An-Najah National University
Faculty of Graduate Studies

Evaluation and Assessment of Growth, yield and uptake of Various non local Barley Cultivars Irrigated with Simulated Wastewater

By

Zakiyeh S. Namrotee

Supervisor
Prof. Marwan Haddad

Co- Supervisor
Dr. Munqez Shtaya

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

2016

Evaluation and Assessment of Growth, yield and uptake of Various non local Barley Cultivars Irrigated with Simulated Wastewater

By:

Zakiyeh Suliman Salem Namrotee

This thesis was defended successfuly on 28/2/2016 and approved by :

Defence Committee Members	**Signature**
Prof.Dr.Marwan Haddad (Supervisor).	....
Dr. Munqez Shtaya(Co- Supervisor).	....
Dr.Mahmood raheel (External Examiner).	....
Dr.Heba AL. Fares ((Internal Examiner).	....

الإهداء

إلى الله ..

منِّي .. وأنا ذره في رحابه شكراً وحمداً لا يوافيان نعمائه ..

إلى النور الذي أضاء الكون بـِ " إقرأ ".. الأميُ الذي تتلمذت على يديه الجهابذه ..
إلى حبيبي رسول الله "صلى الله عليه وسلم "

إلى إبتسامه الشمس في ثغرها .. إلى الربيع في عينيها .. والحب في مُقلتيها
إليها وهي الكُل وهي الإستثناء " أمي "

إلى كُل قطرات العرق المتراقصه على جبهته الطاهره .. إلى الذي ربى .. وعلم .. وكبّر
إليه لأنه الفخرُ والأمان .. وترانيم العلم التي تُليت وتتلى من عقود فتنشأ أجيالا لا تعرف للمستحيل سبيلا .. "أبي "

إلى الزنبقات المدلله .. والرياحين الغضه .. إليهم لأنهم السند والمعونه " أخواتي .. أخَوَي "
إلى كل تلك الفراشات التي حلقت في شتى فصول الصداقه بلا كلل .. لم يحرقها صيف ولم يغيرها خريف .. الى اللامتقلبين مع الفصول .. صديقات المرحله .. وكل المراحل " صديقاتي الصدوقات "

إلى كل هؤلاء الذين وقفوا على القمه ونظروا بإزدراء وزهو .. الى اللذين شكوا باحتمالات النجاح ، وشككوا ! إلى المتساقطين على الطريق .. اللامنتمين لعوالم التحدي والإصرار !

وأخيرا ...
إلى كل تلك الاشواك التي كانت معالم هذه المرحله .. ورفيقها المتدثر بالخذلان

إلى وخزاتها الداميه التي شكلت حافزا للتميز .. والنجاح .. إلى الصبر الذي وهبته لي منذ لقاءنا الأول في هذا الطريق .. حتى هنا .. النهاية التي شقت طريقا لبداية جديده ... نحو القمه !

إليهم جميعا ... أهدي بحثي هذا .... و أهديهم جميعاً لنفسي ..

Acknowledgents

First of all, thanks to Allah for making this possible. I would like to thank Prof. Dr. Eng. Marwan Haddad for his supervision, guidance and constructive advice. Thanks also go to the source of data I used in my study; the Water and Environmental Studies Institute (WESI) that gave me a chance to work on this project. The work carried out in this thesis was fully supported and financially covered by the DFG project.

Special thanks go to Dr. Munqez Shtaya for his technical support in carrying out the experiments. Without his help and support, the completion of this thesis would never have been possible.

Also I like to thank Mr. Zahran Al-Ashqar for his support in carrying out the tests for the simulated wastewater samples.

My parents, brother and sisters, thank you so much for being a great source of support and encouragement . To all my friends and fellow graduate students, thank you .

الإقرار

أنا الموقع أدناه مقدم الرسالة التي تحمل العنوان:

Evaluation and Assessment of Growth, yield and uptake of Various non local Barley Cultivars Irrigated with Simulated Wastewater

أقر 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 لنيل أية درجة أو لقب علمي أو بحثي لدى أية مؤسسة تعليمية أو بحثية أخرى.

Declaration

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

Student's Name: زكية سليمان سالم غروطي **: اسم الطالب**

Signature: [signature] **: التوقيع**

Date: 28/2/2016 **: التاريخ**

Table of Contents

List of Tables

List of Figures

Evaluation and Assessment of Growth, yield and uptake of Various non local Barley Cultivars Irrigated with Simulated Wastewater

By
Zakiyeh S. Namrotee
Supervisor
Prof. Marwan Haddad
Co- Supervisor
Dr. Munqez Shtaya

Abstract

The experiment was implemented in order to study the effect of irrigation with simulated wastewater on soil, growth and yield 7 introduced barley cultivars; and to evaluate the impact of using simulated wastewater in irrigation on the plants , and finally the modeling. The experiment was conducted at the new campus of An-Najah National University. The seeds were planted in the spring season 2014, in separated plastic containers filled with 45 kg sandy clay soil, 15 plants were planted in each container, the distribution of the plots was completely randomized plot design. The plants were irrigated with two types of water as experiment treatment (Fresh water as control and simulated wastewater), with three replicates for each treatment. Chemical analysis has been used for determining the mineral contents of the soil of the experiment for each variety and each type of water for Nitrogen (N), Phosphorous (P) , Potassium (K) and total dissolved solids (TDS). These tests were performed at An-Najah National University Laboratories. Each test was done in accordance to standard methods of analyses for soil and water. All collected data were analyzed statistically using one way analysis of variance to examine treatment effects, means were separated by Duncan's multiple range test at $P \leq 0.05$.

Results show that water type has no effect on the growth vigor and nature of all barley cultivars, whereas tiller number was highly affected by water type where cultivars irrigated with simulated wastewater showed significantly higher number of tellers per plant than those irrigated with fresh water. Plants irrigated with both simulated wastewater and freshwater required nearly the same time to emergence, stem elongation, flowering and maturity while significant differences were observed between the barley cultivars. The highest yield was obtained from cultivars irrigated with simulated wastewater, the cultivars irrigated with simulated wastewater gave nearly twice the yield and spike weight than the cultivars irrigated with freshwater. Also plants irrigated with simulated wastewater gave higher spikes length and higher stem weight. On the other hand, Soil irrigated with simulated wastewater absorbed more nitrogen than the soil irrigated with freshwater, the nitrogen absorbed mainly in the root which had the higher N % compared with amount absorbed by both the stem and the spike, where the N% of the spike was nearly higher than the stem (N% – Root > N%- Spike , N% - Stem). For potassium, Plant absorbed it through the root , spike and stem and that’s related to the fact that the potassium is slowly move in the soil in addition to that it react with the elements found in the simulated wastewater and thus decreased in the plants (K% – Stem> K%- Root , K% - Spike). The soil irrigated with simulated wastewater absorbed more phosphorous than the soil irrigated with freshwater, the phosphorous absorbed mainly in the spike which had the higher P% compared with amount taken by both the stem and the root, where the P% of the root was nearly higher than the stem (P% – Spike > P%- Stem , P% - Root).

The Model equation according to the results obtained will be:

$$Y = - 4.441 + 0.448 * X1 + 18.709 * X2$$

The obtained model could be helpful when used to calculate the yield to the plants when the amount of water used for irrigation and the weight of the seeds before the planting were known.

It should be concluded that barley proved to be a salt-tolerant crop with considerable economic importance. Barley could tolerate saline water without any shortage in the yield of the crop; also, the growth vigor as well as the growth period (from days to emergence to maturity) were not affected with the type of water and only depend on the type of the seeds.

In addition, Simulated wastewater is a promising water resource as alternatives for fresh water to be used in agriculture specially crops with high tolerance to salinity such as barley since the use of simulated wastewater in irrigation increases the nitrogen (N), phosphorous (P) and potassium (K) contents in soil profiles and the quality of water used in irrigation affects the soil texture through increasing the concentrations of some constituents such as nitrogen potassium and phosphorous.

Chapter 1

Introduction

1.1Background

Water is a vital resource for human life and activities including industry, reaction, and agriculture , but a severely limited one in most countries of the Mediterranean region such as Palestine. Therefore, there is an urgent need to conserve and protect fresh water and to use the water of lower quality for irrigation [1]. The use of treated simulated wastewater in countries poor in water resources is less expensive and considered an attractive source of irrigation water and the interest in reusing simulated wastewater for irrigation is rapidly growing in these countries [2]. Consequently the reuse of simulated wastewater for agriculture is highly encouraged [3,4]

The availability of renewable water resources to maintain various human needs in Palestine is poor scarcity acceleration with time. Therefore, alternative water resources development options such as the reuse of treated simulated wastewater and brackish water gaining much importance at present. The use of these options is expected to be obligatory with time[5].

In the West Bank, water resources are under the Israeli control. This situation has restricted the accessibility and availability of water resources to the Palestinians. Palestinians ought to develop their water resources to compensate the shortage in water supply and save the available fresh water for domestic use. One of the most potential and promising alternative solutions is to reuse the treated simulated wastewater for irrigation in agriculture [6].

Simulated wastewater is any water that has been adversely affected in quality by anthropogenic influence. Municipal simulated wastewater is usually conveyed in a combined sewer or sanitary sewer. In most countries around the world, the volumes of urban simulated wastewater flows are increasing sharply. This is more specifically for developing and transition countries, related to relatively high population growth figures, high urbanization rate progress in sanitation facilities and economic development[7]

Irrigation with treated simulated wastewater is considered an environmentally sound simulated wastewater disposal practice compared to its direct disposal to the surface or ground water bodies [3]. In addition, simulated wastewater is a valuable source of plant nutrients and organic matter needed for maintaining fertility and productivity levels of the soil [8]. On the other hand, simulated wastewater may contain undesirable chemical constituents and pathogens that pose negative environmental and health impacts [9]. Consequently, mismanagement of simulated wastewater irrigation would create environmental and health problems to the ecosystem and human beings [10].

When simulated wastewater will be used continuously as the sole source of irrigation water for field crops in arid regions, excessive amounts of nutrients and toxic chemical substances could simultaneously be applied to the soil-plant system. This would cause unfavorable effects on productivity and quality parameters of the crops and the soil [11]. Therefore, management of simulated wastewater irrigation should consider the simulated wastewater nutrient content, specific crop nutrient requirements, soil nutrient content and other soil fertility parameters [3].

The discharge of simulated wastewater, untreated or partially treated, into surface water is a potential environmental threat. At the same time, treated and even untreated wastewater is increasingly used as a source of water for agriculture, if well designed and properly managed an infrastructure that allows collection and secondary treatment of domestic simulated wastewater followed by the use of the effluent in agriculture would help to create relatively cheap and safe disposal of domestic simulated wastewater and make more water available for increasing food demand in water scarce situations. Polices and regulations on this form of integrated water management develop differently in different countries depending on climate, pHysical environment, economic progress and institutional strengths[7].Countries are facing different problems and opportunities and have or have not yet reacted to the increasing urban water flows throw renewed policies, appropriate planning infra structural investment, management training and regulations. In the urban and peri-urban areas of many developing countries, simulated wastewater is used for agriculture. In some situations this is atypical activity of the urban poor who grow crops to supplement household income. In other cases, the traditional peri-urban farmer is confronted with increasing pollution of this originally fresh water source [7].

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, using wastewater 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. Wastewater 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 wastewater 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 simulated wastewater [12].

As aconclosion , 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 wastewater to be used basically in irrigating groups to overcome the water crises.Treated wastewater 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.

The wastewater (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. [11]

The majority of the research conducted on simulated wastewater reuse in agriculture focuses mainly on its short-term effect on plant growth and development with little attention to the changes induced in the soil fertility and chemistry parameters. The objective of this study was to evaluate the impact of short-term application of simulated wastewater on soil fertility parameters and possible accumulation of metals in the soil-plant system by comparing several cultivars irrigated with both fresh and simulated wastewater.

1.2 Research Objectives

The main objectives of this research are:

1. To compare the growth and the yield of different barly cultivars irrigated with fresh and simulated wastewater using statistical analysis .

2. To study the effects of irrigation with simulated wastewater on soil and barley growth and yield.

3. To evaluate and compare the impact of simulated wastewater irrigation on the soil (metal accumulation (N ,P , K).

4. To model the experimental results to predict the yield in soil and plant as a function of barley cultivar type and input simulated wastewater used for irrigation by applying statistical analysis (Regression method) .

1.3 Research Question

The goal of this research is to answer the following questions conveniently:

1- Do the use of simulated wastewater in irrigation affect the growth and yield of the barley cultivars compared with that irrigated with fresh water ?

2- Do the use of simulated wastewater in irrigation have a noticeable impact on soil and plant yield ?

3- Do nutrients in simulated wastewater (Nitrogen ,Phosphorous and Potassium) accumulate in soil and plant compared with that irrigated with freshwater ?

Chapter 2

Literature Review

Introduction

Water scarcity in arid and semi-arid regions enforces the planers and decision makers to look for new conventional and non-conventional water resources. This is essential to compensate the existing shortage in water supply and to promote further development. In the Middle East region, almost all accessible fresh water resources 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 .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 [13] .

2.1 Characteristics of simulated wastewater

Simulated wastewater is a non-conventional water resource that can be used after treatment in irrigation purposes and specific industrial activities. Simulated wastewater reuse in agriculture conserves the freshwater resources for domestic purposes. In addition, it has a high nutrient content that is good for crops, which reduces the needed quantities of fertilizers. Using of brackish water, low quality water, saline water and treated simulated wastewater 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 [14].

Simulated wastewater is comprised of water (99.9 %) together with small concentration of suspended and dissolved organic and inorganic solids, viruses, bacteria, protozoa and helminthes [14] .The main constituents of simulated wastewater are:

1- Total solids that divided into dissolved and suspended solid
2- Nitrogen
3- PHospHorus
4- Chloride
5- Grease
6- BOD5
7- Pathogens that includes: bacteria. Viruses, worms and protozoa
8- Trace and heavy metals

The presence and concentration of these constituents differ from location to location. These differences are due to many reasons that include: the sources of simulated wastewater and water consumption whereas the concentrations of constituents decrease with the increase in consumption[14].

The first use of simulated wastewater in irrigation was historically backed to two thousand years ago in Greece. Simulated wastewater reuse in agriculture is recognized worldwide as an alternative water and nutrient source [15] .

Irrigation with simulated wastewater (sewage) was common in Germany in the sixteenth century and in England in the nineteenth century, while in the United States, the use of simulated wastewater is back to the seventies of the nineteenth century [16] Agriculture accounts for 70 - 95% of the water taken in certain developing countries. Recycling simulated wastewater 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 [16].

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 [12].

2.2 Effects of simulated wastewater on soil characteristics

Soil is a porous media that contains solids, liquids, and gases created at the land surface by weathering processes, derived from biological, geological, and hydrological pHenomena [17]. [18] define soil as the medium that supports plant growth and modulates nutrients and pollutants in the environment. The main functions of soil are the ability to hold, accept and release water to plants and release nutrients and chemicals and media for root growth [17] Soil has pHysical and chemical characteristics such as porosity, permeability, water holding capacity, trace metal concentrations, pH, total carbon and total nitrogen. These characteristics may be affected by the quality of water used for irrigation.

The chemical content and composition of the irrigated soils become stable after about four years of irrigation, subject to variation in crop rotation effects. Sodality 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. 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. Salinity problems will increase by increasing the salt concentration of irrigation water. Salinity affects plant growth and production negatively in most plants. Irrigation water saline water 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[19].

be well supplied with K. A possible exception is sandy soils and irrigated soils grown to high K-requiring crops, e.g., sugar beet and potatoes. [22]

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 [2].

Also, in Egypt, there have been several attempts to improve wheat productivity by selecting tolerant cultivars such as Sakha-8. It was observed that increasing the salinity of soil water by 1 ds/m above 6 ds/m will cause reduction in yield by 8% [4] .

In 1912, the first small urban reuse system began with the irrigation of Golden Gate Park in San Francisco. By the using treated and wastewater to meet the irrigation needs of farming activities. This saves on water resources upstream and reduces pollution downstream. The wastewater can also often represent a source of nutrients for the plantings.

Feigin A., Ravina I., Shalhevet J found that irrigation with simulated wastewater increases soil salinity, increases nutrient contents, increases pathogens in soil, and increases trace metal concentrations in soil. They found also that suspended solids clog the soil pores. [24].

Dojlido Jan R., Best Gerald noticed that high levels of sodium in irrigation water affects on soil structure, infiltration, and permeability rates .[25]

Sadeh, A., and Ravina a pplied 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 [26].

Wang Z., Chang A.found that the use of reclaimed simulated wastewater in irrigation reduce the porosity of soil and reduce nutrient holding capacity[18].

Viviani G. and Iovino carried out a laboratory experiment to investigate the effect of using simulated wastewater in irrigation on the hydraulic conductivity of loam and clay soils. The loam soil hydraulic conductivity was reduced to about 80% of the initial value after infiltration of 175 mm of municipal simulated wastewater with total dissolved solids in the range of 57 to 68 mg/l. Reductions in hydraulic conductivity were more remarkable in the clay soil. [27].

Sharma R. K., Agrawal M studied the effect of using treated and untreated simulated wastewater for irrigation on soil and vegetable contamination by heavy metals in India. The study concludes that irrigation by treated or untreated simulated wastewater has increased the heavy metal concentrations of Zn and Mn in soil and plants of receiving area. Cadmium concentration in irrigation water was found to be above the permissible limit as set by world health organization (WHO) for irrigation of agricultural land at Dinapur and Lohta sites. Heavy metal concentrations in plants show significant spatial and temporal variations. Cd, Pb, and Ni were above the Indian permissible Limits. [28].

Katerji, N., van Hoorn, J., Hamdy 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 . [29]

Katerji, N., van Hoorn, J., Hamdy, A 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. [30]

Herpin, U., Gloaguen, used secondary treated simulated 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[32]

Chapter 3
Methodology

Introduction

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

3.1 Experimental Setup

3.1.1 Experimental Site

Field experiment was conducted at the experimental station of the Water and Environmental Studies Institute (WESI) at An-Najah National University, Nablus, during the 2014/2015 growing season . A plastic containers (35 x 50 x 15 cm) filled with agricultural soil were used for sowing the plants. All varieties were sown on 13th of January 2014 in three complete randomized blocks (Fig. 3.3) each accession was represented by 15 plants per replicate.

3.1.2 Plant material (Barley)

The experiment was carried out using 7 introduced varieties of barley (Table 3.1).

Table 3.1: Barley varieties used in the experiment.

S42IL107	BW281	BW284	Scarlett	BW290	Bowman	G400
1	2	3	4	5	6	7

3.2 Cultural Practices

3.2.1 Irrigation treatments

Plants were irrigated twice per week by adding nearly 8 liters of water / container / week from sowing until the second leaf was fully expanded.A total of (128 liters) of wastewater was used during the period and this amount determined according to the average rainfall in the city and the container space , After that the irrigation with simulated wastewater was started using the same water regimen and quantity.

3.2.2 Simulated wastewater preparation

In this experiment, and based on the definitions of simulated wastewater above ,simulated wastewater (not domestic simulated wastewater) was used by using animal waste with special charactraization (BOD = 400 and salinity of 1% ds/m). BOD was measured for small sample of animal waste by using BOD device, then (NaCl) was added to reach the required salinity. This water with its charactrist (BOD and TDS) used to simulate the simulated wastewater in this experemint which defined to be any water with waste (animal waste in our case and not domestic water).

Table 3.2: Chemical analysis of fresh water, simulated wastewater and soil used through the experiment.

Parameter	Fresh Water	Simulated wastewater	Soil
TDS (mg/l)	384	1492	350
K (ppm)	4.8	88	210
N (%)	0.0072	0.0163	0.46
P (ppm)	0.62	3.30	1.5

3.3 Plant observations

Plant samples were collected during the growing season for measuring the following parameters:

1- Days from sowing to emergence (the number of days from sowing until 90% of plants emerged).

2- Growth vigor (in a scale of 1-7, where 1 is weak growth and 7 is strong).

3- Growth nature (erect-prostrate).

4- Days from emergence to stem elongation (the number of days from plant emergence until the start of stem elongation).

5- Days from emergence to heading (the number of days from plant emergence until 90% of the plants per variety gave flowering).

6- Days from emergence to maturity (the number of days from plant emergence until maturity.

7- Tiller number (the actual count of the fertile numbers of tillers (spike bearing) per plant).

8- Spike length (distance from the base of the spike to the tip of the highest spikelet (excluding own) in cm).

9- Plant height (the distance between the ground level to the tip of the terminal spikelet in cm of the mother plant).

10- Total grain yield.

11- Vegetative biomass.

3.4 Harvesting and evaluation of parameters

In harvesting the main factors that were taken in consideration were :

1- Times of (Emergence , Stem elongation , Anthesis , Maturity)

2-Tiller number and Spike number.

3-Growth vigor and nature .

4-Spike length and Plant height

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 and recorded as shown in the appendix tables.

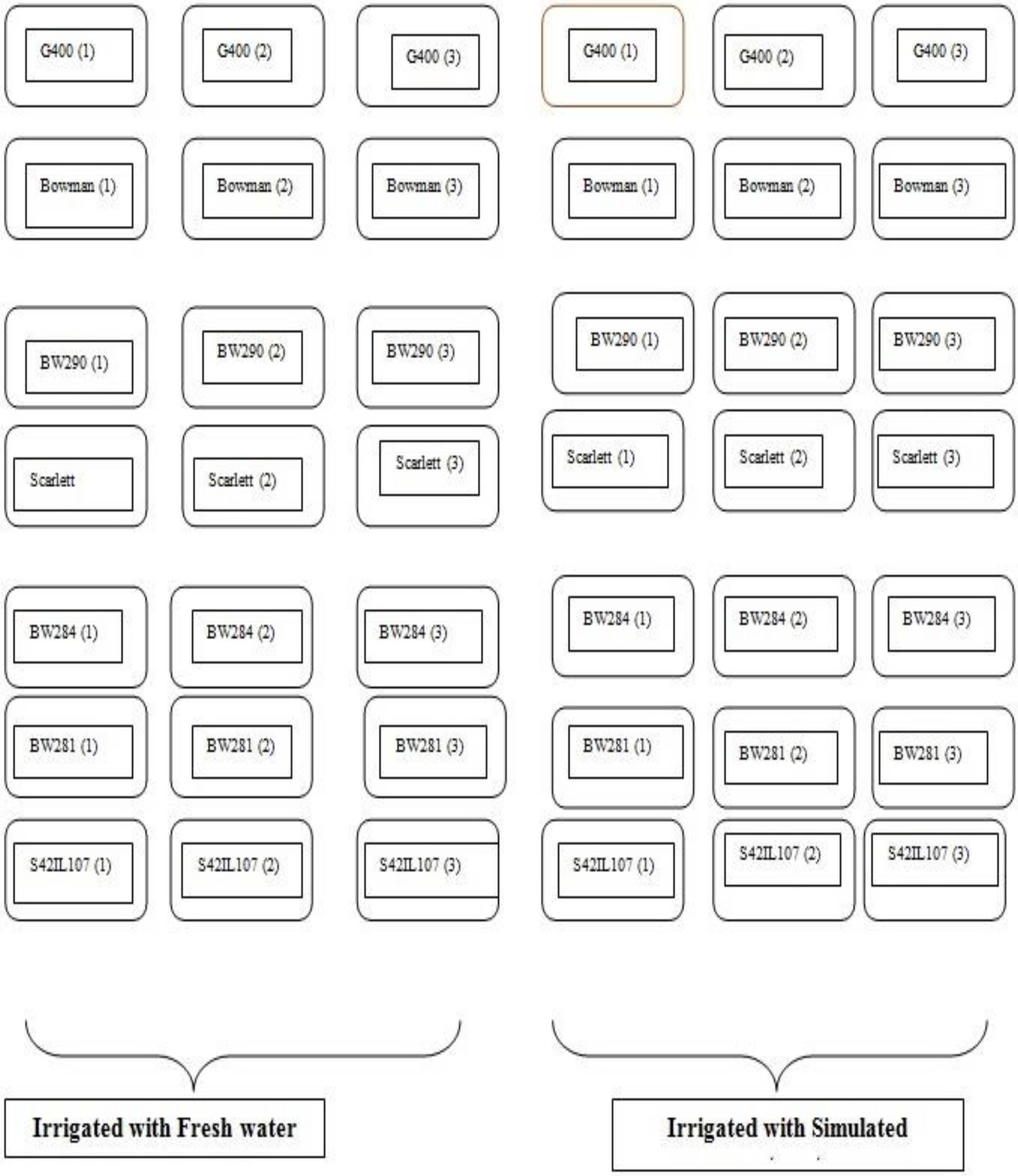


Figure (3.1) : Experimental design of the field experiment

3.5 Soil analysis

Chemical analysis has been used for determining the mineral contents of the soil of the experiment for each variety and each type of water for N, P , k and TDS , 170 samples were analyzed during this experement , 85 samples For freshwater and 85 for simulated wastewater divided as: 63 plant samples (21 root , 21 spike and 21 stem) , 21 soil samples and finally the water sample. these tests were performed at An-Najah National University Laboratories. Each test was done in accordance to standard methods of analyses for soil and water[36]

3.5.1 Potassium (K)

Dry ashing method was used at an ignition temperature of 550 - 600 °C followed by extraction in diluted HCl. The K content was obtained using the flame pHotometer (Model 410). which is calibrated using standard K solutions, the K content of our samples was obtained as ppm K. [45]

3.5.2 PHospHorus (P)

Dry-ashing method was used to determine P content by burning the sample (soil or plant) in an oven for nearly 9 hours at an ignition temperature of 550-600 °C then the ash was dissolved in distillated water. After that the samples were filtrated and titrated. PHospHorus content was measured using the spectra pHotometer (Model 21D) . [45]

3.5.3 Nitrogen (N)

Nitrogen was analyzed by using nitrogen analyzer system (Kjeldal system). The samples were digested in concentrated H_2SO_4 with a catalyst mixture to raise the boiling temperature and to promote the conversion from organic-N to NH_4-N. The NH_4-N from the digest is obtained by steam distillation, using excess NaOH to raise the pH. The distillate is collected in saturated H_3BO_3, and then titrated with dilute (0.04 N) H_2SO_4 to pH 5.0 to determines the nitrogen content. [45]

3.5.4 Electrical Conductivity

Salinity is measured using a conductivity bridge. The salt content estimated by immerse the conductivity cell in the solution and take the reading for the soil , the samples filtrated and tittated then the conductivity meter used to determine the soil salinity [45]

3.6 Statistical analysis

Ms-Excel and SPSS programs were used to manipulate and analyze the data. Model was developed to express the results.

Analysis of variance (ANOVA) and mean separation were conducted using procedure of SPSS software, version 15.0. Multiple comparisons among pairs of lines were performed using the Duncan-test.

The barley yield were explained and customized to find out the relationship between it and the salinity (TDS) , total dry weight of the plant (TDW) , an empirical formula tried :

Yield =∫ [plant weight, TDS , Etc ..]

The yield of the plant depends mainly on two variables; the type of water used for irrigation and the type of the seed.

Regarding to **Regression** the model should be as:

$$\mathbf{Y= a + b_1x_1+ b_2x_2 + \ldots\ldots + b_n\, x_n}$$

Where:

Y = the dependent variable.

X= the predictor (independent) variable.

A= the intercept (the value of Y when X is zero) .

B= the slope (the value that y will change by if x changes one unite).

The SPSS regrrition coefficient output gives very important information which are necessary to build the model. the values of B which called b coefficients, its value means that the dependent variable average plant yield will change if the type of seeds will change .

The obtained model could be helpful when used to calculate the yield to the plants irrigated with freshwater when the amount of water used for irrigation were known and the weight of the seeds before the planting

3.7 Experiment pictures

The pictures below represent the growth of barley cultivar (G400) among the planting period:

Emergence **Stem elongation** **Spike growth** **Maturity**

Chapter 4

Results and Discussion

Introduction

This chapter represents the results that were obtained from the experiment in terms of barley growth and yield, production of grains, spike, the height of the stem, chemical analysis of both fresh water and simulated wastewater, chemical analysis for metal uptake 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. These results will be discussed in the following sections.

4.1 Growth Results

The growth nature and vigor of the different barley cultivars irrigated with both fresh and simulated wastewater were observed during the experiment period. Results shows that the growth nature was divided into two types: erect growth and prostrate growth.

The growth nature and growth vigor were not affected by the water type (Table 4.1). S42IL107, Scarlett and BW290 have prostrate growth while BW281, BW284, Bowman and G400 have an erect growth. Significant differences were also observed between cultivars in growth vigor and tillering. Average tiller number was significantly affected by water type (from 1-3 to 2-6 for fresh water and simulated wastewater respectively).Positive correlation was observed between growth nature and tiller number where cultiveres with postrate growth showed higher tiller number than erect cultivars (Table 4.1).

Table (4.1): Growth nature for the barley irrigated with fresh and wastewater.

No.	Line	Growth Vigor Order (1-7)		Growth Nature (erect-prostrate)		Average tiller no.	
		FW	WW	FW	WW	FW	WW
1	S42IL107	7		Prostrate		3	4
2	BW281	5		Erect		1	5
3	BW284	4		Erect		1	5
4	Scarlett	3		Prostrate		2	5
5	BW290	6		Prostrate		3	6
6	Bowman	2		Erect		2	6
7	G400	1		Erect		1	2

(1) strong growth , (7) weak growth

The growth results showed that G400 was the strongest in both freshwater and simulated wastewater wheares it was the lowest in average tiller number , where S42IL107 showed the weakest growth vigor among the cultivars with an average tiller number of 3 and 4 in fresh water and simulated wastewater respectively.

Figure (4.1) below represent the growth comparison between the cultivars type according to the growth vigor, it's clearly observed that G400 was the best cultivar in growth followed by Bowman, Scarlet, BW284, BW281, BW290 and finally S42IL107 which was the weakest type in growth.

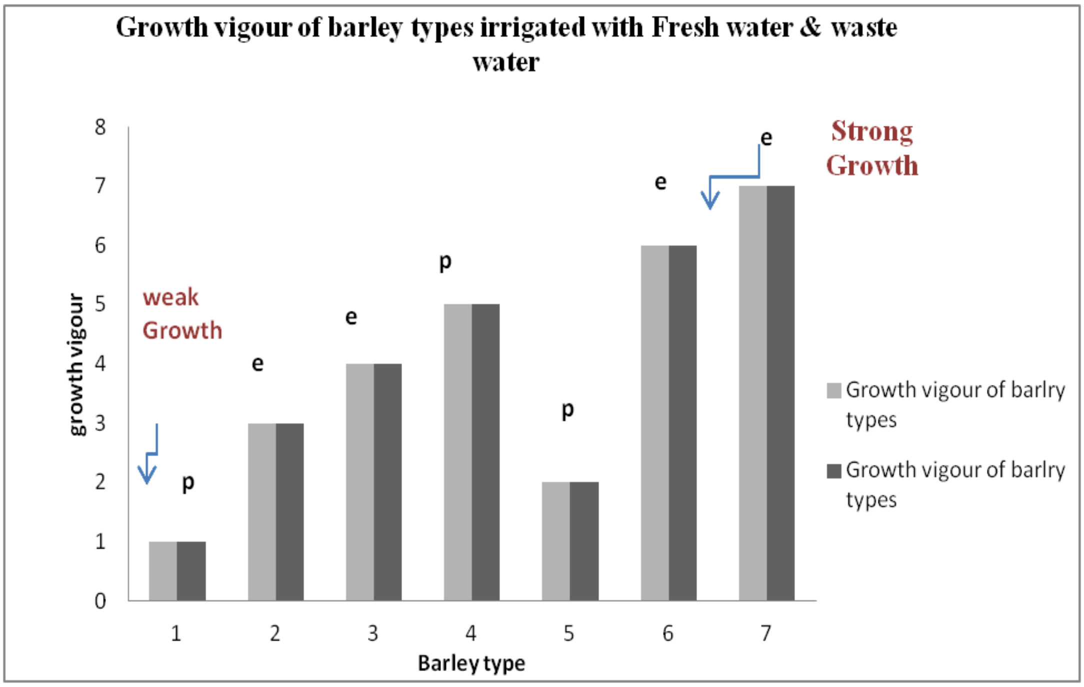


Figure (4.1): General Comparison between the growth of barley types irrigated with fresh water and simulated wastewater

Table (4.2) below represent the growth difference between the fresh and simulated wastewater among the seven barley cultivars types.

Table 4.2 : Growth results of barley irrigated with fresh water and simulated wastewater.

Barley cultivers	Days from sowing to emergence		Days from sowing to stem elongation		Days from sowing to maturity	
	F.W	WW	F.W	WW	F.W	WW
S42IL107	11.00 [a]	10.67 [a]	62.33 [b]	61.00 [b]	153.00 [a]	152.67 [a]
BW281	8.67 [bc]	9.00 [bc]	47.00 [c]	47.00 [c]	152.33 [ab]	151.33 [b]
BW284	10.33 [a]	10.67[a]	40.33[d]	39.67 [d]	151.33 [b]	151.00 [b]
Scarlett	9.33 [b]	9.67 [ab]	39.00 [e]	37.67 [e]	150.00 [c]	149.76 [c]
BW290	10.33 [a]	10.33 [a]	71.67 [a]	71.33 [a]	151.33 [b]	152.00 [ab]
Bowman	8.33 [cd]	8.67 [c]	38.67 [e]	38.00 [e]	149.33[c]	148.76 [cd]
G400	7.67 [d]	8.33[cd]	36.33[f]	35.67 [f]	147.67 [d]	147.76 [d]

* Means with the same letter per column are not significantly different ($p \leq 0.05$).

* Days to (emergence , stem elongation , flowering , maturity) are **not significant** relating to the water type at $p \leq 0.05$ %.

4.1.1 Days from sowing to emergence

Results showed that there was no significant effect of water type on days to emergence whearas there was significant difference between cultivars in days to emergence (Table 4.2). Days to emergence ranged from 8 days (G400) and 11 days (S42IL107). See (Table 4.2) and (Appendix A-table 1).

4.1.2 Days from sowing to stem elongation

Days to stem elongation were not significantly affected by water type whearas significant differences were reported between cultivars within treatments (Table 4.2). it ranged between 36 days for G400 to 71.5 days for BW290.

4.1.3 Days from sowing to maturity

The growth difference between the barley cultivars related to the maturity days represents no significant among the type of water, It should be noted that the barley cultivars irrigated with both freshwater and simulated wastewater had the same days to mature , that's mean that the type of water not affect the growth . G400 was the first type mature within 148 days since the planting in both fresh and simulated wastewater, followed by Bowman. While S42IL107 was the last type mature within 153 days for freshwater and simulated wastewater, and that results that days to mature was close for the seven cultivars. On the other hand, nearly one day delay could be observed among the types irrigated with fresh water compared with that irrigated with simulated wastewater, BW281 for example required 152.33 days to flowering when irrigated with freshwater, while it required also 152.33 days when irrigated with simulated wastewater. See table (4.2) for average results, and see (Appendix A-table 1) for details results.

So, we can conclude that the type of water do not affect the days to flowering. While a significant difference could be observed among the cultivars types. It was also noticed that **G400** required less time to mature, followed by **Bowman, Scarlett, BW284, BW290, BW281** and finally **S42IL107** which was the slowest. As a result , the cultivars type affect the days for emergence more than the water type.

It should be noted that days to maturity was close for the seven cultivars ,which mean that if farmers start planting some weak cultivars earlier they could harvest the plants in the same time with the cultivars that mature earlier .

As a conclosion , the growth of barley cultivar type (G400) that irrigated with fresh water during the planting period (four month nearly) indicates that this cultivar type was the strongest type in growth among the seven cultivars, it required 8 days to emergence ,36 days for stem elongation ,52 for flowering and 148 days to mature since the planting day, when the same barley type (G400) irrigated with simulated wastewater , it was noticed that the growth was better in terms of yield . However, it required the same time for emergence, stem elongation, flowering and mature as well as fresh water . The growth of barley cultivar type (S42IL107) that irrigated with fresh water during the planting period (four month nearly) indicate that this cultivar type was the weakest type in growth among the seven cultivars, it required 11 days to emergence,62 days for stem elongation 70 for flowering and 153 days to mature since the planting day, When the same barley type (S42IL107) irrigated with simulated wastewater , it was noticed that the growth was better in terms of yield .However , it required the same time for emergence as simulated wastewater, 61 days stem elongation, 60 flowering and153 to mature.

While the results shows that both cultivars irrigated with freshwater and simulated wastewater had nearly the same time for flowering and mature , it’s important to combine yield and growth result to improve that plants irrigated with simulated wastewater had higher yield than that irrigated with fresh water and mature at the same period . The following section (Yield Results) discuss the effect of the water type and the cultivars on the yield of the plants in details.

4.2 Yield Components

Variations in yield and quality can occur because of variations in genetics, treatment, and other growing conditions. Statistical analysis makes it possible to determine whether a difference among types is real or whether it might have occurred due to other variations in the field.

Table (4.3): Yield results of barley irrigated with fresh water and simulated wastewater.

Barley cultivers	spike/plant		Spike weight(g)		spike length (cm)		Plant yield (g)		plant height (cm)		Root weight (g)		Stem weight (g)	
	F.W	WW	F.W	WW	F.W	WW	F.W	WW	F.W	WW	F.W	WW	F.W	WW
S42IL107	2.86^{a}	4.42^{a}	0.39^{b}	4.43^{a}	7.53^{d}	16.50^{a}	1.13^{d}	9.90^{a}	32.87^{a}	39.53^{a}	0.39^{cd}	2.10^{a}	0.40^{c}	3.27^{a}
BW281	1.23^{b}	4.94^{a}	0.66^{ab}	4.10^{ab}	6.33^{e}	12.50^{d}	1.56^{bcd}	9.43^{a}	35.70^{a}	39.10^{a}	0.41^{cd}	1.84^{a}	0.63^{abc}	3.21^{a}
BW284	1.36^{b}	3.09^{ab}	0.58^{ab}	0.65^{c}	12.17^{b}	11.33^{e}	1.26^{cd}	3.62^{b}	27.10^{b}	24.60^{cd}	0.27^{d}	0.42^{b}	0.44^{c}	2.15^{abc}
Scarlett	1.60^{b}	5.28^{a}	1.08^{a}	1.84^{bc}	10.80^{c}	13.30^{cd}	2.54^{ab}	4.34^{b}	35.63^{a}	25.50^{c}	1.03^{a}	0.54^{b}	0.55^{bc}	1.86^{bc}
BW290	1.40^{b}	2.59^{ab}	1.07^{a}	2.10^{bc}	12.20^{b}	12.90^{d}	2.51^{ab}	5.66^{b}	33.50^{a}	23.53^{d}	0.54^{bc}	0.64^{b}	0.87^{ab}	3.11^{a}
Bowman	1.57^{b}	3.07^{ab}	1.08^{a}	1.85^{bc}	11.30^{c}	14.30^{bc}	2.82^{a}	6.51^{ab}	35.63^{a}	38.93^{a}	0.64^{b}	2.13^{a}	0.95^{a}	2.90^{ab}
G400	1.13^{b}	1.66^{b}	0.83^{ab}	0.79^{c}	14.33^{a}	15.20^{b}	2.18^{abc}	3.02^{b}	37.23^{a}	29.80^{b}	0.67^{b}	0.60^{b}	0.68^{abc}	1.71^{c}

In table (4.3) , note that :

* Means with the same letter per column are not significantly different ($p \leq 0.05$).

* Spike/plant , Spike weight (g) , Spike length (cm) , Plant yield (g) , plant height (cm) Root weight (g) and Stem weight (g): **Significant** at $p \leq 0.05$ % relating to the water type.

* Spike/plant, Spike weight (g), Spike length (cm) , Plant yield (g) , plant height (cm) Root weight (g) and Stem weight (g) **Significant** at $p \leq 0.05$ %. Relating to the cultivar type at p=0.05% .

Yield results can be explained in terms of weight and length of spike, weight of stem and root and the plant height. Yield Results discussed in details in sections (4.2.1) - (4.2.7). For more yield details, see tables (4.3) and (Appendix A-Table 2).

4.2.1 Average spike/plant

The average spike number per plant has high significant among the type of the plants, the plants irrigated with simulated wastewater gave nearly twice yield higher than that irrigated with fresh water.

Table (4.4) represent the total average spike numbers and the number of the seeds for every cultivar types that used to calculate the percentage of spike per plant showed in the table (4.3).

It should be noted that the experiment carried out on 15 seeds for every container at the beginning of the experiment , but during the experiment and according to many factors , some seeds were not grown in the container and that explained the differences between the types, for example S42IL107 cultivar had 11 seeds out of 15 when irrigated with freshwater

,and this led to that 4 seeds not grown ,while it had 14 seeds out of 15 when irrigated with simulated wastewater ,this can lead us to think about that using simulated wastewater to irrigate the weak cultivars can help to increase the number of seeds that survive and complete the growth , See (Table 4.4) below.

Table (4.4): Average spike/plant of barley irrigated with freshwater and simulated wastewater .

Line	Seeds number out of 15		Total Spike number		spike/plant	
	FW	WW	FW	WW	FW	WW
S42IL107	11	14	30	65	2.73	4.64
BW281	14	13	18	66	1.29	5.08
BW284	10	12	14	39	1.40	3.25
Scarlett	15	13	24	69	1.60	5.31
BW290	14	12	20	35	1.43	2.92
Bowman	14	15	22	46	1.57	3.07
G400	14	12	16	21	1.14	1.75

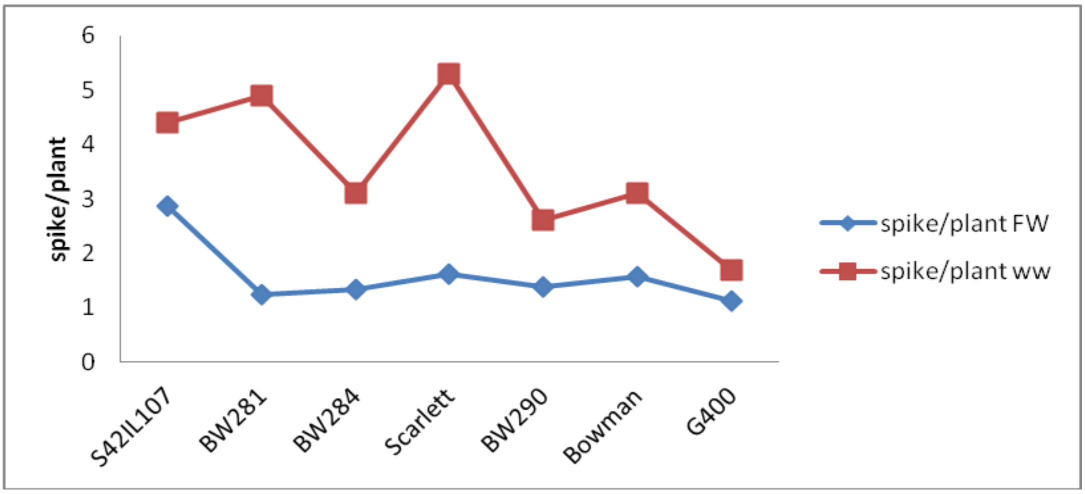
- Total seed numer in each container =15

From table (4.4), it was noticed that scarlet cultivar had a full grown seeds (15 out of 15) , followed by G400,Bowman,BW290 and finally BW281 that had 14 seeds out of 15 when irrigated with feeshwater,for BW284 , it had 10 seeds out of 15, and this could be explained by the uncontrollable damage that noticed in the container during the experemint period that lead to lose 5 seeds out of the total cultivar seeds number in the container. For simulated wastewater, Bowman had a complete number of seeds (15 out of 15),where S42IL107 had (14 seeds out of 15), followed by BW281 and scarlet that loose 2 seeds with total (13 out of 15),on the other hand ,both BW284 BW290 and G400 had 12 seeds out of 15 when irrigated with simulated wastewater.

By comparing the total seeds number of cultivars irrigated with fresh and simulated wastewater , a difference observed during the experemint period,400 cultivar (for example) had 14 seed when irrigated with freshwater while it had only 12 seed when irrigated with simulated wastewater although it's a strong cultivar in growth compared with other types , but the container had damage in the earlier stages of the experiment and that result in the shortage of the seeds grown .Bowman consider good for both fresh and wastewater with nearly complete growth of all the seeds . For the freshwater irrigated cultivars , S42IL107 had 30 spike which is the highest number among the cultivars , although this cultivar type showed a weak growth and late days to flowering and mature but its gave a good number of spikes ,while BW284 had the least spike number (14) among the other types but this can explained by the shortage of the seeds number grown (10 seeds out of 15) .For the simulated wastewater irrigated cultivars , Scarlett had the highest spike number (69) followed by BW281 (66) and finally G400 with only 21 spikes , whish related to the shortage of the seeds number(12) as discussed before .

On the other hand , its observed that the spike number of the cultivars that irrigated with simulated wastewater was nearly twice the number of that irrigated with fresh water , taking in consideration that there's a relation between the seeds number and the spikes grown: as the seeds number is higher , the spikes obtained was with higher numbers too .

As a conclusion, S42IL107 was the best cultivar in the spike/plant when irrigated with freshwater with percent (2.86), while in simulated wastewater, scarlet was the best with (5.3) spike/plant. For both fresh and simulated wastewater, G400 was the worst with (1.13) spike/plant .in freshwater and (1.7) spike/plant in the simulated wastewater. Among the types, nearly no significant could be observed, S42IL107 had the higher yield (average spike/plant), while BW284, Scarlett, Bowman, BW281, BW290, and finally G400 had nearly the same average with no significant (Means with the same letter are not significantly different). Figure(4.2) below summarize the results obtained.



Figure(4.2) : Average spike/plant of barley irrigated with freshwater and simulated wastewater .

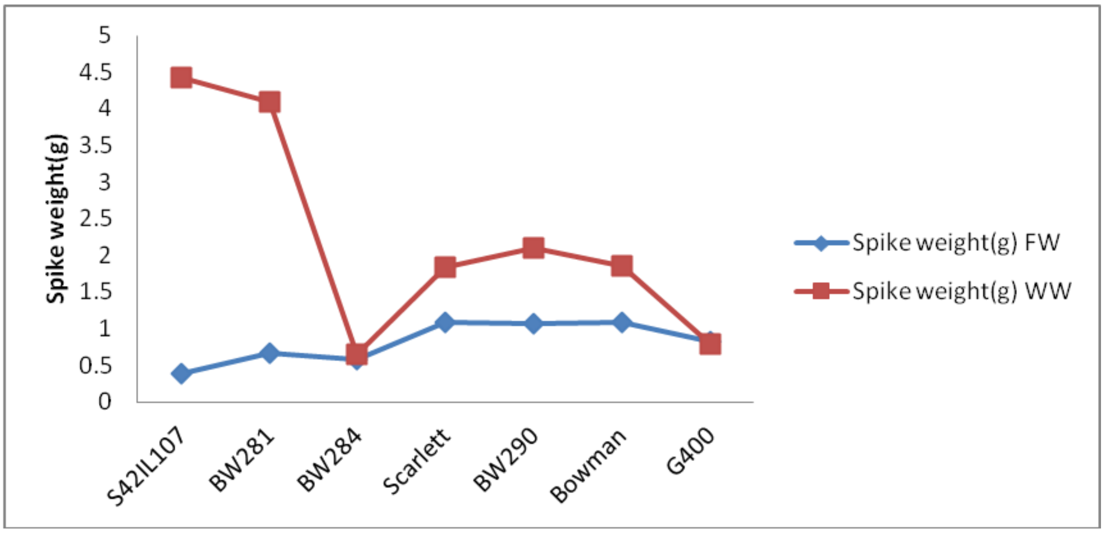
On the other hand, Final grain yield is made up of three components, the most consistent of which is average grain weight. Most yield variation between sites and seasons is due to differences in grain number rather than grain size. There is a strong relationship between grain number/m2 (ears/m2 x grains/ear) and yield, but only a weak relationship between average grain weight and yield. High yields come from achieving the correct ear/spike numbers, maintaining a healthy, green leaf canopy, increasing grain numbers per ear (spike) and grain size. A balanced crop nutrition program including all macro and micro nutrients is essential to help manage all of these components. Spring barley yields about 20% less than winter barley. In spring barley, 30-35% of grain carbohydrate comes from the flag leaf and peduncle (stem), 25-45% from the ear and 20-45% from the rest of the plant. [31]

4.2.2 Average spike weight (g) and length (cm)

High significant could be observed among the type of water, the plants irrigated with simulated wastewater gave nearly twice weight of spikes higher than that irrigated with fresh water .That’s lead to that there was significant increase in spikes weight for the simulated wastewater if compared with freshwater. See table (4.3) for the results.

It could be observed that Bowman and Scarlett had the same spike weight (1.08) g when irrigated with freshwater , followed by BW290 .While in simulated wastewater, S42IL107 was the best in spike weight with (4.4) g followed by BW281(4.1) g.by comparing the spike weight of cultivars irrigated with freshwater with that irrigated with simulated wastewater, it was observed that the spike weight in simulated wastewater is much better by twice time nearly, S42IL107 had (0.32) g in freshwater and (4.4) in simulated wastewater and that’s indicate that using simulated wastewater for irrigation increase the weight of the spikes, and thus increase the yield obtained. On the other hand ,there is a differences observed among the cultivars types irrigated with fresh water , Bowman and scarlet had the same spike weight , followed by BW290 ,G400 , BW281 with (0.66)g average weight , and finally S42IL107 whish was the worst in weight (0.32)g. For the simulated wastewater, S42IL107 was the best with (4.4) g followed by BW281 (4.1) g, while BW290 was better than Bowman and scarlet, BW284 showed the worst results with (0.6) g spike weight.

From a statistical point view , spike weight means with the same letter per column are not significant at ($p \leq 0.05$).For the spike weight of cultivars irrigated with freshwater,it was noticed that both Bowman (1.08^{a}) , BW290 (1.07^{a}) and Scarlet (1.08^{a}) had nearly the same means with similar leteers ,which indicate that no significant observed among these three cultivars when irrigated with freshwater .BW281 (0.66^{ab}),BW284(0.58^{ab}) and G400 (0.83^{ab}) also represent no significant with similar means , For S42IL107(0.39^{b}) asignificant observed among the other types.On the other hand, for the spike weight of cultivars irrigated with simulated wastewater, asignificant difference observed aong the seven types with means with different leters.S41IL107 had a mean (4.43^{a}), followed by BW281(4.10^{ab}) with no significant between them,Scarlet(1.84^{bc}) ,BW290(2.10^{bc}) and Bowman(1.85^{bc}) had no significant difference with similar means, and finally G400 nd BW284 had no significant difference with means (0.79^{c}) and (0.65^{c}) respectively .Figure(4.3) below summarize the results.



Figure(4.3) : Average spike weight of barley irrigated with freshwater and simulated wastewater

Barley grain size is determined by the plants genetics i.e. the variety, and length of the grain filling period. As soon as pollination has occurred the embryo and endosperm begin to develop with the plant redirecting pHotosynthates and also previously stored starch and protein (in leaves and stems) to these developing grains. The longer this period of grain fill is, the larger the barley grain size is likely to be. Besides nutrient management, the grain size can be influenced by water management (irrigation to avoid drought stress), as well as disease management – use fungicides and nutrients to maintain the green leaf area and awns, reducing disease incidence through [43]

For the **average spike length (cm)** , high significant could be observed among the type of water, the plants irrigated with simulated wastewater gave higher spikes length than that irrigated with fresh water and that's lead to that there was significant increase in spikes length for the simulated wastewater if compared with freshwater. See table (4.3).

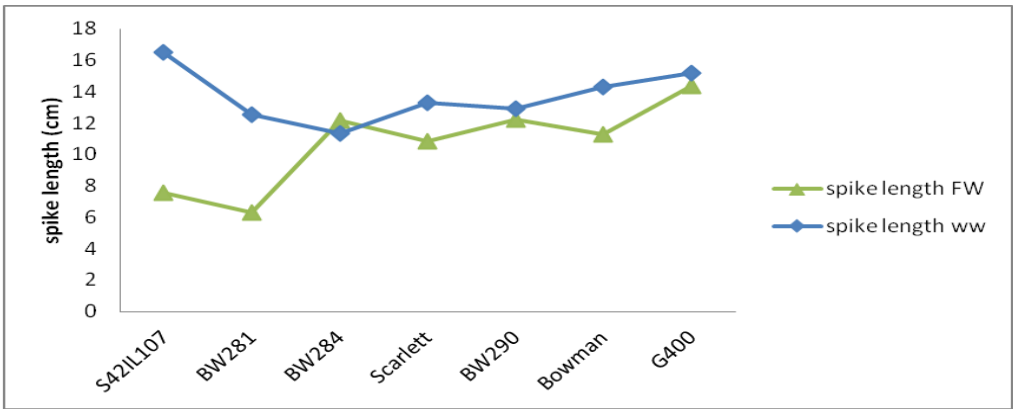
It could be observed that G400 had the taller spike length (14.33) cm when irrigated with freshwater , followed by BW290 and BW284 that had nearly the same length of (12 cm) .While in simulated wastewater, S42IL107 was the best in spike length with (16.5) cm followed by Bowman (14.3) cm . by comparing the spike length of cultivars irrigated with freshwater with that irrigated with simulated wastewater , it was observed that the spike length in simulated wastewater is much better in length , for example , S42IL107 had (7.53) cm in freshwater and (16.5) in simulated wastewater and that's indicate that using simulated wastewater for irrigation increase the height of the spikes , and thus increase the spike weight and the yield obtained.

There is a differences observed among the cultivars types irrigated with fresh water , BW281 was the shortest spike length with (6.33) cm and G400 had the best spike height followed by BW290 , BW284, Bowman with (11.30) cm average height , and finally Scarlett and S42IL107 whish was the second worst type after BW281 with (7.53)cm. For the simulated wastewater , S42IL107 was the best with (16.5) cm followed by G400 (15.2) cm, while Bowman was better than BW284, BW290 and scarlet ,BW284 showed the worst results with (11.3) cm spike height.

From a statistical point view, spike length means with different letters per column are with significan difference at ($p \leq 0.05$).For the spike length of cultivars irrigated with fresheater,it was noticed that G400 had the higher mean among the types (14.33^{a}). BW290(12.20^{b}) and BW284 (12.17^{b})

represent no significant with similar means , For Scarlett (10.80^{c}) and Bowman(11.30^{c}) asignificant observed among the other types, finally S42IL107 (7.53^{d}) and BW281(6.33^{e}) had asignificant difference with the lower means among the other types.

On the other hand , for the spike length of cultivars irrigated with simulated wastewater,asignificant observed among the seven types with means with different leters.S41IL107 had a mean (16.50^{a}), followed by Bowman(14.30^{bc}) and G400(15.20^{b}) with no significant difference between them,Scarlet(13.304^{cd}) ,BW290(12.90^{d}) and BW281(12.50^{d}) had no significant with similar means, and finally BW284 with the lower mean (11.33^{e}). See figure(4.4) below



Figure(4.4) : Average spike length of barley irrigated with freshwater and simulated wastewater

4.2.3 Average plant weight (g) and hight (cm)

High significant could be observed among the type of water related to average plant weight (g). (See table 4.3) .It was also noticed that the plants irrigated with simulated wastewater gave higher yield than that irrigated with fresh water and that's all lead to that there was significant increase in plant yield for the simulated wastewater if compared with freshwater. Bowman had the higher yield (2.82) g when irrigated with freshwater , followed by BW290 and scarlet that had nearly the same yield of (2.5 g) While in simulated wastewater, S42IL107 was the best in yield with (9.9) g followed by BW281 (9.4) g . By comparing yield of cultivars irrigated with freshwater with that irrigated with simulated wastewater , it was observed that the yield in simulated wastewater is much better, for example , S42IL107 had (1.13) g in freshwater and (9.9 g) in simulated wastewater and that's indicate that using simulated wastewater for irrigation increase the yield of the plants 9 times than using freshwater for this cultivar type .For types irrigated with simulated wastewater, it was observed that the yield of BW281 incresed by nearly 9 times , BW284 increased by nearly 3 times Scarlett , Bowman and BW290 by 2 times , and finally G400 increased by nearly 1 time . There is a differences observed among the cultivars types irrigated with fresh water , S42IL107 had the least yield with (1.13) g and Bowman had the best yield followed by Scarlet and BW290 , G400 with (2.18) g average yield , and finally BW284 whish was the second worst type with (1.26)g. For the simulated wastewater, S42IL107 was the best with (9.9) g followed by BW281 (9.4) g, while Bowman was better than BW284, BW290 and scarlet, G400 showed the worst results with (3) g yield. See figure (4.5) that represent the order of the cultivars according to the yield.

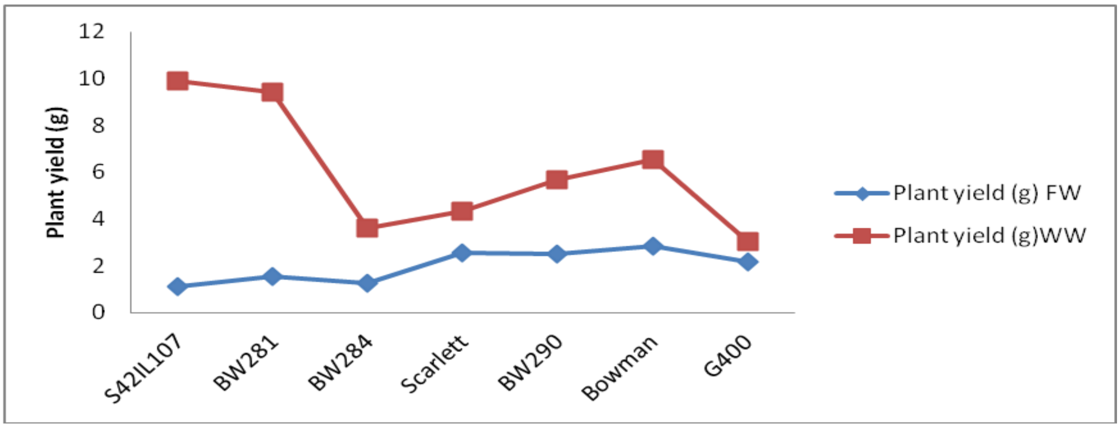


Figure (4.5) : Average plant weight (g) of barley irrigated with freshwater and simulated wastewater .

From the statistical results,it could be observed that in freshwater no significant among these cultivars with nearly the same means with similar letters (Bowman,G400,Scarlet and BW290) where BW281, BW284 and S42IL107 also with no significant difference ,For simulated wastewater , S42IL107 and BW281 had the best yield with means (9.90^{a}) and (9.43^{a}) respectively ,where the other types had also the same means with the same letters which indicate no significant among these types when irrigated with simulated wastewater.

Other studys found that irrigation can increase the productivity of farming activities from 100% to 400% and allow certain crops to be grown in regions with unfavorable environmental conditions. Agriculture accounts for 70%-95% of the water taken in certain developing countries. Recycling wastewater 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 improve the soil fertility.

For the **average plant height (cm),** The average plant height represented in Table (4.3) shows that a significant difference could be observed among the type of water, the plants irrigated with both simulated wastewater and fresh water had nearly the same height with slightly different in means. That’s all lead to that there was a significant increase in plant height for the simulated wastewater if compared with freshwater. G400 had the higher height (37.23) cm when irrigated with freshwater, followed by BW281, then Bowman and scarlet that had nearly the same height of (35.63 cm) .While in simulated wastewater, S42IL107 was the best in height with (39.5) cm followed by BW281 (39.1) cm.by comparing the height of cultivars irrigated with freshwater with that irrigated with simulated wastewater , it was observed that the height in simulated wastewater is better in some cultivars , where in other the freshwater was the best, for example , S42IL107 had (32.87) cm in freshwater and (39.5 cm) in simulated wastewater and that’s indicate that using simulated wastewater for irrigation increase the height of the plants ,on the other hand Scarlet had (35.63) cm height in freshwater , while the height decrease in simulated wastewater (25.5) cm. but at the end we can conclude that the type of water not of high significant to affect the plant height .

There is a differences observed among the cultivars types irrigated with fresh water , BW284 had the least plant height (27.10) cm and G400 had the best yield followed by Bowman , Scarlet and BW281 , and finally S42IL107 whish was the second worst type with (32.87)cm. For the simulated wastewater, S42IL107 was the best with (39.5) cm followed by

BW281 (39.1) cm, while Bowman was better than BW284, G400 and scarlet, BW290 showed the worst results with (23.5 cm height. See Figure (4.6) that represent the order of the cultivars according to the height.

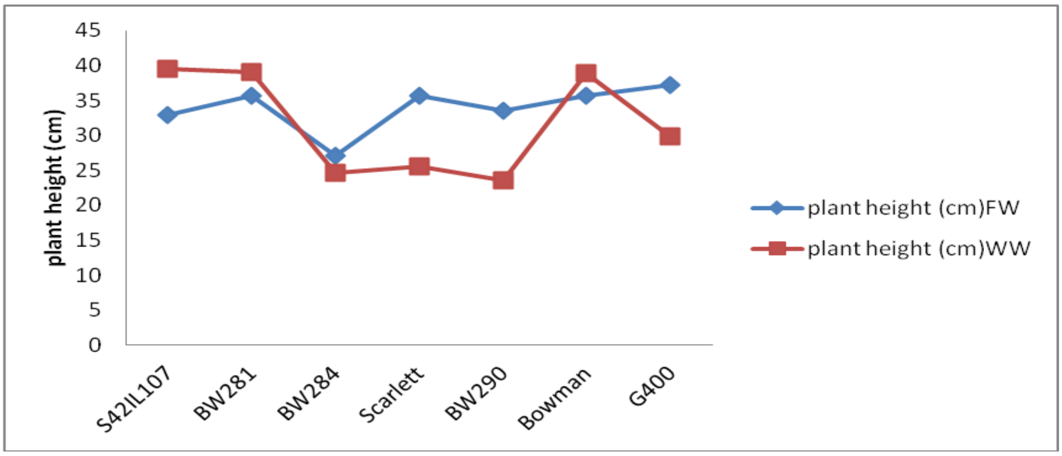


Figure (4.6) : Average plant height (cm) of barley irrigated with freshwater and simulated wastewater .

4.2.4 Average root weight (g)

Average root weight represented in table (4.3) showed that a significant difference was observed among the type of water related to average root weight (g) .It was also noticed that the plants irrigated with both simulated wastewater and fresh water had nearly the same root weight with slightly difference in means.

Scarlet had the higher root weight (1.03) g when irrigated with freshwater , followed by G400 then Bowman and BW290 .While in simulated wastewater, S42IL107 was the best in root weight with (2.1) g as well as Bowman , then followed by BW281 (1.8) g . by comparing the weight of cultivars irrigated with freshwater with that irrigated with simulated wastewater , it was observed that the weight in simulated wastewater is better than that irrigated with fresh water. for example , BW281 had (0.41) g in freshwater and (1.8) g in simulated wastewater and that's indicate that using simulated wastewater for irrigation increase the weight of the plants .So ,we can conclude that the type of water affect the root weight and so the plant yield .

There is a differences observed among the cultivars types irrigated with fresh water , BW284 had the worst root weight (0.27) g and Scarlet had the best root weight followed by G400, Bowman and BW290 , and finally S42IL107 whish was the second worst type with (0.39)g. For the simulated wastewater, S42IL107 and Bowman were the best with (2.1) g followed by BW281 (1.8) g, while G400 and BW290 had the same weight of (0.6), BW284 showed the worst results with (0.4) g weight . From a statistical point view , the root weight means with the same letter per column are not significan difference at ($p \leq 0.05$).For the root weight of cultivars irrigated with freshwater,it was noticed that Scarlett (1.03^{a}) had the best root weight.BW290 (0.54^{bc}), Bowman (0.64^{b}) and G400 (0.67^{b}) also represent no significant with similar means , S42IL107 had a mean (0.39^{cd}), followed by BW281 (0.41^{cd}) and BW281(0.27^{d})with no significant between them.On the other hand, for the root weight of cultivars irrigated with simulated wastewater, no significant observed among these types with nearly similar means with similar letters (S41IL107 had a mean (2.10^{a}), (Bowman 2.13^{a}) and BW281(1.84^{a}) .also no significant found between BW281 (0.42^{b}) BW290 (0.64^{b}), Scarlett (0.54^{b}) and G400(0.60^{b}).Figure (4.7) below summarize the discussed results.

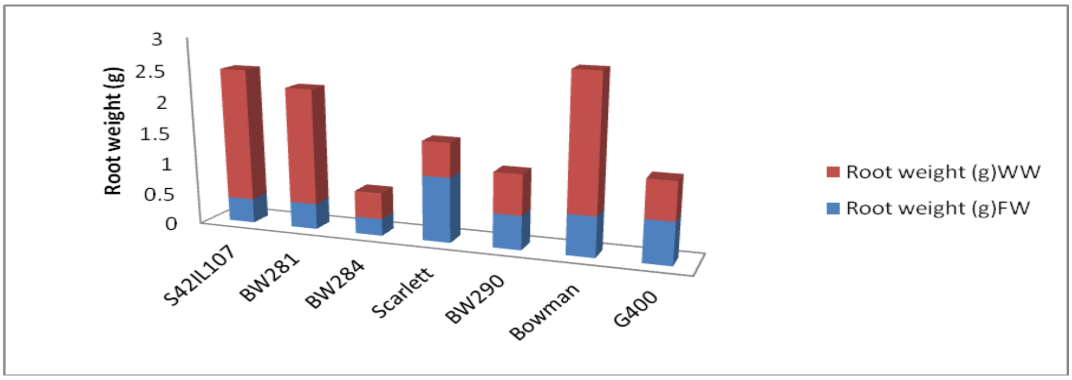


Figure (4.7) : Average root weight (g) of barley irrigated with freshwater and simulated wastewater .

4.2.5 Average stem weight (g)

A significant could be observed among the type of water related to average stem weight (g) .It was also noticed that the plants irrigated with simulated wastewater gave higher stem weight than that irrigated with fresh water . Bowman had the higher stem weight (0.95) g when irrigated with freshwater , followed by BW290 , then G400 and BW281 that had (0.63 g) .While in simulated wastewater, S42IL107 was the best in stem weight with (3.3) g followed by BW281 (3.2) g . By comparing the weight of cultivars irrigated with freshwater with that irrigated with simulated wastewater, it was observed that the weight in simulated wastewater is better than freshwater ,for example S42IL107 had (0.40) g in freshwater and (3.3 g) in simulated wastewater and that's indicate that using simulated wastewater for irrigation increase the stem weight of the plants .So, we can conclude that the type of water is significant and affect the plant yield .There is a differences observed among the cultivars types irrigated with fresh water , S42IL107 had the least stem weight (0.40) g and Bowman had the best stem weight followed by BW290 G400 and

BW281 , and finally BW284 whish was the second worst type with (0.44)g. For the simulated wastewater, S42IL107 was the best with (3.3) g followed by BW281 (3.2) g, while BW290 was better than BW284 and scarlet, G400 showed the worst results with (1.7) g. Figure (4.8) below summarize the discussed results.

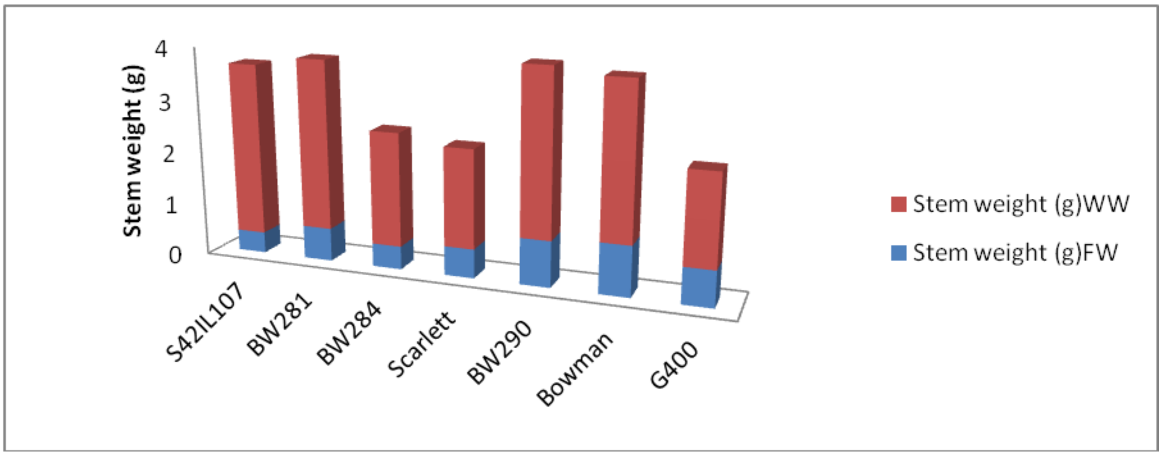


Figure (4.8) : Average stem weight (g) of barley irrigated with freshwater and simulated wastewater .

From a statistical point view , stem weight means with the same letters per column are not significan difference at ($p \leq 0.05$).For the stem weight of cultivars irrigated with freshwater,it was noticed that both Bowman (0.95^{a}), BW290 (0.87^{ab}) and G400 (0.68^{abc}) and BW281(0.63^{abc}) had nearly the same means with similar letters ,which indicate that no significant observed among these cultivars when irrigated with freshwater . Scarlett (0.55^{bc}),BW284(0.44^{c}) and S42IL107 (0.40^{c}) also represent no significant.On the other hand , for the stem weight of cultivars irrigated with simulated wastewater, no significant observed among these types with means with same leters.S41IL107 had a mean (3.27^{a}), BW281(3.21^{a}), BW290 (3.11[a]), Bowman(2.90[ab]) and BW284 (2.15[abc]). Olso no significant between, G400 (1.71[c]) and Scarlett (1.86[bc]).

4.3 Barley Uptake of nutrient.

4.3.1 pH comparison

PH is a measurement of acidity or basicity .This test helps to determine the values of the soil pH after and before the irrigation. The normal range of pH for irrigation water is (6.5-8). pH values were measured using a pH meter [41]

pH comparison between soil irrigated with fresh water and simulated wastewater after and before the irrigation process showed that no significant observed in the soil pH before the irrigation, where a significant could be observed among the type of water for the soil pH after the irrigation process .It was also noticed that the soil irrigated with simulated wastewater gave higher acidity than that irrigated with fresh water ,and that's all lead to that there was a significant decrease in pH for the simulated wastewater if compared with freshwater. See tables (4. 5) below.

Table (4.5): Average Soil pH of barley irrigated with freshwater and simulated wastewater.

Barley lines	Soil pH before		Soil pH after	
	F.W	WW	F.W	WW
S42IL107	7.5[a]		7.64[b]	7.62[a]
BW281	7.5[a]		7.73 [a]	7.44[b]
BW284	7.5[a]		7.59[bc]	7.51[ab]
Scarlett	7.5[a]		7.52[c]	6.63[e]
BW290	7.5[a]		7.13[f]	7.10[c]
Bowman	7.5[a]		7.23[e]	6.72[ed]
G400	7.5[a]		7.42[d]	6.76[d]

Means with the same letter are not significantly different.

Soil pH before is not significant at $p \leq 0.05$ % for both fresh and simulated wastewater.

Soil pH after is significant at $p \leq 0.05$ % relating to the cultivar type and the water type at p=0.05% .

Table (4.5) represent the difference in soil pH between the soil after and before the irrigation , no significant difference could be observed among the pH in the soil before the irrigation. While there's a significant difference among the types after the soil was irrigated, It was also noticed that nearly all the seven types had high acidity that comes from the simulated wastewater. As conclusion , the soil pH was affected by the type of water , using the wastewater reduce the pH of the soil to make it more acidity , but still in the acceptable range that suitable for the soil and with no negative impacts on the environment . It was also noticed that nearly all the soils had high acidity that comes from the simulated wastewater. The results of pH where the values range between 7.13 and 7.73 in freshwater, and 6.63-7.44 in simulated wastewater. These results were expected since all the sampling locations are classified the same and the only difference was in the type of water used in the irrigation process during the experemient period.There are no significant changes between pH values at all locations before the irrigation since the original soil of these locations are the same where a significant observed after the irrigation of simulated wastewater .

4.3.2 Total dissolved solids (TDS)

TDS comparison were carried between barley irrigated with freshwater and simulated wastewater after and before the irrigation process .From the below table (4.6), no significant observed in the soil TDS before the irrigation, where a significant difference could be observed among the type of water for the soil TDS after the irrigation process. It was also noticed that the plants irrigated with simulated wastewater gave higher salinity (TDS) than that irrigated with fresh water.

Table (4.6): TDS of barley irrigated with freshwater and simulated wastewater.

Line	TDS-Soil Before (mg/l)	TDS-Water (mg/l)		TDS-Soil After (mg/l)	
		F.W	WW	F.W	WW
S42IL107	350.00^{a}	384.00^{a}	1492.00^{a}	228.33^{f}	1144.70^{b}
BW281	350.00^{a}	384.00^{a}	1492.00^{a}	304.33^{d}	760.50^{e}
BW284	350.00^{a}	384.00^{a}	1492.00^{a}	396.67^{b}	1212.30^{a}
Scarlett	350.00^{a}	384.00^{a}	1492.00^{a}	393.67^{b}	1165.70^{b}
BW290	350.00^{a}	384.00^{a}	1492.00^{a}	332.33^{c}	906.00^{d}
Bowman	350.00^{a}	384.00^{a}	1492.00^{a}	458.00^{a}	1015.70^{c}
G400	350.00^{a}	384.00^{a}	1492.00^{a}	269.33^{e}	1034.30^{c}

Means with the same letter are not significantly different.

It could be observed that a significant increase in TDS for the concentration simulated wastewater if compared with the salinity of the cultivars that were irrigated with freshwater, when freshwater of TDS=384 µs was used to irrigate the seven types of the barley cultivars planting in a soil of TDS = 350 , the soil was slightly affected by the salinity of the freshwater and stay within the range of its salinity before the planting , some differences observed among the salinity of the soil related to the cultivars types , in the container of the soil were S42IL107 was planting , the soil TDS =228.33 mg/l whish is the least salinity if compared with the other types , were Bowman had the higher soil salinity (TDS) after planting that = 458 mg/l , the other types ranges from 304 -396 mg/l but still in the acceptable range of the soil salinity that's suitable for planting .See table (4.6) for more details.

The soil salinity before the irrigation process was the same of all the seven cultivars (350 mg/l) to insure that any increase in the salinity occurred after the irrigation related to the type of water not to the soil used for planting .The salinity increased by nearly 3 times according to the type of water , the simulated wastewater that was used had a salinity of TDS=1492 mg/l which is 4 times the salinity of the fresh water (384 mg/l),that could explain that the increase in the soil salinity after the irrigation of simulated wastewater comes from the type of water .

The difference in soil TDS between the barley cultivars after and before the irrigation, no significant could be observed among the TDS in the soil before the irrigation. also there’s no significant difference among the types after the soil was irrigated .It was also noticed that BW284 nearly had high salinity that comes from the simulated wastewater compares with other types followed by, scarlet, S42IL107, G400, Bowman ,BW290, and finally BW281which had less TDS value (760.50).

For the types that irrigated with freshwater , a slightly increase in the salinity comes from the freshwater (384 mg/l), Bowman had the higher soil salinity compared with the other types (458 mg/l) followed by BW284 ,Scarlet and BW290, where BW281 and G400 had leas soil salinity compared with them. On the other hand, for the types irrigated with simulated wastewater, BW281 had the least soil salinity of (760.5) mg/l whish indicate that this cultivar is good tolerance to the salinity of the soil and could absorbed high amount of salinity and reduce it from the soil

.BW284 had the higher salinity of (1212.3) mg/l followed by Scarlet , S42IL107 , G400 and Bowman, where BW290 showed the second best cultivar in absorbing the salinity with (906) mg/l TDS .

By combing the results of both fresh and wastewater , it could be noted that the salinity increased among all the seven barley types when irrigated with simulated wastewater ,the increase differ from type to type , the cultivar that had the higher soil TDS represent that this cultivar is not of a good tolerance to the salinity that comes from the water , in simulated wastewater, BW284 had a soil salinity of 3 times more than in fresh water,(1212.3) mg/l in simulated wastewater while (396.67 mg/l) in freshwater. Other types showed the same percent of increase nearly, for example: BW290 and Scarlet increased 3 times of salinity in simulated wastewater compared with freshwater.G400 and S42IL107 had high increased by 4 and 5 times respectively .

So , it should be concluded that the cultivars type had a differences in tolerating the salinity of water used in irrigation and that using simulated wastewater increased the soil salinity , this results is similar to [24] that found that irrigation with simulated wastewater increases soil salinity, increases nutrient contents . in addition other studies similar to this research gave nearly the same results , [29] 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 [29].

Similar studies were carried on barley cultivars showed nearly the same results , [47] 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 [47].

Other studies related to the salinity was conducted , [48] 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.

As aresult, it could be conclouded that the salinity problems will increase by increasing the salt concentrationof 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 such as barley .

On the other hand, 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 aunit 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 [46].

4.3.3 Nitrogen of plant tissues

Nitrogen comparison between barley cultivars irrigated with fresh water and simulated wastewater after and before irrigation process . From table (4.7) below, there’s no significant difference observed in the soil N% before the irrigation, where a significant difference could be observed among the type of water for the soil N% after the irrigation process .It was also noticed that the plants irrigated with simulated wastewater had higher N% than that irrigated with fresh water .

The results showed that the simulated wastewater contain more nitrogen content than freshwater , the simulated wastewater contain (0.0163) % N were the fresh water contain (0.0072) % N .It was observed that the soil before the planting was contain (0.46) %N , after planting , the nitrogen content in the soil decreased for both the cultivars irrigated with fresh and simulated wastewater . So , it could be noticed that the soil irrigated with simulated wastewater absorbed more nitrogen than the soil irrigated with freshwater, the increase in nitrogen content of simulated wastewater was nearly twice than that of freshwater. See table (4.7) below.

Table (4.7): Nitrogen data of barley irrigated with freshwater and simulated wastewater.

Line	Nitrogen before planting %	N % in irrigation water		N%-Soil After		N%-Root		N%-Spike		N%-Stem	
		F.W	WW	F.W	WW	F.W	WW	F.W	WW	F.W	WW
S42IL107	0.46[a]	0.0072[a]	0.0163[a]	0.14[e]	0.17[c]	0.49[f]	1.07[d]	1.37[f]	1.60[f]	0.56[c]	0.63[f]
BW281	0.46[a]	0.0072[a]	0.0163[a]	0.13[f]	0.15[d]	0.62[a]	0.93[e]	1.41[e]	1.70[e]	0.65[b]	0.63[f]
BW284	0.46[a]	0.0072[a]	0.0163[a]	0.17[b]	0.19[b]	0.45[g]	0.95[e]	1.58[b]	2.10[b]	0.82[a]	0.85[d]
Scarlett	0.46[a]	0.0072[a]	0.0163[a]	0.14[d]	0.21[a]	0.53[d]	0.70[f]	1.56[c]	1.90[c]	0.54[e]	0.88[c]
BW290	0.46[a]	0.0072[a]	0.0163[a]	0.14[f]	0.22[a]	0.60[b]	1.43[a]	1.45[d]	1.80[d]	0.36[f]	0.94[b]
Bowman	0.46[a]	0.0072[a]	0.0163[a]	0.15[c]	0.15[d]	0.51[e]	1.22[b]	1.55[c]	1.80[c]	0.56[c]	0.79[e]
G400	0.46[a]	0.0072[a]	0.0163[a]	0.21[a]	0.22[a]	0.59[c]	1.12[c]	1.78[a]	2.50[a]	0.55[d]	0.99[a]

No significant difference was observed among the N% in the soil before the irrigation. While a significant difference observed among the types after the soil was irrigated, the nitrogen content of the types irrigated with simulated wastewater was nearly twice than that irrigated with freshwater. For freshwater, G400 cultivar absorbed the higher nitrogen content by the soil among the other types with N%=0.21 while BW281 absorbed the lower nitrogen content with N% of (0.13). For simulated wastewater, nearly all the cultivars absorbed the same amount of nitrogen by the soil, with N% =0.2 ,while BW281 absorbed the lower nitrogen content with %N of (0.1). There is a differences observed among the cultivars types irrigated with fresh water , G400 was absorbed the highest amount of nitrogen content by the soil with (0.21) followed by BW284 and Bowman that had (0.15) , where S42IL107 , Scarlett and BW290 had the same nitrogen content with (0.14) % and finally BW281 whish had the lowest amount of nitrogen content . For the simulated wastewater , BW281 was the lowest with (0.1) N% , the other types had the same nitrogen content of (0.2) N% .

4.3.3. A Nitrogen (N %) – Root

A significant could be observed among the type of water related to N%-Root . It was also noticed that the roots of the plants irrigated with simulated wastewater absorbed higher nitrogen than that irrigated with fresh water. See table (4.7).

The results showed that the cultivars irrigated with simulated wastewater absorb more nitrogen content by the root than the cultivars irrigated with freshwater. For freshwater, BW281 cultivar absorbed the higher nitrogen content by the root among the other types with N%=0.62 while BW284 absorbed the lower nitrogen content with N% of (0.45). For simulated wastewater , BW290 cultivar absorbed the higher nitrogen content by the root among the other types with N%=1.4 while Scarlett absorbed the lower nitrogen content with N% of (0.7).There is a differences observed among the cultivars types irrigated with fresh water, BW281 was absorbed the highest amount of nitrogen content by the root with (0.62) followed by BW290 and G400 that had (0.59), followed by Scarlett, Bowman and S42IL107 . For the simulated wastewater, Scarlett was the lowest with (0.7) N% , where BW290 had the higher nitrogen content of (1.4) N% . See figure (4.12) below.

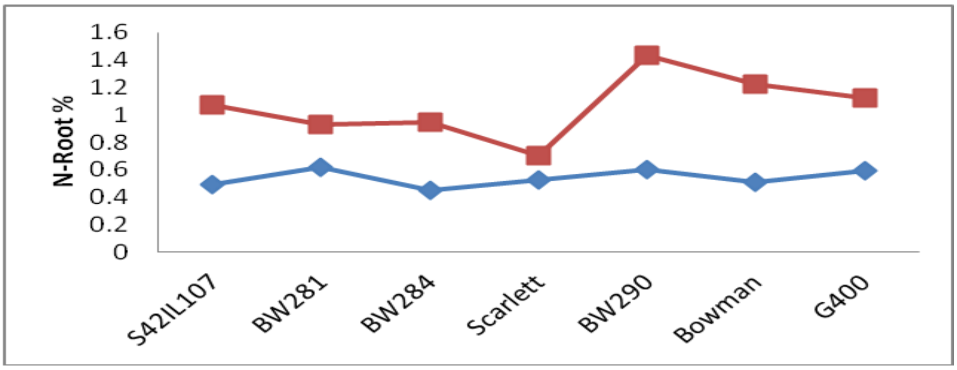


Figure (4.9) : N% of the root of plants irrigated with both fresh and simulated wastewater .

4.3.3 . B Nitrogen (N%) of Spike

The nitrogen content of the spike shown in Table(4.7) , no significant could be observed among the type of water related to N%-Spike although the spikes of the plants irrigated with simulated wastewater absorbed higher nitrogen than that irrigated with fresh water.For freshwater , G400 cultivar absorbed the higher nitrogen content by the spike among the other types with N%=1.78 while S42IL107absorbed the lower nitrogen content with N% of (1.37) . For simulated wastewater, G400 cultivar absorbed the higher nitrogen content by the spike among the other types with N%=2.5 while S42IL107 absorbed the lower nitrogen content with N% of (1.6). See figure (4.13)below.

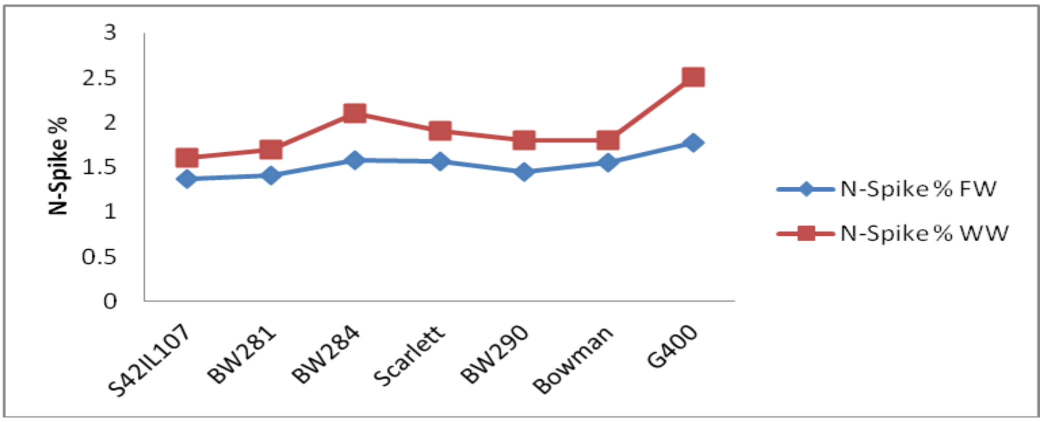


Figure (4.10) : N% of the spike of plants irrigated with both fresh and simulated wastewater .

4.3.3. C Nitrogen (N%) of Stem

A significant could be observed among the type of water, the stems of the plants irrigated with simulated wastewater absorbed higher nitrogen than that irrigated with fresh water. The cultivars irrigated with simulated wastewater absorb more nitrogen content by the stem than the cultivars irrigated with freshwater. For freshwater, BW284 cultivar absorbed the higher nitrogen content by the stem among the other types with N%=0.82 while BW290 absorbed the lower nitrogen content with N% of (0.36). For simulated wastewater, G400 cultivar absorbed the higher nitrogen content by the stem among the other types with N%=1 while BW281 absorbed the lower nitrogen content with N% of (0.6) as well as S42IL107 .

There is a differences observed among the cultivars types irrigated with fresh water , BW284 was absorbed the highest amount of nitrogen content by the stem with (0.82) followed by BW281 and S42IL107 and Bowman that had the same percentage (0.56), followed by finally G400 and Scarlett, and . For the simulated wastewater , BW281 and S42IL107 were the lowest with (0.6) N% , where G400 had the higher nitrogen content of (1) N% .

As aconclosion ,the wastewater contains very variable proportions of nutrient 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. See figure (4.13)below.

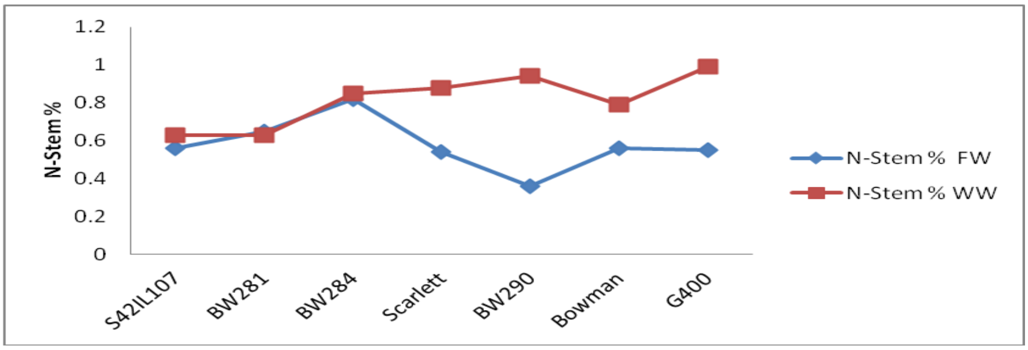


Figure (4.11) : N% of the stem of plants irrigated with both fresh and simulated wastewater .

Other studies showed that 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 wastewater 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. Plant essential nutrient (total N, P, and K) were higher in plants grown in soils irrigated with simulated wastewater for different cultivers. The soil of the types irrigated with simulated wastewater absorbed more nitrogen than the soil irrigated with freshwater, the increase in nitrogen content of simulated wastewater was nearly twice than that of freshwater. On the other hand , the roots , stems and the spikes of the plants irrigated with simulated wastewater absorbed higher nitrogen than that irrigated with fresh water.

The enhancement of plant N content with simulated wastewater application indicates that simulated wastewater application provided the soil with these nutrients which enhanced required for plant growth and soil fertility. However, nitrate content should be monitored periodically to avoid its accumulation to critical levels that might affect its quality for animal feeds.

Nitrogen concentration in plant shoots was reported to be higher when grown with simulated wastewater [49], who found that N recovery in plants with simulated wastewater was higher than the N recovery in plant material grown with fresh water. These results were attributed to significant increase in soil nitrogen with simulated wastewater irrigation compared with the control. These results were attributed to significant increase in soil nitrogen with simulated wastewater irrigation compared with the control. On the other hand, Papadopoulos and Stylianou [42] reported that during the third irrigation season for trickle irrigation cotton (Gossypium hirsutum L. cv.), the NO3-N in petioles was greater with the treated effluent supplemented with no nitrogen, also in lamina; NO3-N was greater at sampling of the lower N level.

4.3.4 Potassium (K) comparison

Potassium (K) comparison between barley irrigated with fresh water and simulated wastewater after and before the irrigation process showed in Tables(4.8), no significant observed in the soil K before the irrigation, where a significant could be observed among the type of water for the soil K after the irrigation process .It was also noticed that the plants irrigated with simulated wastewater had higher K than that irrigated with fresh .That's all lead to that there was a significant increase in K content in soil for the simulated wastewater if compared with freshwater. The simulated wastewater contain (88) ppm were the fresh water contain (4.8) ppm ,it was observed that the soil before the planting was contain (210) ppm , after the planting , the potassium content in the soil decreased for both the cultivars irrigated with fresh and simulated wastewater .So , it could be noticed that the soil of the types irrigated with simulated wastewater absorbed more potassium than the soil irrigated with freshwater, the increase in potassium content of simulated wastewater was nearly 3 times more than that of freshwater which related to the amount of potassium found in the simulated wastewater.

Table (4.8) represents the difference in soil K between the barley cultivars after and before the irrigation , no significant could be observed among the

K in the soil before the irrigation , where a significant difference observed among the types after the soil was irrigated .See table (4.8) below.

Table (4.8): Potassium (K) data of barley irrigated with freshwater and simulated wastewater.

Line	K-soil before (ppm)	K-water (ppm)		K-Soil After (ppm)		K-Root (ppm)		K-Spike (ppm)		K-Stem (ppm)	
		F.W	WW	F.W	WW	F.W	WW	F.W	WW	F.W	WW
S42IL107	210.00^{a}	4.80^{a}	88.0^{a}	12.77^{g}	83.30^{f}	28.67^{b}	7.50^{d}	64.33^{abc}	39.60^{c}	116.67^{b}	106.70^{b}
BW281	210.00^{a}	4.80^{a}	88.0^{a}	15.17^{f}	173.00^{c}	31.67^{ab}	26.50^{b}	66.00^{ab}	58.40^{b}	136.33^{a}	113.70^{a}
BW284	210.00^{a}	4.80^{a}	88.0^{a}	36.67^{b}	136.70^{d}	16.03^{c}	8.70^{d}	61.00^{bc}	40.20^{c}	104.00^{c}	68.90^{d}
Scarlett	210.00^{a}	4.80^{a}	88.0^{a}	29.13^{c}	103.40^{e}	37.53^{a}	21.40^{c}	72.33^{a}	93.10^{a}	114.00^{b}	50.80^{e}
BW290	210.00^{a}	4.80^{a}	88.0^{a}	44.43^{a}	193.70^{b}	27.33^{b}	36.30^{a}	57.17^{c}	91.40^{a}	105.10^{c}	84.70^{c}
Bowman	210.00^{a}	4.80^{a}	88.0^{a}	20.13^{e}	112.20^{e}	11.77^{c}	8.60^{d}	35.93^{d}	45.50^{c}	95.17^{d}	87.40^{c}
G400	210.00^{a}	4.80^{a}	88.0^{a}	25.83^{d}	234.00^{a}	12.83^{c}	4.30^{e}	42.00^{d}	22.40^{d}	69.30^{e}	20.90^{f}

From the potassium (K) data of the soil, it was observed that BW290 cultivar absorbed the higher potassium content by the soil among the other types with K=44.43 ppm while S42IL107 absorbed the lower potassium content with K of (12.77) ppm . For simulated wastewater , G400 absorbed the higher potassium content with K of (234)ppm , while S42IL107 absorbed the lower amount (83.3) ppm .There is a differences observed among the cultivars types irrigated with fresh water , BW290 was absorbed the highest amount of potassium content by the soil with (44.43) followed by BW284 and Scarlett that had (29.13) , followed by G400 , Bowman and BW281 and finally BW281 whish had the second lowest amount of potassium content . For the simulated wastewater , S42IL1071 was the lowest with (83.3) ppm where G400 was the highest with (234) ppm.

4.3.4. A Potassium (K) –Root

A significant observed among the type of water related to K-Root. It was also noticed that the roots of the plants irrigated with fresh water absorbed higher K content than that irrigated with simulated wastewater. That’s all lead to that there was a significant decrease in root K content for the concentration simulated wastewater if compared with freshwater.

From table (4.8), the results showed that the cultivars irrigated with simulated wastewater absorb less potassium content by the root than the cultivars irrigated with freshwater For freshwater , Scarlett cultivar absorbed the higher potassium content by the root among the other types with K=37.53ppm while Bowman absorbed the lower potassium content with K of (11.77)ppm . For simulated wastewater, BW290 cultivar absorbed the higher potassium content by the root among the other types with K=36.3 while G400 absorbed the lower potassium content with K of (4.3)ppm.

There is a differences observed among the cultivars types irrigated with fresh water relating to the summary tables , Scarlett was absorbed the highest amount of potassium content by the root with (37.53)ppm followed by BW281 and S42IL107 that had (028.6),where G400 had the second least potassium (12.83) ppm. For the simulated wastewater, G400 was the lowest with (4.3) ppm , where BW290 had the higher potassium content of (36.6) ppm .

4.3.4. B Potassium(K)-Spike

A significant observed among the type of water related to K-Spike .It was also noticed that the spikes of the plants irrigated with freshwater absorbed higher K content than that irrigated with simulated wastewater .That's all lead to that there was a significant decrease in spike K content for the concentration simulated wastewater if compared with freshwater.

The results showed that the cultivars irrigated with simulated wastewater absorb less potassium content by the spike than the cultivars irrigated with freshwater . For freshwater , Scarlett cultivar absorbed the higher potassium content by the spike among the other types with K=72.33 ppm while Bowman absorbed the lower potassium content with K of (35.93)ppm . For simulated wastewater , Scarlett cultivar absorbed the higher potassium content by the spike among the other types with K=93.1ppm while G400 absorbed the lower potassium content with K of (22.4)ppm. It could be observed from the results that the spike absorbed more potassium than the others part of the plant that irrigated with the same type of water , also it could be noticed that the plants irrigated with simulated wastewater absorbed less potassium content than the cultivars irrigated with freshwater.

4.3.4. C Potassium (K) of Stem

From table (4.8), a significant could be observed among the type of water related to K-Stem. It was also noticed that the stems of the plants irrigated with freshwater absorbed higher potassium than that irrigated with simulated wastewater, a significant decrease in stem content of potassium for the concentration simulated wastewater if compared with freshwater.

the results showed that the cultivars irrigated with simulated wastewater absorb less potassium content by the stem than the cultivars irrigated with freshwater . For freshwater , BW281 cultivar absorbed the higher potassium content by the stem among the other types with K=136.33 ppm while G400 absorbed the lower potassium content with K of (69.3) ppm . For simulated wastewater , BW281 cultivar absorbed the higher potassium content by the stem among the other types with K=113.7 ppm while G400 absorbed the lower potassium content with K of (20.9) ppm .It could be observed that cultivars irrigated with simulated wastewater absorb low amounts of the potassium through the root , spike and stem , although the stem had the higher amount absorbed , but by comparing with the freshwater , low absorption of potassium occurred after the irrigation process . The figures below(15,16,17) summarized the results.

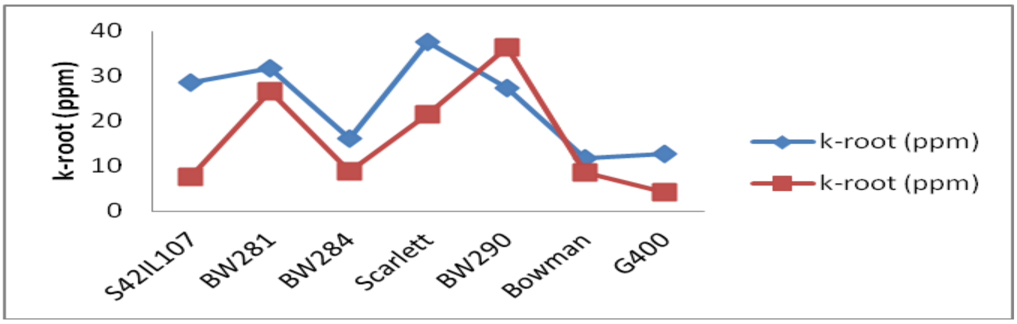


Figure (4.12) : k-root (ppm) for fresh and simulated wastewater .

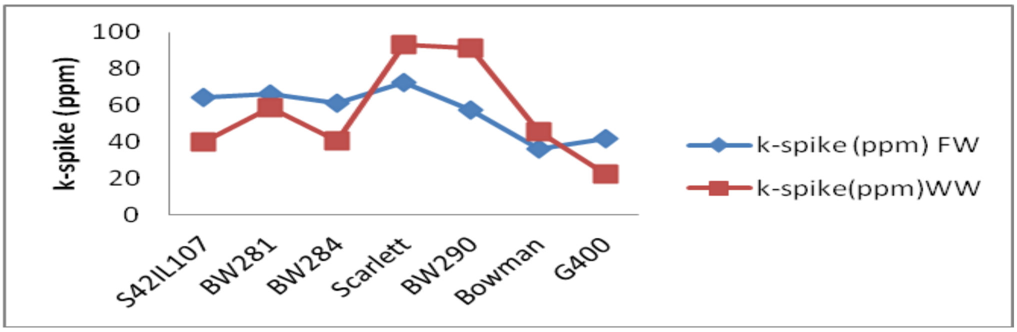


Figure (4.13) : k-spike(ppm) for fresh and simulated wastewater .

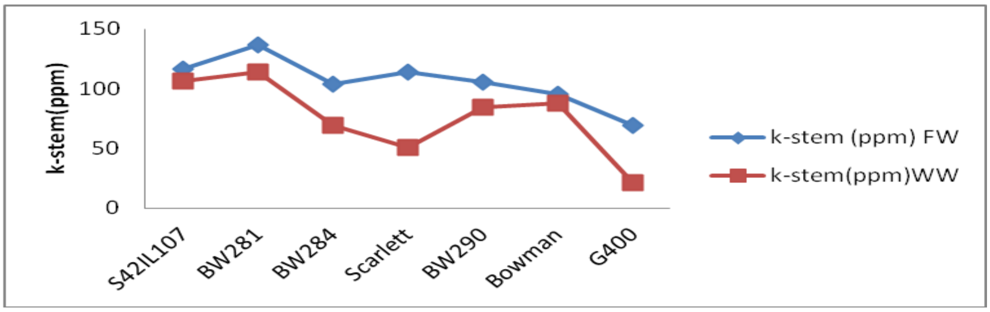


Figure (4.14) : k-stem (ppm) for fresh and simulated wastewater .

4.3.5 Phosphorous (P) comparison

Phosphorous (P) comparison between barley irrigated with fresh water and simulated wastewater after and before the irrigation process represented in Tables(4.9), no significant observed in the soil P before the irrigation, where a significant could be observed among the type of water for the soil P after the irrigation process .It was also noticed that the plants irrigated with simulated wastewater had higher P than that irrigated with fresh water ,there was a significant increase in P content in soil for the concentration simulated wastewater if compared with freshwater.

The results showed that the simulated wastewater contain more phosphorous content than the freshwater , the simulated wastewater contain (3.3)ppm were the fresh water contain (0.62) ppm .It was observed that the soil before the planting was contain (1.5) ppm , after the planting , the phosphorous content in the soil decreased for both the cultivars irrigated with fresh and simulated wastewater . So , it could be noticed that the soil irrigated with simulated wastewater absorbed more phosphorous than the soil irrigated with freshwater, the increase in phosphorous content of simulated wastewater was nearly 2 times more than that of freshwater which related to the amount of phosphorous found in the simulated wastewater. See table (4.9).

Table (4.9): Phosphorous (P) data of barley irrigated with freshwater and simulated wastewater.

Line	P-soil before (ppm)	P-water (ppm)		P-Soil After (ppm)		P-Root (ppm)		P-Spike (ppm)		P-Stem (ppm)	
		F.W	WW	F.W	WW	F.W	WW	F.W	WW	F.W	WW
S42IL107	1.50[a]	0.62[a]	3.30[a]	0.20[d]	0.30[f]	0.27[b]	3.70[c]	0.47[c]	5.10[a]	0.09[d]	3.50[b]
BW281	1.50[a]	0.62[a]	3.30[a]	0.23[d]	0.40[e]	0.15[bc]	5.20[a]	0.26[d]	4.00[ab]	0.21[cd]	4.20[a]
BW284	1.50[a]	0.62[a]	3.30[a]	0.24[d]	0.40[e]	1.35[a]	4.50[b]	0.32[cd]	3.20[b]	1.30[a]	4.20[a]
Scarlett	1.50[a]	0.62[a]	3.30[a]	0.63[b]	0.80[c]	1.30[a]	3.20[c]	0.45[c]	4.00[ab]	0.47[b]	2.60[c]
BW290	1.50[a]	0.62[a]	3.30[a]	0.19[d]	1.30[b]	0.10[c]	1.30[d]	2.66[a]	4.00[ab]	0.09[d]	0.60[d]
Bowman	1.50[a]	0.62[a]	3.30[a]	0.37[c]	0.70[d]	0.28[b]	0.90[de]	0.22[d]	4.60[a]	0.26[c]	0.80[d]
G400	1.50[a]	0.62[a]	3.30[a]	0.92[a]	1.70[a]	0.29[b]	0.74[e]	1.69[b]	4.60[a]	0.33[c]	0.72[d]

From the phosphorous (P) data of the soil, its observed that the phosphorous content of the plants irrigated with simulated wastewater was nearly 2 times more than that irrigated with freshwater. For freshwater, G400 cultivar absorbed the higher phosphorous content by the soil among the other types with P=0.92 ppm while BW290 absorbed the lower phosphorous content with P of (0.19) ppm . For simulated wastewater, G400 absorbed the higher phosphorous content with P of (1.7) ppm , while S42IL107 absorbed the lower amount (0.3) ppm. There is a differences observed among the cultivars types irrigated with fresh water , G400 was absorbed the highest amount of phosphorous content by the soil with (0.92) followed by Scarlett and Bowman that had (0.37)ppm , followed by BW284, and BW281 and finally S42IL107 which had the second lowest amount of phosphorous content . For the simulated wastewater, S42IL107 was the lowest with (0.3) ppm where G400 was the highest with (1.7) ppm.

4.3.5. A Phosphorous (P) –Root

The phosphorous content in the root represent that a significant could be observed among the type of water, the plants irrigated with simulated wastewater absorbed higher P content than that irrigated with fresh water.That’s all lead to that there was a significant increase in root P content for the concentration simulated wastewater if compared with freshwater.

The results showed that the cultivars irrigated with simulated wastewater absorb more phosphorous content by the root than the cultivars irrigated with freshwater. For freshwater, BW284 cultivar absorbed the higher phosphorous content by the root among the other types with P=1.35 ppm while BW290 absorbed the lower phosphorous content with P of (0.1) ppm . For simulated wastewater, BW281 cultivar absorbed the higher phosphorous content by the root among the other types with P=5.2 while G400 absorbed the lower phosphorous content with P of (0.74) ppm. There is a differences observed among the cultivars types irrigated with fresh water, BW284 was absorbed the highest amount of phosphorous content by the root with (1.35)ppm followed by Scarlett and G400 that had (0.29),where BW281 had the second least phosphorous (0.15) ppm. For the simulated wastewater, G400 was the lowest with (0.74) ppm , where BW281 had the higher phosphorous content of (5.2) ppm .

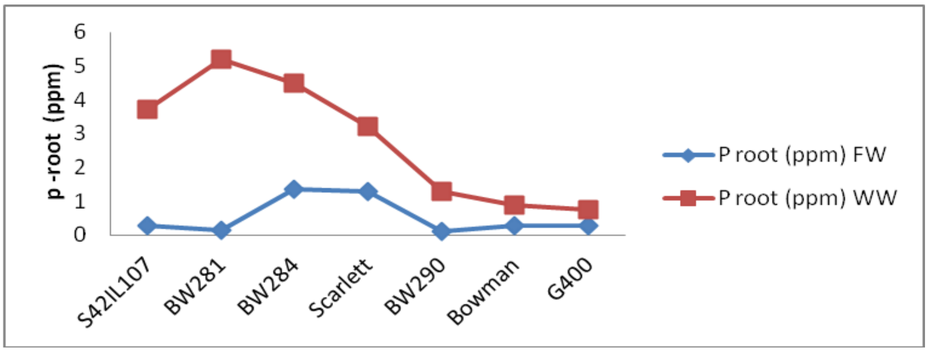


Figure (4.15) : P-root (ppm) for fresh and simulated wastewater .

4.3.5. B Phosphorous(P)-Spike

From table (4.9) , a significant could be observed among the type of water related to P-Spike .It was also noticed that the spikes of the plants irrigated with simulated wastewater absorbed higher P content than that irrigated with freshwater ,the cultivars irrigated with simulated wastewater absorb more phosphorous content by the spike than the cultivars irrigated with freshwater. For freshwater , BW290 cultivar absorbed the higher phosphorous content by the spike among the other types with P=2.66 ppm while Bowman absorbed the lower phosphorous content with P of (0.22) ppm . For simulated wastewater, S42IL107 cultivar absorbed the higher phosphorous content by the spike among the other types with P=5.1 ppm while BW284 absorbed the lower phosphorous content with P of (3.2)ppm. It could be observed from the results that the spike absorbed more phosphorous than the others part of the plant that irrigated with the same type of water , also it could be noted that the plants irrigated with simulated wastewater absorbed more phosphorous content than the cultivars irrigated with freshwater.

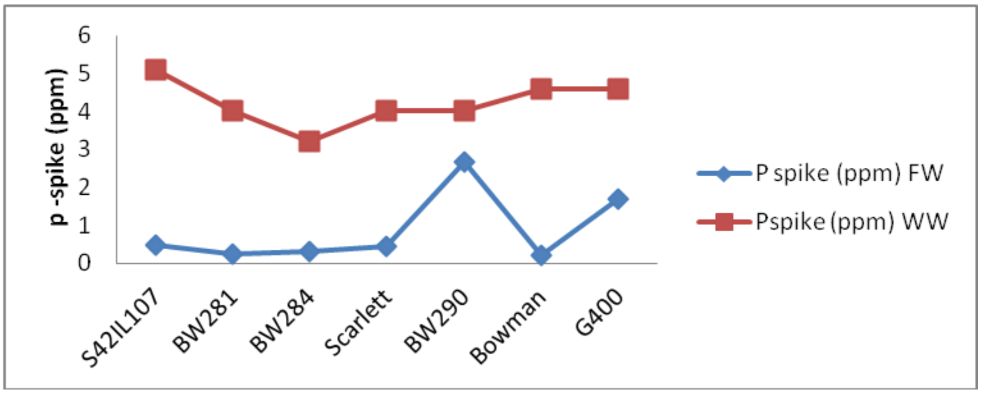


Figure (4.16) : P-spike (ppm) for fresh and simulated wastewater .

4.3.5. C Phosphorous (P) for Stem

Table (4.9) represent that a significant could be observed among the type of water related to P-Stem. the stems of the plants irrigated with simulated wastewater absorbed higher phosphorous than that irrigated with freshwater .The results showed that the cultivars irrigated with simulated wastewater absorb more phosphorous content by the stem than the cultivars irrigated with freshwater . For freshwater , BW284 cultivar absorbed the higher phosphorous content by the stem among the other types with P=1.30 ppm while S42IL107 absorbed the lower phosphorous content with P of (0.09)ppm as well as BW290. For simulated wastewater , BW284 and BW281 cultivars absorbed the higher phosphorous content by the stem among the other types with P=4.2 ppm while BW290 absorbed the lower phosphorous content with P of (0.6)ppm. It could be observed that cultivars irrigated with simulated wastewater absorb more amounts of the phosphorous through the root , spike and stem , although the spike had the higher amount absorbed compared with the stem and the root , but the absorption after the irrigation of simulated wastewater was better for all the parts of the plants compared with the freshwater.

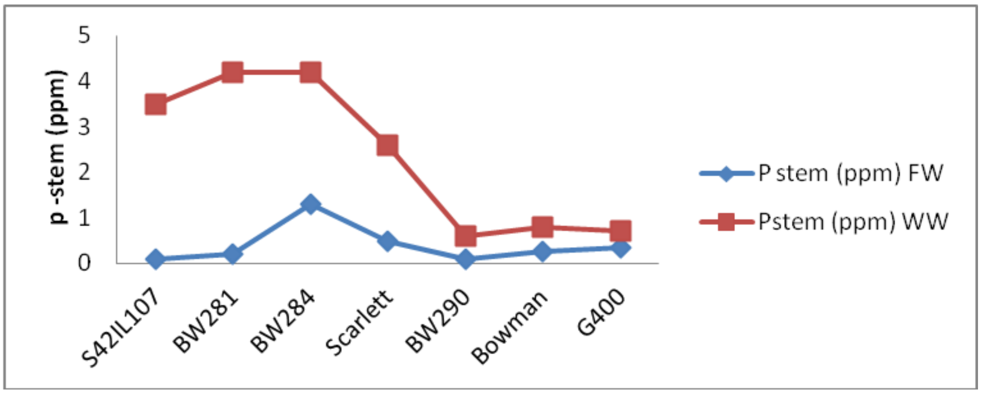


Figure (4.17) : P-stem (ppm) for fresh and simulated wastewater .

4.4 Model Development

The interactive effects of the type of water on the plant and the soil on the growth and the yield of the plant were investigated. It was found that the biomass production increased considerably when the plants irrigated with simulated wastewater with acceptable properties. It could be noticed that the yield of the plant depends mainly on two variables; the type of water used for irrigation and the cultiver of the seed. Table (4.10) represent the observed yield data obtained through the experiment.

Table (4.10): Plant yield under freshwater and wastewate irrigation.

Seed type	Plant Yield (g)		Plant Yield (hectar)	
	FW	WW	FW	WW
S42IL107	0.32	4.4	1332.8	18326
BW281	0.66	4.1	2748.9	17076.5
BW284	0.58	0.6	2415.7	2499
Scarlett	1.08	1.8	4498.2	7497
BW290	1.07	2.1	4456.55	8746.5
Bowman	1.08	1.9	4498.2	7913.5
G400	0.83	0.8	3456.95	3332

* Data represented in (Table (4.10) are averages .

Regarding to **Regression** the model should be as:

$$\mathbf{Y = a + b_1x_1 + b_2x_2 + \ldots\ldots + b_n\, x_n}$$

Where:

Y = the dependent variable.

X= the predictor (independent) variable.

A= the intercept (the value of Y when X is zero) .

B= the slope (the value that y will change by if x changes one unite).

The dependent variable (yield) tables and the coefficient required for the above model represented in Tables 4.11 and 4.12 and Figure 4.1 below .

4.4.1 Plant yield model summary

The output (table 4.11 and 4.12) , shows that the independent variables able to predict dependent variables. From the measures in the table we can say that the predictors explained about 0.589 from the changes which happened in the dependent variables "average plant yield". According to [44] that's means that the model is strong fit. figure (4.1 and 4.2) represent the normal P-P plot of regression for yield.

Table (4.11) : Model summary of plant yield

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	0.768a	0.589	0.568	8.05926	0.589	28.001	2	39	0.000

a. Predictors: (Constant), The Kind of water, The replicate number, The type of seeds

b. Dependent Variable: Average plant yield

The general model equation:

$$\mathbf{Y = a + b_1\, x_1 + b_2 x_2}$$

Where: Y the dependent variable= yield

X_1 the independent variable = type of seeds

X_2 the independent variable = kind of water

A the intercept the value of y when x is zero.

The Coefficient output gives us very important information which are necessary to build our model. Regarding to the table the values of B which called b coefficients, its value means that the dependent variable average plant yield will change 0.448 if the type of seeds will change the effect of the type of seeds is positive) . On the other hand, when the kind of water increased one unit the average plant yield will increased which means that the effect of the kind of water is positive for dependent variable.

The Model equation according to the results obtained from the above tables will be :

$$\mathbf{Y = - 4.441 + 0.448 * X_1 + 18.709 * X_2}$$

Where:

Y= Yield / unit area / season

X_1= the value of the type of seeds (weight of the seeds in g)

X_2= the value of kind of water (amount of water in L)

Table (4.12) below represent the model summary of plant yield and the Coefficients that used to build in the model obtained .

Table (4.12): Model summary of plant yield/Coefficients

Coefficients[a]

Model	Unstandardized Coefficients		Standardized Coefficients			95% Confidence Interval for B		Collinearity Statistics	
	B	Std. Error	Beta	t	Sig.	Lower Bound	Upper Bound	Tolerance	VIF
1 (Constant)	-4.441-	3.981		-1.116-	.271	-12.493-	3.611		
The type of seeds	-.448-	.245	-.190-	-1.829-	.075	-.943-	.047	.979	1.021
The Kind of water	18.709	2.513	.772	7.444	.000	13.625	23.792	.979	1.021

a. Dependent Variable: Average plant yield

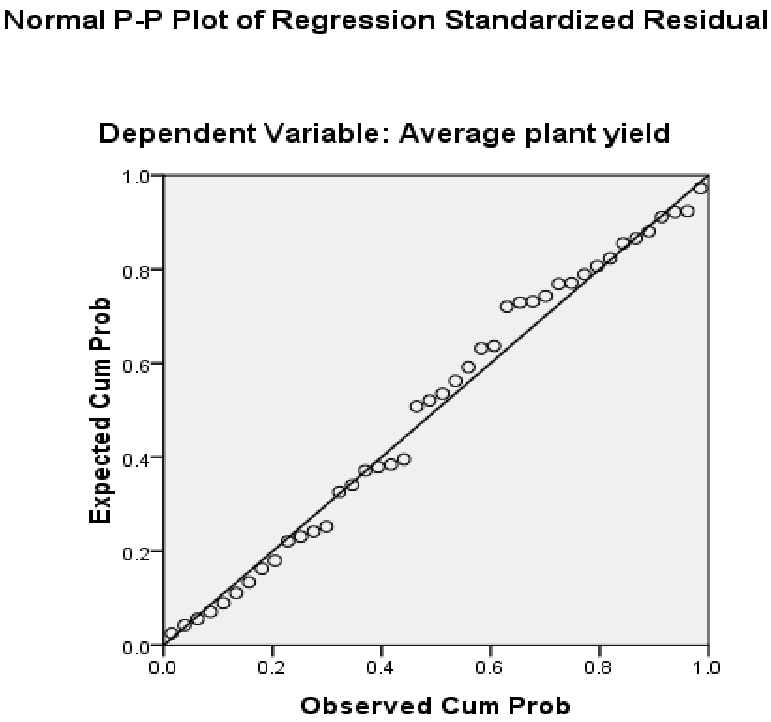


Figure (4.18) : Normal P-P plot of regression for yield .

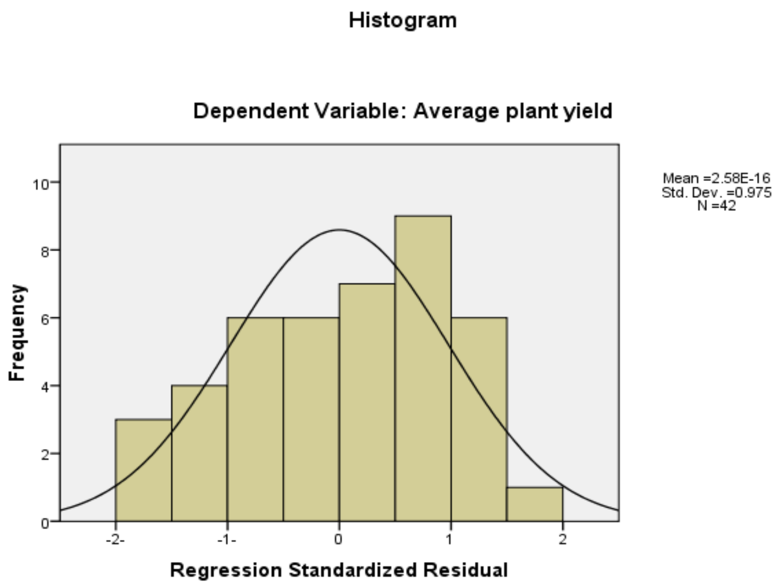


Figure (4.19) : Normal P-P plot of regression for yield .

Figure(4.1) and (4.2) represent the Normal P-P plot of regression for the yield , the figures shows that the date followed a normal distribution that fit nearly the perfect line or come around it with some obtained points that set away from the prefect results .

By comparing the yield results obtained from the experiment (data in tables (4.10) with the output of the model , the following figures obtained (figure 4.3) and (4.4) :

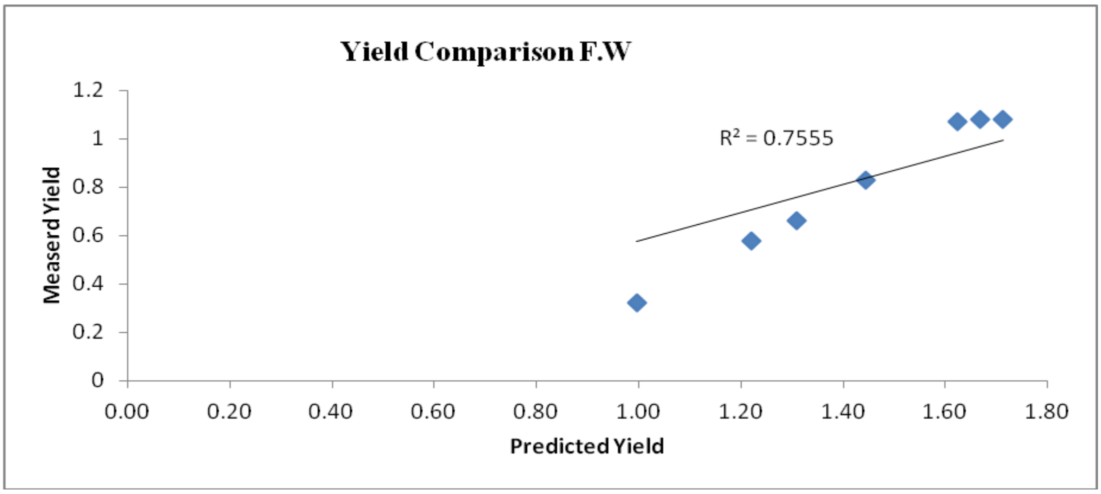


Figure (4.20) : measured and observed results of the yield for freshwater.

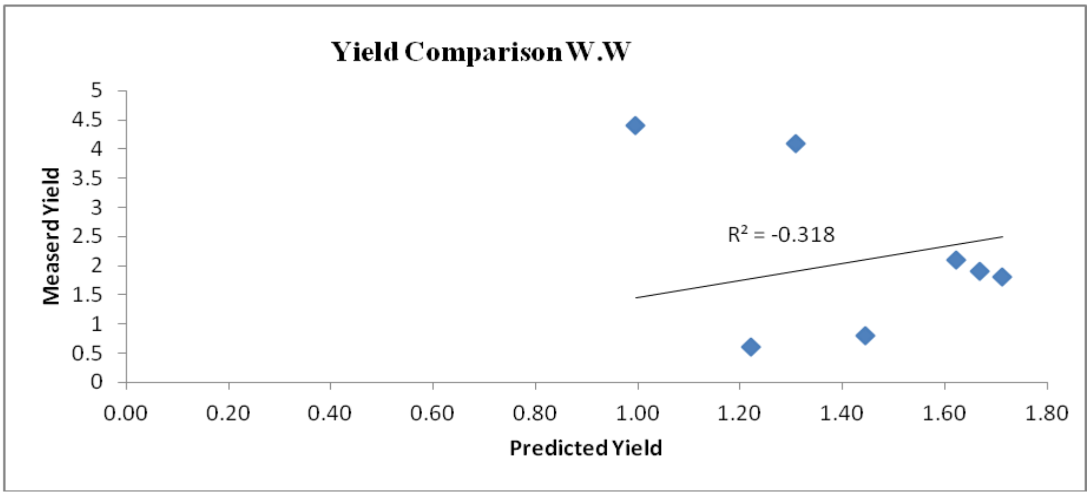


Figure (4.21) : measured and observed results of the yield for simulated wastewater.

The obtained model could be helpful when used to calculate the yield to the plants irrigated with freshwater when the amount of water used for irrigation were known and the weight of the seeds before the planting , the results obtained from the model nearly close to that from the experiment (R^2 =0.75) , On the hand , the model failed in describing the yield obtained from the simulated wastewater because the model concerned in the quantity of water used for irrigation not the quality , and that's lead to that the noticeable increase in the yield of the plants that irrigated with simulated wastewater related to the nutrients contained in the simulated wastewater (nitrogen , phosphorous and potassium) not the amount used (R^2 = -0.318).

From the other studies that carried in the same field, [26] 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 Stalinization processes.

4.5 Summary

The biomass production of barley as an animal feed measured as fresh weight and dry weight in farm per one meter, compared to crops grown in the control (where simulated wastewater was never applied) biomass production was significantly higher. Both added simulated wastewater and nutrients provided with simulated wastewater application can be attributed to such increase in biomass production [10]. Similar results were reported by Day et al. [40] who observed that wheat irrigated with simulated wastewater produced taller plants, more heads per unit area, heavier seeds, higher grain yields than did wheat grown with pump water alone. They attributed this increase to the nitrogen and phosphorus in the added simulated wastewater.

The results showed that the barley cultivars irrigated with both fresh and simulated wastewater had in general the same growth vigor and growth nature , G400 had the best erect growth vigor while S42IL107 had the weakest prostrate growth ,also the branch numbers of cultivars irrigated with simulated wastewater was more than that for freshwater . Plants irrigated with both simulated wastewater and freshwater required the same time to (emergence , stem elongation, flowering and maturity) with no significant observed among the water types, while a significant observed among the barly types .

It's clearly observed that plants irrigated with simulated wastewater gave nearly twice yield higher than that irrigated with fresh water , Although , plants irrigated with both simulated wastewater and fresh water had nearly the same height with slightly different in mean , high significant could be observed among the types. BW281 had the higher plant height.The spikes averge weight increased for the plants irrigated with simulated wastewater and also gave higher spikes length than that irrigated with fresh water ,and this Prove that the simulated wastewater is better in irrigation to obtain higher yield since it contain more usefull nutrirnts that improve the plants growth and give higher yields .Plants irrigated with simulated wastewater had nearly the same root weight while plants irrigated with simulated wastewater gave higher stem weight than that irrigated with fresh water .

In the average, the simulated wastewater is alkaline with basic pH value of 7.3 and had a moderate level of total dissolved solids (TDS) of 1490 mg L^{-1} , The simulated wastewater contains considerable amount of nitrate, phosphate and potassium which are considered essential nutrients for improving plant growth and soil fertility and productivity levels.

The soil is characterized by being basic and calcareous with pH value of 7.8 and has a fine texture. The soil is moderately saline with TDS (350 **mg/l**) and high potassium content , but poor in nitrogen and pHospHorus content.

Simulated wastewater irrigation increased significantly the soil N, P, and K, Several researchers reported accumulation of N, P, and K in the soil with simulated wastewater application which was attributed to the original contents of these nutrients in the simulated wastewater applied [48]. Simulated wastewater can provide N, P, and K in amount equal to 4, 10 and 8 time of the fertilizers requirement of the forage crops [47]. These results agree with those reported by [3,46] who found that extractable pHospHorus was higher in soils irrigated with simulated wastewater than in soil irrigated with fresh water or rainfall water.

Plant essential nutrient (total N, P, and K) were higher in plants grown in soils irrigated with simulated wastewater for different cultivers. The soil of the types irrigated with simulated wastewater absorbed more nitrogen than the soil irrigated with freshwater, the increase in nitrogen content of simulated wastewater was nearly twice than that of freshwater. On the other hand , the roots , stems and the spikes of the plants irrigated with simulated wastewater absorbed higher nitrogen than that irrigated with fresh water.

The enhancement of plant N content with simulated wastewater application indicates that simulated wastewater application provided the soil with these nutrients which enhanced required for plant growth and soil fertility. However, nitrate content should be monitored periodically to avoid its accumulation to critical levels that might affect its quality for animal feeds.

Nitrogen concentration in plant shoots was reported to be higher when grown with simulated wastewater [44] found that N recovery in plants with simulated wastewater was higher than the N recovery in plant material grown with fresh water. These results were attributed to significant increase in soil nitrogen with simulated wastewater irrigation compared with the control. These results were attributed to significant increase in soil nitrogen with simulated wastewater irrigation compared with the control. On the other hand, Papadopoulos and Stylianou [41] reported that during the third irrigation season for trickle irrigation cotton (Gossypium hirsutum L. cv.), the NO3-N in petioles was greater with the treated effluent supplemented with no nitrogen, also in lamina; NO3-N was greater at sampling of the lower N level.

the increase in potassium content (K) of simulated wastewater was nearly 3 times more than that of freshwater which related to the amount of potassium found in the simulated wastewater. the roots of the plants irrigated with fresh water absorbed higher K content than that irrigated with simulated wastewater, the same results were obtained for the stem and the spike.

The plants irrigated with simulated wastewater had higher Phosphorous content than that irrigated with fresh water. the roots of the plants irrigated with simulated wastewater absorbed higher Phosphorous content than that irrigated with fresh water, the same results were obtained for the stem and the spike.

Soil and crop quality parameters are significantly affected by simulated wastewater irrigation. This is mainly determined by the management of simulated wastewater irrigation and its composition. In addition, continuous irrigation with simulated wastewater may lead to accumulation of salts, plant nutrients and heavy metals beyond crop tolerance levels. Therefore, these concerns should be essential components of any management of simulated wastewater irrigation. On the other hand, plant growth, soil fertility and productivity can be enhanced with properly managed simulated wastewater irrigation, through increasing levels of plant nutrients and soil organic matter. It can be concluded, based on these results that proper management of simulated wastewater irrigation and periodic monitoring of soil fertility and quality parameters are required to ensure successful, safe and long term reuse of simulated wastewater for irrigation.

The Model equation according to the results obtained will be :

$$\mathbf{Y = -\ 4.441 + 0.448 * X1 + 18.709 * X2}$$

The obtained model could be helpful when used to calculate the yield to the plants when the amount of water used for irrigation were known and the weight of the seeds before the planting .

Chapter 5
Conclusion & Recommendations

5.1 Conclusion

The following are the research main conclusions:

1- The growth vigor as well as the growth period (from days to emergence to maturity) were not affected with the type of water and only depend on the type of the cultiver.

2- The yields vary relating to the type of water used for irrigation .The highest yield were obtained in the plants irrigated with simulated wastewater, the cultivars irrigated with simulated wastewater gave nearly twice the yield of that irrigated with freshwater .BW290 cultivar showed the best highest yield among the seven types.

3- The use of simulated wastewater in irrigation increases the nitrogen(N) , phosphorous (P) and potassium (K) contents in soil profiles .The quality of water used in irrigation affects the soil through increasing the concentrations of some constituents such as nitrogen potassium and phosphorous.

4- Soil irrigated with simulated wastewater contain more nitrogen than the soil irrigated with freshwater, the increase in nitrogen content of simulated wastewater was nearly twice than that of freshwater and that results in increase of the nitrogen content in the plant parts . The nitrogen accumlate mainly in the root which had the higher N % compared with amount accumlated by both the stem and the spike

,where the N% of the spike was nearly higher than the stem (N% – Root > N%- Spike , N% - Stem) .

5- Plant absorbed the potassium through the root and the spike and stem and that's related to the fact that the potassium is slowly move in the soil in addition to that it react with the elements found in the simulated wastewater and thus decreased in the plants.

(K% – Stem> K%- Root , K% - Spike) .

6- The soil of the cultivers irrigated with simulated wastewater contain more phosphorous than the soil irrigated with freshwater, the phosphorous absorbed mainly in the spike whish had the higher P% compared with amount absorbed by both the stem and the root ,where the P% of the root was nearly higher than the stem (P% – Spike > P%- Stem , P% - Root) .

7- The obtained model could be helpful when used to calculate the yield of the plants when the amount of water used for irrigation and the weight of the seeds were known .

5.2 Recommendations

Based on the outcome of this thesis, the following can be recommended:

1- The potential to develop new crops from the diverse halophytic flora is 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.

2- Build up stations for treating wastewater for facing the water crises especially in arid regions.

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

References

[1] M.F. Al-Rashed and M.M. Sherif, **Water resources in the GCC countries: an overview**, **Water Res. Manag**., 14 (1) (2000) 59–73.

[2] A. Arar, **Water management and conservation measures under semi-arid and arid conditions, in: Optimization of Water in Agriculture, Proceedings of the Regional Seminar; Amman, Jordan**, 21–24 Nov., 1994, p. 177.

[3] M.J. Mohammad and N. Mazahreh, **Changes in soil fertility parameters in response to irrigation of forage crops with secondary treated simulated wastewater, Comm.** Soil Sci. Plant Anal., 34 (9 & 10) (2003) 1281–1294.

[4] S.S. Al-Salem, **Environmental considerations for simulated wastewater reuse in agriculture,** Water Sci. Technol., 33 (10–11) (1996) 345–353.

[5] UNDP, **Sustainable Management of Water Resources and the Aquatic Environment: UNDP s Role to date and strategy framework**. Available online at: UNEP, 2003, Desk Study on the Environment in the Occupied Palestinian Territories Available online: at: [http://www.unep.org/download_file.multilingual.asp?FileID=105] accessed 24 Jul 2015.

[6] N. Haruvy, **Agriculture Reuse of Simulated wastewater: Nation-Wide Cost-Benefit Analysis, Agriculture Ecosystems and Environment**, (1997) Vol. 66, PP. 113-119.

[7] A. Duran ,**Use of wastewater in irrigated agriculture, Country studies from Bolivia, Ghana and Tunisia** ,(2003)

[8] B. Weber, Y. Avnimelech and M. Juanico, **Salt enrichment of municipal sewage - new prevention approaches in Israel, Environ**. Manag., 20 (4) (1996) 487–495.

[9] I. Papadopoulos, **Simulated wastewater management for agriculture protection in the Near East Region, Technical Bulletin, FAO, Regional Office for the Near East,** Cairo, Egypt, 1995.

[10] M.J. Mohammad and M. Ayadi, **Forage yield and nutrient uptake as influenced by secondary treated simulated wastewater, J**. Pl. Nutr., 27 (2) (2004) 351–365.

[11] O. Vazquezmontiel, N.J. **Horan and D.D. Mara, Management of domestic simulated wastewater for reuse in irrigation, Water Sci**. Technol., 33 (10–11) (1996) 355–362.

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

[13] FAO publications , **Reuse of treated wastewater Guidance manual 385-2188-002 FAO user manual for using treated wastewater**. May (2003).

[14] FAO ,**Simulated wastewater Treatment and Use in Agriculture;** Irrigation and Drainage Paper 47. (1992).

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

[16] S. Afifi ,**Simulated wastewater irrigation farm sector interests " International water and irrigation Review 24 " Environmental Eng.** Ho Ward.S. Peavy INT. Edition. **Introduction to Effluent Quality and Reuse** . (1999)

[17] Sposito Garrison , **The Chemistry of Soils, Oxford University Press** (1989).

[18] Wang Z., Chang A.C., Wu L., Crowley D. **Assessing the Soil Quality of Long-Term Reclaimed Simulated wastewater-Irrigation Cropland, Geoderma,** (2003). Vol. 114, PP. 261-278.

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

[20] C. Siebe, **Nutrient inputs to soils and their uptake by alfalfa through long-term irrigation with untreated sewage effluent in**

Mexico, Soil-Use-Manage, CAB International, Oxford, 1998, pp. 119–122.

[21] Weltzien, H.C. and N. Ketterer, 1988. **Control of Downy Mildew, Plasmopara viticola (de Bary) Berlese et de Toni, on grapevine leaves through water extracts from composted organic wastes.** PHytopathology, 76: 1104.

[22] J. Nyamangara and J. Mzezewa, **Effect of long term application of sewage sludge to a grass pasture on organic carbon and nutrients of a clay soil in Zimbabwe, Nutr.** Cycling Agroecosyst., 59 (2000) 13–18.

[23] George Estefan, Rolf Sommer, and John Ryan. **Methods of Soil, Plant, and Water Analysis : A manual for the West Asia and North Africa region.** Third Edition (2013)

[24] Feigin A., Ravina I., Shalhevet J. **Irrigation with Treated Sewage Effluent**. (1991).

[25] Dojlido Jan R., **Best Gerald A. Chemistry of Water and Water Pollution, Ellis Horwood Limited**. (1993).

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

[27] Viviani G. and Iovino M. ***Simulated wastewater Reuse Effects on Soil Hydraulic Conductivity,*** **Journal of Irrigation and Drainage Engineering,** (2004). Vol. 130, pp. 476-482

[28] Sharma R. K., Agrawal M. and Marshall F. **Heavy Metal Contamination of Soil and Vegetables in Suburban Areas of Varanasi, India,** ELSEVIER, Ecotoxicology and Environmental Safety. (2005).

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

[30] 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

[31] Moreno, J.L., Garcı´a, C., Herna´ndez, T., Pascual, J.A., 1996. **Transference of heavy metals from a calcareous soil amended with sewage-sludge compost to barley plants**. Biores. Technol.

55, 251–258.

[32] 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 simulated wastewater irrigated coffee plantation A pilot field study in Brazil**

Agricultural Water Management, Volume 89, Issues 1-2, 16 April 2007, Pages 105-115.

[33] **Central Bureau of Statistics**, 2002 .

[34] Applied Research Institute-Jerusalem (ARIJ) (1994). **Environmental Profile for the West Bank,** (Vol. 3. Chapter 6)

[35] Gosheh, Z. A. (1996). **Developing Barley and Wheat production in West Bank and Gaza Strip. Ramallah, West Bank, Ministry of Agriculture.**

[36] International Center for Agricultural Research in the Dry Areas (ICARDA), ICARDA@cgiar.org www.icarda.org

[37] Hansson, B. **‘‘Risk Aversion as a Problem of Conjoint Measurement,’’ in Decision, Probability, and Utility, eds. P. Gardenfors and N.-E.** Sahlin, Cambridge University Press, (1988), 136-158.

[38] Edwards, W. (ed.) ,**Utility Theories: Measurements and Applications**, Boston: Kluwer. (1992)

[39] Deng, X., Shan, L., Zhang, H., and Turner, N., **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

[40] A.D. Day, J.A. McFadyen, T.C. Tucker and C.B. Cluff, **Commercial production of wheat grain irrigated with municipal wastewater and pump water, J. Environ**. Qual., 8 (1979) 3.

[41] Clesceri L. S., Greenberg A. E. and Eaton A. D. (1998). **Standard Methods for the examination of Water and Simulated wastewater,** 20th edition.

[42] I. Papadopoulos and Y. Stylianou, **Trickle irrigation of cotton with treated effluent, J. Environ**. Qual., 17 (1988) 4.

[43] M.J. Mohammad and M. Ayadi, **Forage yield and nutrient uptake as influenced by secondary treated simulated wastewater,** J. Pl. Nutr., 27 (2) (2004) 351–365.

[44] Cohen, J. & Cohen, P. (1983). **Applied multiple regression correlation analysis for the behavioral sciences (2nd edn).** New York: Erlbaum.

[45] Anonymous. 1992. **Handbook on reference methods for soil analysis.** Soil and plant Analysis Council, Athens, Georgia, USA.

[46] A.D. Day, A. Rahman, F.R. Katterman and J.A. Ryan, **Effect of treated municipal simulated wastewater and commercial fertilizer on growth, fiber, acidsoluble nucleotides, protein, and amino acid content in Wheat Hay, J. Environ**. Qual., 3 (1) (1974) 17–19.

[47] J.C. Burns, P. Westerman, L.D. King, G.A. Cummings, M.R. Overcash and L. Goode, **Swine lagoon effluent applied to coastal bermudagrass:1. Forage yield, quality, and element removal, J. Environ**. Qual., 14 (1) (1985) 9–1

[48] G.T. Monnett, R.B. Reneau and C. Hagedorn, **Evaluation of spray irrigation for on-site simulated wastewater treatment and disposal on marginal soils, Water Environ.** Res., 68 (1) (1996) 11–18.

Appendix A

Table 1: Growth data of barley cultivars

Line	Rep.	Treatment	Days to emergence	Days to stem elongation	Days to flowering	Days to maturity
S42IL107	1	FW	11	62	70	153
S42IL107	2	FW	11	62	70	153
S42IL107	3	FW	11	63	71	153
BW281	1	FW	9	47	62	152
BW281	2	FW	8	47	60	153
BW281	3	FW	9	47	62	152
BW284	1	FW	10	40	51	151
BW284	2	FW	10	41	52	152
BW284	3	FW	11	40	51	151
Scarlett	1	FW	9	38	54	150
Scarlett	2	FW	10	39	54	150
Scarlett	3	FW	9	40	53	150
BW290	1	FW	10	71	76	152
BW290	2	FW	10	72	75	152
BW290	3	FW	11	72	76	150
Bowman	1	FW	8	38	71	149
Bowman	2	FW	8	38	70	150

Bowman	3	FW	9	40	70	149
G400	1	FW	8	36	52	148
G400	2	FW	7	37	52	148
G400	3	FW	8	36	50	147
S42IL107	1	WW	11	61	69	153
S42IL107	2	WW	10	62	70	153
S42IL107	3	WW	11	60	69	152
BW281	1	WW	9	47	62	152
BW281	2	WW	9	47	60	152
BW281	3	WW	9	47	61	150
BW284	1	WW	11	39	51	151
BW284	2	WW	11	40	51	151
BW284	3	WW	10	40	50	151
Scarlett	1	WW	10	38	54	150
Scarlett	2	WW	10	38	53	149
Scarlett	3	WW	9	37	54	150
BW290	1	WW	10	72	76	152
BW290	2	WW	11	70	76	152
BW290	3	WW	10	72	75	152
Bowman	1	WW	8	38	70	149
Bowman	2	WW	9	38	70	148

Bowman	3	WW	9	38	69	149
G400	1	WW	8	36	52	148
G400	2	WW	8	35	50	148
G400	3	WW	9	36	52	147

Table 2 : Yield data of barley cultivars .

Line	Rep.	Treatment	avg. spike/plant	avg .Spike wt. (g)	avg. spike length (cm)	avg. Plant yield (g)
S42IL107	1	FW	2.7	0.234	7.4	1.1
S42IL107	2	FW	3.6	0.382	7.7	1.14
S42IL107	3	FW	2.3	0.553	7.5	1.158
BW281	1	FW	1.0	0.485	6.2	1.32
BW281	2	FW	1.3	0.673	6.3	1.77
BW281	3	FW	1.4	0.828	6.5	1.58
BW284	1	FW	1.3	0.45	12.3	1.16
BW284	2	FW	1.5	0.733	12.7	1.28
BW284	3	FW	1.3	0.56	11.5	1.34
Scarlett	1	FW	1.3	0.474	11.2	1.69
Scarlett	2	FW	1.7	1.07	10.5	2.87
Scarlett	3	FW	1.8	1.69	10.7	3.07
BW290	1	FW	1.4	0.814	12.2	2.47
BW290	2	FW	1.3	0.985	12.3	2.51
BW290	3	FW	1.5	1.42	12.1	2.55
Bowman	1	FW	1.9	1.27	11.2	3.67
Bowman	2	FW	1.7	1.3	11.3	2.98
Bowman	3	FW	1.1	0.668	11.4	1.81
G400	1	FW	1.4	1.21	14.2	2.92
G400	2	FW	1.0	0.684	14.3	1.96
G400	3	FW	1.0	0.593	14.5	1.66
S42IL107	1	WW	3.7	3.9	17.1	9.6
S42IL107	2	WW	4.5	3.6	15.2	8.8
S42IL107	3	WW	5.0	5.8	17.3	11.3
BW281	1	WW	4.7	3.5	13.1	8.2
BW281	2	WW	4.1	2.9	12.2	8.6
BW281	3	WW	6.1	5.89	12.2	11.5
BW284	1	WW	3.1	0.94	10.5	3.68
BW284	2	WW	2.4	0.414	11.4	3.5
BW284	3	WW	3.8	0.586	12.1	3.69
Scarlett	1	WW	5.4	1.38	13.2	3.08

Scarlett	2	WW	2.5	0.618	13.3	2.1
Scarlett	3	WW	7.9	3.53	13.4	7.83
BW290	1	WW	2.9	3.64	13.1	6.55
BW290	2	WW	0.7	0.26	12.5	2.26
BW290	3	WW	4.2	2.4	13.1	8.16
Bowman	1	WW	3.8	2.72	14.3	8.14
Bowman	2	WW	2.3	1.12	14.2	4.83
Bowman	3	WW	3.1	1.72	14.4	6.56
G400	1	WW	1.0	0.33	15.1	2.28
G400	2	WW	1.5	0.775	15.2	2.7
G400	3	WW	2.5	1.27	15.3	4.07

Table 2 : Yield

Line	Rep.	Treatment	avg. plant height (cm)	avg. Root wt. (g)	avg. Stem wt. (g)	avg. plant height (cm)
S42IL107	1	FW	34.7	0.395	0.525	34.7
S42IL107	2	FW	33.5	0.475	0.365	33.5
S42IL107	3	FW	30.4	0.288	0.316	30.4
BW281	1	FW	35.8	0.335	0.542	35.8
BW281	2	FW	35.8	0.6	0.526	35.8
BW281	3	FW	35.5	0.307	0.828	35.5
BW284	1	FW	28	0.25	0.491	28
BW284	2	FW	26.6	0.225	0.391	26.6
BW284	3	FW	26.7	0.325	0.436	26.7
Scarlett	1	FW	39.5	0.895	0.346	39.5
Scarlett	2	FW	32	1.13	0.74	32
Scarlett	3	FW	35.4	1.07	0.56	35.4
BW290	1	FW	34.2	0.621	0.807	34.2
BW290	2	FW	34.8	0.521	1.13	34.8
BW290	3	FW	31.5	0.468	0.662	31.5
Bowman	1	FW	36.3	0.75	1.24	36.3
Bowman	2	FW	34.6	0.671	1.01	34.6
Bowman	3	FW	36	0.51	0.6	36
G400	1	FW	41.3	0.84	0.866	41.3

G400	2	FW	35.8	0.623	0.661	35.8
G400	3	FW	34.6	0.56	0.513	34.6
S42IL107	1	WW	39	1.9	3.7	39
S42IL107	2	WW	39.6	2.1	2.8	39.6
S42IL107	3	WW	40	2.3	3.3	40
BW281	1	WW	39	1.2	3.1	39
BW281	2	WW	39	2.1	3.2	39
BW281	3	WW	39.4	2.22	3.32	39.4
BW284	1	WW	24.2	0.577	2.18	24.2
BW284	2	WW	24.7	0.235	1.78	24.7
BW284	3	WW	24.9	0.46	2.48	24.9
Scarlett	1	WW	25.5	0.393	1.36	25.5
Scarlett	2	WW	25	0.181	1.53	25
Scarlett	3	WW	26	1.04	2.69	26
BW290	1	WW	23.9	0.293	3.19	23.9
BW290	2	WW	23.6	0.22	1.89	23.6
BW290	3	WW	23.1	1.4	4.25	23.1
Bowman	1	WW	39.4	2.22	3.26	39.4
Bowman	2	WW	38.2	1.86	2.7	38.2
Bowman	3	WW	39.2	2.3	2.75	39.2
G400	1	WW	28.1	0.352	1.55	28.1
G400	2	WW	30.7	0.45	1.4	30.7
G400	3	WW	30.6	0.987	2.18	30.6

Table (3) PH

Line	Rep.	Treatment	Soil-PH Before	Soil-PH After
S42IL107	1	FW	7.5	7.61
S42IL107	2	FW	7.5	7.63
S42IL107	3	FW	7.5	7.68
BW281	1	FW	7.5	7.75
BW281	2	FW	7.5	7.73
BW281	3	FW	7.5	7.72
BW284	1	FW	7.5	7.53
BW284	2	FW	7.5	7.5
BW284	3	FW	7.5	7.74
Scarlett	1	FW	7.5	7.54
Scarlett	2	FW	7.5	7.5
Scarlett	3	FW	7.5	7.54
BW290	1	FW	7.5	7.14
BW290	2	FW	7.5	7.12
BW290	3	FW	7.5	7.13
Bowman	1	FW	7.5	7.23
Bowman	2	FW	7.5	7.22
Bowman	3	FW	7.5	7.24
G400	1	FW	7.5	7.41
G400	2	FW	7.5	7.43
G400	3	FW	7.5	7.44
S42IL107	1	WW	7.5	7.62
S42IL107	2	WW	7.5	7.63
S42IL107	3	WW	7.5	7.61
BW281	1	WW	7.5	7.48
BW281	2	WW	7.5	7.43
BW281	3	WW	7.5	7.41
BW284	1	WW	7.5	7.51
BW284	2	WW	7.5	7.52
BW284	3	WW	7.5	7.51
Scarlett	1	WW	7.5	6.62
Scarlett	2	WW	7.5	6.63
Scarlett	3	WW	7.5	6.64

BW290	1	WW	7.5	7
BW290	2	WW	7.5	7.1
BW290	3	WW	7.5	7.2
Bowman	1	WW	7.5	6.71
Bowman	2	WW	7.5	6.73
Bowman	3	WW	7.5	6.74
G400	1	WW	7.5	6.8
G400	2	WW	7.5	6.9
G400	3	WW	7.5	6.6

Table TDS

Line	Rep.	Treatment	TDS-Water (µs)	TDS-Soil Before (µs)	TDS-Soil After (µs)	TDS-Root (µs)	TDS-Spike (µs)	TDS-Stem (µs)
S42IL107	1	FW	384	350	226	120	163	112
S42IL107	2	FW	384	350	229	118	168	117
S42IL107	3	FW	384	350	230	121	162	110
BW281	1	FW	384	350	306	110	240	198
BW281	2	FW	384	350	302	116	241	196
BW281	3	FW	384	350	305	119	240	201
BW284	1	FW	384	350	397	112	180	100
BW284	2	FW	384	350	395	115	183	98
BW284	3	FW	384	350	398	116	186	97
Scarlett	1	FW	384	350	394	101	117	98
Scarlett	2	FW	384	350	390	114	120	95
Scarlett	3	FW	384	350	397	107	125	100
BW290	1	FW	384	350	337	100	310	106
BW290	2	FW	384	350	325	98	343	105
BW290	3	FW	384	350	335	90	316	100
Bowman	1	FW	384	350	443	100	230	133
Bowman	2	FW	384	350	456	112	233	116
Bowman	3	FW	384	350	475	123	221	108
G400	1	FW	384	350	268	81	279	145
G400	2	FW	384	350	265	97	288	139
G400	3	FW	384	350	275	142	225	129
S42IL107	1	WW	1492	350	1163	178	385	210
S42IL107	2	WW	1492	350	1167	195	390	200
S42IL107	3	WW	1492	350	1104	198	398	217
BW281	1	WW	1492	350	767	460	520	260
BW281	2	WW	1492	350	787	412	590	210
BW281	3	WW	1492	350	728	413	560	250
BW284	1	WW	1492	350	1207	203	401	204
BW284	2	WW	1492	350	1214	206	400	210
BW284	3	WW	1492	350	1216	214	412	218
Scarlett	1	WW	1492	350	1133	265	259	268
Scarlett	2	WW	1492	350	1187	230	289	270
Scarlett	3	WW	1492	350	1177	250	296	263
BW290	1	WW	1492	350	902	360	436	317
BW290	2	WW	1492	350	905	340	448	320
BW290	3	WW	1492	350	911	330	450	316
Bowman	1	WW	1492	350	1012	406	397	211
Bowman	2	WW	1492	350	1018	404	393	210
Bowman	3	WW	1492	350	1017	401	390	215
G400	1	WW	1492	350	1036	302	437	226
G400	2	WW	1492	350	1032	310	440	210
G400	3	WW	1492	350	1035	328	446	200

Table 6- % N analysis

N-water %	N-soil before %	N-Soil After %	N-Root %	N-Spike %	N-Stem %
0.0072	0.456	0.1401	0.4981	1.3809	0.569
0.0072	0.456	0.1380	0.4812	1.37	0.567
0.0072	0.456	0.1412	0.4987	1.35	0.556
0.0072	0.456	0.1356	0.6173	1.4166	0.6533
0.0072	0.456	0.1320	0.6162	1.412	0.6544
0.0072	0.456	0.1311	0.6156	1.414	0.645
0.0072	0.456	0.1689	0.4471	1.5951	0.8215
0.0072	0.456	0.1680	0.4472	1.588	0.8213
0.0072	0.456	0.1677	0.446	1.567	0.8215
0.0072	0.456	0.1454	0.5325	1.5577	0.5427
0.0072	0.456	0.1440	0.533	1.56	0.5312
0.0072	0.456	0.1437	0.532	1.57	0.536
0.0072	0.456	0.1344	0.6008	1.4615	0.3614
0.0072	0.456	0.1350	0.601	1.45	0.3512
0.0072	0.456	0.1359	0.603	1.43	0.3567
0.0072	0.456	0.1503	0.5134	1.5652	0.5617
0.0072	0.456	0.1514	0.514	1.54	0.5612
0.0072	0.456	0.1512	0.516	1.55	0.5637
0.0072	0.456	0.2054	0.5920	1.7801	0.5503
0.0072	0.456	0.2120	0.588	1.781	0.5512
0.0072	0.456	0.2134	0.589	1.779	0.5513
0.0163	0.456	0.1733	1.0936	1.557	0.6261
0.0163	0.456	0.1729	1.09	1.58	0.6263
0.0163	0.456	0.1720	1.012	1.57	0.6261
0.0163	0.456	0.1609	0.9304	1.706	0.6261
0.0163	0.456	0.1612	0.9312	1.712	0.6212
0.0163	0.456	0.1232	0.9312	1.734	0.634
0.0163	0.456	0.1910	0.9543	2.046	0.8532
0.0163	0.456	0.1912	0.9512	2.123	0.8453
0.0163	0.456	0.1920	0.9532	2.134	0.8412
0.0163	0.456	0.2015	0.6987	1.837	0.8869
0.0163	0.456	0.2120	0.6981	1.875	0.8823
0.0163	0.456	0.2134	0.695	1.883	0.8812
0.0163	0.456	0.2141	1.4268	1.777	0.9537
0.0163	0.456	0.2112	1.434	1.765	0.9512
0.0163	0.456	0.2210	1.436	1.789	0.9234
0.0163	0.456	0.1541	1.2061	1.830	0.7978
0.0163	0.456	0.1542	1.214	1.836	0.7912
0.0163	0.456	0.1534	1.244	1.832	0.7934
0.0163	0.456	0.2100	1.1032	2.458	0.9963
0.0163	0.456	0.2300	1.124	2.467	0.9934
0.0163	0.456	0.2140	1.123	2.487	0.9912

Tabel 7

K-water (ppm)	K-soil before(ppm)	K-Soil after(ppm)	K-Root(ppm)	K-Spike(ppm)	K-Stem(ppm)
4.8	210	12.8	27	62	114
4.8	210	13.1	35	65	119
4.8	210	12.4	24	66	117
4.8	210	15.6	33	60	132
4.8	210	14.7	32	61	142
4.8	210	15.2	30	77	135
4.8	210	37.4	19	62	104
4.8	210	35.9	14	59	107
4.8	210	36.7	15	62	101
4.8	210	29.4	34.5	71	117
4.8	210	28.4	45.4	70	113
4.8	210	29.6	32.7	76	112
4.8	210	44	30.4	57.7	111
4.8	210	45.5	27.8	58	99.3
4.8	210	43.8	23.8	55.8	105
4.8	210	20.4	9.2	32.4	99.3
4.8	210	19.5	11.1	35.4	93.2
4.8	210	20.5	15	40	93
4.8	210	25.4	12.7	46	62.2
4.8	210	26.4	13	44	75
4.8	210	25.7	12.8	36	70.7
88	210	88	8.3	38	111
88	210	87	7.3	40.8	105
88	210	75	7	40.1	104
88	210	168	26.4	55.5	111
88	210	165	26	56.7	114
88	210	186	27	63	116
88	210	139	9.4	39.8	68.3
88	210	139	8	34.6	70.4
88	210	132	8.7	46.3	68.1
88	210	102.4	20.2	88.4	57.4
88	210	106.5	23	98	50
88	210	101.4	20.9	93	45
88	210	196	36.4	87	84
88	210	187	34	98	87
88	210	198	38.5	89.3	83.2
88	210	111	10.2	46.3	86
88	210	112	9	43	87
88	210	114	6.5	47.2	89.2
88	210	228	5.2	25.5	20.6
88	210	232	3.5	22	22
88	210	242	4.1	19.8	20.1

Table 8

P-water (ppm)	P-soil before(ppm)	P-Soil after(ppm)	P-Root(ppm)	P-Spike(ppm)	P-Stem(ppm)
0.62	1.51	0.201	0.25	0.48	0.09
0.62	1.51	0.216	0.32	0.49	0.1
0.62	1.51	0.19	0.25	0.45	0.09
0.62	1.51	0.227	0.12	0.24	0.2
0.62	1.51	0.238	0.16	0.25	0.19
0.62	1.51	0.223	0.16	0.28	0.24
0.62	1.51	0.249	1.21	0.36	1.2
0.62	1.51	0.227	1.35	0.29	1.4
0.62	1.51	0.235	1.49	0.32	1.3
0.62	1.51	0.6	1.22	0.43	0.3
0.62	1.51	0.675	1.18	0.41	0.5
0.62	1.51	0.614	1.49	0.52	0.6
0.62	1.51	0.183	0.09	2.85	0.09
0.62	1.51	0.201	0.1	2.73	0.1
0.62	1.51	0.194	0.11	2.41	0.09
0.62	1.51	0.374	0.29	0.24	0.23
0.62	1.51	0.363	0.26	0.3	0.28
0.62	1.51	0.385	0.28	0.11	0.27
0.62	1.51	0.95	0.36	1.68	0.34
0.62	1.51	0.85	0.29	1.75	0.29
0.62	1.51	0.96	0.21	1.65	0.36
3.255	1.51	0.27	3.8	4.11	3.64
3.255	1.51	0.26	3.22	5.4	3.69
3.255	1.51	0.28	4.22	5.89	3.05
3.255	1.51	0.41	5.19	4.19	4.07
3.255	1.51	0.39	5.71	4.29	3.75
3.255	1.51	0.4	4.73	3.48	4.72
3.255	1.51	0.43	4.52	3.79	4.2
3.255	1.51	0.46	4.11	3.25	4.7
3.255	1.51	0.41	4.79	2.66	3.8
3.255	1.51	0.82	3.3	4.33	2.9
3.255	1.51	0.8	3.24	3.45	2.5
3.255	1.51	0.82	3.19	4.26	2.3
3.255	1.51	1.43	1.3	4.4	0.61
3.255	1.51	1.27	1.45	3.34	0.65
3.255	1.51	1.29	1.15	4.16	0.54
3.255	1.51	0.68	0.81	4.11	0.6
3.255	1.51	0.79	0.93	5.34	1
3.255	1.51	0.69	0.92	4.24	0.76
3.255	1.51	1.647	0.73	5.12	0.78
3.255	1.51	1.669	0.79	4.37	0.59
3.255	1.51	1.658	0.69	4.25	0.78

جامعه النجاح الوطنية

كليه الدراسات العليا

تقييم وتقدير نمو وإنتاج وإمتصاص أصناف شعير غير محلية مروية بمياه عادمة

إعداد

زكية سليمان سالم نمروطي

إشراف

أ.د. مروان حداد

د. منقذ شتية

قدمت هذه الأطروحة إستكمالا لمتطلبات درجة الماجستير في هندسة المياه والبيئة في كلية الدراسات العليا بجامعة النجاح الوطنية في نابلس، فلسطين.

2016

تقييم وتقدير نمو وإنتاج وإمتصاص أصناف شعير غير محلية مروية بمياه عادمة

إعداد

زكية سليمان سالم نمروطي

إشراف

أ.د . مروان حداد

د. منقذ شتية

الملخص

تم تطبيق هذه التجربة من أجل دراسة تأثير الري طويل الأمد باستخدام المياه العادمه على التربة وعلى نمو وإنتاج سبعة أصناف من بذور الشعير من أجل تقييم تأثير إستخدام المياه العادمه في الري على الصحة العامة وكذلك دراسة ونمذجة تقييم الأثر البيئي .تم إجراء هذه التجربة في الحرم الجامعي الجديد في جامعه النجاح الوطنيه حيث تمت عمليه زراعه البذور خلال فصل الربيع من العام2014 في أحواض بلاستيكية منفصله تحتوي على تربه رمليه طينيه "45 كغم " بمعدل 15 بذرة في كل حوض . وقد تم توزيع الأحواض بشكل عشوائي ثم تم ري النباتات بنوعين من المياه خلال التجربه " المياه العذبة كمرجع والمياه العادمه " بمعدل ثلاث متكررات لكل صنف. أستخدِمت التحليلات الكيميائيه من اجل حساب محتوى التربه من النيتروجين والفسفور والبوتاسيوم وكذلك الملوحة لكل صنف من الاصناف المرويه بالمياه العذبه والعادمه . هذا وقد تم اجراء هذه التجارب في مختبرات جامعه النجاح الوطنيه حسب قواعد التحليل الاساسيه المستخدمه لحساب التربه والماء. تم استخدام التحليل الاحصائي لجميع البيانات التي تم جمعها لدراسة تأثير المياه باستخدام تحليل الانحدار الخطي بحدود ثقه($P \leq 0.05$).

أظهرت النتائج بأنه لا يوجد تأثير لنوعيه المياه على قوة وطبيعة نمو أصناف الشعير، بينما تأثرت عدد السبلات بنوعيه المياه حيث أظهرت النتائج بأن عدد السبلات للنبته الواحده كان أكبر في حالة استخدام المياه العادمه بالري .كما أن النباتات المرويه بالمياه العادمه والعذبه على حد سواء استغرقت نفس الوقت تقريبا للانبات، ظهور الساق، الازهار وكذلك النضوج مع وجود فروقات بسيطه بين اصناف الشعير المستخدمه. الانتاج كان أكبر في حالة النباتات المرويه بالمياه

العادمه، حيث اظهرت النتائج ان النباتات التي تم ريها بالمياه العادمه اعطت تقريبا ضعف الانتاج ووزن السنبله من تلك التي تم ريها بالمياه العذبه . كما اظهرت النباتات المرويه بالمياه العادمه وزنا أكبر للجذور وقياسا أطول لطول السنابل.

من ناحية اخرى فان النباتات المرويه بالمياه العادمه أظهرت قدرة أكبر على امتصاص الملوحه من تلك المرويه بالمياه العذبه، كذلك أظهرت النباتات التي تم ريها بالمياه العادمه قدرة اكبر على امتصاص النيتروجين من التربه من تلك المرويه بالمياه العذبه حيث تركزت الكميه الاكبر من النيتروجين في الجذور يليها السنبلة واخيرا في الساق . بالنسبه للبوتاسيوم فهو يتركز بشكل كبير في الساق ثم في الجذر واخيرا في السنبلة وذلك يعود لكونه عنصر بطئ الحركة داخل التربه كما انه يتفاعل مع المكونات الموجوده في المواد العادمه . واخيرا أظهرت النتائج أيضا أن عنصر الفسفور يتركز بشكل كبير في السنبله يليها الساق واخيرا في الجذر وهذا لوحظ بشكل أكبر في النباتات المرويه بالمياه العادمه .

بناء على النتائج التي تم الحصول عليها من التجربه تم الحصول على المعادله التاليه :

$$Y = -4.441 + (0.448 * X_1) + (18.709 * X_2)$$

وتهدف هذه المعادله لحساب كميه الانتاج من النباتات عندما تكون كميه المياه المستخدمه في الري وكذلك وزن البذور معروفا قبل عمليه الزراعه .

مما سبق يمكن اعتبار نبات الشعير من النباتات المقاومه للملوحه حيث أظهرت الدراسه أنه يستطيع إحتمال الملوحه دون أن تتأثر انتاجيه النبات أو قوة وشدة النمو. وكذلك فترة النمو من بداية الإنبات وحتى النضوج لم تتأثر بنوعيه المياه واعتمدت فقط على نوعيه الاصناف وبالتالي يمكن اعتبار المياه العادمه كمصادر واعدة بديله للمياه العذبة المستخدمة في الزراعه خاصة في المحاصيل المتحملة للملوحة مثل نبات الشعير. كما انها تسهم في زياده نسبه العناصر الاساسيه مثل النيتروجين والفسفور والبوتاسيوم في التربه مما يسهم في تحسين نوعيه وانتاج النبات .