An-Najah National University
Faculty of Graduate Studies

Salinity Management for Barley Production in Brackish and Treated Effluent Irrigated Agricultural Systems

By
Maher Abd Allah Ahmed Salahat

Supervisor
Prof. Dr. Marwan Haddad

Co- Supervisor
Dr. Numan Mizyed

This Thesis is Submitted in Partial Fulfillment of the Requirements for the Degree of Master of Plant Production, Faculty of Graduate Studies, An- Najah National University, Nablus, Palestine.

2013

Salinity Management for Barley Production in Brackish and Treated Effluent Irrigated Agricultural Systems

By
Maher Abd Allah Ahmed Salahat

This Thesis was defended successfully on 14/3 /2013 and approved by:

Defense Committee Members	Signature
Prof. Dr. Marwan Haddad (Supervisor).	……………………
Dr. Numan Mizyed (Co-Supervisor).	……………………
Dr. Abdalla Al-Omary (External Examiner).	……………………
Dr. Heba AL-Fares (Internal Examiner).	……………………

Dedication

First, my heartfelt thanks to Allah the Almighty for giving me the energy to complete this thesis, for being my inspiration along the way.

To the soul of my father,

To the soul of my brother Amjad.

Deepest gratitude goes to my precious mother who urged me to complete this thesis. Thanks for her love, support and encouragement, without whose support, this thesis would not have been possible.

Deepest gratitude and love go to my precious wife, my sons and my daughter who urged me to complete this thesis.

Deepest thanks go to my ,brothers and sisters and their families, especially Dr. Rami for help and encouragement.

To all my friends and all the staff members of Ministry of Agriculture.

To all the Palestinian Students at homeland and outside.

To my homeland Palestine, I dedicate this simple work.

Acknowledgments

Words cannot truly express my deepest gratitude to my supervisor, Prof., Dr. Marwan Haddad whose encouragement, guidance and support, from the initial stage to the final one, enabled me to develop and understand the subject.

My thanks and appreciations go to all the defense committee: Dr Numan Mizyed, Dr. Heba AL-Fares, and Dr. Abdalla Al-Omary, for their valuable notice and extensions.

I would also like to extend my gratitude to all who contributed to this study successfully. In particular, to my University An-Najah National University for supporting this work and for the staff of the faculty of Agriculture especially, Dr Hassan Abu Qauod for his support and help.

Thanks also go to appreciate the efforts of all respected teachers and staff of my previous educational stages.

I extend my thanks to all of those who supported me in any respect during the production of this thesis

Its time to express my deep respect to the faculty of engineering laboratories Managers and employees، for helping me in analyzing the soil samples.

I would like to thank all members of Ministry of Agriculture especially my friends in Tubas Governorate.

إقـرار

أنا الموقع أدناه مقدم الرسالة التي تحمل العنوان:

Salinity Management for Barley Production in Brackish and Treated Effluent Irrigated Agricultural Systems

أثر الملوحة على إنتاج الشعير المروي بالمياه المالحة والمعالجة

اقر بأن ما اشتملت عليه هذه الرسالة إنما هي نتاج جهدي الخاص، باستثناء ما تمت الإشارة إليه حيثما ورد، وأن هذه الرسالة ككل، أو أي جزء منها لم يقدم من قبل لنيل أية درجة علمية أو بحث علمي أو بحثي لدى أية مؤسسة تعليمية أو بحثية أخرى.

Declaration

The work provided in this thesis, unless otherwise referenced, is the researcher's own work, and has not been submitted elsewhere for any other degree or qualification.

Student Name:	....	اسم الطالب:
Signature:	....	التوقيع:
Date:	....	التاريخ:

Table of Contents

List of Tables

List of Figures

List of Abbreviations

ICBA	International Center for Biosaline Agriculture , Dubai
Variety 1	ICBA 91/2A
Variety 2	ICBA 186AD
Variety 3	ICBA 51 1B
Variety 4	ICBA ICARDA20
Variety 5	ICBA AD 187
BOD	Biological oxygen demand
TDS	Total dissolved solids
TSS	Total suspended solids
FC	Fecal coli form
conc	Concentration
str	Straw
wt	Weight in grams
S1	Salinity concentration with TDS=1080 ppm
S2	Salinity concentration with TDS= 3240 ppm
S3	Salinity concentration with TDS= 9720 ppm
Fw	Fresh water with TDS concentration =442 ppm
Tww	Treated wastewater with TDS concentration =1200 ppm
ppm	Parts per million
FAO	United Nations for Food and Agricultural Organization
Ece	Electrical conductivity of soil extraction

Salinity Management for Barley Production in Brackish and Treated Effluent Irrigated Agricultural Systems

By
Maher Abd Allah Ahmed Salahat
Supervisor
Prof. Dr. Marwan Haddad
Co- Supervisor
Dr. Numan Mizyed

Abstract

Marginal water resources such as brackish, and treated waste water are promising water resources as alternatives for fresh water to be used in agriculture specially crops with high tolerance to salinity such as barley.

This study aims to; evaluate the effect of five different water concentrations on the behavior and productivity of five different barley varieties to demonstrate the salinity tolerance of each variety.

Five barley varieties *Hordium Vlgure* were cultivated under five different water applications, the applications included fresh water(Fw) as a control with TDS concentration of 442 ppm[1], treated wastewater (Tww) with salinity of 1200 ppm, and three levels of water salinity. The levels of salinity were: S1 (1080 ppm), S2 (3240 ppm), and S3 (9720 ppm). The experiment was designed under CRBD by split plot design with 3 replications.

The results of the experiment showed that in all cases there is a significant ($p \leq 0.05$) difference between the high concentration (S3) and

[1] Parts per million

other concentrations, causing a reduction in the grain and straw yields of barely. Also, the analysis show that straw yield and height of plants were significantly smaller for the high salinity concentration (S3). Results also showed that there is a significant increase in yield when using Tww[2] compared with other treatments. When treated wastewater was used, the grain yield, straw[3] yield and height of plants were significantly higher than those in the other treatments for all varieties of barley.

On the other hand, concentrations S1, S2 and Fw[4] didn't show significant differences among them in terms of grain yield. However, S1 and S2 didn`t give significant differences in straw yield, and there was no significant difference between S2 and Fw. For height, S3 treatment produced significantly shorter plants. Tww treatment produced plants higher than those of other treatments. According to varieties, variety 4 and variety 1 gave the highest yield of grains and there are significant differences among variety 4 and varieties 2,3,and5 while there was no significant difference among varieties1, 2, 3, and 5. On the other hand it was observed that there was no significant differences between varieties 4 and 1

For straw yield, varieties 1 and 4 showed the highest yield so, there were significant differences between variety1 and varieties 2,3, and 5.

[2] Treated wastewater
[3] Is an agricultural by-product, the dry stalks of cereal plants
[4] Freshwater

There was a significant difference between variety 4 and varieties 2, 3, and 5. It has been concluded no significant differences between 4 and1.

For interaction between salinity and variety, the environmental conditions should be the main reason for selecting the suitable variety.

Its clear that the use of brackish water and Tww in irrigating such crops will be promising and saving traditional water sources for domestic uses. which couldn't use Tww and brackish water for that.

Chapter One

Introduction

Introduction to the domains and the Core of the study

1-1 Introduction

1-2 Background

1-3 Literature review

1-3-1 Brackish water and agriculture

1-3-1-1 Mediterranean countries experience

1-3-2 Treated waste water in agriculture

1-3-3 Summary

1-4 Definitions

1-5 The problem set

1-6 The aim of the study

Chapter One

Introduction to the domains and the core of the study

1-1 Introduction:

Water crises are a widely acknowledged fact all through the world, especially in the Middle Eastern region. Because almost all accessible fresh water resources in the region have been already committed, it is only natural to turn to non-conventional water resources for satisfying the accelerated rates of demand for fresh water" (FAO, 2003). Nowadays this solution is reaching its natural limit (FAO,2003)

The world population is increasing continuously and the need for food and water is continually growing. Such conditions put decision makers all over the world in continuous stress to look for new sources of food and water supply. This leads continuously to think in how to increase the agricultural production by increasing the area and productivity requiring investigating new sources of water.

Treated waste water produced as effluents from sewage systems of urban communities represent non-conventional renewable water which could be an attractive and a cheap source to be used for agriculture. (FAO, 2003).

The actual consumption of water is high and approaching the limits of the available resources in many countries, thus agricultural areas continuously shrinking due to the diversion of water from agriculture to other sectors. For these countries, water is becoming a major factor for development and accordingly a major economic, social and political challenge. So the use of nonconventional water resources and the overall management of water efficiently and effectively become a pressing challenge in these countries.

Using of brackish water, low quality water, saline water and treated waste water could be promising techniques for a good management of all water resources, because it releases the fresh water for domestic supply and other priority uses.

Reuse of water is a good contribution to energy and water conservation and to improve quality of life. Treated waste water reuse in a good properly planned and managed matter will have a positive impact on the environment, socio-economics and public health. However reuse of treated waste water may also have negative aspects on the environment and public health if it is not managed appropriately, so that means the use of waste water has smany restrictions. (Mehari, Schultz, and Depeweg 2006).

The increasing usage of brackish, low quality, and treated effluent water in agriculture increased the need to quantify the impact of irrigation water quality on the irrigated crops.

Rapid urban population growth has put enormous pressures on limited freshwater supplies. Many states and local governments have reacted by placing restrictions on the use of potable water for irrigation, instead requiring the use of reclaimed or other secondary saline water sources (Marcum 2006).

Salinity problems will increase by increasing the salt concentration of irrigation water, salinity affects plant growth and production negatively in most plants. Irrigation water salinity reduces the available water for plants by reducing soil water potential when increasing the concentration of salts in the root zone. One of the options to mange salinity is to select crops or varieties which are tolerant to salinity.

In Egypt, there have been several attempts to improve wheat productivity by selecting tolerant cultivars such as Sakha-8. It was observed that each increase in the salinity of soil water by 1 ds/m above 6 ds/m will cause reduction in yield by 8% (Hassan et al,1995).

Also, in Jordan, researchers attempted to use saline water for the irrigation of barley and onion. The Jordanian studies investigated the best water management systems for the use of saline water for irrigation (Fardos et.al., 1998).

Several studies are carried out in different Arab countries such as Algeria, Iraq and Libya with the aim of looking for the best management irrigation procedures for cultivation of the best tolerant crops under different salinity conditions.

Wastewater reuse in agriculture is recognized worldwide as an alternative water and nutrient source. Large-scale cropland application of municipal wastewater was first practiced about 150 years ago after flush toilets and sewerage systems were introduced into cities in Western Europe and North America (Snow, 1936).

Wastewater was discharged without any treatment, and receiving watercourses became heavily polluted. The problem was illustrated by the situation in London in the 1850s when the "stink" from the River Thames obliged the House of Parliament to drench their drapes in chloride of lime (Snow, 1936).

Water shortage in Palestine, is very serious especially in the West Bank and the Gaza Strip. The agricultural sector is a major consumer of groundwater in the Gaza Strip (Palestine), where the level of groundwater, the main water resource, is being depleted and its quality is adversely affected. Wastewater reuse was identified to solve the water shortage problems in Palestine as shown in the National Palestinian Water Policy (Yassin et. al, 2008).

Salinity, in topsoil and subsoil, is one of the major biotic environmental stresses to crop production. Good water management combined with appropriate soil management is necessary for sustainable crop production in dry lands.

It was experimentally shown by Katerji et. al, (2006) that barley has a high salt tolerance expressed during the growth period in:

- Higher stomata conductance during the irrigation interval;
- Higher maximum osmotic potential;
- More vigorous growth, less affected by salinity;
- Less salinity effect on water use efficiency.

1-2 Background:

Sadeh and Ravina, (2000) Applied a model to field crops in the Negev, in three case studies, using existing linear and non-linear relationships between yield and irrigation and between yield and salinity. Model coefficients were estimated from experimental data. Results were consistent with actual yield of corn and cotton in the single season cases. Simulation of wheat growing in the winter with supplemental irrigation with brackish water for 13 years showed interesting results of accumulation of soil salinity and reduction of yield. The model can be easily applied to other crops and growing areas. It can be used for the analysis of long-term soil salinization processes .

Marshall and Randall (1997) conducted an economic analysis of agricultural cost of soil salinity in the Murrumbidgee Irrigation Area in southeast inland Australia, and investigated the present value of the agricultural cost under an assumption of immediate response was found to be 63% of that under the preferred assumption of a 10-year average delay in response. The estimate under an assumption of no farmer response was 4·5 times greater than under the preferred assumption. This confirms that accounting for on-farm response is required if the economic impact of soil salinity is to be accurately estimated.

In a salinity impact assessment on crop yield study, it was concluded that the water management reforms cannot double crop production (especially of maize which had reductions between 30-100%) unless the management and allocations of floodwaters take into account the need to control soil salinity (Mehari, Schultz, and Depeweg 2006).

Katerji et. al (2006) investigated the classification and salt tolerance of six barley varieties in a greenhouse experiment; it was found that varietal salt tolerance clearly affects the water use efficiency and the salt tolerance classification. Variety Melusine was the best for its combination of high yield and salt tolerance. Variety ISABON3, a very salt tolerant land race originally from Afghanistan showed a larger grain and straw yield under non-saline and saline conditions (Katerji et. al 2006).

Herpin et al, (2007) used secondary treated wastewater (STW) over 3 years and 7 months to irrigate coffee (Coffea Arabica L). The study revealed that STW can effectively increase water resources for irrigation, however, innovative and adapted fertilizer/STW management strategies are needed to diminish sodicity risks and to sustain adequate and balanced nutritional conditions in the soil–plant system

Al-Busaidi, (2006) says that poor management of saline water may increase the soil salinity to a level higher than crop tolerance, so the lands which are irrigated with saline water required to reduce salt accumulation through good range system as one of procedure of good management in addition to adding excess amount of water to the crop in order to control salts which is called leaching as another procedure of good management.

Hamdy (2006) designed an experiment that deals with leaching requirements for barley growth under saline irrigation. Hamdy analyzed soil samples for Ece, pH and SAR and they created the required ECw through mixing freshwater with saline by the proper ratio. He separated plots from each other by space with 2 meters between each plot and using drip irrigation. He found that crops response to salinity depends on plants species, soil texture, water holding capacity and composition of salts. Through their experiment varieties positively affected by low salinity concentration by increasing tillering, leaf area index, which leads to increase the grain yield and straw yield if compared to high salinity concentration by decreasing the straw and grains production

Al-Busaidi, (2006) conducted an experiment on the effect of salinity on barley in different growth conditions which were green house, growth chamber and glass house, 2 salinity levels in each growth condition which were 3 ds/m and 13 ds/m. The three cases showed that there was a significant difference between 3 ds/m and 13 ds/m. The concentration of 13 ds/m showed a decrease in the yield for the three cases.

Al -Shammary(1998) conducted an experiment in King Abdul-Aziz city for Science and Technology in Saudi Arabia, His work was on 4 barley varieties which were Qatifi, Gusto, Alkharji, Haili, using five different concentrations of water salinity ranging from 2.85 ds/m up to 15.95 ds/m. This experiment was laid out is split plot design. The results of this experiment showed that there was correlation between the increasing salinity concentration of the irrigated water as salinity concentration increases, the production of grain yield, straw yield and height of plants will reduce significantly. The tolerance of the varieties used in this experiment to salinity differs from one variety to another (Fardos et.al., 1998) .

Al-Khafaf et, al. (1990) studied the response of barley to water stress at different growth stages at various levels of soil salinity in cylindrical wooden containers (1.1 m long and 0. 6 m in diameter). The treatments consisted of three salinity levels (low = S_1, medium = S_2 and high = S_3) and two irrigation treatments, no water stress at any given growth stage and plants exposed to water stress at either tillering, vegetative, flowering or seed formation stage and normally irrigated in the other stages. Comparison in above-ground dry weights indicated a significant variation (p=0.05) between different treatments at each sampling date. The interaction between salinity and water stress was also significant. Maximum reduction in shoot dry weight was 70% under S_3 treatment when the plants were imposed to water stress in the vegetative growth stage. The relative reductions in shoot dry weights due to salinity at the vegetative growth stage were 33% and 46% for S_2 and S_3, respectively, in comparison to S_1. Root dry weights significantly varied between different treatments. The highest reduction in root dry weights were recorded when the plants were exposed to water stress and/or salinity at the vegetative growth stage.

The interactive effects of salinity and potassium deficiency on the growth, mineral elements and photosynthetic performance were investigated. It was found that in both species, biomass production decreased considerably when the two constraints were applied simultaneously. Salinity affected shoots more than roots, whereas for potassium deficiency, the reverse occurred. Generally, potassium uptake was more affected in the wild more than in cultivated barley and, independent of potassium availability, 100 mM NaCl increased Na^+ content in both species, whereas K^+ deprivation increased Na^+ content only in H. maritimum shoots (0-0). (Degl'Innocenti et al 2009).

It was found that the increasing levels of subsoil NaCl salinity had significant depressing effect on shoot and root biomass, root/shoot ratio, water uptake and water use efficiency (shoot biomass production with a unit amount of applied water), leaves K: Na ratio and Ca: Na ratio of all the four species, but the magnitude of effect varied considerably among the species. There was 37% reduction in shoot dry weight of barley by highest subsoil salinity. Similarly water uptake by barley declined by 31%. Results also suggest that the growing of comparatively tolerant species like barley and canola may be the better option for sustaining crop production and higher water use efficiency on sodic vertisols with high subsoil NaCl salinity (Grewal, 2010).

A pot culture experiment was conducted (Ahmad et al 2010) using sand dune soil under greenhouse conditions to evaluate the response of wheat (Triticum aestivum L.) to the application of farmyard manure (FYM) or poultry manure (PM), and irrigation with water at two salinity levels (0.11 11 and 2.0 dS/ m) and two irrigation intervals (daily and every second day). It was reported that farmyard manure FYM treatment resulted in 78 and 21% higher dry matter yield compared to the control and poultry manure PM treatments, respectively, under daily irrigation using good-quality water. The increase was 29 and 55%, respectively, when saline water was used for daily irrigation. A similar trend was observed with the alternate day irrigation treatment; FYM gave the highest dry matter yield. The number of tillers and plant height showed that FYM was better than PM, which in turn was better than the control under irrigation with good-quality water regardless of the irrigation interval. When water of the highest salinity was used for irrigation, FYM was still always the best, but the control was now better than the PM treatment(Ahmad et al 2010).

In studying the use of saline and non-potable water in the turf grass industry, Marcum (2006) found that soil salinity must be maintained below the level deemed detrimental to the turf, by maintaining sufficient leaching. Sodium/bicarbonate affected soils must be managed to maintain sufficient permeability to permit adequate leaching and salt tolerant turf species/ cultivars must be used. Long-term solutions to the salinity problem will require development of improved salt-tolerant varieties/cultivars Marcum (2006).

It was indicated that the salt tolerant variety Cham-1, established by ICARDA, showed a higher grain yield than the less salt tolerant landrace Haurani, but the main parameters for the pasta quality declined considerably. Salinity had a slight positive effect on the grain quality of the Cham-1 variety, whereas the Haurani variety showed no salinity effect on grain quality. A decrease in ash content corresponded with an increase in water use efficiency. The relationship between ash content and water use efficiency may be useful for selecting varieties with high water efficiency under saline conditions (Katerji et. al. , 2005).

1-3 Literature review:

1-3-1 Brackish water and agriculture:

A selected review of some representative examples of the commercial use that has been made of saline waters for irrigation under different circumstances around the world follows. The examples were chosen to be representative of the worldwide experience of such use and because relevant information, including water quality, climate, soil type, crops, irrigation systems and methods, other management practices, yields and period of use, was available. These reviews supplement those given elsewhere (Rhoades 1990a) and serve to illustrate the wide range of experience that exists in using saline water for irrigation under different conditions and to demonstrate that waters of much higher salinities than those customarily classified as "suitable for irrigation" can, in fact, be used effectively for the production of selected crops under the right conditions.

They also illustrate some of the management practices that have been found to be effective to facilitate such use.

In the USA, saline waters have been successfully used for irrigation for periods of from 75 to 100 years in several areas of the Southwest, including the Arkansas River Valley of Colorado, the Salt River Valley of Arizona, and the Rio Grande and Pecos River Valleys of New Mexico and West Texas (Erickson 1980). The principal crops grown in these areas are cotton, sugar beet, alfalfa and small grains.. The following discussion gives more detail for some of these areas.

Cotton is grown successfully with a gypsiferous water of up to 8 dS/m EC using alternate-row, furrow irrigation and double-row plantings on wide beds or by using single-row plantings on narrow beds.. Sprinkler irrigation of cotton is carried out during night or twilight hours using water of up to about 5 dS/m in EC. Alfalfa and several other forages are produced with minimal yield losses using waters of up to 3 to 5 dS/m, as have been tomatoes.. Alfalfa yields in saline areas near Dell City have been 12.3 to 13.4 t/ha, whereas yields of 17.9 to 20.1 t/ha are common in the van Horn area.

Double-row planting on flat beds is practiced with lettuce, onions and in some cases with cotton. Seeds are planted on the edges of the bed where salt accumulation is minimal. Excellent stand and production of cotton have been obtained using this system with water of 5.4 dS/m in EC. This practice does not prevent seedling damage caused by saline-water splash associated with light rains and the presence of high surface accumulations of salts near the seedlings. Planting seed in the water-furrow is advantageous because the lower levels of salinity that occur there, but this practice has serious disadvantages as well. As soil in the furrow crusts badly and is colder, seedling diseases and weed infections are worse. Thus this method is used only in extremely saline soils for the establishment of some forage crops.

In the Dell City area, alfalfa leaves frequently show margin leaf-burn, although no major yield reductions are reported, when sprinkler-irrigated with water of up to 3.0 to 5.0 dS/m in EC. In summary, the experience in Far West Texas shows that good crop production of suitable crops can be achieved with use of saline waters (up to about 8 dS/m in EC) for irrigation if care is taken to obtain stand.

O'Leary (1984) has shown in pilot-sized operations that several halophytes (such as Atriplex nummalaria) have potential for use as crop plants and can be grown with seawater. Yields of forage have been achieved which exceed the average yield of conventional crops, like alfalfa, irrigated with freshwater. The most productive halophytes yielded the equivalent of 8 to 17 metric tonnes of dry matter per hectare. These yields contributed the equivalent of 0.6 to 2.6 metric tonnes of protein per hectare, which compares to that obtained for alfalfa irrigated with fresh water.

These halophytes yield even more when grown with water of lower salinity. For example, about double the above yields were obtained using water of 10 000 mg/l TDS for irrigation. Some halophytes, such as Salicornia, appear to have even better potential as oil seed crops. The use of secondary drainage waters for the growth of such crops after their first use for more conventional crops would facilitate the disposal of drainage waters by reducing the ultimate volume needing such disposal, as proposed by Rhoades (1977) and van Schilfgaarde and Rhoades (1984). Limited commercial use of such halophytes is now being attempted in various places in the world, but insufficient long term results are available to document its success.

1.3.1.1. Mediterranean countries experience:

Considerable use has been made of saline waters for irrigation in Israel. The majority of the saline groundwaters range between 2 and 8 dS/m in EC (about 1200 to 5600 mg/l in TDS). The average annual evapotranspiration is about 20 000 m3 per hectare. Average annual rainfall exceeds 200 mm in over half of the country and is about 500 mm in the main agricultural area (600 mm in the coastal plain); most of the rain falls in the winter season.

The climate is Mediterranean with a moderately hot, dry summer (April to March). Heavy dews occur in many parts of the country, especially near the coast. Mostly sprinkler or drip irrigation is used. The soils are generally permeable and drainage is good. Much of the saline water is introduced into the national carrier system; thus it is diluted before use. Because most of the crops are irrigated by sprinkler methods, some crops suffer poor emergence related to crusting. Thus they are sometimes started by furrow irrigation. Extra water (equivalent to about 25 to 30 percent in excess of evapotranspiration) is typically given for leaching.

According to Israeli general recommendations, light- and medium-textured soils can be irrigated with any saline water in the range of the salinity tolerance of the crop, and heavy soils can be irrigated with waters having EC values of up to 3.5 to 5.5 dS/m where artificial drainage is provided (gypsum applications are advised for such waters). Cotton is successfully grown commercially in the Nahal Oz area of Israel with saline groundwater of 5 dS/m in EC and 26 of SAR provided the. Silty clay soil is treated annually with gypsum and national carrier water is used (usually during the winter) to bring the soil to field capacity through a depth of 150 to 180 cm prior to planting (Frenkel and Shainberg 1975; Keren and Shainberg 1978).

The saline Medjerda River water of Tunisia (average annual EC of 3.0 dS/m; is successfully used to irrigate date palm, sorghum, barley, alfalfa, rye grass and artichokes. The soils are calcareous (up to 35 percent CaCO3) heavy clays with low infiltration rates, especially after winter rainfall. During the growing season large cracks form (fissures of up to 5 cm in width) as the soil dries, subsequently permitting water to enter rapidly when first irrigated.

Winter rainfall produces leaching of salts only to depths in the soil of about 15 cm. However, with properly timed irrigations and use of appropriate crops, such saline waters are being successfully used in Tunisia for the irrigation of even such relatively impervious soils (Van't Leven and Haddad 1968; van Hoorn 1971).

The chemical content and composition of the irrigated soils become stable after about four years of irrigation, subject to variation in crop rotation effects. Sodicity does not become a significant problem. Winter rainfall can be effectively exploited for leaching purposes by keeping the soil high in water content just prior to rain events. (It should be noted that rainfall is higher in the coastal regions of Tunisia than is typical of most semi-arid regions; furthermore, much of the rainfall occurs in relatively intense storms in the winter months.) Good yields of appropriate crops can be obtained with use of typical well waters for irrigation (though with some reduction relative to the use of freshwater) provided certain precautions are taken. Salinity in the irrigation waters is concluded not to be an insurmountable barrier.

It primarily affects the summer crops whereas the winter crops are more strongly influenced by amount of rainfall and initial level of salinity present in the soil in the autumn of the year. Germination and emergence (especially the latter) are crucial to the success of cropping and establishment of stand is the major bottleneck. The physical condition of the soil surface layer has a major effect on emergence and methods of irrigation and tillage are very influential in this regard and given too little attention compared to salinity in management considerations. Poor aeration is a major problem when excessive amounts of irrigation water are given, such as might be encouraged when saline waters are used.

These Tunisian studies point out the need to pay close attention to other factors besides salinity per se (some of which, however, are influenced by salinity) which must also be controlled if successful irrigation with saline waters is to be achieved.

Egypt is a predominantly arid country and the scattered rain showers in the north can hardly support any agricultural crops. The needed increase in food production to support the acceleration of population growth (2.7%), compels the country to use all sources of water (i.e. drainage water, groundwater and treated sewage water) for the expansion of irrigated agriculture.

The policy of the Egyptian Government is to use drainage water (up to salinity of 4.5 dS/m) after it is blended with fresh Nile water (if its salinity exceeds 1.0 dS/m) to form blended water of a salinity equivalent to 1.0 dS/m.

In fact, direct use of drainage water for irrigation with salinity varying from 2 to 3 dS/m, is common in the districts of Northern Delta where there are no other alternatives or in areas of limited better water quality supply. Farmers in Beheira, Kafr-El-Sheikh, Damietta and Dakhlia Governorates have successfully used drainage water directly for periods of 25 years to irrigate over 10 000 ha of land, using traditional farming practices.. The major crops include clover "Berseem", rice, wheat, barley, sugar beet and cotton. Yield reductions of 25 to 30 percent are apparently acceptable to local farmers. Yield reductions observed are attributed to water logging and salinization resulting from over-irrigation and other forms of poor agricultural, soil and water management.

Pilot studies carried out in Kafr el Sheik and Beheira Governorates showed that by applying appropriate management practices (i.e. crop selection, use of soil amendments, deep ploughing, tillage for seedbed preparation, land leveling, fertilization, minimum leaching requirements, mulching and organic manuring), drainage water of salinity 2 to 2.5 dS/m can be safely used for irrigation without long term hazardous consequences to crops or soils.

The following strategy emerges from these demonstrations, i.e. to irrigate sensitive crops (maize, pepper, onion, alfalfa, etc.) in the rotation with fresh Nile water and salt tolerant crops (wheat, cotton, sugarbeet, etc.) directly with drainage water, and moderately sensitive crops (tomato, lettuce, potato, sunflower, etc.) can be irrigated with drainage water but after seedling establishment with fresh Nile water. Based on these results, the Governorate is planning to reclaim 4000 ha using the drainage water.

The estimated present annual abstraction from groundwater resources in the Nile Valley and Delta is about 2.6 billon cubic meter (for agricultural, municipal and industrial use) with an average salinity of 1.5 dS/m but ranging far higher, at least to 4.0 dS/m. Saline groundwaters ranging 2.0 to 4.0 dS/m have been successfully used for decades to irrigate a variety of crops in large areas of scattered farms in the Nile Valley and Delta. Crops now grown are mostly forage, cereals and vegetables.

1-3-2 Treated waste water in aagriculture:

For nearly 100 years, highly treated reclaimed water has been used in the United States.

In the early days of water reclamation and reuse, many of the large-volume uses of reclaimed water were for applications (e.g., pasture irrigation) in the vicinity of wastewater treatment plants that did not require a high-quality effluent. These applications were often perceived as a method of wastewater disposal. In 1912, the first small urban reuse system began with the irrigation of Golden Gate Park in San

Francisco. By the using treated and waste water to meet the irrigation needs of farming activities. This saves on water resources upstream and reduces pollution downstream. The waste water can also often represent a source of nutrients for the plantings.

Waste water is recycled extensively in regions suffering from water shortages, mainly Japan, the Mediterranean basin (Israel, Turkey, Cyprus and Spain), the United States (especially California) and also Asia and the Gulf region.

Irrigation can increase the productivity of farming activities from 100% to 400% and allow certain crops to be grown in regions with un favorable environmental conditions. Agriculture accounts for 70%_95% of the water taken in certain developing countries. Recycling waste water is one solution in facing up to the increasing demand for water resources for irrigation. At the same time, it is a natural way of reducing the environmental impacts and providing the nutrients (mainly nitrogen and phosphorous) which will fertilize the soil.

Waste water recycling is above all suitable in regions with limited water resources compared with existing demand. And yet, some crops are better suited than others to this technique based on the inherent risks of consuming products irrigated with recycled water.

Crops to which recycled waste water applies include barley, corn, oats, cotton, avocado sugar beet, sugar cane, apricot, orange, plum, vine, flowers and wood and each crop needs a certain class of treated waste water.

Waste water recycling involves using the water, whether or not pretreated, for new uses (irrigation, pastures, golf courses, gardening, cooling power plants, etc.) rather than releasing it into the environment above all in terms of soil use, the region's hydrological conditions and the impacts on the water tables.

The waste water (whether or not purified) contains very variable proportions of nutritive substances for the plants like nitrogen, phosphorous, potassium and the trace elements, zinc, boron and sulphur. In some circumstances, these elements may be too much for the needs of the plant and cause negative effects to both the crops and the soil. The amount of nutrients found in the effluent must be checked regularly to take account of the fertilizer requirements of irrigated crops.

The water must be checked for certain substances to ensure a good quality for the irrigation system: 1960s, landscape irrigation had become a major use for reclaimed water.

During a recycled waste water irrigation project, it will perhaps be necessary to raise the awareness of all the parties involved to the existing issues. Firstly, the safety of consumers and farmers must be guaranteed, by demonstrating that their health is not in danger. Secondly, the environmental impacts must be controlled. A transparent approach is the only way to ensure that the project is accepted by the population, farmers and governmental bodies involved.

To protect the population, a conventional rule adopted when recycling waste water is to paint the pipes and equipment in a distinctive color, usually purple. The use of recycled water must also be signaled by posters and panels.

- Using waste water is an alternative to the water shortages faced by some regions on the planet.

- This represents a source of reliable water for the farmers. In addition, the recycled water normally contains nutrients that reduce fertilization costs.
- Waste water recycling reduces the environmental impact caused by releasing effluents into the natural environment.

1-3-3 Summary:

Palestinian people and Palestinian farmers still suffering of shortage of fresh water resources ,this makes the specialists search for unconventional water resource , which are mainly brackish water and treated waste water to be used basically in irrigating groups to overcome the water crises. Using brackish water in agriculture could be one of the strategies to overcome water crises.

The use of such water in agriculture is restricted by some limitations to avoid establishing use problems in long term in irrigation.

The main problem in using brackish water in irrigation that the sort accumulation which leads to soil salinity, sodic soil. Continuous irrigating with brackish water for long time will cause problems in the irrigation system as a result of salt accumulation.

When using brackish water in irrigation only specific groups could be irrigated with such water which is the moderate tolerant and tolerant crops to salinity such as barley and balm. While sensitive crops couldn’t be irrigated by this kind of water because of the negative effect on the growth and development of plants.

Treated waste water could be considered as unconventional water resource to be used in agriculture as a part of overcoming the water crises, in addition to the environmental needs of waste water treatment. Treated waste water could be considered as a good practice in reducing the use of chemical fertilizers, because it’s a rich source of the plant nutrients which mostly leads to more yield in most crops, a cheap source of water if it compared to fresh water costs. The use of this source of water also has its restrictions and limitations in the aspect of the kind of treatment.

According to Palestinian Standard Institution treated waste water classified in to four categories depends on the BOD, TSS and Fc in each category of this water.

The use of each class is restricted for specific crops with specific procedures to be sure that the use of such water to each crop hasn't any healthy hazards.

The treated waste water should be used under its specific restrictions and limitations to avoid healthy hazards for people who use this water.

1-4 Definition of terms:

Brackish water: water that the concentration of TDS in it is more than fresh water and less than sea water.

Barley: it is an annual cereal grain grass and its one member of Kingdome *Plantae.* Family*: Poaceae* Genus: *Hordem* Species: *H. vulgare*

Waste water: the combination of the liquid or water carried wastes removed from residences, institutions, and commercial and industrial establishments (Marcum, 2006)

Treated waste water: waste water has been subjected to one or more chemically, physically, biologically processes to reduce its potentially of being a health hazard and in our study the salinity level of treated wastewater was nearly 1200mg/l

Salinity: This term refers to the concentration of anions and cations that are present in specific volume of water or soil and this concentration indicates the possibility of growing and irrigating crops

Fresh water: Water which is colorless, odorless and its contents of salts not more than 0.05% and in our study salinity level is 442 mg/l

TDS: refers to the concentration of total dissolved solids in specific volume of water

S1: salinity level of 1080 mg/l, to reach this level, we had to add 638mg of slats per liter of water

S2: salinity level of 3240 mg/l and to reach this level, we had to add2798mg of slats per liter of water

S3: salinity level of 9720mg/l and to reach this level, we had to add 9278mg of salts per liter of water.

BOD :the amount of oxygen which is dissolved in water to satisfy the respiration requirements for microorganisms to decompose organic matter in water

TSS ; The amount of solids which is present in water as emulsion

FC : the number of colonels of Fecal Coliform which is present in each 100 ml of water

Class A : a classification of treated wastewater in accordance to Palestinian standards (M F 2003) which is defines as the treated waste water which contains maximum 20mg/l of BOD, 30 mg/l of TSS and less than 200 colony of FC/ 100 ml of water

Class B ; the treated waste water which contains maximum 20 mg/l BOD and 30 mg/ l of TSS and less than 1000 colony of FC/ 100ml of water

Class C; the treated waste water which contains maximum 40 mg/l BOD, 50 mg/l TSS and less than 1000 colony /100 ml of water

Class D; the treated waste water which contains maximum 60 mg/l BOD, 90m/l TSS and less than 1000 colony /100 ml of water

1-5: The problem set:

The rapid increase in world population makes scientists and decision makers give more attention to manage the natural resources in a more efficient pattern.

One of the most important resources is water and as mentioned above rapidly growing water demand while very limited increase in fresh water resources, this leads us to look for new and none traditional sources of water, looking also to improve the fresh water quality and prevent deteriorating its quality in addition, using alternative sources of water to be used in agriculture.

Many agricultural lands all over the world are suffering from salinity effect and many crops couldn’t be cultivated in these soils. This experiment studies the effect of using saline water and treated waste water in barley production. The results could be extended for irrigating other forage crops.

The study also aimed at studying the effects of these water qualities on specific barley varieties to compare and evaluate the performance of these varieties to allow selecting the best one.

1-6 Aim of the study:

In this experiment, the performance of different varieties of barely irrigation water quality was evaluated. The response is assessed by measuring the grain yield of barely taking into consideration the quality and quantity. The quality was analyzed in the lab and the quantity by measuring the weight as a main product.

The other factor of response for barely is the straw yield which is also assessed according to quantity and quality.

Height of plants were another factor to be evaluated, and this factor was obtained by measuring the plant average height and in this way we could consider the effect of each water concentration on the growth of each variety and this effect will be appear in these factors.

The aim is to investigate five varieties of barley under different levels of salinity to have an idea about the best variety which grows and produces a promising yield in quality and quantity.

Chapter Two

Materials and Methods

Chapter Two

Materials and Methods

Introduction:

This chapter is devoted to specify the steps and the methodology taken in carrying out the research. This chapter discusses research approach, experimental design, data collection procedures, and the statistical analysis.

2-1 Study location and layout

The experiment deals with the irrigation of barley by saline and treated waste water. It was conducted at the new campus of An-Najah National University. The average annual precipitation at our experiment site was estimated at 630 mm. However, actual annual rainfall was 538 mm in the year of 2009/2010. Most of this rainfall occurred by the beginning of February as only 17 mm of rainfall were observed in March. The duration of the experiment was from January to the end of May of the report ,season 2009/2010).

Table (2.1): Rain fall precipitation distribution during the season 2009/2010 in Nablus in millimeters (document).

Month	Quantity of precipitation
September	2
October	39
November	78.5
December	94
January	76.5
February	241
March	17
April	2
Total	550

The field of the experiment was designed into three main rows; each one consisted of 25 sub blocks. Each of the sub block was 2 m^2, so the total number of sub blocks was 75 and total planted area was 150 m^2(each sub block is separated from the other sub block by 50 cm and each row was separated from the other row by 2 m apart.

Five plastic tanks each of 1 m^3 in size were used and each tank of them represented one level of water concentration, and these tanks were regularly filled with water with assigned level of salt concentration, and used through the irrigating process through our experiment. To insure that we have uniform water distribution of irrigation water five electric pumps with one horsepower each were used through the irrigation process. Drip irrigation was used because it is more suitable for this kind of work as it will not allow over lapping effect of water application and for health aspects it is suitable for irrigation with treated wastewater (Figure2.1)

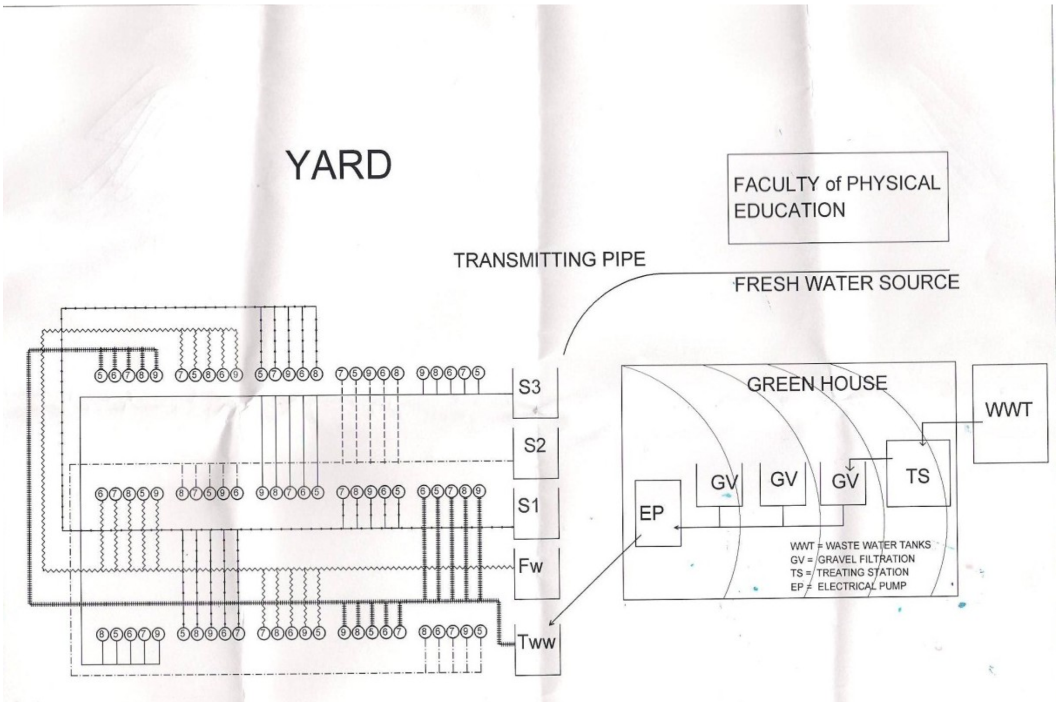

Figure (2.1): The figure explains the experiment layout and design.

2-2 Salinities and barley varieties:

Five different water concentrations have been used in this study, the first is the control water (fresh water) with TDS (442 ppm) which represents a control treatment, and represented by symbol FW, the second water concentration is the treated wastewater, which got from a purification unit, which is already presented near the site of the experiment, and represented by the symbol Tww. The third water concentration is salinity level with total TDS (1080 ppm), and we obtained this concentration by adding NaCl to water, it is represented by the symbol (S1).

The fourth water concentration that level of salinity with the concentration of (3240 ppm) TDS, and obtained by adding NaCl until reaching this level of concentration, it was represented by the symbol (S2).

Finally the fifth treatment was water with concentration of (9720 ppm) TDS, and reaching it by completing the concentration by adding NaCl to reach this concentration, it was represented by symbol (S3).

So as mentioned above, we have five different water concentrations which were represented by the symbols (FW, S1, S2, S3, TWW)

According to barley, we have five barley varieties used in our experiment which are (V1, V2, V3, V4, and V5) and each variety was irrigated with each water level by 3 replicates, so each variety was tested under each water concentration to evaluate the performance of each variety production of grains and straw.

2-3 Irrigation schedule and frequency:

In the earlier period of January and February there was no need for irrigation because of rain fall. According to rainfall in that season; the total rainfall was 550 ml. During that season (the year 2010), the total amount of rainfall during March was 17 mm and this amount was distributed 5mm in the first day of that month, and 12 mm in the last week of that month (Ministry of Agriculture, season 2009/2010) Thus, this quantity of rain was too little to cause leaching or diluting effect to salt concentrations of the treatments. The actual need of irrigation started in the second half of February. Because the temperature starts to rise in that month, more biological processes and more respiration, more transpiration and more photosynthesis as a result of warm temperature and longer photoperiod

The evapotranspiration in Nablus city is about 4 mm/day during irrigation period (metrological Asker station), so our planted area required 600 L of water daily, we programmed our irrigation frequency so that we need to irrigate 2 times/week adding the required amount of water each time.

Therefore, we estimated that the crops planted in the experiment require 55 m^3 of water until harvest, this amount of water don`t include water from precipitation which was negligible during the growing period.

2-4 Harvesting and evaluation of parameters:

In harvesting three factors are important: the variety, water treatment and blocks. Recording of the variety type, water salt concentration and block number, the harvesting was done manually in order to be sure that there were no impurities in the harvest and to insure accuracy. After harvesting grains of each sub block were separated and weighted. Also straw was weighted and recorded as shown in the appendix tables for: 1-Grain weight (gm.) 2- straw weight (gm.) 3-hieght (cm)

2-5 Chemical analysis:

2-5-1 Soil:

Chemical analysis has been used for determining the mineral contents of the soil of the experiment for each variety and each concentration for N, P, K, Ca, Mg, Cl, and Na, and these tests were performed at An-Najah National University Laboratories (the faculty of engineering). Each test was done in accordance to standard methods of analyses for soil and water.

The soil analysis was done in order to find if there was sequence between the results of the experiment (grains, straw yield) and TDS content. No sequence was found between the results of the experiment and the soil content of TDS. This could be explained that the soil of the experiment was sandy, and the water holding capacity of such soil is less than the other soils .

Nitrogen was analyzed by using nitrogen analyzer system which is Kjeldah system.

For phosphorus, its content was obtained by burning a known weight of soil in an oven for nearly 20 hours then dissolving the samples in distillated water then heating and titrating pH, preparing the calibration reference diagram, then we continue our work by using the spectra photometer and then the results are obtained from the calibrated diagram and expressed as phosphorus content of our samples in ppm.

The K content was obtained using the flame photometer which is calibrated using standard K solutions, the K content of our samples was obtained as ppm K. The following tables will give the minerals contents for our work components.

2-5-2 For water:

In the same manor all water concentrations that used in our experiment was analyzed at An-Najah National University laboratories, Faculty of engineering to know the concentrations of each major cation and anion. According to water with concentrations S1, S2, S3 we adjusted the water in to its desired concentration. Additional analyses were done to verify the concentrations after adjustments. The following table shows the content of each water concentration used in our work.

The chemical content of each water concentration used in our work

Table (2.2): Water used in the experiment

Sample	N ppm	P ppm	K ppm	Ca ppm	Mg ppm	Cl ppm	Na ppm	Ec ds\m	TDS (mg/l)
FW	18	1	5	12.01	18	42.54	32	0.69	442
TWW	224	11	33	110	28	175	85	1.87	1203
S1	28	1	11	20.01	23	425.4	530	1.68	1080
S2	112	2	23	32	41	1276	1779	5.06	3240
S3	360	2	38	40.02	60.8	4431	5709	12..15	9720

2-6 Barley analysis:

This experiment deals with barley, and it should be remembered that barley is mainly used as forage crop. It could be used as green forage or dry forage which is the most common use for it in many countries of the world.

According to the Palestinian Standards Institution for treated wastewater reuse "PMA2003", Treated wastewater is classified into four classes according to the contents of BOD, TSS and FC. For the Tww used in this work, it is classified as class C with BOD less than 40, TSS 50 and FC is less than 1000/100 ml Thus, this treated wastewater is suitable for irrigating fodder crops such as barely. Thus, there was no need to analyze the barley crop obtained from our work to be sure that there are no health risks involved in using this kind of water to irrigate barely.

2-7 Statistical analysis:

This work was based on using 3 main blocks and each block contained 25 sub blocks having 2 variables to assess the effect of water on production of barley. Thus, the split plot design with two ways of analysis have been used.

Chapter Three

Results

Chapter Three

Results

3-1 Introduction

This chapter represents the results that were obtained from the experiment in terms of barley production of grains, straw, the height of plants, chemical analysis of each water treatment, chemical analysis of soil of the field experiment and finally statistical analysis of the results of each variety and its response to the treatments of the experiment .

3-2 Analysis of variance

The following table represents the ANOVA table for the production of the grains

Table (3.1): Analysis of variance for grains (grams) of the barley genotypes under different water quality.

Variety: grains weight **Source of variation**	**df**	**SS**	**Ms**	**F value**	**P value**
replication stratum	2	5339	2670	1.04	
Replication .Salinity. Variety					
Salinity	4	18560.7	4640.2	18.10	<.001
Varieties	4	4345.7	1086.4	4.24	0.006
Replication. Salinity	8	2218.5	2773	1.08	0.395
Salinity* Variety	16	8961	560.1	2.18	0.023
Residual	40	10254.9	256.4		
Total	74	44874.7			

From this table, a significant (0.05) variation among barley genotypes for grains yield could be observed. It was also noticed that there is a significant (0.05) variation among salinity levels. Another significant variation (0.05) is also observed for interaction between salinity concentrations and varieties which represents the interaction between the environment and the variety.

Table (3.2): Means for grains weight for salinities, and varieties (grams)

Salinities	Fw	S1	TWW	S2	S3
	50.8	57.5	79.5	59.2	30.5
Varieties	V1	V2	V3	V4	V 5
	57.9	47.1	52.5	69.1	50.9

This table (3.2) represents the means of grain weight in respect of each salinity concentration and each barley variety.

By calculating the least significant difference for these means which is for grains=11.82, for salinities =11.82 and for interaction =26.42 it could be observed that there was significant increase in grains yield for the concentration Tww if compared with all other treatments, while at the S3 concentration, there was significant reduction in grains yield if compared with all other treatments, while no significant difference between the treatments S1, S2 and Fw is observed.

For varieties, it could be observed that variety 4 has the heigest grain yield and there was a significant difference between it and all other varieties while no significant difference was observed among varieties (1,2, 3 and 5) ,as in table(3.3) which explains the significance of varieties and salinities.

Table (3.3): The significant differences between the salinities and varieties for grains production

Salinity	**S3**	**Fw**	**S1**	**S2**	**Tww**
	30.5a	50.8b	57.5b	59.2b	79.5c
Varieties	V2	V5	V3	V1	V4
	47.1a	50.9a	52.5a	57.9ab	69.1b

Where the same letter means non significance while different letters means significance.

3-3 Interaction between salinity and variety for grains:

It was found that variety 1 gives the maximum grains weight at treated waste water concentration causing significant increase in grains yield more than all the other salinities, for variety 2, it also gives the maximum yield when irrigated with treated waste water casing significant difference between it and salinities(Fw, S3,and S2) while showing no significance difference with S1concentration. For variety 3, it gives the highest yield at S1 concentration causing significant difference with S2,and S3, and no significant difference with Fw and treated waste water. Variety 4 gives the highest yield when irrigated with treated wastewater causing significant difference with Fw, and S3 while not significant difference with S2,andS1 concentrations is seen. Finally, for variety 5, it gives the highest grains yield when irrigated with S2 concentration causing significant difference with S1, and S3 while no significant difference with Fw, and S3 concentrations is observed.

Table (3.4): The interaction between salinity and variety for grains (grams)

Variety / Salinity	V1	V2	V3	V4	V5
Fw	52.7	41.7	46.7	60.3	52.7
S1	41.7	55	70.7	79.7	40.3
Tww	103.3	71.3	69.7	94.7	58.3
S2	60	40.3	39	83.7	73
S3	31.7	27.3	36.3	27	30.3

3-4 Mean separation for straw yield:

The following table represents the ANOVA table for the production of the straw.

Table :(3.5) Analysis of variance for straw (grams) of the barley Genotypes under different water quality.

Source of variation	**Df**	**SS**	**Ms**	**F value**	**P value**
Replication stratum	2	46.1	230.8	2.15	
Replication*salinity*variety stratum					
Salinity	4	123936.3	30984.1	288.53	<.001
Variety	4	17754.1	4438.5	41.33	<.001
Replication*salinity	8	1469.7	183.7	1.71	0.126
Salinity*variety	16	53128.1	3320.5	30.92	<.001
Residual	40	4295.5	107.4		
total	74	201045.1			

It was found that the straw production was significantly affected by the treatments of the study which is very clear from table 3.5. Salinities, varieties, and interaction are significantly affected as the following 3-4-1 Mean separation for straw yield according to salinities

3-4-1 Mean separation according to salinities:

It was found that the treated wastewater caused significant differences if compared with all the other treatments by increasing the straw yield more than all other treatments, while S3 caused significant difference if compared with all the other treatments by reducing the straw yield less than all other treatments and this is illustrated in the following table.

Table (3.6): Means for straw yield with respect to salinities, varieties (grams).

Salinity	Fw	S1	TWW	S2	S3
	66.4	73.9	161.4	81.3	40.9
Varieties	V1	V2	V3	V4	V 5
	105.9	70.8	71.8	101.0	74.3

3-4-2 Mean separation for straw yield according to varieties:

It was observed that the variety 1 produced the highest straw yield causing significant difference with varieties (2,3 ,and5) , while it was not significant with variety 4. For varieties (2,3,and 5) , they didn't show significant differences among them which is illustrated in table (3.7) for both salinities and varieties.

Table (3.7): The significant differences between the salinities and varieties for straw weight.

Salinities	**S3**	**Fw**	**S1**	**S2**	**Tww**
	40.9a	66.4b	73.9b	81.3bc	161.4d
Varieties	V2	V3	V5	V4	V1
	70.8a	71.8a	74.3a	101b	105.9b

Where the same letter means non significant, the different letters means significant.

By calculating the least significant difference of means of this experiment for straw, table 3.7 illustrates it .

Table (3.8): The L.S.D for salinities, varieties, interaction for straw weight (grams)

Table	salinity	variety	rep*salinity	salinity*variety
Replication	15	15	5	3
d.f.	40	40	40	40
l.s.d.	7.65	7.65	13.25	17.10

3-5 Interaction for straw weight:

It was found that all barley varieties used in the experiment when irrigated by the treated wastewater produced the highest straw production causing significant differences with all other concentrations. Additionally, most of the barley varieties have significant difference when irrigated with S3 concentration causing reduction in straw yield and table (3.6) illustrates this result.

Table (3.9): The interaction between salinities and barley varieties for straw yield (grams)

salinity	variety	V1	V2	V3	V4	V 5
S 1		66.7	70.7	76.7	94.0	61.3
S 2		86.7	58.7	60.7	112.3	88.0
S 3		34.3	39.7	46.3	46.3	38.0
Fw\		58.7	57.3	67.7	91.7	56.7
Tww		283.3	127.7	107.7	160.7	127.7

3-6 Means separation of plant height:

3-6-1 Means separation of plant height according to salinities:

It was found that barley which is irrigated with treated wastewater was taller than all the others causing significant differences if compared with other concentrations, while S3 concentration caused significant differences if compared with other concentrations causing reduction in plants height. While the concentrations (S1, S2, and Fw) were not significant among them.

3-6-2 Means separation of plant height according to varieties:

It was observed that differences among all varieties were not significant, and the following table explains the significance for salinities and varieties

Table (3.10): The significant differences between the salinities and varieties for plant height.

Salinities	**S3**	**S2**	**S1**	**Fw**	**Tww**
	34.93a	45b	45.73b	46.27b	56.47c
Varieties	V2	V3	V5	V4	V1
	44.73a	44.87a	45.47a	45.87a	47.47a

Where the same letter means non significance while different letters means significant.

Table (3.11): Table of means for concentrations, varieties for plant height (centimeters)

Salinity	Fw	S1	Tww	S2	S3
	46.27	45.73	56.47	45	34.93
Variety	V1	V2	V3	V4	V5
	47.47	44.73	44.87	45.87	45.47

3-7 The least significant difference

The least significant difference was calculated for salinities, varieties and interaction as shown in the following table 3.12

Table(3.12): Least significant differences of means for plant height (salinities, varieties, interaction)

Table	salinity	var	rep	salinity
			var	var
Rep.	15	15	5	3
l.s.d.	3.350	2.793	4.837	6.272
d.f.	8	32	32	39.91
Except when comparing means with the same level (s) of				
Salinity				6.245
d.f.				32

3-8 Interaction between salinities and varieties for plant height:

It was observed that all varieties of barley used in the experiment produced taller plants when irrigated with treated wastewater causing significant differences from all other salinities by producing taller plants, otherwise all varieties when irrigated with S3 concentration produced the shortest plants causing significant differences if it compared to all other salinities, while all varieties have no significant differences when irrigated with S1,S2 and Fw concentrations, as shown in the following table.

Table (3.13): The interaction between salinities and varieties for plant height (centimeters)

Salinity / Variety	V1	V2	V3	V4	V5
S1	46	47.67	44	45.67	45.53
S2	46.67	44.33	43.33	45.67	45
S3	37	34	34.33	35	34.33
Fw	46.33	43.33	47	48.33	46.33
Tww	61.33	54.33	55.67	54.67	56.33

From table 3.13 it's clear that the plants of all varieties were the highest when they were irrigated with treated waste water with significant increase, on the other hand all the plant of all varieties were the shortest when irrigated with S3 concentration with significant reduction .

3-9 Variety one analysis:

The relationships related to salinity concentration and grains were negatively correlated.

3-9-1 Grains analysis: The relationships between grains weight and salinity concentration were negative and quadratic or linear relation was obtained for variety one (Fig :3.1) grains production was significantly reduced as salinity increased with P value equal to 0.000 as shown in table (3.14).

Table (3.14): Polynomial regression analysis: grain versus concentration for variety one

Source	DF	SS	MS	F	P
Regression	2	7265.58	3632.79	28.73	0.000
Error	12	1517.36	126.45		
Total	14	8782.93			

Table (3.14) shows the results of a Two-way ANOVA between subjects which were conducted to compare the effects of salinity concentrations on grains. The analysis showed that there was a significant effect of salinity concentration on grains at a significance level (p) of.$\leq$0.05 level for the different salinity conditions [F(2,14) =28.73,p = 0.000].

However, the salinity concentration suggests that high levels of salinity really do have an effect on grains. These results suggest that when there is a high salinity concentration it negatively affects the grain.

Table (3.15): Sequential analysis of variance for variety one

Source	DF	SS	F	P
Linear	1	5350.87	20.27	0.001
Quadratic	1	1914.70	15.14	0.002

These results suggest that high levels of salinity really do have an effect on grains weight. These results suggest that when there is a high salinity concentration it negatively affects grain.

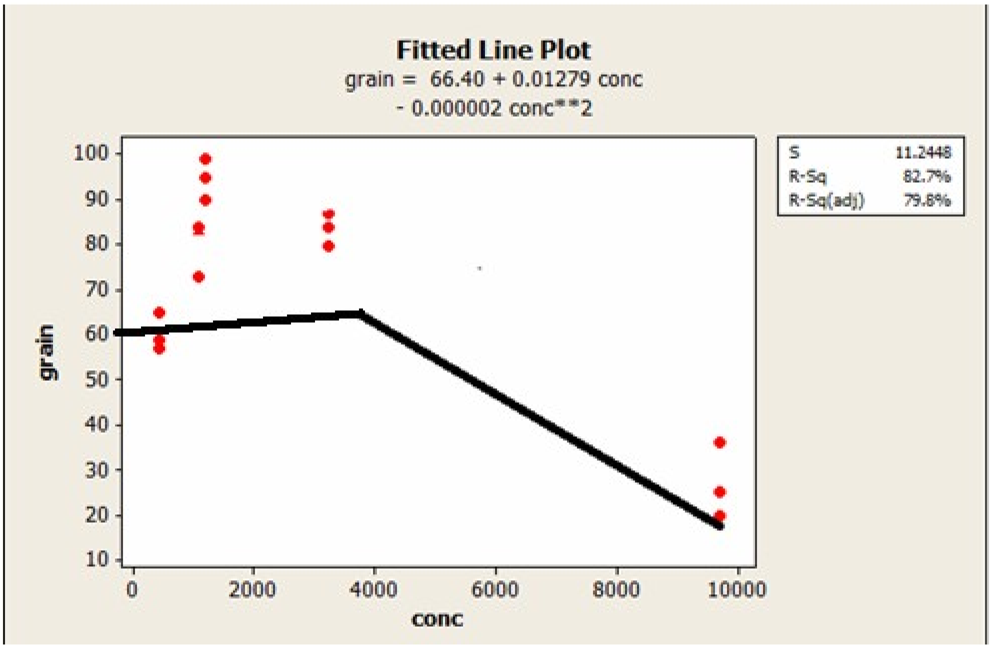

Figure (3.1): The effect of increasing salinity of water in grain yield of variety one.

3-9-2 Straw Analysis:

The straw yield was more sensitive than grains, this result suggests that estimates of straw yield show the effect of salinity due to the fact that grains yield may not decrease until a given salinity is reduced (Mass and Huffman 1977). The analysis of variance using polynomial regression showed significant influence of salinity in straw weight with P value 0.007 table (3.16) with negative effect Fig (3.2).

Table (3.16): Polynomial Regression Analysis: straw wt versus concentration for variety one

Source	DF	SS	MS	F	P
Regression	2	11827.1	5913.53	7.66	0.007
Error	12	9264.9	772.08		
Total	14	21092.0			

Polynomial Regression analysis was conducted (Table 3.16) to represent the effect of salinity concentration on straw weight. There was a significant effect of salinity concentration on straw weight at $p \leq 0.05$ level for the different salinity conditions [$F(2, 14) = 7.66$, $p = 0.007$]. These results suggest that high levels of salinity concentration really have an effect on straw weight. Specifically, the results suggest that when there is a high salinity concentration it affects negatively the straw weight. Sequential analysis showed that data fitted into linear equation Fig (3.2). This suggests that as salinity increase straw weight will decrease

Table (3.17): Sequential analysis of variance for variety one

Source	DF	SS	F	P
Linear	1	9676.26	11.02	0.006
Quadratic	1	2150.81	2.79	0.121

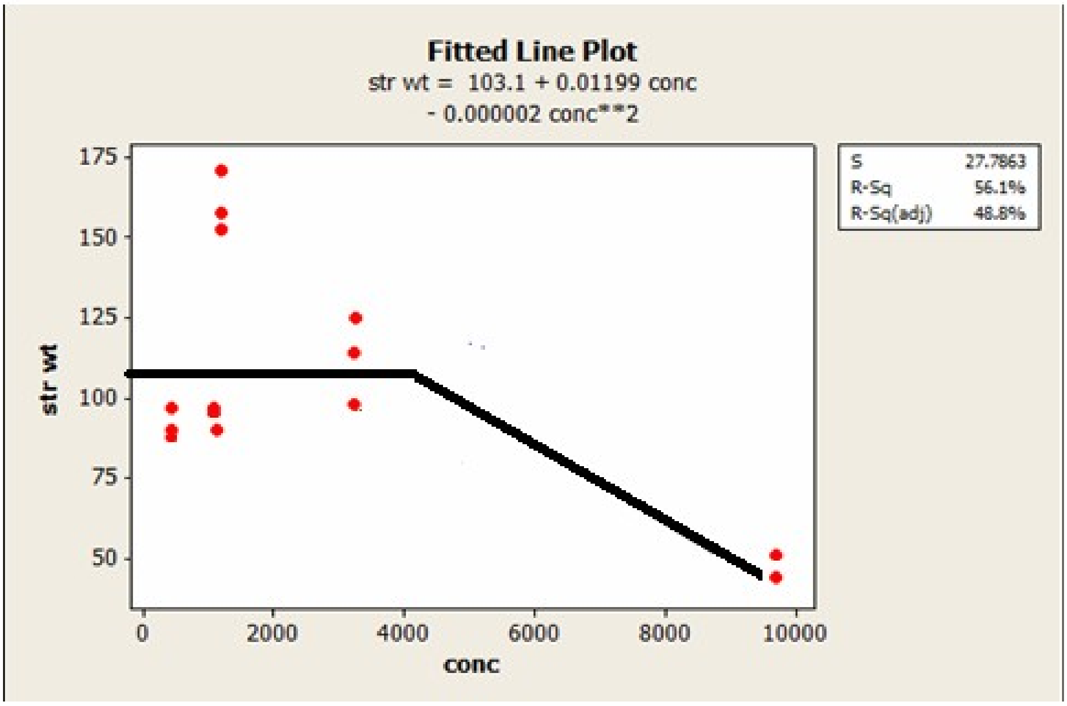

Figure (3.2): The effect of increasing salinity of water in straw yield of variety one

3-9-3 Plant height analysis: For plant height the analysis of variance for variety one also shows significant reduction in plant height with P=0.02 as table 3.14 shows.

Table (3.18): Polynomial Regression Analysis: height versus concentration for variety one

Source	DF	SS	MS	F	P
Regression	2	464.400	232.200	10.83	0.002
Error	12	257.333	21.444		
Total	14	721.733			

Polynomial regression analysis was conducted (Table:3.18) to study the effect of salinity concentration on plant height. There was a significant effect of salinity concentration on plant height at the $p \leq 0.05$ level for the different salinity conditions. [F(2, 14) =10.38, p = 0.002] reduction in plant height under the studied treatment was significant.

Table (3.19): Sequential analysis of variance for variety one

Source	DF	SS	F		P
Linear	1	460.511	0.18	22.92	0.000
Quadratic	1	3.890	0.678		

Sequential analysis of variance was conducted (Table::3.19) to evaluate the significance of the polynomial regression in representing the effect of salinity concentration on plant height. There was a significant effect of salinity concentration on plant height at the p≤0.05 level for the different salinity conditions. [F(1, 1) = 22.92, p = 0.000]. Taken together, these results suggest that high levels of salinity concentration really have an effect on plant height. Specifically, our results suggest that when there is a high salinity concentration it negatively affects the plant height.

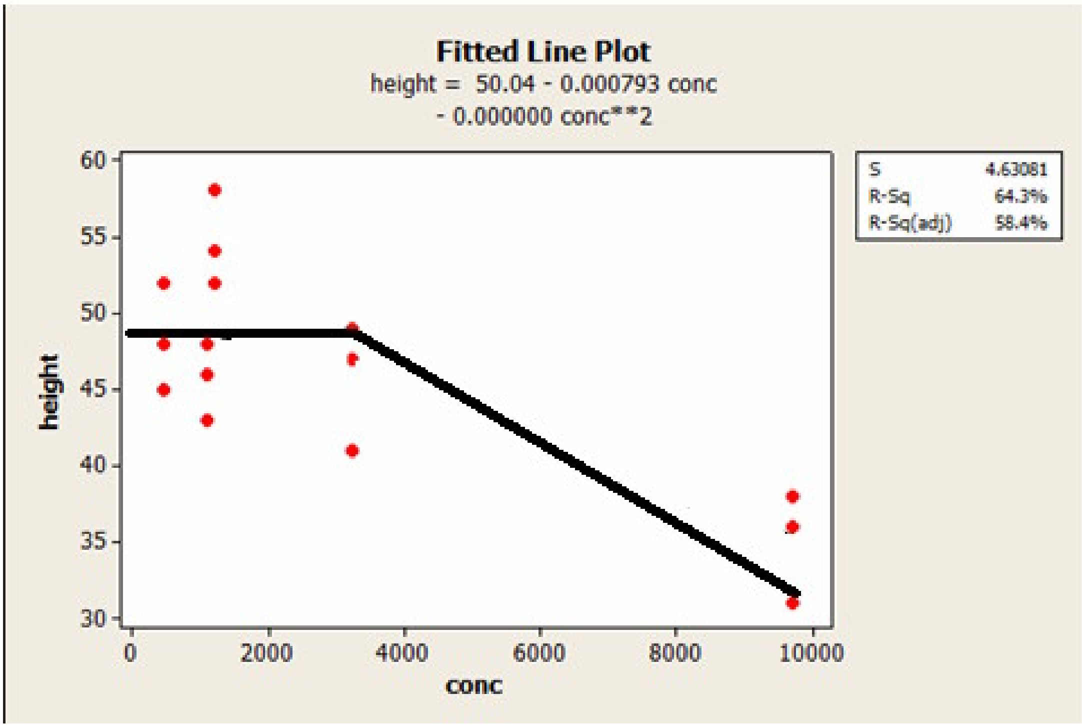

Figure 3.3 The effect of increasing salinity of water on the height of plants for variety one

Table (3.20): Varieties (2,3,4, and5) and their statistical analysis and response for water treatments

Variety	df	ss	ms	F	P
Variety 2 grains	2	1648.47	824.233	5.20	0.024
Variety 2 straw	2	4032.6	2016.30	2.47	0.127
Variety 2 height	2	448.189	224.095	7.89	0.006
Variety 3 grains	2	1480.36	740.180	3.96	0.048
Variety 3 straw	2	2894.07	1447.04	4.48	0.035
Variety 3 height	2	456.171	228.085	6.28	0.014
Variety 4 grains	2	7265.58	3632.79	28.73	0.000
Variety 4 straw	2	11827.1	5913.53	7.66	0.007
Variety 4 height	2	464.400	232.200	10.83	0.002
Variety 5grains	2	2518.18	1259.09	12.88	0.001
Variety 5 straw	2	6153.2	3076.62	3.93	0.049
Variety 5 height	2	485.041	242.521	7.05	0.009

3.10 Varieties; two, three, four and five:

3.10.1 Grains production:

For these varieties it could be observed that these varieties nearly have the same trend in grain production with variety five, because no significant difference between them was seen except variety four. Variety four has the highest grain production with significant difference compared with varieties two, three, five while not significant difference was seen with variety one. This means variety four and variety one have similar trend and varieties two, three, five have also similar trend. While all five varieties response to the treatments in the same behavior with the increasing salinity concentration till specific point nearly do not affect the production of grains while increasing the salinity concentration more than that threshold will cause high reduction in the production (Mass and

Hoffman 1977). Figures (3.4), (3.7), (3.10), and (3.13) will explain the trend of these varieties by increasing the salinity concentration

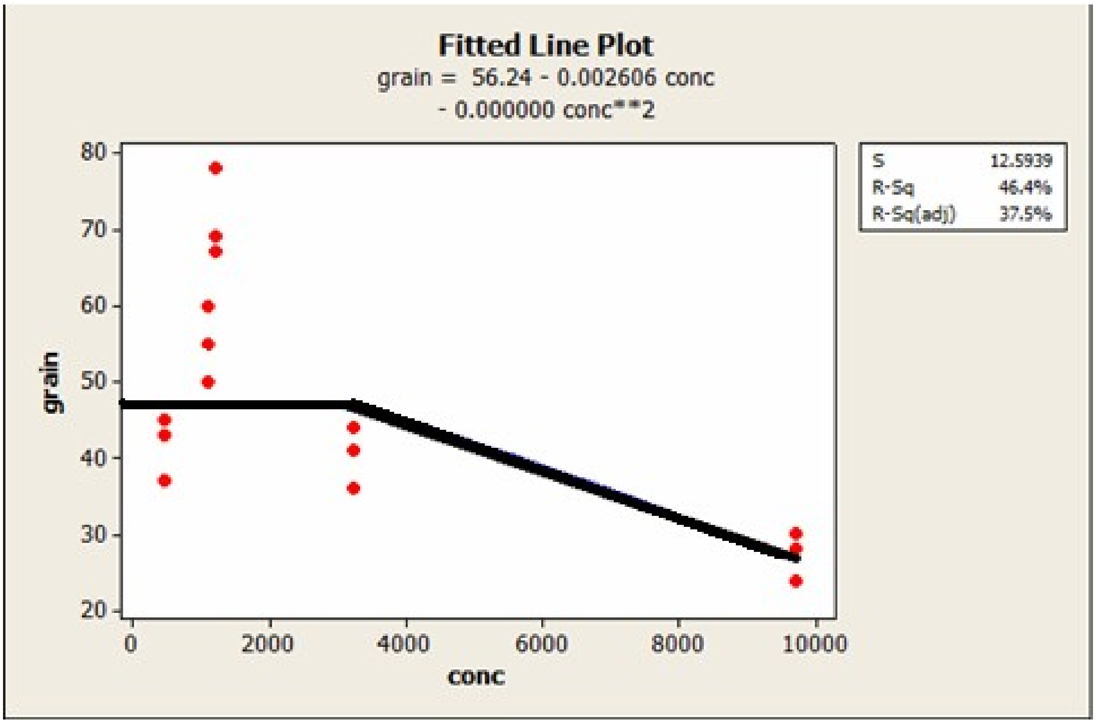

Figure (3.4): The effect of increasing salinity of water on grain yield of variety two

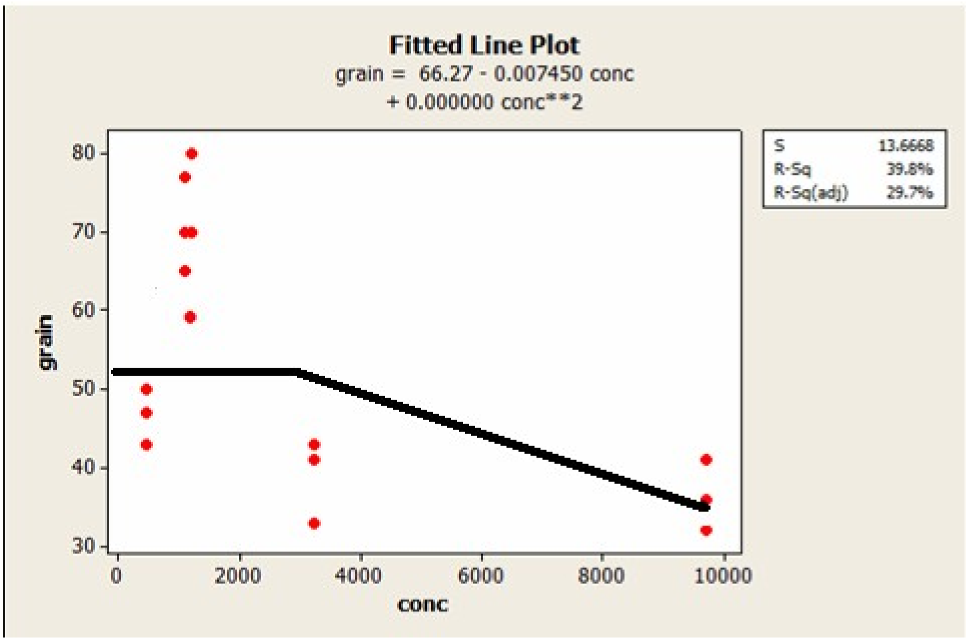

Figure (3.5): The effect of increasing salinity of water on grain yield of variety three

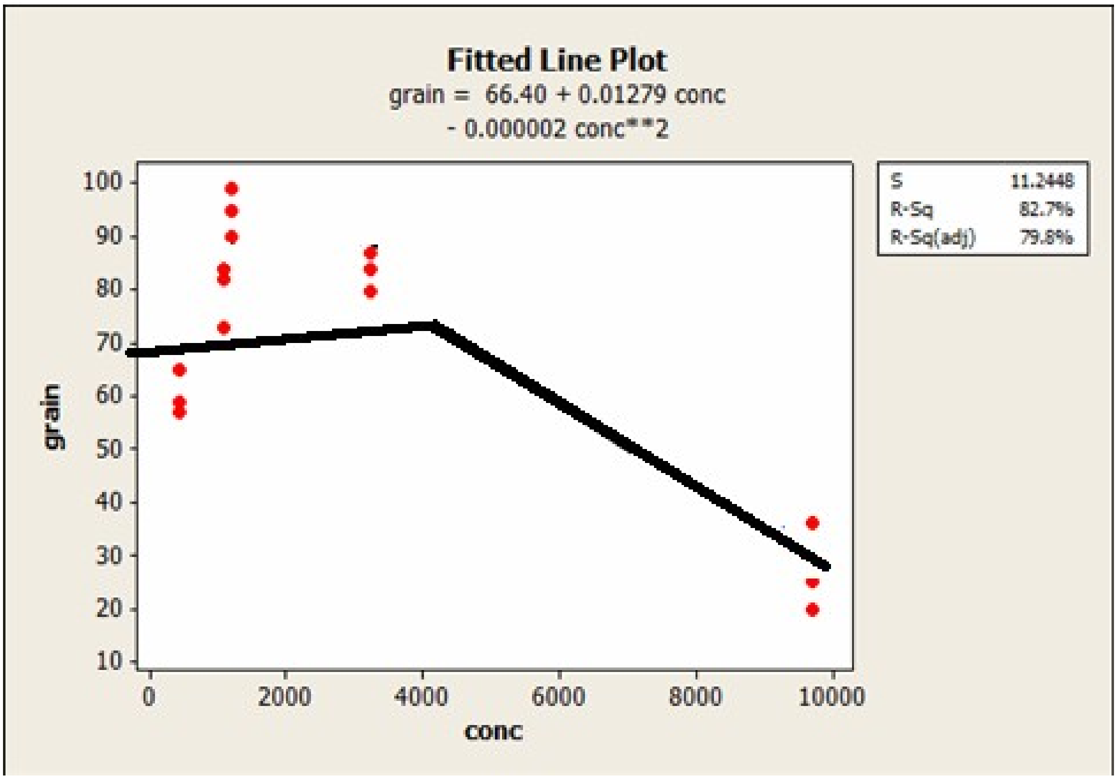

Figure (3.6): The effect of increasing salinity of water on grains yield of variety four

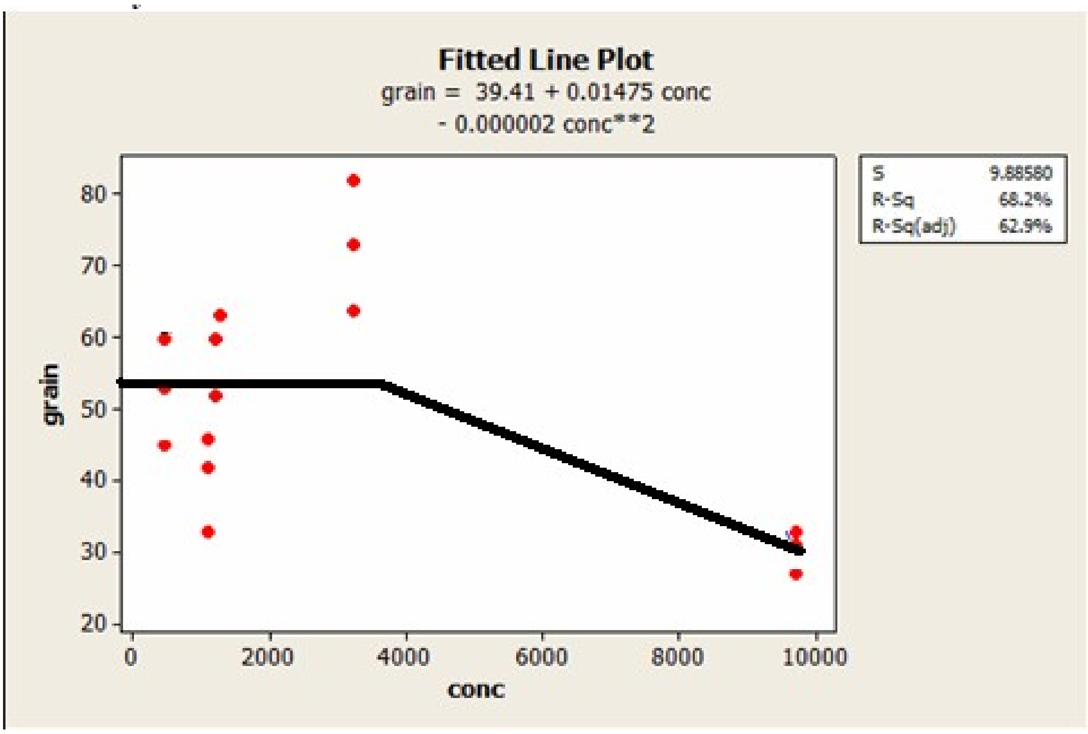

Figure (3.7): The effect of increasing salinity of water on grain yield of variety five

3.10.2 Straw production:

Straw production also has been affected by increasing the salinity concentration for these varieties. Varieties two three, and five didn't show significant differences. varieties one and four didn't also have significant difference. So here it seems that the varieties are two groups of varieties except variety two, the treatments was not significant in regard to straw production as in table(3.12) while all other varieties are negatively affected by the treatments in relation to the same model of Mass and Hoffman model (Mass and Hoffman , 1977) and the figures (3.8), and(3.14) explain the trend of each variety .

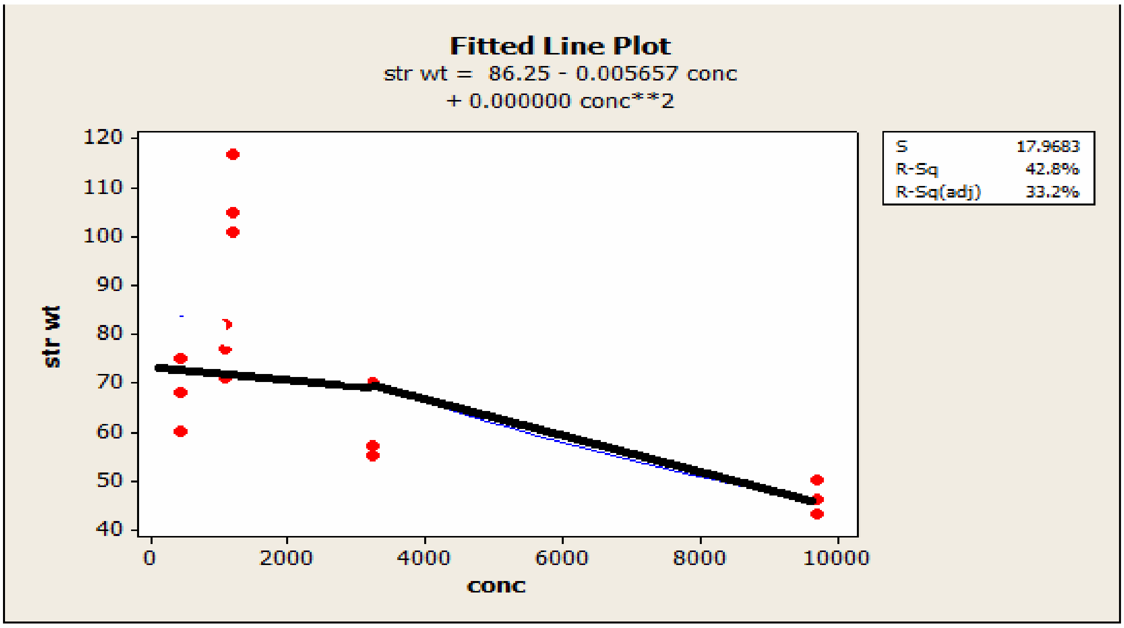

Figure (3.8): The effect of increasing salinity of water on straw yield of variety three

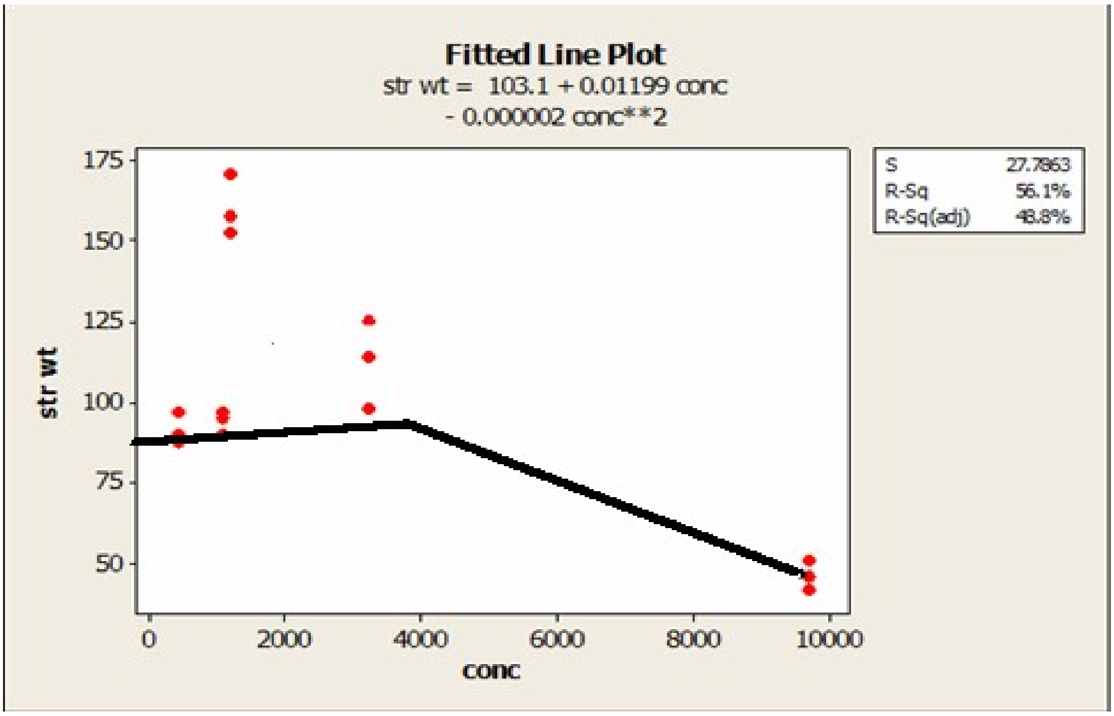

Figure (3.9): The effect of increasing salinity of water on straw yield of variety four

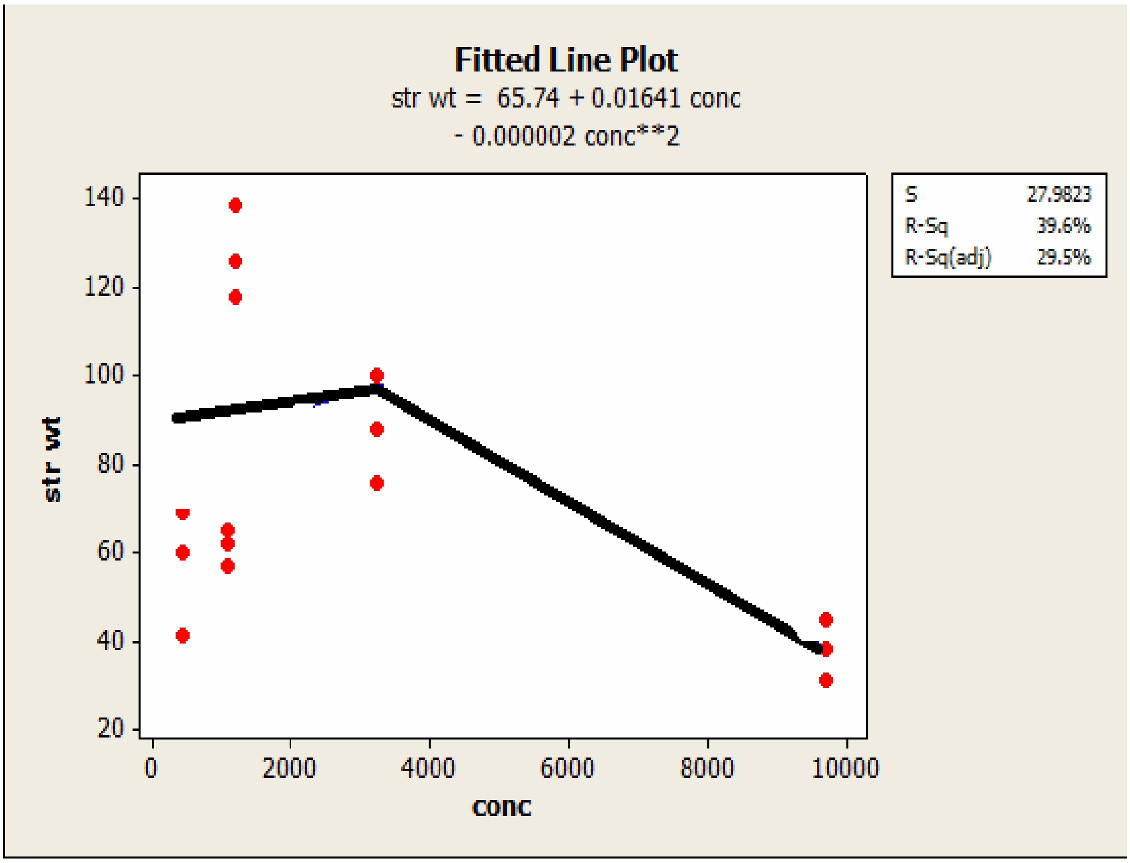

Figure (3.10): The effect of increasing salinity of water on straw yield of variety five

3-10-3 Plant height:

All the varieties used in this experiment have the same response to the treatments of this study which caused significant differences in the plant height, and the relation in a negative pattern. This means increasing salinity concentration till the threshold hasn’t a clear effect on plant height while increasing the salinity concentration more than the threshold will cause clear negative effect on plant height (Mass and Hoffman 1977).

The varieties’ response in the same trend showed no significant differences found as figures(3.6), (3.9,)(3.12), and (3.15) illustrate the effect of the treatments on the varieties six, seven, eight and nine and the plant height.

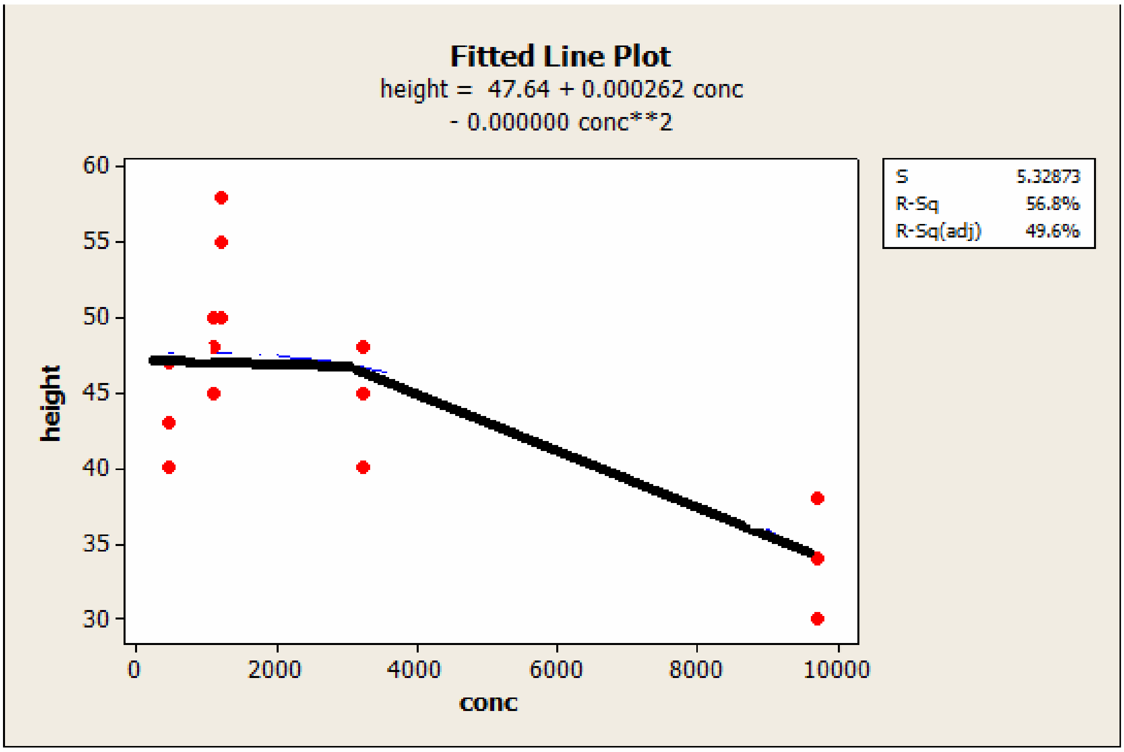

Figure (3.11): The effect of increasing salinity of water on height of plants of variety two

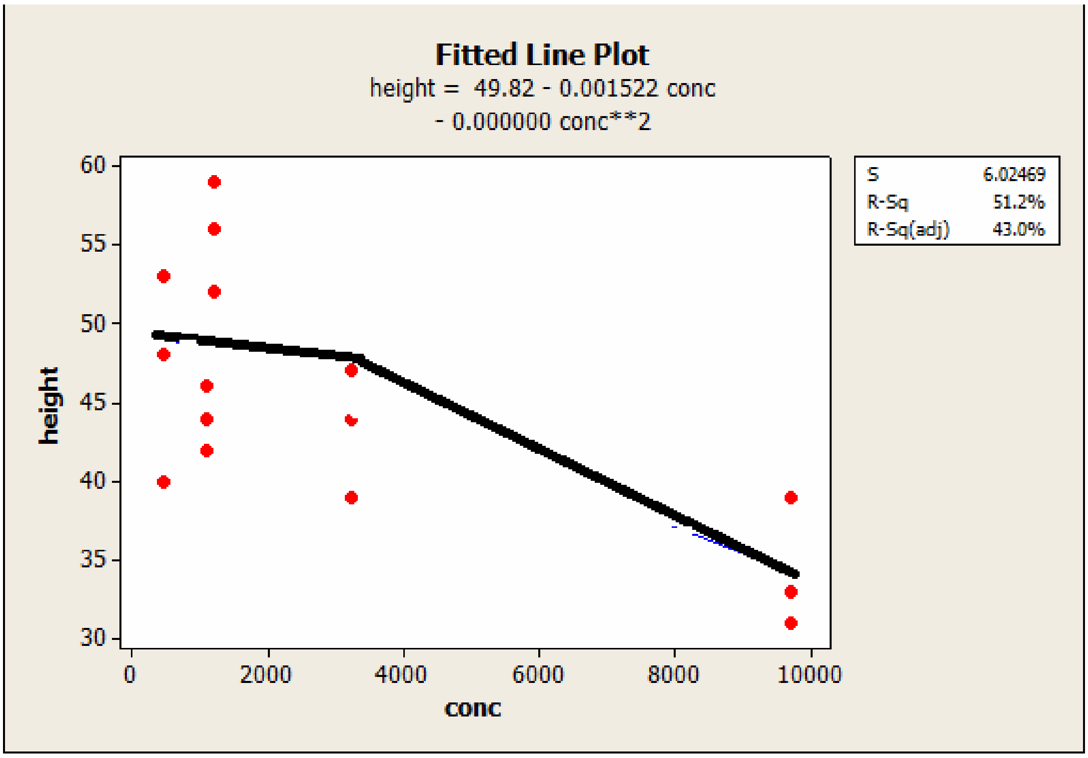

Figure (3.12) The effect of increasing salinity of water on height of plants of variety three

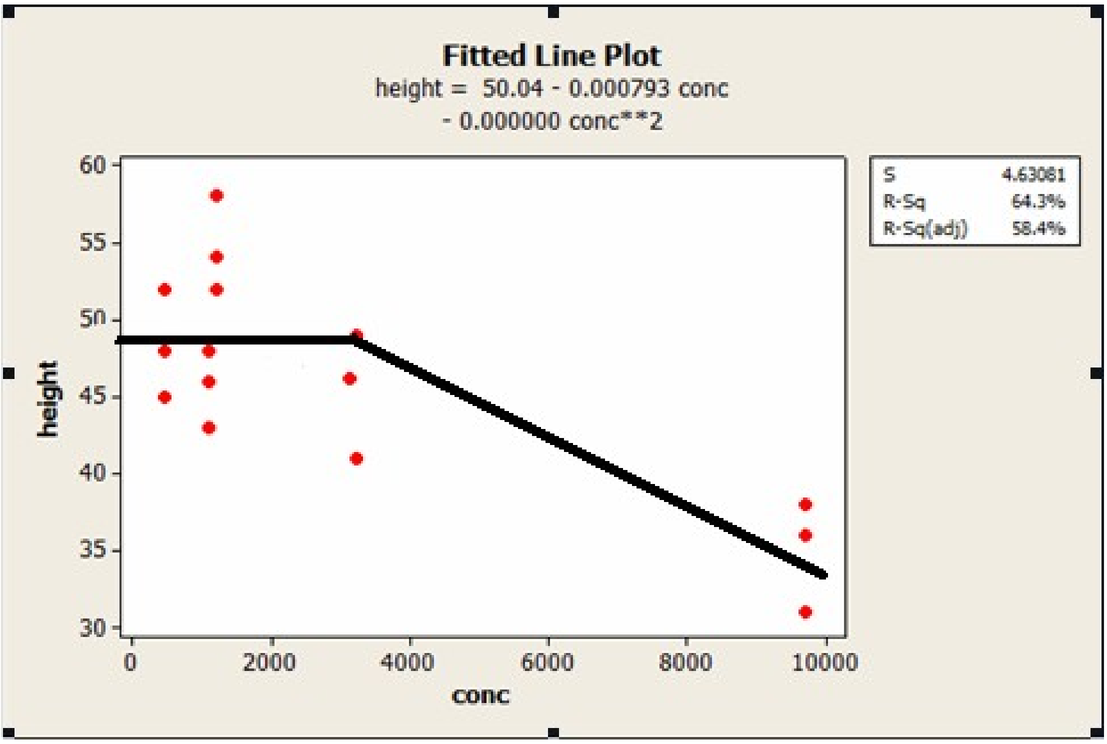

Figure (3.13): The effect of increasing salinity of water on height of plants of variety four

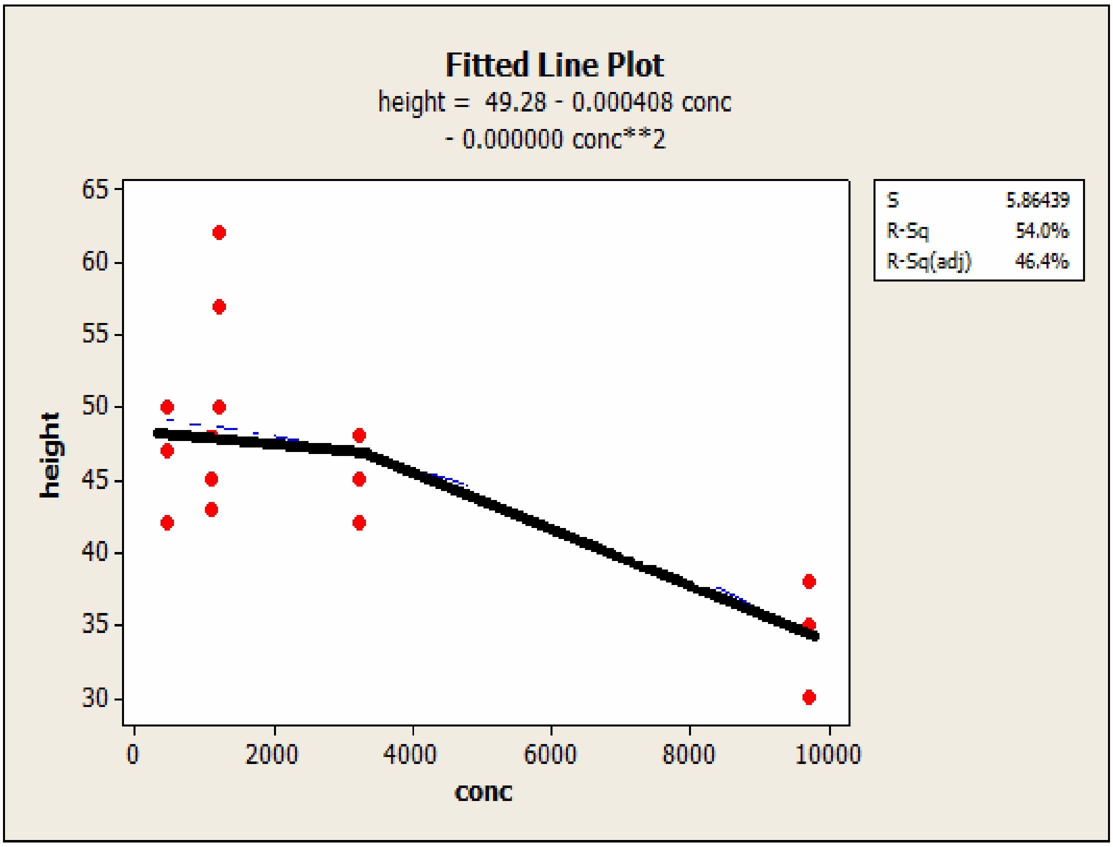

Figure (3.14): The effect of increasing salinity of water on height of plants of variety five

3-11 Comparative analysis between varieties:

This study concerned with three estimators ,which are grains production ,straw production, and height of plants for the varieties used in it ,and this could be explained in the following

3-11-1 Grains production for the varieties:

From the statistical analysis for grains production for each variety ,it could be observed that the varieties (1 and 4) produced the heigest grains production of grains, without significant difference between them .While the varieties (2, 3 and 5) produced less production of grains with significantly effect if compared to varieties (1 and4).

Its clear when the varieties were irrigated with the concentration treated waste water ,the production of grains was the highest with significant increase, while when the concentration S3was used the grains production was the lowest with significant reduction, and by taking the genotype environment interaction for grains production. It could be observed that variety one when it was irrigated by treated waste water produced the highest grains yield with significant increase with the other treatments, while when it was irrigated with S3 treatment no significant difference was observed with the S1and Fw treatments.

For variety two when irrigated with treated waste water treatment no significant difference with S1treatment, while significant with S2 and Fw. When S3 was used for irrigation no significant difference with S2 and Fw, which means having the same response to the treatment

For variety three when treated waste water was used, no significant difference with S1and Fw, which means having the same response ,while significant difference to S2 which means having different response. When S3 treatment was used no significant differences with S2and Fw which means having the same response, while significant reduction if compared to S1, which means having different response .

For variety four when Tww was used no significant differences with S1and S2, which means the same response, while significant difference with fresh water which means having different response. When S3 treatment was used for irrigation significant reduction was observed less than other treatments, which means having different response

For variety five when Tww was used for irrigation no significant differences with S2 and Fw, which means having the same response, while significant with S1concentration, which means different response, while when S3 was used, no significant difference with the treatments S1 and Fw, which means having the same response, while significant difference with S2and Tww, which means having different response.

3-11-2 Straw production for varieties:

Its clear from the statistical analysis that the varieties (1 and4) produced the same amount of straw yield, which significantly more than the production of the varieties (2,3 and 5) respectively, so it could be observed that varieties (1and 4) have the same response to treatments ,also varieties (2,3 and 5) have the same response to the treatments.

It could be observed when the Tww was used for irrigation ,the heigest production was produced with significant increase in straw yield, while when S3 treatment was used significant reduction was obtained of straw yield.

According to genotype environment interaction ,it could be observed that all the varieties produced the heigest straw production when irrigated with treatment Tww with significant increase. On the other hand varieties (1,2,4 and 5) produced the lowest straw production when they were irrigated with S3 treatment with significant reduction, if compared to other treatments. Variety (3) when it was irrigated with S3 treatment produced straw without significant difference with the treatment S2, while it was significantly reduction in straw if compared to S1and Fw which means having different response than the others.

3-11-3 Plant height varieties:

From the statistical analysis ,it could be observed that no significant differences between the height of plants of the five varieties in this work .On the other hand it could be observed that when the varieties were irrigated with the treatment Tww, the plants were the heigest with significant increase ,while the irrigation by the treatment S3 produced the shortest plants with significant reduction in plant height

According to genotype environment inter action it could be observed that varieties (1, 2, 3 and 5)produced significantly the tallest plants when irrigated by the treatment Tww, while variety(4) didn't show significant difference between the treatment Tww and the treatment Fw while significant difference with other treatments Otherwise it could be observed that all five varieties in this study produced shortest plants when irrigated with S3 treatment with significant reduction of plant height .

It could be observed that the varieties (1and 4) produced the heigest production of grains and straw in this study

It could be observed that the irrigation of plant by the treatment of Tww produced the most grains, straw production and the tallest plants. Otherwise the treatment S3 produced the lowest grains yield, lowest straw production and the shortest plants

From this study it could be emphasized that the selection of the correct variety of these varieties to be planted depends on the environmental conditions in the planting area, (available water and soil and there salinity) and depends on the aim of the crop which is for seeds, grains or straw.

Chapter Four

Discussion and Recommendations

Chapter Four

Discussion and Recommendations

4.1. Discussion of Study Results:

Barley is a salt-tolerant crop species with considerable economic importance, increasing salt stress significantly decreased production rate in barley.

Barley is well adapted to a wide range of soil types except those prone to water logging, with a low soil pH or high boron levels. The major factor in selecting a soil type suitable for growing malting barley is nitrogen supply and water supply during grain filling. Variety options are available that are better adapted to soils with a low soil pH or high boron levels, although cropping varieties for these conditions may not always be the best economic option due to maturity length or status of the variety.

Malting barley is best suited to lighter, sandy surfaced soils with a low risk of water logging. Soils with an ability to hold moisture and water during the grain filling period are ideal for malting barley to allow for the production of plump grains. Do not sow malting barley varieties on highly fertile soils following a long history of legumes or heavy soils in low rainfall areas as this may result in a grain protein that is above the required level.

No barley variety is tolerant to very high levels of soil salinity, however, barley in general is more tolerant salinity than wheat and so it is often the cereal crop preferred for sodic soils. The varieties Beecher and Skiff have been grown on sodic soils in southern areas.

In general this study indicates that all treatments were decreased in response to salinity in all 5 barley varieties. These results are close conformity with the earlier findings of Ashraf et al. [10]. Kingsburg and Epstein [9] and Ahmad et al. [13]. In which they reported that increasing salinity level decreased all seedling growth in barley. Also, we show that varieties one and four at all salinity levels had the highest production while varieties two ,three ,and five seem to be the lowest production under the same condition of salt stress.

Cropping on saline land is restricted by the low tolerance of crops to salinity and water logging. Prospects for improving salt tolerance in wheat and barley include the use of: (i) intra-specific variation, (ii) variation for salt tolerance in the progenitors of these cereals, (iii) wide-hybridization with halophytic 'wild' relatives (an option for wheat, but not barley), and (iv) transgenic techniques. In this review, key traits contributing to salt tolerance, and sources of variation for these within the Triticeae, are identified and recommendations for use of these traits in screening for salt tolerance are summarized. The potential of the approaches to deliver substantial improvements in salt tolerance is discussed, and the importance of adverse interactions between varieties and salinity are emphasized. The potential to develop new crops from the diverse halophytic flora is also considered.

The results also revealed that, the highest grains weight and biomass was obtained from variety four. Biomass and grains yield were also decreased upon salinity, significantly. Overall, it appeared that less adverse effect of salinity on varieties four and one, may indicate that these varieties might be suitable for saline soils, an object which is worth more investigations.

Brackish water, marginal water, treated waste water are promising water resources as alternative source for fresh water to be used in agriculture specially crops with good potential of tolerating saline water. Barely is one of these crops which is tolerant to salinity (plant nutrient management in Hawaii`s soils, chapter 17 soil and water salinity, 2000)

The experiment deals with five barely verities which are cultivated under five different water concentrations, which are fresh water as control with TDS[1] concentration (442 ppm)[2], salinity concentration S1 (1080 ppm), salinity concentration S2 (3240 ppm), salinity concentration S3 (9720 ppm) and treated waste water with concentration (1200 ppm), results show that in all cases there is a significant difference between the concentration S3 and other concentrations, causing a reduction in the yield of barely in grains yield, straw yield and in height of plants. While there is also significant difference in using Tww[3] between the yield at this concentration and all of the other concentrations, causing more production in the grains

[1] Total Dissolved Solids
[2] Parts per million
[3] Treated wastewater

yield, straw[1] yield and height of plants by comparing it to all other concentrations and all varieties, on the other hand, concentration S1and S2 and Fw[2] didn't show a significant differences between them in grain yield, while S1 concentration and S2 concentrations didn`t give significant difference straw yield, although no significant differences is present in S2 and Fw, S2 gives more straw yield. According to height, S3 has significant differences between other concentrations causing a reflection in plant height less than others, as a result of high stress which is due to high salinity suppressing plant growth and development, while Tww has significant differences between the other concentrations causing taller plants than all the others as a result of high content of nitrogen, phosphorus and potassium which are very important for plant growth and development and they are available in this concentration more than others.

Although these results agreed with several studies indicating that barley could tolerate saline water until 5ds/m without any shortage in the yield of the crop, there are unrelated results as seen with the different variaties.

According to variety four, it gives the highest yield of grains and there is a significant difference between variety four and varieties two, three,and five, while no significant difference between varieties one, two,

---

[1] Is an agricultural by-product, the dry stalks of cereal plants
[2] Freshwater

three,and five in the other hand we saw that there is no significant differences between four and one.

According to height, there was no significant differences between all verities within treatments.

According to interaction between salinity and variety the environmental conditions could be the main reason for the correct decision to chose the suitable variety that should be used .

It could be observed that using brackish water and Tww in irrigating such crops will be promising and saving traditional water sources for human uses which couldn`t use Tww brackish water for it .

The experiment was designed under CRBD by split plot design with 3 replications with P value ≤ .,05.

4.2. Recommendations:

On the light of the study findings, the researcher recommended the following:

Cropping on saline land is restricted by the low tolerance of crops to salinity. In this respect, key traits contributing to salt tolerance, and sources of variation for these within some barley varieties, are identified and recommendations for use of these traits in screening for salt tolerance are summarized. The potential of the approaches to deliver substantial improvements in salt tolerance is discussed, and the importance of the interactions between variety and salinity are emphasized. The potential to develop new crops from the diverse halophytic flora is also considered. Each variety of the varieties used in this research is suitable for certain conditions to give its best production, and before using any one of them the environmental conditions should be considered.

On the other hand, we can see that Tww is a very important unconventional water source, so it is very essential to build up stations for treating waste water as a good procedure for facing the water crises especially in arid regions, and for its importance in facing environmentally high pollution such as decreasing the amounts of chemical fertilizers that added to the agricultural crops which is irrigated with Tww.

Further studies are recommended about the crops that could be irrigated by the treated waste water by considering the healthy and safety aspects for the use of crop production and workers.

References

Ahmed, B., Inoue, M., and Moritani, S., (2010). **Effect of saline water irrigation and manure application on the available water content, soil salinity, and growth of wheat**. Agricultural Water Management 97 (2010) 165–170.

Al-Khafaf, S., Andan, A., and Al-Asadi, N., (1990**). Dynamics of root and shoot growth of barley under various levels of salinity and water stress**. Agricultural Water Management, Volume 18, Issue 1, May 1990, Pages 63-75.

Al-Sa'ed R., (2005). **Obstacles and chances to cut pollution load discharges from the urban Palestine.**Water International,30(4), 538–544.

Bakir, H.A., (2001). ***Sustainable wastewater management for small communities in the Middle East and North Africa***. **Journal of Environmental Management**, 61,319–328.

Degl'Innocenti, E., Hafsi, C., Guidi, L., and Navari-Izzo, F., (2009). ***The effect of salinity on photosynthetic activity in potassium-deficient barley species*. Journal of Plant Physiology**, In Press, Corrected Proof, Available online 14 July 2009

Deng, X., Shan, L., Zhang, H., and Turner, N., (2006**). Improving agricultural water use efficiency in arid and semiarid areas of China**. Agricultural Water Management, Volume 80, Issues 1-3, 24 February 2006, Pages 23-40

Erickson J.R. (1980)**. Using high salinity waters in the Southwest. Proc**. Speciality Conference on Irrigation and Drainage, Today's Challenges. 23-25 July 1980, Boise, Idaho. ASCE, New York. pp. 198-204.

FAO publications May (2012). **Reuse of treated waste water Guidance manual 385-2188-002** FAO user manual for using treated waste water.

Frenkel H. and Shainberg I. (1975). **Chemical and hydraulic changes in soils irrigated with brackish water under cotton production. Proc. Internal. Symposium on Irrigation with Brackish Water**, Beer Sheva, Israel. Negev Press, pp. 175-183.

Gardner-Outlaw, Tom and Robert Engelman (1997). **"Sustaining Water, Easing MALR n.d., Economic Affairs Sector, General Dept**. of Agriculture Economics, National Agriculture Income, different issues.

Grewal, H., (2010). **Water uptake, water use efficiency, plant growth and ionic balance of wheat, barley, canola and chickpea plants on a sodic vertosol with variable subsoil NaCl salinity**. Agricultural Water Management Journal 97 (2010) 148–156

Herpin, U., Gloaguen, T., Fonseca, A., Montes, C., Mendonça, F., Piveli, R., Breulmann, G., Forti, M., and Melfi, A., (2007). **Chemical effects on the soil–plant system in a secondary treated wastewater irrigated coffee plantation—A pilot field study in Brazil**. Agricultural Water Management, Volume 89, Issues 1-2, 16 April 2007, Pages 105-115.

Katerji, N., van Hoorn, J., Fares. C., Hamdy, A., Mastrorilli, M., and Oweis, T., (2005). **Salinity effect on grain quality of two durum wheat varieties differing in salt tolerance**. Agricultural Water Management, Volume 75, Issue 2, 15 July 2005, Pages 85-91

Katerji, N., van Hoorn, J., Hamdy, A., Mastrorilli, M., Fares, C., Ceccarelli, S., Grando, S., and Oweis, T., (2006). **Classification and salt tolerance analysis of barley varieties.** Agricultural Water Management, Volume 85, Issues 1-2, 16 September 2006, Pages 184-192

Keren R. and Shainberg I. (1978)**. Irrigation with sodic and brackish water and its effect on the soil and on cotton fields**. Hassade 58: 963-976.

Lidgren, A., Rodhe, H. and Huisingh, D., (2006). **A systemic approach to incorporate sustainability into univer-sity courses and curricula.**Journal of Cleaner Production,14,797–809.

Marcum, K., (2006). **Use of saline and non-potable water in the turfgrass industry: Constraints and developments. Agricultural Water Management,** Volume 80, Issues 1-3, 24 February 2006, Pages 132-146

Marshall, G., and Randall E. (1997). **Significance of supply response for estimating agricultural costs of soil salinity**. Agricultural Systems, Volume 53, Issues 2-3, February-March 1997, Pages 231-252

Mehari, A., Schultz, B., and Depeweg, H., (2006). **Salinity impact assessment on crop yield for Wadi Laba spate irrigation system in Eritrea.** Agricultural Water Management, Volume 85, Issues 1-2, 16 September 2006, Pages 27-37

Metrological Nablus Station data "2010"

O'Leary J.W. 1984. **High productivity from halophytic crops using highly saline irrigation water. In: Water Today and Tomorrow**. J.R. Replogle and K.G. Renard (eds.). Proc. Speciality Conf. Irrigation and Drainage Division of ASCE, Flagstaff, Arizona, 24-26 July 1984. ASCE, New York. pp. 213-217.

Rhoades J.D. 1977. **Potential for using saline agricultural drainage waters for irrigation. Proc.** Water Management for Irrigation and Drainage, ASCE, Reno, Nevada, July. 177: 85-116.

Rhoades J.D. 1990a. Blending saline and non-saline waters reduces water usable for crop production. In: Proc. 1990 Conf. Irrigation and Drainage. S.C. Harris (ed.). 11-13 July 1990, Durango, Colorado, pp. 442-452.

Sadeh, A., and Ravina, I., (2000). **Relationships between yield and irrigation with low-quality water - a system approach. Agricultural Systems,** Volume 64, Issue 2, May 2000, Pages 99-113

Snow, J. 1936. **Snow on Cholera, Being a reprint of two papers by John Snow M. D**. Hafner Publishing Co. London.

Supit, I, and Wagner, W., (1999). **Analysis of yield, sowing and flowering dates of barley of field survey results in Spain**. Agricultural Systems, Volume 59, Issue 2, February 1999, Pages 107-122.

UNDP, 1998, **Sustainable Management of Water Resources and the Aquatic Environment: UNDP's Role todate and strategy framework.** Available online at:

UNEP, 2003**, Desk Study on the Environment in the Occupied PalestinianTerritories** Availableonline at:[http://www.unep.org/download_file.multilingual.asp?FileID=105] accessed 24 January 2010.

van Hoorn J.W. 1971. **Quality of irrigation water, limits of use and prediction of long-term effects**. In: Salinity Seminar, Baghdad. Irrigation and Drainage Paper 7. FAO, Rome. pp. 117-135.

van Schilfgaarde J. and Rhoades J.D. 1984. **Coping with salinity**. In: Water Scarcity, Impacts in Western Agriculture. E.A. Englebert (ed.). University of California Press 6: 157-179.

World Bank, 1993, **Developing the Occupied Territories: an investment in peace. World Bank,** WA, USA.IBRD Staff Report.

Yassin, M., Tubail, K., and Al Dadah, J., (2008). **Twoards strategies for pollution control on the use of wastewater effluent in sustainable agriculture in the Gaza Strip.** World Review of Science, Technology and Sustainable Development, Vol. 5, No. 1, 2008, pp 66-78

Zekri, S. and Albisu, M., (1993). **Economic impact of soil salinity in agriculture**. A case study of Bardenas area, Spain. Agricultural Systems, Volume 41, Issue 3, 1993, Pages 369-386.

[http://www.undp.org/seed/water/strategy] accessed 1December 2009.

مراجع باللغة العربية:

مؤسسة المواصفات والمقاييس الفلسطينية م ف 742 - (2003) **نوعية المياه العادمة المعالجة في الري الزراعي ص3 .**

مؤسسة المواصفات والمقاييس الفلسطينية م ف 742 - 2003 **المحاصيل التي يمكـــن ريهـــا بدون حواجز** ص5 .

Appendixes

1- Grain weight (gm.)

Table A.1 : Grain weight in gm.

Treatment	Variety	Grains weight block 1	Grains weight block 2	Grains weigh block3
S1	V1	35	43	47
S1	V2	60	55	50
S1	V3	70	77	65
S1	V4	84	82	73
S1	V5	33	42	46
S2	V1	56	61	63
S2	V2	36	44	41
S2	V3	33	43	41
S2	V4	80	84	87
S2	V5	82	64	73
S3	V1	32	28	35
S3	V2	30	28	24
S3	V3	32	41	36
S3	V4	36	25	20
S3	V5	33	31	27
FW	V1	48	53	57
FW	V2	43	37	45
FW	V3	43	50	47

FW	V4	65	59	57
FW	V5	45	60	53
TWW	V1	151	143	16
TWW	V2	78	67	69
TWW	V3	80	59	70
TWW	V4	90	95	99
TWW	V5	60	63	52

2-.Straw weight in grams

Table (A-2): Straw weight (gm.)

Treatment	variety	Straw weight block 1	Straw weight block 2	Straw weight block 3
S1	V1	63	77	60
S1	V2	75	67	70
S1	V3	82	71	77
S1	V4	90	97	95
S1	V5	65	62	57
S2	V1	92	82	86
S2	V2	63	58	55
S2	V3	55	70	57
S2	V4	114	125	98
2S	V5	76	88	100

S3	V1	30	38	35
S3	V2	42	37	40
S3	V3	46	50	43
S3	V4	51	42	46
S3	V5	45	38	31
FW	V1	57	66	53
FW	V2	53	62	57
FW	V3	60	68	75
FW	V4	97	90	88
FW	V5	41	69	60
TWW	V1	330	270	250
TWW	V2	129	135	119
TWW	V3	117	105	101
TWW	V4	158	171	153
TWW	V5	139	118	126

3- Finally height of plants (cm)

TableA.3 height of plant in centimeters

Treatment	Variety	Plant height block1	Plant height block2	Plant height block3
S1	V1	55	43	40
S1	V2	45	50	48
S1	V3	46	44	42
S1	V4	43	48	46
S1	V5	48	43	45
S2	V1	50	42	48
S2	V2	40	45	48
S2	V3	39	47	44
S2	V4	47	41	49
S2	V5	42	45	48
S3	V1	39	35	37
S3	V2	34	30	38
S3	V3	39	33	31
S3	V4	31	38	36
S3	V5	38	35	30
Fw	V1	49	44	46
Fw	V2	40	47	43
Fw	V3	48	53	40
Fw	V4	52	48	45
Fw	V5	42	50	47
Tww	V1	61	65	58
Tww	V2	55	50	58
Tww	V3	56	59	52
Tww	V4	54	52	58
Tww	V5	57	62	50

STable A.4 Soil Nitrogen content

Variety / Sample content	FW ppm	TWW ppm	S1 ppm	S2 Ppm	S3 ppm
V1	47, 6	111	56	88	115
V2	63	100	180	280	307
V3	54	196	188	227	255
V4	41, 7	123	63	81	73
V5	52	117	229	266	315

Blank: 101

Table A.5 Phosphorus soil content

Variety / Sample content	FW ppm	TWW ppm	S1 ppm	S2 ppm	S3 ppm
V1	44	37	63	49	15
V2	63	23	180	56	30
V3	54	106	56	47	44
V4	38	59	63	43	12
V5	56	53, 7	68	50	50

Blank: 10

Table A. 6 Potassium soil content

Variety / Sample content	FW ppm	TWW ppm	S1 ppm	S2 ppm	S3 ppm
V1	130	18	9	21, 7	15
V2	14	23	19	17	25
V3	21	22	15	19	22, 7
V4	11	14	10	13, 3	12
V5	14	24	17	17	12

Blank: 10

Table A.7 Calcium soil content

Variety / Sample content	FW ppm	TWW ppm	S1 ppm	S2 ppm	S3 ppm
V1	22	60, 01	12, 15	17, 07	20, 01
V2	19, 44	26, 5	56, 02	32, 01	51
V3	16	24, 01	24, 3	44, 03	47
V4	17	33, 02	60, 02	40, 02	28, 01
V5	24, 3	36	32, 01	40, 02	27

Blank ;8

Table A.8 Magnesium soil content

Variety / Sample content	FW ppm	TWW ppm	S1 ppm	S2 ppm	S3 ppm
V1	48, 6	72, 9	20, 01	88	36, 45
V2	20, 01	89	61	65, 61	77, 4
V3	29, 16	94, 77	40, 02	73	89, 2
V4	44, 8	63, 7	72, 9	97, 2	31, 59
V5	40, 02	87, 1	45	72, 9	62

Blank: 34, 02

Table A.9 Chlorides soil content

Variety / Sample content	FW ppm	TWW ppm	S1 ppm	S2 ppm	S3 ppm
V1	70	463, 5	142	689, 3	744
V2	71	215	223	634	780
V3	36	213	195	631, 7	763, 2
V4	49, 7	407, 3	135	673, 5	695
V5	52	236	124	617	701

Blank; 106

Table A.10 Sodium soil content

Variety / Sample content	FW ppm	TWW ppm	S1 ppm	S2 ppm	S3
V1	47, 4	150	70	183, 9	272
V2	40	220	85	220	297
V3	32	71	89	207, 5	301, 2
V4	43, 5	185, 6	71	177	280
V5	30	113, 8	70	210	280

Blank: 39

Table A.11 EC Extract of soils (ds\m

Variety / Sample content	V1	V2	V3	V4	V5
FW	0, 708	0, 492	0, 573	0, 505	0, 606
S1	0, 719	0, 992	1, 11	0, 782	1, 052
TWW	1, 09	1, 232	1, 317	1, 06	1, 12
S2	2, 05	2, 48	2, 42	2, 1	2, 373
S3	3, 11	2, 65	2, 84	3, 05	2, 985

Blank: 0, 679

Maher analysis

Grain wt

Analysis of variance

Variate: gwt

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
rep stratum	2	533.9	267.0	1.04	
rep.salinity.var stratum					
salinity	4	18560.7	4640.2	18.10	<.001
var	4	4345.7	1086.4	4.24	0.006
rep.salinity	8	2218.5	277.3	1.08	0.395
salinity.var	16	8961.0	560.1	2.18	0.023
Residual	40	10254.9	256.4		
Total	74	44874.7			

Information summary

Aliased model terms
rep.salinity.var

Message: the following units have large residuals.

rep 1 salinity 5 var 5	35.3	s.e.	11.7
rep 2 salinity 5 var 5	33.7	s.e.	11.7
rep 3 salinity 5 var 5	-69.1	s.e.	11.7

Tables of means

Variate: gwt

Grand mean 55.5

salinity	1	2	3	4	5
	57.5	59.2	30.5	50.8	79.5

var	1	2	3	4	5
	57.9	47.1	52.5	69.1	50.9

rep	salinity	1	2	3	4	5
1		54.5	55.5	30.7	46.9	89.9
2		57.9	57.3	28.7	49.9	83.5
3		60.0	64.8	32.2	55.6	65.0

salinity	var	5	6	7	8	9
1		41.7	55.0	70.7	79.7	40.3
2		60.0	40.3	39.0	83.7	73.0

3	31.7	27.3	36.3	27.0	30.3
4	52.7	41.7	46.7	60.3	52.7
5	103.3	71.3	69.7	94.7	58.3

Standard errors of means

Table	salinity	var	rep salinity	salinity var
rep.	15	15	5	3
d.f.	40	40	40	40
e.s.e.	4.13	4.13	7.16	9.24

Least significant differences of means (5% level)

Table	salinity	var	rep salinity	salinity var
rep.	15	15	5	3
d.f.	40	40	40	40
l.s.d.	11.82	11.82	20.47	26.42

Stratum standard errors and coefficients of variation

Variate: gwt

Stratum	d.f.	s.e.	cv%
rep	2	3.27	5.9
rep.salinity.var	40	16.01	28.9

Straw wt

Analysis of variance

Variate: strawwt

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
rep stratum	2	461.5	230.8	2.15	
rep.salinity.var stratum					
salinity	4	123936.3	30984.1	288.53	<.001
var	4	17754.1	4438.5	41.33	<.001
rep.salinity	8	1469.7	183.7	1.71	0.126
salinity.var	16	53128.1	3320.5	30.92	<.001
Residual	40	4295.5	107.4		
Total	74	201045.1			

Information summary

Aliased model terms
rep.salinity.var

Message: the following units have large residuals.

rep 1 salinity 5 var 5	33.5	s.e. 7.6
rep 2 salinity 5 var 5	-21.7	s.e. 7.6

Tables of means

Variate: strawwt

Grand mean 84.8

salinity	1	2	3	4	5
	73.9	81.3	40.9	66.4	161.4

var	1	2	3	4	5
	105.9	70.8	71.8	101.0	74.3

rep	salinity	1	2	3	4	5
1		73.0	78.0	40.8	59.6	172.6
2		75.3	82.7	42.5	70.1	153.3
3		73.3	83.1	39.5	69.5	158.3

salinity	var	1	2	3	4	5
1		66.7	70.7	76.7	94.0	61.3
2		86.7	58.7	60.7	112.3	88.0
3		34.3	39.7	46.3	46.3	38.0
4		58.7	57.3	67.7	91.7	56.7
5		283.3	127.7	107.7	160.7	127.7

Standard errors of means

Table	salinity	var	rep salinity	salinity var
rep.	15	15	5	3
d.f.	40	40	40	40
e.s.e.	2.68	2.68	4.63	5.98

Least significant differences of means (5% level)

Table	salinity	var	rep salinity	salinity var
rep.	15	15	5	3
d.f.	40	40	40	40
l.s.d.	7.65	7.65	13.25	17.10

Stratum standard errors and coefficients of variation

Variate: strawwt

Stratum	d.f.	s.e.	cv%

rep	2	3.04	3.6
rep.salinity.var	40	10.36	12.2

Plant height

Analysis of variance

Variate: hight

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
rep stratum	2	13.52	6.76	0.43	
rep.salinity stratum					
salinity	4	3489.79	872.45	55.13	<.001
Residual	8	126.61	15.83	1.12	
rep.salinity.var stratum					
var	4	72.45	18.11	1.28	0.297
rep.var	8	220.75	27.59	1.96	0.085
salinity.var	16	122.08	7.63	0.54	0.903
Residual	32	451.12	14.10		
Total	74	4496.32			

Information summary

Aliased model terms
rep.salinity.var

Message: the following units have large residuals.

rep 3 salinity 2	3.00	s.e.	1.30

Tables of means

Variate: hight

Grand mean 45.68

salinity	1	2	3	4	5
	45.73	45.00	34.93	46.27	56.47

var	1	2	3	4	5
	47.47	44.73	44.87	45.87	45.47

rep	var	5	6	7	8	9
1		50.48	42.48	45.28	45.08	45.08
2		45.52	44.12	46.92	45.12	46.72
3		46.40	47.60	42.40	47.40	44.60

salinity	var	1	2	3	4	5
1		46.00	47.67	44.00	45.67	45.33
2		46.67	44.33	43.33	45.67	45.00

3	37.00	34.00	34.33	35.00	34.33
4	46.33	43.33	47.00	48.33	46.33
5	61.33	54.33	55.67	54.67	56.33

Standard errors of means

Table	salinity	var	rep var	salinity var
rep.	15	15	5	3
e.s.e.	1.027	0.969	1.679	2.194
d.f.	8	32	32	39.91
Except when comparing means with the same level(s) of				
salinity				2.168
d.f.				32

Least significant differences of means (5% level)

Table	salinity	var	rep var	salinity var
rep.	15	15	5	3
l.s.d.	3.350	2.793	4.837	6.272
d.f.	8	32	32	39.91
Except when comparing means with the same level(s) of				
salinity				6.245
d.f.				32

Stratum standard errors and coefficients of variation

Variate: hight

Stratum	d.f.	s.e.	cv%
rep	2	0.520	1.1
rep.salinity	8	1.779	3.9
rep.salinity.var	32	3.755	8.2

Table B.1\ Polynomial regression Analysis: grains versus concentration for variety two

Source	DF	SS	MS	F	P
Regression	2	1648.47	824.233	5.20	0.024
Error	12	1903.27	158.606		
Total	14	3551.73			

Table B.2 Sequential analysis of variance for variety two

Source	DF	SS	F	P
Linear	1	1647.28	11.24	0.005
Quadratic	1	1.18	0.01	0.933

Table B.3 Polynomial regression analysis: straw wt versus concentration for variety two

Source	DF	SS	MS	F	P
Regression	2	4032.6	2016.30	2.47	0.127
Error	12	9811.8	817.65		
Total	14	13844.4			

Table B.4 Sequential analysis of variance of variety two

Source	DF	SS	F	P
Linear	1	4007.97	5.30	0.03
Quadratic	1	24.63	0.865	0.039

Table B.5 Polynomial regression analysis: height versus concentration for variety two

Source	DF	SS	MS	F	P
Regression	2	448.189	224.095	7.89	0.006
Error	12	340.744	28.395		
Total	14	788.933			

Table B. 6 Sequential analysis of variance for variety two

Source	DF	SS	F	P
Linear	1	429.180	15.51	0.002
Quadratic	1	19.009	0.67	0.429

Table B.7 Polynomial regression analysis: grain versus concentration for variety three

Source	DF	SS	MS	F	P
Regression	2	1480.36	740.180	3.96	0.048
Error	12	2241.37	186.781		
Total	14	3721.73			

Table .B. 8 Sequential analysis of variance for variety three

Source	DF	SS	F	P
Linear	1	1355.61	7.45	0.017
Quadratic	1	124.75	0.67	0.430

Table B.9 Polynomial regression analysis: straw weight versus concentration for variety three

Source	DF	SS	Ms	F	p
Regression	2	2894.07	1447.04	4.48	0.035
Error	12	3874.33	322.86		
Total	14	6768.40			

Table B .10 Sequential analysis of variance for variety three

Source	DF	SS	F	P
Linear	1	2879.28	9.62	0.008
Quadratic	1	14.80	0.834	0.05

Table B.11 Polynomial regression analysis: height versus concentration for variety three

Source	DF	SS	MS	F	P
Regression	2	456.171	228.085	6.28	0.014
Error	12	435.563	36.297		
Total	14	891.733			

Table B.12 Sequential analysis of variance for variety three

Source	DF	SS	F	P
Linear	1	456.125	13.61	0.003
Quadratic	1	0.046	0.00	0.972

Table B .13 Polynomial regression analysis: grain versus concentration for variety four

Source	DF	SS	MS	F	P
Regression	2	7265.58	3632.79	28.73	0.000
Error	12	1517.36	126.45		
Total	14	8782.93			

Table B.14 Sequential analysis of variance for variety four

Source	DF	SS	F	P
Linear	1	5350.87	20.27	0.001
Quadratic	1	1914.70	15.14	0.002

Table B.15 Polynomial regression analysis: straw wt versus concentration for variety four

Source	DF	SS	MS	F	P
Regression	2	11827.1	5913.53	7.66	0.007
Error	12	9264.9	772.08		
Total	14	21092.0			

Table B.16 Sequential Analysis of variance for variety four

Source	DF	SS	F	P
Linear	1	9676.26	11.02	0.006
Quadratic	1	2150.81	2.79	0.121

Table B. 17 Polynomial regression analysis: height versus concentration for variety four

Source	DF	SS	MS	F	P
Regression	2	464.400	232.200	10.83	0.002
Error	12	257.333	21.444		
Total	14	721.733			

Table B.18 Sequential analysis of variance for variety four

Source	DF	SS	F	P
Linear	1	460.511	22.92	0.000
Quadratic	1	3.890	0.18	0.678

Table B .19 Polynomial regression analysis: grain versus concentration for variety five

Source	DF	SS	MS	F	P
Regression	2	2518.18	1259.09	12.88	0.001
Error	12	1172.75	97.73		
Total	14	3690.93			

Table B.20 Sequential analysis of variance for variety five

Source	DF	SS	F	P
Linear	1	872.47	4.02	0.066
Quadratic	1	1645.71	16.84	0.001

Table B .21 Polynomial regression analysis: straw wt versus concentration for variety five

Source	DF	SS	MS	F	P
Regression	2	6153.2	3076.62	3.93	0.049
Error	12	9396.1	783.01		
Total	14	15549.3			

Table B.22 Sequential analysis of variance for variety five

Source	DF	SS	F	P
Linear	1	3642.64	3.98	0.05
Quadratic	1	2510.60	3.21	0.099

Table B. 23 Polynomial regression analysis: height versus concentration for variety five

Source	DF	SS	MS	F	P
Regression	2	485.041	242.521	7.05	0.009
Error	12	412.692	34.391		
Total	14	897.733			

Table B. 24 Sequential analysis of variance for variety five

Source	DF	SS	F	P
Linear	1	476.291	14.69	0.002
Quadratic	1	8.750	0.623	0.25

جامعة النجاح الوطنية
كلية الدراسات العليا

أثر الملوحة على إنتاج الشعير المروي بالمياه المالحة والمعالجة

إعداد
ماهر عبدالله احمد صلاحات

إشراف
أ.د مروان حداد
الدكتور نعمان مزيد

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

2013

أثر الملوحة على إنتاج الشعير المروي بالمياه المالحة والمعالجة

اعداد

ماهر عبدالله احمد صلا حات

اشراف

أ. د. مروان حداد

د. نعمان مزيد

الملخص

مصادر المياه الجانبية كالمياه الهامشية والمياه العادمة المعالجة تعتبر مصادر مائية واعدة كبديل للمياه العذبة المستخدمة في الزراعة خاصة في المحاصيل المتحملة للملوحة. يعتبر الشعير أحد المحاصيل المتحملة للملوحة.

تهدف هذه الدراسة إلى تقييم اثر خمسة تراكيز من المياه على إنتاجية خمسة أصناف من الشعير لمعرفة مدى تحمل هذه الأصناف للملوحة.

في هذه الدراسة تم زراعة خمسة أصناف من الشعير وريها بخمسة تراكيز مختلفة من المياه والتي استعملت المياه العذبة كشاهد بتركيز (مجموع المواد الصلبة الذائبة) 442 جزء بالمليون ثلاثة تراكيز من المياه المالحة) استخدمت للري تراكيز الملوحة كانت س1 1080 جزء بالمليون س2 3240 جزء بالمليون، وس3 9720 جزء بالمليون بالإضافة للمياه العادمة المعالجة والتي بلغ تركيزها 1200 جزء بالمليون.

أجريت الدراسة بالنظام العشوائي ذات القطاعات المحددة وبحدود ثقة $P\leq0.05$، قسمت التجربة إلى ثلاثة قطاعات رئيسية كل قطاع يحتوي 25 وحدة تجريبية بحيث يحتوي كل قطاع على كافة الأصناف المستعملة وكافة تراكيز المياه المستخدمة.

أظهرت نتائج الدراسة انه في جميع الحالات كان هناك فروق احصائية بين تركيز الملوحة العالي س 3 والتراكيز الأخرى مسببة نقصا في انتاج الحبوب في الشعير كذلك أظهرت الدراسة أن وزن القش وارتفاع النباتات كان اقل عند الري بالتركيز س3. اظهرت النتائج ان هناك فروق احصائية في زيادة المحصول عند استخدام المياه العادمة المعالجة

بالمقارنة بالمعاملات الأخرى فإنتاج الحبوب وزن القش وارتفاع النباتات كانت أعلى من المعاملات الاخرى لجميع اصناف الشعير المستخدمة.

بالمقابل التراكيز س2 والمياه العذبة والتركيز س1 لم تظهر فروق احصائية واضحة في انتاج الحبوب ايضا لا يوجد فروق بين س1 س2 في وزن القش بالمقابل يوجد فروق إحصائية بين س2 والمياه العذبة.

بالنسبة للارتفاع س3 أعطت نتائج نباتات اقصر من جميع المعاملات الاخرى بدلالة احصائية.

بالنسبة للمياه العادمة المعالجة كانت النباتات أطول من المعاملات الاخرى بدلالة إحصائية.

بالنسبة للأصناف الصنف 4 أعطى أعلى إنتاج حبوب حيث هناك فروق احصائية بين الصنف 4 والأصناف الأخرى (2 3 ، و5) بالمقابل لا يوجد بين الأصناف (1 2 ، 3، و5) بالمقابل نرى انه لا فرق احصائي بين الصنف 4 والصنف1.

بالنسبة لوزن القش الصنف 4 أعطى أعلى إنتاج بالمقابل لا يوجد فرق احصائي بين الصنف 4 والأصناف (2 3، و 5) كما انه هناك فرق احصائي بين الصنف 4 والأصناف الأخرى (2 3، و5) أيضا الصنف 4 ينطبق عليه الشيء ذاته نلاحظ انه لا فرق احصائي بين الصنف 1 والصنف 4.

بالنسبة لتداخل الأصناف مع الظروف البيئية نرى أن الصنف 4 أعطى أعلى إنتاج من الحبوب عند ريه بالمياه العادمة المعالجة بدلالة إحصائية هذا الصنف تفوق على الأصناف الأخرى عند ذات التركيز في إنتاج القش بينما عند مقارنة طول النباتات نلاحظ أن الأصناف (1 3، و5) لم تكن الفروق بينها ذات دلالة إحصائية.

مما سبق نرى ان استخدام المياه الهامشية والمياه العادمة المعالجة في ري مثل هذه المحاصيل تعتبر مصادر مائية واعدة وموفرة لمصادر المياه التقليدية للاستخدام البشري الذي لا يمكن فيه استخدام المياه العادمة المعالجة والمياه الهامشية.