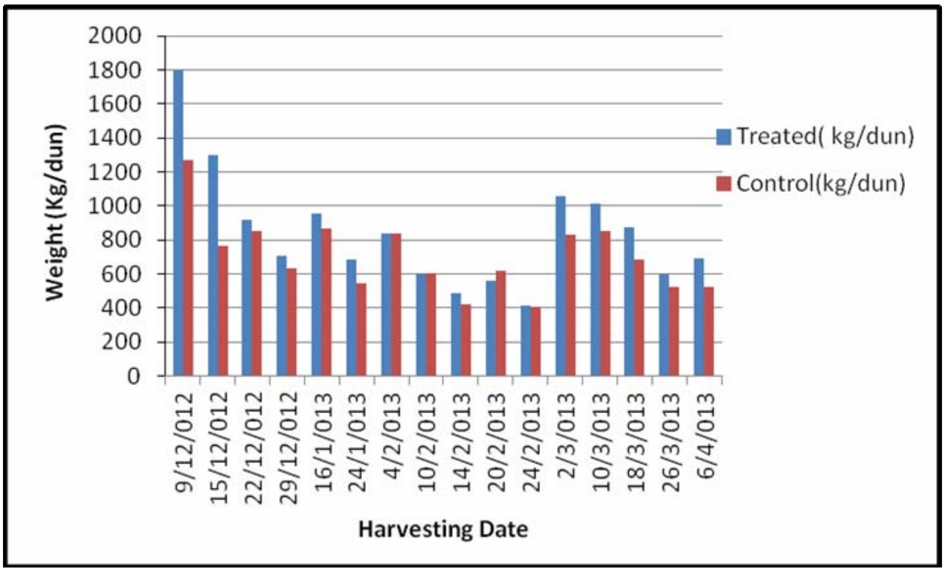
Appendix 4: Magnesium Concentration of Bell Pepper Plant Soil in Different Depth for Treated (T) and Control (C) Water.



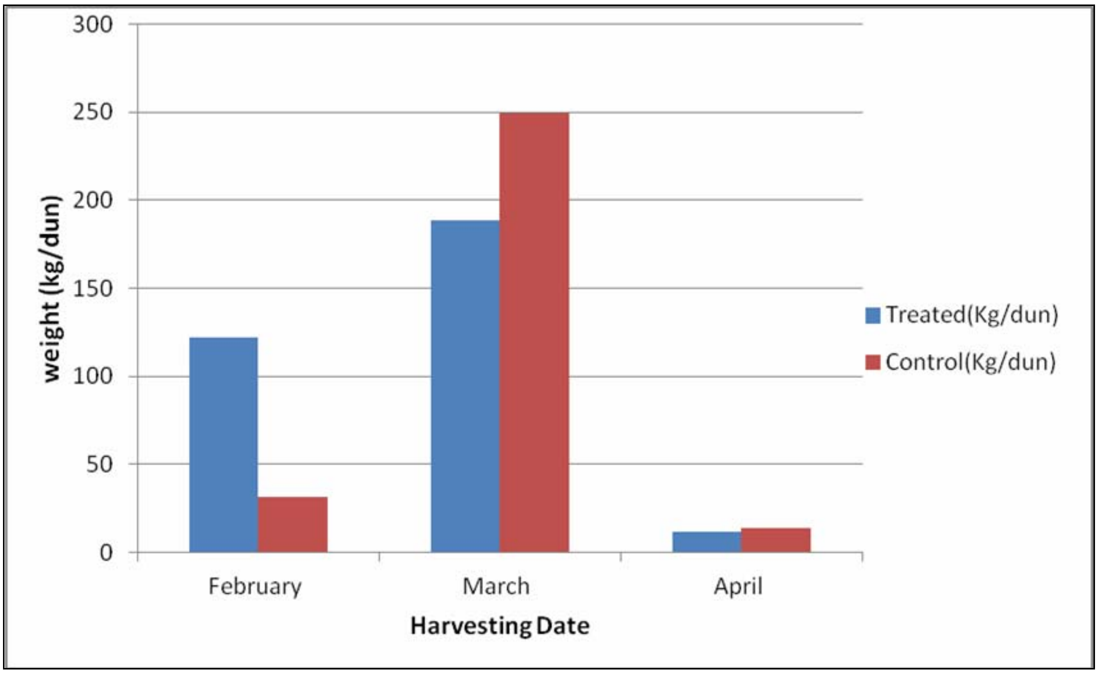
Appendix 5: Calcium Concentration of Bell Pepper Plant Soil in Different Depth for Treated (T) and Control (C) Water.



Appendix 6: Yield Weight by kg/dun for Treated and Control Bell Pepper During Season.



Appendix 7: Yield Weight by kg/dun for Treated and Control Beans During Season.



Appendix 8: Detailed Mean Root Mass of Bell Pepper Plant for Treated and Control.

Variable ROOT M	N	Mean	Std. Deviation	Significant value ((Sig. (2-tailed)))	significant or not
rootMT	36	93.89	40.043	.043	significant (treatment and control)
rootMC	36	73.83	28.422		

Appendix 9 : Figures of Treatment Plant.

Appendix 10 : Figures of Bell Pepper Plant During Study.

Appendix 11: Figures of Beans Plant During Study.

Appendix 12: Figures of Bell Pepper Analysis in Lab