# Study of changes occurring on plants in terms of lengths, seed quality, and total mass of developing parts above and below the soil surface were treated by three different levels of saline irrigation water

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**Abstract- A field experiment was conducted to study the effect of salinity irrigation water on different varieties of wheat. Nine varieties of wheat with three replicates were planted in a greenhouse at Newcastle University in the UK. Seeds and modular compost plus sand was used for plantation. Seeds were treated with solutions of NaCl in treatments of 0.4, 5 and 10 dS/m. Salinity concentrations were added gradually after 12 days of plantation. Plant samples were harvested to estimate crop characteristics under saline and non-saline treatments. Also, all plants with their root samples were taken with their soils to a laboratory. Laboratory analysis was carried out to investigate the extent of changes in the dry weight of aboveground and underground parts. Maximum plants height was recorded a day before harvest. Dry biomass of spikes, stems, 100 seeds, and dry roots biomass were measured to investigate the differences between underground and aboveground parts and determine the effects of salinity on the main parts of plant. Stomatal resistance of leaves was measured under the natural light intensity for some plants. The soil electrical conductivity, pH values, and soil moisture were recorded and analyzed to determine the changes in soil around the root zone under saline conditions. Results showed that the increasing of salinity irrigation water decreased wheat dry matter weight, grain yield, seeds weight, andtotal biomass of aboveground and underground. Therefore, there was no significant difference between treatments affected plant length. The experiment proved that wheat is a salt resistant plant although it is placed under high levels of salt water as it has reached the stage of complete death despite the lack of quality of the crop under the influence of 10 dS/m treatment.**
**Keywords- salinity treatments -stomatal resistance -plant Length -seeds weight - salts accumulation - underground and aboveground biomass.**

## I. INTRODUCTION

*1.1 Introduction:*

Salinity has been identified as an indicator of concentration of salts in a body of water. Sodium chloride (NaCl), calcium sulphate (CaSO4), magnesium sulphate (MgSO4), Potassium carbonate (K2CO3), and sodium bicarbonate (NaHCO3) are the most common salts in irrigation water affected by salinization ( Grattan, 2000).Salinity is variable from region to the other, because of many factors which cause the increasing and decreasing of salinity in soil or water such as quality of precipitation, groundwater flow, freezing, runoff, evaporation, and melting of ice. Salinity refers to the situation when the availability of salts in the land causes problems with plants, biodiversity, soil, and water. Salinity doesnot affect agricultural crops only, but it has widely impacts on the livelihood strategies of poor farmers in many parts of the world (Sharma and Rao, 1998).Salinity problem has started long human beings on the earth and before the agricultural practice. Today, it is a very serious problem for crop production which constitute about one third of the world's land surface. Water salinity is commonly identified by researchers and scientists to recognize the visual signs of salinity which affects plant growth and reduces crops in order to find solutions to its problem. The quality of irrigation water can vary greatly in the quantity of dissolved salts(Zheng, et al. 2009). Water salinity is measured on the basis physical, chemical and biological characteristics. It can be measured by tasting is a simple of water. Salts in irrigation water can be presented from dissolution or weathering of lime, gypsum and other minerals in the soil. The kind of salts is also important to determine the suitability of water for irrigation (Albacete, et al. 2014). Many agricultural problem increase as the total salts contents increase; these salts require a special management practice to maintain crop yields. The relationship between salinity and irrigation water depends on water use efficiency. Water use efficiency includes any measure that reduces the amount of water per unit of any given activity. Increase WUE may conflict with the growth rate in plant characteristics. On the other hand, plants with high WUEs are the most suitable for use in salts stress and drought conditions, as well as, with low

WUEs for use in irrigated conditions (Pessarakli, 1999). WUE can be increased by using less water per unit of output to develop crops that require less water. Over the current years, nearly one-half of the water used in cultivate could be kept through increased irrigation water efficiency (Seckler, 1996). High salinity build up occurs in soils irrigatedwith high electrical conductivity of irrigation water (Chauhan, et al. 1991). Accumulated salts will certainly affect agricultural crops at different rates depending on so many factors, such as soil characteristics under saline irrigation, soil management, seasonal variation, and salt tolerance of the crop type. The high salt tolerance of wild and hybrid species with respect to local tomatoes was observed at the fruit level because these genotypes were less affected by dry weight absorption under salinity (Balibrea,et al. 2003).
The choice of subject was mainly wheat varieties and irrigation of salinity water, because wheat is the second most important cereal crop in the world, as well as, the leading source of vegetable protein in human food. Wheat can be grown under rain-fed of irrigated agricultural. The quality of wheat and its seeds are estimated by many factors, such as availability of protein ratio, vitamins, starch, and minerals (Bajaj, 1990).

### *1.2 Aims and Objectives:*

This experiment aims to:
Investigate the changes of different varieties of wheat under saline agricultural conditions.
Provide useful information about the similarities between varieties of the same crop in terms of their sensitive to salinity.
Understand the relationships between the accumulations of salts in soil and reduce the ability of plants to absorb water and nutrients from the soil, as well as, compare the effects of different salinity water levels (ECiw) on the plant growth.
The objectives of this study were:
To establish the variation in soils that are treated with the same saline conditions and different wheat genotypes.
To investigate the impact of salt stress on roots, stems, and leaves of wheat varieties.
To provide information out follow-up and analysis laboratory and field methods of estimating changes of plants affected by salinity.
The objective of this study was also to determine the effects of the variation of grain size in order to understand what changes occur with grain in terms of its quality and size, as well as, whether these changes increased with the increase of salt level in irrigation water. Thus, there was a need to assess the effect of salts concentration on root growth, how does salinity affect the root growth of wheat and does root weight change with high concentration of salt.

## II. MATERIALS AND METHODS

### *2.1 Irrigation water:*

Three levels of saline water was used for irrigation:
The first treatment of saline irrigation water is T1= 0.4 dS/m which used as a control(1dS/m = 1mmhos/cm).
The second treatment of saline irrigation wateris T2 = 5 dS/m.
The third treatment of saline irrigation wateris T3 = 10 dS/m.

### *2.2- Varieties:*

In this experiment, nine varieties of wheat were treated with the saltwater aspresented in table (1):
Table (1): varieties of wheat were used in the experiment with different salinity levels and the number of seeds in each pot

| Number | Variety type | Pots number | Number of seeds per pot | Used treatments |
|---|---|---|---|---|
| 1 | T. aestivum | 9 | 10 | T1, T2, T3 |
| 2 | T. timopheevii | 9 | 10 | T1, T2, T3 |
| 3 | T. turgidum | 9 | 10 | T1, T2, T3 |
| 4 | T. urartu | 9 | 10 | T1, T2, T3 |
| 5 | T. vavilovii | 9 | 10 | T1, T2, T3 |
| 6 | T. zhnkorskyi | 9 | 10 | T1, T2, T3 |
| 7 | T. durum | 9 | 10 | T1, T2, T3 |
| 8 | T. turanicum | 9 | 10 | T1, T2, T3 |
| 9 | T. compactum | 9 | 10 | T1, T2, T3 |

*2.3 Experimental Site:*

The project location was taken place at a greenhouse in Moorbank Botanic Gardens of School of Biology, Newcastle University at the top end of Claremont road on the Town Moor which is about 15 minutes walking from Newcastle City Centre as shown in figure (1). Moorbank Gardens aim to link educational programs, field experiments and plots plants inside greenhouses and landscape.

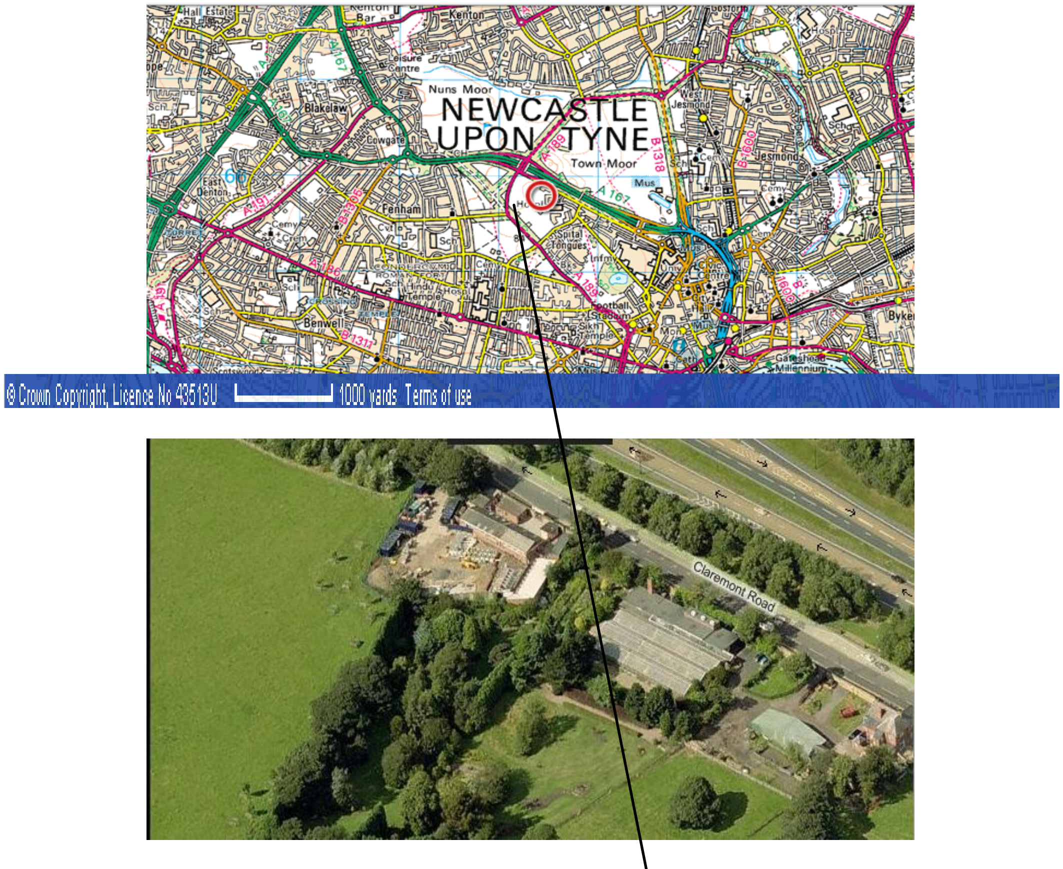



Figure (1): project site in a greenhouse in Moorbank Botanic Gardens of School of Biology, Newcastle University

*2.4 Seeding and Harvesting Methods:*

Ninevarieties of seeds were soak in distillery water for 24 hr before plantation on the 10th of March.

Seed and modular compost was put in 81 pots plus sand. The compost has a medium base level of fertilizer to meet the individual requirements of crops and their growing regimes.

Next day all varieties were removed to the pots and irrigated with fresh water for 12 days (500 ml) for each pot on the 11th of March.

Plants of treatments 2 and 3 were irrigated with saltwater treatments on the 23rd March after 12 days of sowing the seeds. Salt was increased gradually in the water every irrigation time until it arrived to the required 5dS/m for treatment two and 10 dS/m for treatment three.

Irrigation was decreased for treatment two and three after 63 days of plantation (12th May). Firstly, because they had very wet soil. Secondly, soils had strong smell because of the extra water. At the same time, pots of treatment one had too dry soil and required irrigation constantly every 3 or 4 days.

The new amount of water is given in table (2) for each treatment which was reduced increase of salt concentration in the soil.

Table (2): the amount of water after 63 days of plantation

| Treatment | T1 | T2 | T3 |
|---|---|---|---|
| Amount of water | 500 ml | 250 ml | 200 ml |

Irrigation was stopped 15 days before harvest process. Irrigation stop was after 113 days of plantation on the 1st July.

*2.5 Soil Moisture Measurement:*

TheataMeter (type HH1) was used for measuring soil moisture by pushing its stainless steel measurements into the soil as shown in figure (2) before the irrigation of plants each time.

AP4 porometer is an electronic device which was used to measure the stomatal resistance of wheat leaves for plants that were treated with three different concentration of saltwater (O'Toole and Cruz, 1980). Stomatal controls both the water loss from plant leaves and the uptake of CO2 for photosynthesis (Eckert and Kaldenhoff, 2000), because the stomatal is sensitive to light intensity, leaf age, pollution, carbon dioxide, water stress, diseases, wind speed, temperature, pressure, and relative humidity (Day, 1977). Leaves were selected to measure their stomatal resistance from soma pots and  it was done twice a week before the irrigation process as is shown in figure (3).


Figure (2): Theata Meter was used for measuring soil moisture

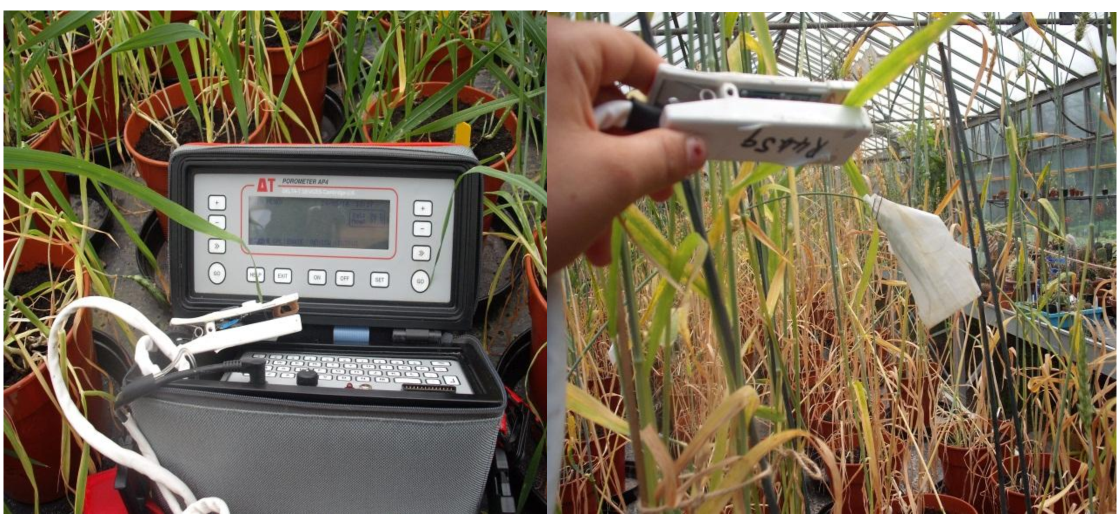



Figure (3): AP4 porometer was used for measuring the stomatal resistance

Plant LengthMeasurements: Maximum plant height was recorded at maturity stage on the 14th of July after 126 days of plantation for spikes and stems before roots zone using a ruler (100 cm).

Plant Harvest: Wheat plants were harvested on the 14th of July by cutting the above grounds of the plants and saving them in medium size of bags, as well as, their soils.

Laboratory Methods: Firstly plants were transferred to the laboratory for testing their above ground, below ground and soils for laboratory tests needed to investigate reflected changes on plants which affected and non-affected by salinity levels.

Grain Measurements: Total grain weight per pot, 100 seeds per pot, and seeds per spike were counted and weighted to investigate the worst and better varieties and to determine their relative yields.
Above Ground Measurements: Number of heads where accounted per pot, as well as, total dry heads weight per pot was taken. Thus, total dry weight of stems per pot was recorded.
Soil Measurement: Soil samples were taken from pots after harvest the plants. The salinity of soils samples were determined by measuring the electrical conductivity in units of decisiemens per centimeter (dS/cm). Soil solution measurements was carried out on the soil per pot by adding distilled water to samples of 100 gm of air-dry soil and allows mixture to stand overnight. After that, samples filtered under suction through filter papers to extract the soil solution. Electrical conductivity, temperature and pH of saturated soil samples were measured using Ulrameter 6P.
Root Measurements: Samples of fresh materials were dried within an oven under 60-65C0 for 48 hr to estimate the constant weight of roots per pot and determine whether they were affected by various salt treatments.
Statistical Analysis Methods: Collecting data was transferred to Microsoft Excel © for further analysis. One way ANOVA was used to test the statistical differences between varieties and treatments for each individually group. Critical differences at p-value<0.05 of significance were tested using Tukey Simultaneous Test.

## III. RESULTS AND DISCUSSION

This study indicated different patterns of mean frequency that differ among the wheat genetic material groups.
Statistical analysis of the data obtained from the laboratory had a significant effect between treatment (p-value < 0.05) on plant height, stem weight, spike weight, total aboveground weight, grain yield weight, and 100 grain weight per pot.
The variation between wheat varieties can divided up into several points of view from the experiment results. Plats were closer to their natural characteristics under fresh water irrigation (0.4 dS/m), as well as, they showed their ability to resist salinity under salt concentrations.

### *3.1- Plant Lengths:*

Data revealed that, there was no significant difference between treatments affected plant length (p-value = 0.987), but there was significant difference between plant varieties in terms of their length (p-value = 0.000) as shown in figure (4) .

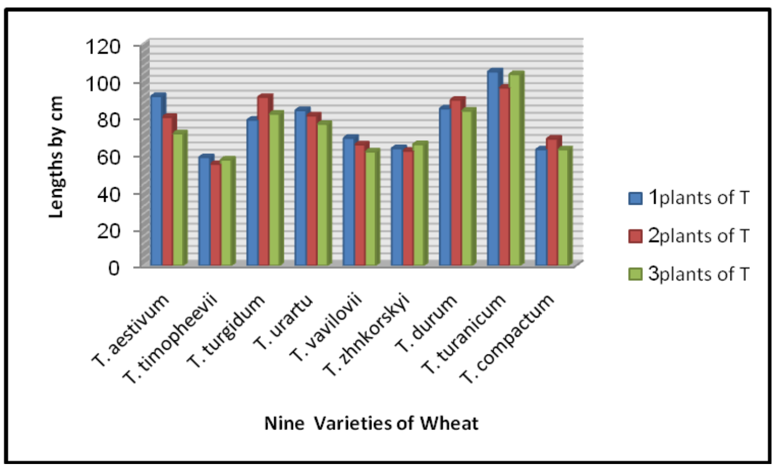



Figure (4): Plant lengths at maturity stage (cm)

### *3.2- Grain yield:*

Total yield weight was decreased for all varieties. Total yield weight of T. aestivum had the highest value under non-saline condition and saline condition of 5 dS/m than varieties per pot, whereas T. timopheevii had the highest value under saline condition of 10 ds/mas shown in figure (5); only T.durum increased more at T3 than it was at T3. . there was significant differences between used treatments and 100 grain weight per pot (p-value = 0.00). 100 seeds weight was decreased significantly with the increase of salinity levels as presented in figure (5).Varieties had different significantly in terms of their 100 seeds weight and total seeds yield weight per pot. Total seeds weight per pot in unit of grams appeared to be sensitive to salinity. Figure (6) presented that, T.durum seeds weight per spike was not affected by salinity levels and that can be seen from the increasing in its weight per spike under T3 which was 1.5 gm.

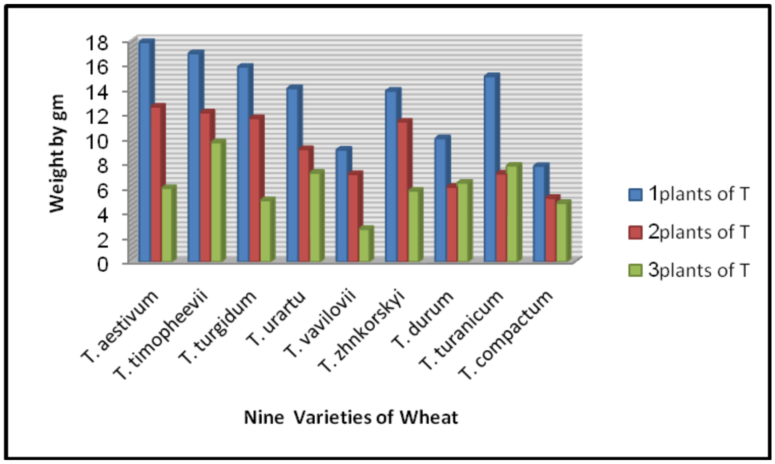



Figure (5): Total yield weight – per pot (gm)

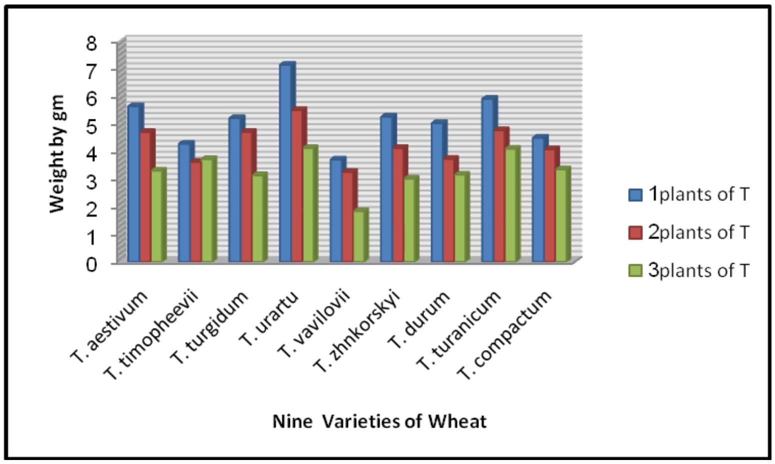



Figure (6): 100 seeds weight – per pot (gm)

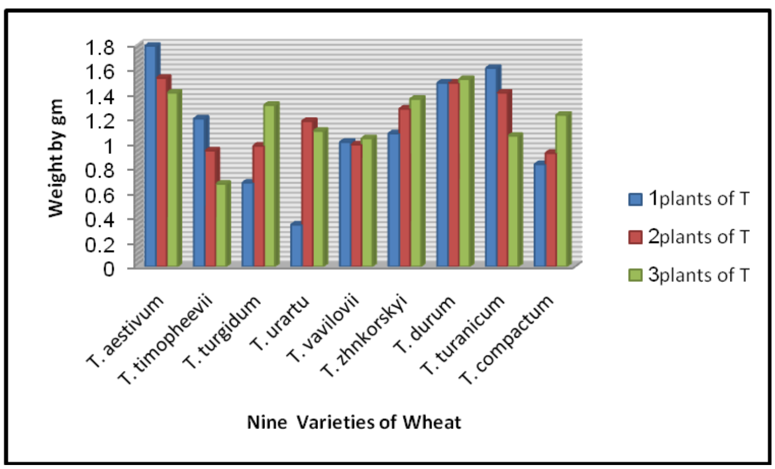



Figure (7): Seeds weight - per spike (gm)

Moreover, number of seeds per pot and seeds weight per spike increased at T3 than they were at T2 at the same previous variety. Seeds weight per spike for this variety was equal at T1 and T2 (both=1.49 gm) as shown in figures (7) and (8).

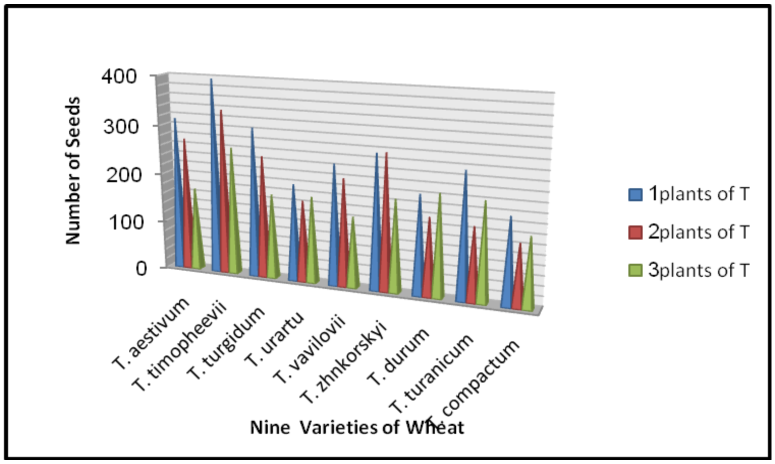



Figure (8): Number of seeds – per pot

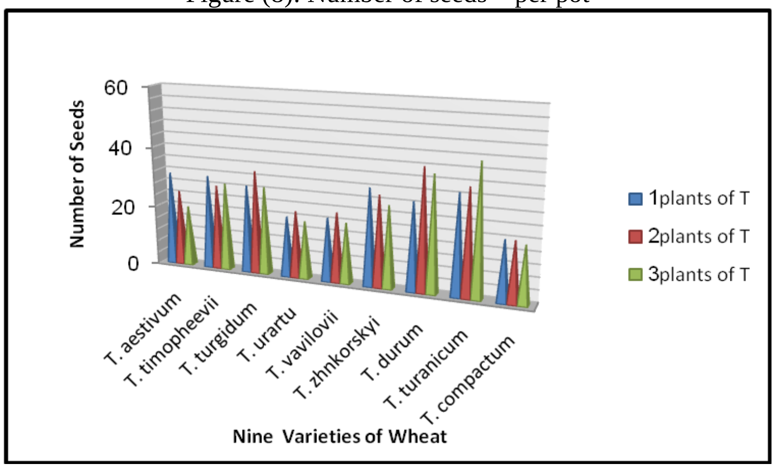
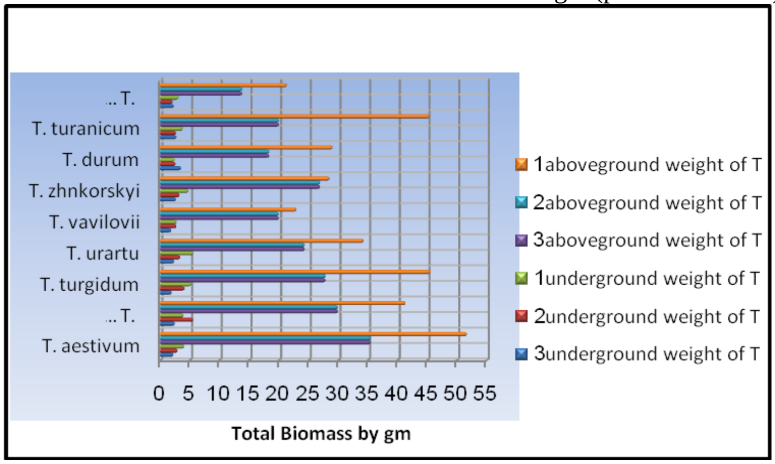



Figure (9): Number of seeds per spike

The low yield of some varieties of wheat affected by salinity might be due to weak seedling establishment and low grain germination as guessed by Abro, et al. (2009).
Collecting data is shown the relative yield of wheat probability will be 100% for all varieties affected by (0.4 dS/m); the electrical conductivity at the end of the experiment of treatment 1 (0.4 dS/m) was between (0.8 and 2.6 dS/m). It tells us that, the yield loss would be 0% of all varieties were irrigated by low salinity treatments. On the other hand, the relative yield of treatment 2 (5 dS/m) estimated to be zero for most varieties as a result of their soil salinity, which is between (17 and 29 dS/m). However, the relative yield of T.vavilovii concluded to be 24%, because of its low soil salinity which was about 17 dS/m. In fact, the relative yield of experience results was 77.8% which was not the highest value of relative seed loss. T.zhnkorskyiobtained the highest relative yield than other varieties which arrived to 78.6% with only 22.2% of yield loss; however soil salinity of this variety was higher than it was at variety T.vavilovii. the relative yield of T.compactum was 62.5% which was the highest value than other varieties under treatment3 (10 dS/m), however it was suggested to be zero as a result of the final data. In this study, all used varieties had a relative yield under T3 at different growth and yield loss rates, maybe because salts had accumulated in the soil gradually, and that gave the plants a chance to grow.

*3.3- Comparison between Underground and Aboveground Biomass:*
Measuring the weight of plants rootwas indicated to be an efficient step for the recognition of salt-tolerant wheat varieties in the presence of salt accumulation in their root zone. Figure (9) indicates a decrease in aboveground dry weight with increasing salinity at most varieties. Root growth of wheat seedling was proved through measuring dry weight of roots after washing them by fresh water and drying in oven for 48 hr. The plant root weight analyses showed that there was significant different between the total dry roots weight per pot (p-value=0.003). the effects of salt on roots weight of wheat cultivars indicate that the response of wheat cultivars to different salt amount differs

among different cultivars.Also, treatments had significant difference on roots (p-value = 0.003), however varieties had no significant difference between each other in terms of their root weight (p-value = 0.697).




Figure(10): Total biomass of aboveground and underground (gm)

The relative yield of aboveground was decreased from T1 to T2 for all wheat varieties as presented in figure (9). On the other hand, some varieties had relative yield at T2 more than it was at T3, such as, T. urartu, T. durum, T. turanicum and T. compactum which decreased the yield losses of aboveground at these varieties. This distinctive point can by suggested by looking at most of these above-mentioned varieties in terms of their relative yield of underground parts. Roots weight of T. durum was increased at T2 more than it was at T1 and then increased again at T3 than it was at T1 and T2. Perhaps the reason is that plants try to increase the roots zone to be able to absorb the soil solution and that encourage the growth of green parts of plants, also, roots weights of T. turanicumand T.compactum were more under T2 than they were under T3, which might be due to salinity resistance in wheat varieties.

*3.4- StomatalResistance:*

Stomatal resistance in leaves was measured for some plants to determine whether there were any changes. The results showed that stomatal apertures of varieties have different sensitivities to salinity (Zheng, et al. 2009). Toxic level increased with increasing salt stress and that reduced photosynthetic leaf area which caused pressure on plants growth as suggested by (Misra, et al. 2002).

*3.5- Salts Accumulation in the Soil:*

At the beginning of the experiment, soils had the same ability to absorb water amount naturally at the irrigation treatments and no problems appeared on the plants. After about 60 days of plantation, it was observed that plants of treatments 2 and 3 could not absorb water due to accumulation of salts in their soils. There was direct relationship between uptake and added water to soil at salinity treatments. The salinity of saturation paste extract increased with the irrigation water salinity increased and plant absorption decreased. Salts accumulate in the soil due to plant transpiration and soil surface evaporation(Zheng, et al. 2009). High concentration of salts has savage effects on plants growth. Water salinity of 10 dS/m had caused greatest soil salinity, as well as, 5 dS/m was able to decrease soil salinity. There was enough salt in the soil to prevent the uptake of waterand nutrients required for plants health. Salinity tolerance improvement of used varieties may be possible under salinity conditions by providing a system for washing the soil before the accumulation of salts in it.

As a result of pH varied between 6.02 and 7.26, which indicate that the pH of soil used for plantation (seeds and modular compost with sand) was increased for all experiment pots from (between 5.5 and 6) to (between 6.02 and 7.26) under salinity treatments.

There was a decrease in water uptake by plants which was investigated by measuring soil moisture for treatments 2 and 3, because of the high concentration of salts. There are direct relation between plants andthe additive water under salinity conditions compared with plants under non-saline treatment.

One of the most common problems of salt accumulation in the soil is that, salts make soil water unavailable for plants and that reduce wheat yield. There are some disadvantages of the experiment that suggested to be further investigated, such as the high accumulation of salts in the soil. Washing out the salts from soils by fresh water from time to time is one of the important recommendations that should be taken in the reserves when you do an experiment about studying the impact of salinity on agricultural crops to maintain the level of saltiness in the soil to be studied, as well as, analyses electrical conductivity of the soil during your experiment. The quality and quantity of water are very important factors for reclamation of saline soils to leach soluble salts from the soil as suggested by Hoffman, et al. (1979). Also, there was a missing value of T. durum under 10 ds/m, which caused difficultly at statistical analysis. Representation of missing values needs to determine the statue of lost values.

## IV. CONCLUSION

This study has shown the differences between varieties of wheat in terms of their aboveground and underground parts. Most wheat varieties are negatively affected by increasing soil salinity levels due to irrigation with low efficiency water, but in different ratios based on the natural genetic variation within the plants. It can be strongly argued that all varieties of wheat are affected by high concentration of salts in the root zone in terms of their stems growth rate, grain yield, maximum dry spikes weight, leaf area. The reduction in the relative yield may be due to toxic effects of the high concentration of salts in the maturity stage. As investigated from this experiment, wheat growth is especially resistant to salinity, but there is a relationship between the accumulations of salts in soil and reduce the ability of wheat plants to absorb water and nutrients from the soil. At saline treatments, electrical conductivity increases with increasing the irrigation by saltwater and that leads to increase soil moisture with increasing soil salinity.

Roots weights of T. timopheevii and T. durum were increased under saline treatments. There was a significant difference (p- value = 0.003) between treatments in dry root biomass.

Stomatal resistance of wheat varieties had different sensitivities to salinity concentrations due to sensitive guard cells causing stomatal closure. The rate of stomatal conductivity was decreased under saline conditions. The main findings of this study were that T. compactum had the best grain yield compared with other varieties. The stomatal resistance decreased dramatically with increasing soil salinity and that decreased photosynthesis; however plants depend on energy produced from photosynthesis for their nutrition. The growth rates in the experiment probably due to the low concentration of salts at the early stages of plants.

Over all, wheat indicated to be tolerant to salinity, because there was high accumulation of salt in the soil. Maharet al. (2003) defined wheat as a good yield potential in terms of its tolerance to salinity, however yield decreasing with increasing salinity level in the soil.

Finally, it can be stated that,  the study can be improved by maintaining the level of salts in the soil at the required levels. If possible, avoid the use of high saline water levels for the preservation of our land from the accumulation of salt. It is hoped that this publication will provide guidelines to many developing as well as developed countries in order that they may manage their saline waters for productive purposes in a sustainable manner (Rhoades, et al. 1992).

## V. ACKNOWLEDGEMENT

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