

# **EFFECT OF USING SOILCONDITIONERS ON WATER USE EFFICIENCY AND PRODUCTIVITY OF TOMATO PLANT**

By

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B. Sc. Agric. Sc. (Horticulture), Ain Shams University, 1999

M. Sc. Agric. Sc. (Horticulture), Ain Shams University, 2005

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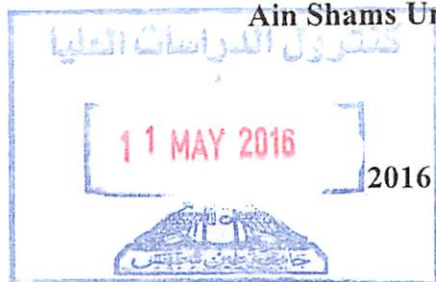
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Ain Shams University**



## Approval Sheet

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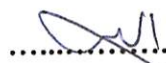
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## **ABSTRACT**

**Mohamed Rashad Mostafa El Dolify: Effect of Using Soil Conditioners on Water Use Efficiency and Productivity of Tomato Plant. Unpublished Ph.D. Thesis, Department of Horticulture, Faculty of Agriculture, Ain Shams University, 2016.**

The current study was performed to investigate the effect of three water regimes as well as, three different soil conditioners on the yield and the quality of tomato fruit. The studied water regimes were namely; 60, 80 and 100% of class A pan. The tested soil conditioners were “Hundz soil”, “Oligo plus” and “Bioconditioner”. Impact of the two investigated factors was studied separately, as well as, the interaction. The experiment was carried out at El-Dolify Farm, Khatatba, Monofia Governorate during two seasons (2012/2013 and 2013/2014). Tomato hybrid Yara F1 was used in this investigation. The obtained results confirmed that, using the “Hundz soil” or “Oligo plus” lead to the significant increments in all tested parameters related to the yield and the fruit quality. It also enhanced all vegetative growth measurements (plant height, leaves number per plant, fresh and dry weight of leaves). The treatments increased all assayed a chemical constituent of plant leaves i.e. chlorophyll, total nitrogen, phosphorus and potassium as well as total acidity and L.Ascorbic acid content. Moreover; interaction between “Hundz soil” or “Oligo plus” and any tested water regimes were significantly better than Bioconditioer and control in number of fruits per plant, average fruit weight, early, marketable and total yield. In addition, the results show that the chemical properties of tomato fruits were improved by applying the “Hundz soil” or “Oligo plus”. Concerning the water use efficiency, the tested soil conditioners had a significant effect compared to control treatment (untreated). Whereas, irrigating the tomato plants under this experimental condition confirmed the validation of using the 80% irrigation regime without significant losses in the crop yield.

**Key words:**

Tomat, Water regimes, Soil conditioners, Hundz soil, Oligo plus , Bioconditioner , Yield, Water use efficiency

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## INTRODUCTION

Tomato (*Solanum lycopersicum* L.) is an important vegetable crop grown worldwide and Egypt for both fresh and processing markets. Egypt produces 3853341 ton during summer cultivation from the area of 238376 feddan, and the average of production is 16.165 ton/feddan (MALR 2013). Researchers acknowledge that tomato has a higher acreage of any vegetable crop in the world (Ho *et al.*, 1999), and it also requires a high water requirement for both, optimal vegetative and reproductive development (Arturo *et al.*, 1995; Jones, 1999). Water plays a crucial role in determining the yield of tomato. However, it is most likely that a water scarcity period will have to be faced in the not too distant future. The unpredictable rainfall and increasing competition for water resources will compel the adoption of irrigation strategies in Africa. Deficit irrigation could allow saving water and in the same time it maintains satisfactory yields or production levels (Topcu *et al.*, 2007). Under this strategy, crops are deliberately allowed to sustain some degree of water deficit and yield reduction. Deficit irrigation is irrigating the root-zone with less water than required for evapotranspiration (Zegbe-Dominguez *et al.*, 2003). However, deficit irrigation for most vegetables such as tomato has been extensively studied, but with contrasting results (Dorji *et al.*, 2005). For example, Zegbe-Dominguez *et al.* (2003) revealed that tomato dry mass yield did not decrease under deficit irrigation compared to full irrigation, besides making a 50% saving in water and approximately 200% increase in irrigation water use efficiency and relevant fruit quality attributes improved. In this respect, many investigations were carried out to study the effect of irrigation regime on vegetative growth and productivity of tomato plants. In this connection, El-Beltagy *et al.* (1984), Fattahallah (1992), Merghaney (1997), Navarrete and Jeannequin (2000), all reported negative effects of water stress on tomato growth, chemical constituents and fruit yield and quality of plant foliage. Under Egyptian conditions, irrigation water is a limited

## INTRODUCTION

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agricultural resource. This study addresses the rationalized of using water in the intensive tomato growing technology. The principal resource of water in Egypt is the Nile River which provides us yearly with about 55.5 billion cubic meters. The second source is the underground water. Agriculture share of the water budget was about 81% and increased to 85% in 2006 **El-Beltagy and Abou-Hadid (2008)**. Irrigation water is gradually becoming scare especially in arid and semi-arid regions. Therefore, water saving and conservation now in Egypt is essential to support agricultural development needed. Also, the efficient use of water by irrigation is becoming increasingly important. Crop water consumption is thermal dependent, therefore, it is expected that crop water requirement may be improved by using soil conditioners during growth season. Such treatment contributes to save water and improve water use efficiencies and the quality of fruits (**Lorenzo *et al.*, 2003**).

The aim of this investigation is to perform a study on the effect of adding three soil conditioners and three irrigation levels as well as their interaction on vegetative growth, chemical constituents of plant foliage, yield quantity and quality, and water use efficiency of tomato plants to reveal the best combination between irrigation level and soil conditioner that can be recommended to increase yield and save water consumption of tomato plants grown during summer season under sandy soil conditions.

## REVIEW OF LITERATURE

One of the major concerns in agricultural production is poor productivity of sandy soils. Production in these soils is limited by their low water-holding capacity and excessive deep percolation. On the other hand, the availability of water is the most important factor that limits development of agriculture in arid and semiarid regions. Competition for water resources has become stiffer due to the rapid growth of population, industrialization and urbanization. Water stress is one of the major constraints to plant growth and affects agriculture and horticulture worldwide. Plants that have experienced water stress usually show decreased growth and development, low leaf water and turgor potentials **Tahi *et al.* (2007)**, and transpiration rates **Ozenc (2008)**.

In order to have a wide view on the effect of soil conditioners and irrigation regime on growth, yield and its components, chemical composition of plant foliage and fruits of tomato more reviews are illustrated in the following:

### **2.1 Soil conditioners:**

As a start the soil conditioners, were known since the 1950, **Hedrick and Mowry (1952)**. However, their wide commercial application failed even though the scientific basis for their use was quite well established. These polymers were developed to improve the physical properties of soil in view of:

- increasing their water-holding capacity
- increasing water use efficiency
- enhancing soil permeability and infiltration rates
- reducing irrigation frequency
- reducing compaction tendency
- stopping erosion and water run-off
- increasing plant performance (especially in areas subject to drought).

With respect to first requirement the soil conditioner is a product which is added to soil to improve the soil's physical qualities, especially

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its ability to provide nutrition for plants. In general usage the term soil conditioner is often thought of as a subset of the category soil amendments, which more often is understood to include a wide range of fertilizers and non-organic materials **Hedrick and Mowry (1952)** as cited by **Chatzoudis and Valkanas (1995)**. Gel polymers are commonly sold in horticultural markets as super absorbers with the capability of absorbing 400 to 1500g of water per gram of dry gel polymer and as such can build an additional water reservoir in the soil **Johnson (1984)**; **Woodhouse and Johnson (1991)**; **Bouranis *et al.* (1995)**.

The soil conditioners can be used to improve poor soils, or to rebuild soils which have been damaged by improper management. They can make poor soils more usable, and can be used to maintain soils in peak condition. Soil conditioners may be used to improve water retention in dry, coarse soils which are not holding water well. The addition of organic material for instance can greatly improve the water retention abilities of sandy soils and they can be added to adjust the pH of the soil to meet the needs of specific plants or to make highly acidic or alkaline soils more usable. The possibility of using other materials to assume the role of composts and clays in improving the soil was investigated on a scientific basis earlier in the 20<sup>th</sup> century, and the term soil conditioning was coined. The criteria by which such materials are judged most often remains their cost-effectiveness, their ability to increase soil moisture for longer periods, stimulate microbiological activity, increase nutrient levels and improve plant survival rates. The first synthetic soil conditioners were introduced in the 1950s, when the chemical hydrolysed polyacrylonitrile was the most used. Because of their ability to absorb several hundred times their own weight in water. It has been reported that gel-polymers upon contact with water expand to form gel that, in a growing medium constitutes a reservoir of moisture available for uptake by plants **Johnson and Leah (1990)**. According to **Bouranis *et al.* (1995)** hundreds of gel polymers exists. However,



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studies have shown differences in effectiveness of gel polymers on plant growth and soil improvement. The introduction of alternative soil conditioners like gel polymers for conserving soil moisture and nutrients, for efficient water and nutrient utilization by the plants are becoming important especially where water availability is limited. Polyacrylamide (PAM) is a long chain synthetic polymer that acts as a strengthening agent, binding soil particles together and consequently these larger and heavier particles cannot be removed easily by water. Polyacrylamide are being marketed under different trade names like: Terrasorb, Hydrosorb, Hydro Mulch, Water Crystals, PAM, Copolymer, Moist Soil, Aquasorb, Agrosorb etc. All these products are polymers, but not all polyacrylamide are alike. Polyacrylamide was developed in the 60's to grow plants in the desert and has been refined to last longer and absorb water at higher rates over a period of time. Polymers as soil additives have recently been introduced in the market with great success. These polymers are sold under the names of "Smart Soil" and "Moist Soil" to hold water (20 times its weight), but polyacrylamide (400 times) is now used for this purpose. The interaction of the polymers depends on both the properties of polymer and properties of soil. It is effective in stabilizing soil aggregates, reducing soil erosion and increasing water infiltration and also indirectly profoundly affects crop growth and yield (Sefara, 1994).

### **2.1.1. Effect of soil conditioners on soil characteristics:**

One of the major concerns in agricultural production is poor productivity of sandy soils, of which production is limited by their low water holding capacity and excessive deep percolation. So the good soil physical structure is important for water and nutrient availability for plant growth, development and yield. Several studies have been conducted on sandy soil to test the effect of gel polymer soil amendment on water retention Johnson (1984); Johnson and Leah (1990); Blodgett *et al.* (1993); Choudhary *et al.* (1995); Al-Harbi *et al.* (1999); Huttermann

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*et al.* (1999). It is well documented that the addition of gel polymers has the potential to improve, soil structure, soil texture, to reduce the evaporation rate and soil bulk density **Johnson (1984); Choudhary *et al.* (1995); Al-Harbi *et al.* (1999); Eiasu (2004).**

Investigations by **Woodhouse and Johnson (1991)** found positive response of gel polymers as soil conditioners to aid plant establishment in drought-prone soils. It is well documented that gel polymers have a potential to increase water holding capacity of sandy textured soils and delay the onset of permanent wilting where evaporation is intense (**Johnson, 1984**). Other researchers found a reduction in the evaporation rate of soils amended with gel polymers (**Choudhary *et al.* 1995**).

Most authors agree that when gel polymers are incorporated in the soil, the following can be observed: (1) control of soil erosion and water runoff **Wallace and Wallace (1990)**. (2) increased infiltration capacity **Zhang and Miller (1996)**. (3) increased soil aggregate size **Wallace and Wallace (1986)**. (4) reduced soil bulk density **Al-Harbi *et al.* (1999)**. (5) increased water retention **Johnson (1984); Bres and Weston (1993)**. (6) improved survival of seedlings subjected to drought **Huttermann *et al.* (1999)**. (7) improved nutrient recovery from applied fertilizers **Smith and Harrison (1991); Bres and Weston (1993)**. and (8) reduced irrigation frequency **Taylor and Halfacre (1986)**. Conversely, other authors reported that the addition of gel-polymers did not have any beneficial effect to the soil **Wang and Boogher (1987); Tripepi *et al.* (1991); Austin and Bondari (1992); Bres and Weston (1993)**. explained that such differences might be related to gelpolymer type and quantity applied.

One of the soil conditioner are composts, which are used in agriculture and horticulture to improve soil fertility and quality because they can increase organic matter content, especially in sandy soils which have low water and nutrient holding capacity (**Lakhdar *et al.*, 2009**). By increasing soil organic matter content, composts improve soil physical properties such as structural stability (**Tejada *et al.*, 2009**), total porosity

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and hydraulic conductivity (Aggelides and Londra, 2000), aggregate formation (Sodhi *et al.*, 2009), and water holding capacity (Curtis and Claassen, 2005). In addition, compost has a unique ability to improve the chemical, physical, and biological characteristics of soils. It improves water retention in sandy soils and promotes soil structure by increasing the stability of soil aggregates. Soil becomes microbially active and more suppressive to root pathogens. Enhanced microbial activity also accelerates the breakdown of pesticides Wisconsin and Zuhlke (2002). Maboko (2006) mentioned that the results demonstrated that gel-polymer soil amendment improved sandy soil.

### 2.1.2 Effect of soil conditioners on Water efficiency:

Water used for agricultural purposes has become more scarce and expensive. As a result, the need for efficient water use in agricultural production has become a major concern. Water use efficiency can be increased by growing crops in soils enhanced with water-holding amendments like gel polymers (Johnson and Leah, 1990). These gel-polymers are becoming more and more important in regions where water availability is insufficient. The gel-polymer can absorb water hundred folds its own weight. When a gel polymer is applied to poor agricultural soil, it can absorb and retain water and dissolved nutrients and release it when required by the plant (Johnson and Leah, 1990). Bouranis, *et al.* (1995) reported that there are hundreds of gel-polymers, which, however, differ in their effectiveness in the plant/soil environment. In summary, researchers have widely used gel-polymers as additives to potting media to increase water use efficiency and improve water-holding capacity (Johnson and Leah, (1990); Blodgett *et al.*, (1993); Huttermann *et al.*, (1999), reduce irrigation requirements and water consumption Flannery and Buscher (1982); Taylor and Halfacre (1986).

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### 2.1.3 Effect of soil conditioners on growth characteristics:

An experiment conducted by **Boatright et al. (1997)** found an increased dry weight for *Petunia parviflora* (petunia) in a soil incorporated with gelpolymers in dry conditions. On the other hand, **Tripepi et al. (1991)** mentioned that the addition of a gel-polymer into the growing medium had little effect for container production of birch. They mentioned that gel polymers held higher amounts of moisture than a medium without gel-polymers. However, the moisture was retained by the expanded gel-polymer rather than being available for plant uptake. Other researchers, among them **Farag et al. (2015)** observed that using rice straw as a cultivated media is useful for encouraging vegetative growth. **Austin and Bondari (1992)** reported that mixing the growing media with a gel-polymer were detrimental to plant survival. **Deghen et al. (1994)** mentioned that growth response to gel polymer amendments varied with plant species and number of irrigations. Several studies have shown gel polymers to increase germination and establishment **Woodhouse and Johnson (1991)** increase seedling survival **Orzolek (1993)** and also to lengthen shelf-life of pot plants **Gehring and Lewis (1980)**. Some studies did, however, not show any benefits to plant growth when adding gel polymers to the soil **Ingram and Yeager (1987)**; **Tripepi et al. (1991)**. Findings on seedling survival on soil incorporated with gel polymers have been inconsistent. **Johnson and Leah (1990)** found increased dry weight of *Lactuca sativa* (lettuce), *Raphanus sativa* (radish), and *Triticum aestivum* (wheat) seedlings when gel-polymers were incorporated into sand media. In an experiment conducted by **Theron (2002)** a 83, 75 and 34% increase, respectively, for the mean root and shoot mass and mean height of *Pinus patula* were found when seedlings were grown on Aqua-Soil™ (gel-polymer) in comparison to the control. In other words **Maboko (2006)** found that gel polymer amendments increased productivity of tomato on a sandy soil. As well as growing lettuce in soil amended with higher pure gel polymer (Stock 8) level and both fertilizer-fused gel-

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polymer (Aqua 20 and Aqua 40) would likely be economically advantageous for a grower due to improved growth and higher yield of good quality lettuce.

### 2.1.4 Effect of soil conditioners on yield:

An experiment conducted by **Boatright *et al.* (1997)** found an increased number of flowers when added soil conditioners. **Hatayi and Ali (2004)** showed that maximum fruit yield (497.7g) was observed with 1.25% Aquasorb application which was significantly higher than all other levels of Aquasorb and minimum fruit yield was observed in control treatment (87.92) without soil conditioners. Addition of polymers to growing media had beneficial effects on shoot dry weight and fruit production. Fruit quality was also improved by the application of polymers to growing media due to the reduced impact of water stress during the growing cycle (**Johnson and Piper, 1997**). Other researchers, among them **Farag *et al.* (2015)**, Using rice straw as a cultivated media is useful for encouraging high total yield.

### 2.1.5 Effect of soil conditioners on nutrient:

Studies on incorporation of gel-polymers in a poor soil resulted in improved nutrient uptake by plants and minimizing nutrient losses through leaching. Under highly leached conditions, **Mikkelsen (1994)** found an improved growth of *Festuca arundinacea L.* (fescue) with increased accumulation of N and reduced nitrogen leaching. **Magalhaes, *et al.* (1987)** found higher retention of  $\text{NH}_4^+$ ,  $\text{K}^+$ ,  $\text{Ca}^{++}$ ,  $\text{Mg}^{++}$ ,  $\text{Zn}^{++}$ , and  $\text{Fe}^{++}$  on an oxisol treated with gel-polymers compared to the untreated soil. In addition, an increase in radish shoot growth and also better N, K, and Fe uptake was found in soil amended with gel-polymers. **Mikkelsen (1994)** concluded that the gel-polymers act as slow-nutrient release fertilizers. **Mikkelsen (1995)** experimented with four formulations of manganese to soils containing Glycine max (soybean) plants to determine response when a gel-polymer was in the soil. All of the G. max plants were higher in manganese content and showed increased

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biomass except where no gel-polymer was added. In an experiment comparing the leaching effects of 2000 mm of rainfall on fertilizers in sandy soil, it was found that Aqua-Soil™ retained up to 400% more nitrogen and 300% more potassium than standard quick release and slow release fertilizers **Bredenkamp (2000)**. As mentioned before, this implies that addition of gel-polymers not only could increase yield and conserve moisture, but minimized the leaching of nutrients, thus preventing groundwater pollution.

### **2.2 Effect of irrigation regime:**

With regard to second requirement in this study irrigation is considered as one of the main agricultural practices that effect on plant life. Water is a major constituent of living plant tissues, which consists of about 90%. Whereas, all biological processes within the living plants were depend on water. Irrigation water requirements in agriculture vary depending on Evapotranspiration (**Ezzo et al., 2010**).

#### **2.2.1. Evapotranspiration and irrigation water requirements:**

Reference evapotranspiration ( $ET_0$ ) is a calculated quantity of the maximum quantity of water capable of being lost as water vapor, under a given climate, by a continuous extensive stretch of vegetation covering the ground when there is no shortage of water (**Gangopadhyay et al., 1966**). The knowledge of crop transpiration over time may serve to improve irrigation control, since an accurate and dynamic control of the water supply is needed to meet plants, water requirements, due to the low water-holding capacity and limited volume of certain substrates (**De Boodt and Verdonck, 1972**). Computer controlled irrigation enables the use of more or less simplified algorithms to estimate the crop transpiration rate based on environmental and physiological factors. Crop transpiration can be effectively modelled using the Penman–Monteith equation (**Monteith, 1990**) Most of these studies have been conducted in a specific growth phase of the crop, while there is little information available on the transpiration rate over the plant's ontogeny and it's

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modeling over the entire crop cycle. Evapotranspiration ( $ET_0$ ) can be characterized as a process of mass transport where in the rate of evaporation is treated as a diffusive process driven by the vapor pressure gradient (MeKenney and Rosenberg, 1991). Cornelius *et al.*, (1995) pointed out that, numbers of methods exist or have been proposed for scheduling irrigation effectively, can be grouped into four categories:

- 1- Entirely empirical and without any kind of ongoing measurement.
- 2- Based on monitoring soil moisture.
- 3- Based on estimates of water use from weather data.
- 4- Based on tracking the condition of the crop usually referred to as crop water stress.

Joshi *et al.*, (1995) reported that  $ET_0$  can be estimated by the following methods:

- 1- FAO- Penman method.
- 2- FAO- Blamey- Criddle method.
- 3- FAO- Radiation method.
- 4- FAO- Pan evaporation method.
- 5- Penman- Monteith method.
- 6- Hargreaves Method.
- 7- Christiansen Method.
- 8- Jensen-Hais Method.
- 9- Class A pan Method.

One of the most debated issues in irrigation science is estimating  $ET_0$  using weather data (Doorenbos and Pruitt, 1977). Irrigation scheduling based on  $ET_0$  data depends on continual availability of such data. Estimation of  $ET_0$  is needed to support irrigation design and scheduling, watershed hydrology studies, process-based crop growth models, and other molds that attempt to simulate the soil water budget (Donnatlli *et al.*, 2006). On the other hand, Joshi *et al.* (1995) reported that, irrigation water requirement may be defined as the quantity of water that must be supplied by irrigation to satisfy evapotranspiration, leaching.

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Consumptive use by the crops and miscellaneous water requirements that were not provided by water stored in the soil and precipitation that enters the soil. **Dorais *et al.* (2001)** reported that plant water consumptive use increased with the progressive in plant growth depending on crop variety, plant growth stage and climatic condition. Irrigation water is gradually becoming scarce not only in arid and semi-arid regions but also in the regions where rainfall is abundant. Therefore, the water saving and conservation is essential to support agricultural activities. On the other hand, sandy soils suffer due to water deficiency, while intensifying mineral fertilization with irrigation water supply endangers the environment. Therefore, there are needs to cultivate the sandy soils to fight against hunger in the world but with the least amount of irrigation (**Saleh and Ozawa, 2006**).

### 2.2.2 Vegetative growth characteristics

The vegetative growth is an indicator to judge on tomato plants grown in the field. In this respect, many investigators studied the effect of irrigation regime on vegetative growth of tomato plants. Among these, **El-Beltagy *et al.* (1984)** who investigated the effect of three irrigation regimes, i.e., growing plants under condition of 100% of available soil moisture (wet) or depressing the available soil moisture down before re-watering to 65% (medium) or to 30% (dry) on growth of tomato plants. Results revealed that plant height, fresh and dry weight of leaves and stem as well as whole plant were increased with increasing the available soil moisture up to the highest used level (100% of available soil moisture). **Colla *et al.* (1999)** reported that during the first growth phase on tomato, irrigation treatments had no effect on above ground plant dry weight and leaf area. In addition, **Giardini *et al.* (1988)** working on tomato plants grown under protected cultivation reported that the maximum growth and the lowest dry matter percent were obtained when all layers of the soil (0-90cm) were maintained near the field capacity. Furthermore, **Fattahallah (1992)** investigated the effect of four different amounts of water using



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drip irrigation system. The amounts of water were 1.67, 3.34, 5.01 and 6.68 l/m<sup>2</sup>, where these amounts of irrigation water were applied either every day, two or three days. He noticed that plant dry weight, leaf area and relative growth rate were increased with the application of the highest amount of irrigation water (6.68 l/m<sup>2</sup>) daily or every two days. Moreover, **Merghaney (1997)** reported that plant dry weight and relative growth rate of tomato plants were positively influenced by increasing irrigation water also the same result was found with **El-Sawy (2014)**. In this concern, **Byari and Al-Sayed (1999)** investigated the effect of the different irrigation regimes on five greenhouse tomato cultivars under evaporative cooled greenhouse during fall and spring seasons. They reported that, irrigation water regimes slowed plant growth rate and reduced it in the two seasons of fall and spring. Water deficit decreased plant height, number of leaves/plant; stem thickness as well as dry weight of stem, leaves and roots. Moreover, **Navarrete and Jeannequin (2000)** studied the response of tomato plants to three irrigation moisture regimes corresponding to 100, 80 or 60% of crop water requirements. They indicated that using 100% of crop water requirement reflected the maximum values of plant height and leaf area. In addition, **Ibrahim (2005)** working on tomato reported that changing the irrigation regime through increasing the used rate of irrigation i.e., 12, 14, 16 m<sup>3</sup> water/fed daily by over addition of 4 or 8 m<sup>3</sup> water /fed. daily during the second month after transplanting and 8 or 16 m<sup>3</sup> water/ fed. daily during the last three months of growing season positively increased all vegetative growth parameters (plant height, number of branches, fresh and dry weight/plant) compared with using 12,14,16,18 m<sup>3</sup> water/fed. daily as a constant rate all over the growing season. In a poly net greenhouse, **Harmanto et al. (2005)** studied the effect of four different levels of drip fertigation equivalent to 100, 75, 50 and 25% of crop evapotranspiration (E<sub>c</sub>) on tomato growth. Results were compared with the open cultivation system as a control. Two mode of irrigation application namely continuous and

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intermittent was used. Drip irrigation system with emitter of 2, 4, 6 and 8 l/h discharge were used. The results revealed that the optimum water requirement for cv. Troy 489 of tomato is around 75% of the  $ET_c$ . Recently, **Sibomana *et al.* (2013)** reported that tomato cv. Many maker was subjected to four soil moisture threshold levels of 100,80,60 and 40% field capacity (F.C.) water stress resulted in significant decrease in leaf relative water content and vegetative growth. Severe water stress (40% F.C) reduced plant height by 24% and stem diameter by 18% compared to the control. As mentioned before, **Luvai *et al.* (2014)**, were found out that crop growth characteristics, crop yield and soil water content were significantly reduced when the amount of irrigation water and irrigation frequency were decreased. The optimum water requirement for Anna F1 variety of tomato grown in a greenhouse was around 80 % of the crop evapotranspiration ( $ET_c$ ) calculated based on the microclimate inside the greenhouse. Irrigation applied with 80% of crop evapotranspiration ( $ET_c$ ) was found to be the optimum irrigation amount for a greenhouse located in a semi-arid environment and therefore recommended. **El-Shinawy (1997)** illustrated the effect of irrigation treatments on plant height of cucumber. The results indicated that plant growth under irrigation with 100% class A pan was higher than the plants irrigated with 75% class A pan. Leaves of cucumber plants which received 100% of Class A Pan had lower chlorophyll contents compared to those irrigated with 75% Class A Pan. These increases on vegetative growth can be due to the fact that available more water enhances nutrient availability which improves nitrogen and other macro- and micro-elements absorption as well as enhancing the production and translocation of the dry matter content from source to fruit (**Gonzalez and Castel, 2000 and Tuzel *et al.*, 2001**). In addition **El-Sawy (2014)** used irrigation regimes on tomato plants under (80,100 or 120% of water requirements) that, enhanced all vegetative growth measurements (plant height, leaves

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number per plant, fresh and dry weight of leaves, stem and whole plant) when, were positively influenced by increasing irrigation water.

### **2.2.3 Chemical composition of plant foliage:**

#### **2.2.3.1 Chlorophyll and photosynthetic pigments:**

As for the effect of irrigation regimes on photosynthetic pigments, **Hatem *et al.* (2006)** indicated that under greenhouse conditions an, experiment was performed to investigate the effects of different levels of water stress on leaf water potential and chlorophyll content of tomato plants. Results revealed that moderate and severe water stress (i.e.,  $s = -0.51$  and  $-1.22$  MPa, respectively) caused a decrease in chlorophyll content compared with unstressed plants. In addition, **Kahlaoui *et al.* (2011)** working on tomato investigated the effect of water regimes 100%, 85% and 70% of the crop water requirement according to climatic data on photosynthetic pigments (chlorophyll a, b and total chlorophyll). They found that high total chlorophyll content was increased from 0.54, 0.47 and 0.45 mg/g fresh weight in the control (100% water requirement) to 0.80, 0.66 and 0.69 mg/g fresh weight in the more deficit water treatment (70% water requirement), respectively. Recently, **Sibomana *et al.* (2013)** working on tomato to quantify the effect of water stress on tomato cv. Money maker which subjected to four soil moisture threshold levels of 100%, 80%, 60% and 40% of field capacity on leaf chlorophyll content. Results indicated that water stress resulted in significant decreases in chlorophyll content. Sever water stress (40% of F.C) reduced chlorophyll concentration by 32% compared to the control (100% of field capacity).

#### **2.2.3.2 Mineral constituents:**

Concerning the effect of irrigation regimes on mineral constituents of plant foliage, many investigators reported that the concentrations of macro-elements of plant foliage were varied according to the time of irrigation and the amount of water applied. In this respect, **Locascio *et al.* (1986)** found that with elongation the time between irrigation for tomato plants, the uptake of nutritional elements (NPK) was

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decreased. In addition **Fattahallah (1992)** found that total nitrogen, phosphorus and potassium content in tomato leaves were increased with increasing the amounts of irrigation water applied, Moreover, **Locascio and Smajstrla (1996)** indicated that tomato leaf nitrogen concentration were slightly reduced with each increase in applied water quantity Moreover, **Nahar and Gretzmacher (2002)** reported that the uptake of nitrogen, phosphorus and potassium was significantly reduced by water stress in the plants at 100, 70 and 40% of field capacity. The highest percentage of such macro-nutrients was noticed in case of 100% of field capacity. **Ibrahim (2005)** showed that increasing the irrigation level either in case of irrigation with constant rate (12, 14, 16 or 18m<sup>3</sup> water/fed. daily) through the growing season or follow a change rate by increasing the aforementioned rates of application by (4 or 8m<sup>3</sup> water/fed. daily during the next last three months along the growing season decreased the total nitrogen, phosphorus and potassium concentration of plant foliage. The highest concentration for all assayed macro-nutrients was obtained as results of using 12 m<sup>3</sup> water/fed. i.e., irrigation at 52.8% of field capacity daily elongated the growing season. In this connection, **El-Nemr (1997)** under protected cultivation conditions on clay soil found that, decreasing the volume of applied irrigation water resulted in increasing N, P and K contents of pepper plant leaves. Similar results were also reported by **De-Pascale et al. (2000)** who indicated that decreasing the levels of irrigation water from 100% to 50% of class A pan evaporation resulted in increasing N, P and K content of pepper plant leaves. **Salvadore et al. (1996)** studied the effect of water scheduling by pan evaporation for tomato under drip-irrigation found that tomato leaf N concentrations was reduced slightly with each increase with water quantity applied.

### 2.2.4 Fruit yield:

**Salvadore et al. (1996)** studied the effect of water application scheduling by pan evaporation for drip-irrigated tomato and they found

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that total fruit yields were highest with irrigation quantities of 0.75 and 1.0 times Class A pan and significantly lower with 0.25 and 0.50 times pan. **Candido *et al.* (2000)** tested the effect of irrigation regime on yield and quality of processing tomato (*Lycopersicon esculentum* Mill.). They found that the highest marketable yield was obtained with maximum restoration of crop evapotranspiration. A similar behaviour was observed for total yield. High fruit yield with good quality of tomato plants can only be reached in the conditions of optimal soil moisture. Moreover, water deficiency may cause fruit yield decrease and fruit quality deterioration. In this connection, **Locascio and Samjstrla (1996)** applied 0.25, 0.5, 0.75 and 1.0 times pan evaporation in one application per day to polyethylene-mulched tomato and reported that total fruit yield was higher with irrigation quantities of 0.75 and 1.0 times pan evaporation and significantly lower with 0.25 and 0.50 times pan evaporation. Moreover, an increase in irrigation water quantity from 0.25 to 0.75 times pan evaporation only increased fruit yield from 65.9 to 74.1 t/ha. In addition, **Cetin *et al.* (2002)** working on tomato investigated the irrigation schedule of drip irrigated tomatoes cv. Duol large F1 using class A pan evaporation where irrigation water was applied as a certain ratio of class A pan evaporation ( $K_{pc}=0.5, 0.75, 1.00$  and  $1.25$ ) with different irrigation intervals 2, 4 and 6 days. In this respect, significant differences in fruit yields were obtained between the treatments, whereby the maximum marketable fruit yield was found at 1.00 kpc where it was ranged from 116.6 to 176.3 t/ha. In this connection, **Isrefil *et al.* (2002)** investigated the relationships of irrigation water requirement, times and number as well as evapotranspiration ( $E_t$ ) and water yield ( $y$ ) of tomato. Treatments included irrigation at 14, 21 and 28 day intervals. Results revealed that no significant differences in the yield between treatments were found, therefore 28 days intervals were suggested to be practice. **Saleh *et al.* (2007)**, studied the effect of drip irrigation frequencies, 1 and 3 days and three irrigation timings, early morning (8.00h), afternoon (14.00h) and

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night (20.00h) on fruit yield of tomato plant cv. First power was grown under greenhouse conditions. They found that the best irrigation frequency was 3 days. The average yield in 3 days frequency was 70 ton/ha compared with 63 ton/ha in 1day frequency. The effect of irrigation timing varied with irrigation frequency. For 3 days frequency, irrigation at early morning was better than at after noon and night. Irrigation at early morning increased the average yield by 15% and 14% than irrigation at afternoon and night, respectively. In this concept, **Birhanu and Tilahun (2010)** reported that both the number and size of tomato fruits were found to be decreased with moisture stress, while the harvest index was increased with stress level when tomato plants cvs Melka Shola and Melkassa Marglobe were exposed to four irrigation water deficit levels expressed as percentages of potential evapotranspiration ( $E_t$ ) as 0, 25, 50 and 75%  $E_t$  deficit. In this regard, cv. Melkassa Marglobe was preferable. Similarly, **Panigrahi *et al.* (2010)** investigated the effects of variable water supply by drip irrigation at 100, 80 and 60% crop evapotranspiration ( $E_t$ ), replenishment and furrow irrigation at 1.2 TW: CPE (TW=irrigation water of depth 5 cm and CPE=cumulative pan evaporation) on yield and water use of tomato crop. Results indicated that, the yield of the crop was found to be maximal (180.97 q/ha) for drip irrigation at 100%  $E_t$  replenishment whereas those for treatments 80, 60% and 1.2 TW were 162.77, 145.12 and 156.86 q/ha, respectively. The study revealed that drip irrigation at 100%  $E_t$  replenishment in tomato can increase the yield by 15.4% besides saving 17.9% more costly irrigation water than the conventional furrow irrigation practiced by most of the farmers. Also, the applied irrigation amount on the watering method significantly affect the crop yield, dry matter content, pH and skin resistance were slightly changed during harvesting period (**Mohammadi-ghahsare *et al.*, 2010**). In addition, **Baye (2011)** working on tomato conducted an experiment to evaluate the effect of three levels of water namely 315, 440 and 565 mm) combined with three

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mulch treatments namely without mulch, black plastic mulch and straw or crop residue mulch. Results revealed that the highest net benefit was obtained via 440mm water with straw mulch. Recently, **Olanik and Madramootoo (2014)** studied the response of greenhouse grown bell pepper to four variable irrigation treatments (120, 100, 80 and 40%) replenishment of crop evapotranspiration. They found that the highest marketable yield and irrigation water use efficiency were obtained with 120% hence this treatment received 20% more water than 100% to produce 23% more marketable yield. In other hand, **Farag *et al.* (2015)** showed that the use of 1.00 and 1.20 of  $ET_0$  from measured evapotranspiration in the experiment is useful for increasing the tomato fruit yield.

### **2.2.5 Fruit quality:**

#### **2.2.5.1 Physical fruit quality:**

Physical fruit quality expressed as weight, length, diameter and size were affected by irrigation regimes. In this respect, **El-Beltagy *et al.* (1984)** studied the effect of different water regime, i.e. irrigation at 30, 65 and 100% of available soil moisture on tomato cv. Pritchard. They found that average fruit weight was depressed as available soil moisture was decreased. The same trend was found by **Fattahallah (1992)**, who reported that when tomato plants cv. Castle Rock were irrigated by 4 different amounts of water, i.e., 1.67, 3.34, 5.01 and 6.68 l/m<sup>2</sup>, fruit weight and size were increased with increasing amount of irrigation water. In the same time fruit firmness was decreased. In this regard, **Ortego *et al.* (2001)** evaluated the effect of different levels of drip irrigation (70, 100 and 150% of the real crop evapotranspiration,  $E_t$  real) on quality of tomato cv. FA.144. They noticed that fruit size was significantly increased with the highest level of irrigation water. However, no significant differences were noticed on average fruit weight. In addition, **Harmanto *et al.* (2005)** reported that both irrigation water amount (100, 75, 50 and 25% of crop evapotranspiration ( $ET_c$ ) and

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irrigation model (continuous and intermittent where water application at once or three times a day) did not affect the fruit quality, i.e., fruit weight and diameter. Similar results were reported by **Ibrahim (2005)**, who mentioned that the highest values in all fruit physical characters (average fruit weight, length and diameter) were obtained from the irrigation with rate of 14 m<sup>3</sup> water/fed. daily during the first month increased to 22 m<sup>3</sup>/water/fed. During the second month and 30 m<sup>3</sup> water/fed.daily during the last three months of growth with a total amount of water (3780 m<sup>3</sup>/fed). Also, **Baye (2011)** studied the effect of three water levels (Namely 315, 440 and 565 mm) and found that increasing the amount of water used significantly enhanced average weight of fruit. Soil moisture content is the most conducive condition for tomato fruit cracking. When the availability of soil moisture surrounding the roots is inconsistent, physiological disorders such as fruit cracking could occur. In the greenhouse, more frequent watering was shown to increase the incidence of radial cracking, and there are also a few reports in field tomato crops of increased cracking at higher levels of soil moisture **Peet and Willits (1995)**. As previously mentioned, a high irrigation regime reduces fruit quality due to the tendency of the fruit to crack as was found by **Kamimura et al. (1972)**. Regardless of fertilizer applied to the plant, other studies have reported that plants receiving high amounts of water were more prone to cracking (**Peet and Willits, 1995**). Irregular irrigation, especially when dry a soil becomes moist and subsequently dry again, favours the incidence of fruit cracking (**Peet, 1992; Pascual et al., 1999; Dorais et al. 2004**). **Peet and Willits (1995)** observed the reduction of the incidence of fruit cracking when daily irrigation frequency was changed from 1 to 4 watering per day, while total daily irrigation quantity remained the same. It was shown **Kamimura et al. (1972)** that a sudden increase in the growing media's water content, reduced the elasticity of the tomato cuticle and increased root pressure. Under higher soil moisture conditions, the water-uptake



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will also be higher which rapidly increased turgor pressure. **Cheryld *et al.* (1997)** reported that fruit cracking would be the result of cell expansion, placing pressure on the epidermis and cuticle. Furthermore, limited elasticity or weakness in the cuticular layer would then lead to fruit cracking. The skin strength of the tomato fruit is mostly affected by changes in soil moisture. It was reported by **Peet (1992)** that when the soil moisture content decreased, the skin strength increased. Conversely, it was also mentioned that when the soil moisture content increased, the skin strength decreased. Inadequate watering on fruit cracking has also been reported for field grown tomato (**Emmons and Scott, 1997**). As previously mentioned, **Maboko (2006)** found that when used soil conditioners resulted in greater tomato plant growth and yield while in lettuce greater yields of good quality heads were obtained.

### **2.2.5.2 Chemical fruit quality:**

Many investigators reported the main role of irrigation on chemical quality traits of tomato fruits. In this respect, **El-Beltagy *et al.* (1984)** studied the effect of different water regime i.e., irrigation at 30, 65 and 100% of available soil moisture on tomato cv. Pritchard. They found that total soluble solids, vitamin-C and titratable acidity were increased as the available soil moisture was decreased. Similar trend was noticed by **Fattahallah (1992)** who indicated that when tomato plants cv. Castle Rock were irrigated by four different amounts of water, i.e., 1.67, 3.34, 5.01 and 6.68 l/m<sup>2</sup>, fruit content of vitamin-C and total soluble solids were decreased with increasing amount of irrigation water. In addition, **Tan (1995)** noticed that total soluble solids (TSS) in fruits were positively influenced by irrigation. **Cohn *et al.* (2003)** found that early irrigation cutoff increased soluble solids of fruits when treatment were sufficiently severe to reduce soil moisture in the upper 70 cm of the soil profile during fruit ripening. In this concern, **Ibrahim (2005)** working on tomato cv. Faculta 38 mentioned that increasing the rate of irrigation either in case of irrigation with a constant level during the growth season (12, 14, 16 and

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18 m<sup>3</sup> water/fed.daily) or follow an over increasing level during the second and the last three months of growth led to a significant decrease in all assayed organic constituents (total acidity, total sugars, vitamin-C and total soluble solids). **Miguel and Amor (2007)** investigated the effect of surface and subsurface drip irrigation with 100 and 50% of crop evapotranspiration (ET<sub>c</sub>). The results showed that water stressed treatment increased the pH and the acidity of the fruit. **Vijitha and Mahendran (2010)** indicated that moisture stress for four days at fruit ripening stage reduced the vitamin-C content of fruits. The TSS and acid content of the fruits were slightly affected by moisture stress when the stress was imposed during the fruit ripening stage but they were not significant. Vitamin-C, TSS and acidity of fruits were unaffected by moisture stress given during vegetative, flowering and early fruit stage (moisture stress for 4 days during each stage). Other authors **Obreza et al. (1996)**; **Ho (1999)** acknowledged that soil water and crop water supply have an influence on tomato total soluble solids (% Brix).

### 2.2.6 Water use efficiency (WUE):

**El-Gindy et al. (2001)** noticed that the daily ET<sub>o</sub> values were varied as climatic conditions and plant growth stage changing. Moreover, the rates of ET<sub>o</sub> were increased with the progressive growth and this was in the case of maize production. They concluded that, the yield and it's attributed of maize and water use efficiency was highly affected by the amount of irrigation water added through maize growth season, where values of the above mean water added increased. Parameters were increased as the amount of irrigation water added increased. **Abdrabbo et al. (2010)** showed that increasing irrigation quantity over 0.80 (ET) led to decrease water use efficiency for all irrigation treatments. The highest WUE was obtained by 0.80 (ET). The 1.20 (ET) combined with control treatment had the lowest WUE during the two studied seasons. These results were in line with those obtained by **Hashem et al. (2011)**. This necessitates rationalizing water use in crop production. Strategies to

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increase efficiency of water use in agriculture are based on two approaches: the technological and biological methodologies. Technological methods include utilization of advanced irrigation systems and scheduling of irrigation frequencies. Biological approach includes domestication of potentially drought resistant plant species and breeding drought tolerant crop plants. **Novello and de Palma (1997)** reported that under semi-arid climatic conditions, cultivars and rootstock efficiency in water utilization has a marked influence in determining most of the physiological and agronomical performances observed in crop plants, especially woody fruit species. Irrigation can be important for vegetable crops because many are shallow rooted and therefore sensitive to water shortage. Vegetable production is a high-cost enterprise with a high value end product and many growers feel the need to have irrigation available as an insurance against drought. There are several potential benefits from irrigating vegetables, e.g. yield increase, improvement in plant establishment, continuity of supply to market or processor, and increased quality (**Bailey, 1990**). As water supplies become scarcer and the cost of water for irrigation increases, irrigation-scheduling methodologies need to be more precise (**Gonzalez and Castel, 2000**). Therefore, this study was conducted to determine the effects of cultivate tomato in the rice straw media and response of tomato plants to different water levels under net house conditions. In the other hand, **Zegbe-Dominguez *et al.*, (2006)** and **Saleh and Ozawa (2006)** and **El-Sawy (2014)** reported that economically, it can be recommended to use the less water regime (80%) with the highest shading density (73%) in order to get optimum yield with saving water. moreover, **Castilla (1996)** reported that IWUE values of 34 kg/m<sup>3</sup> for greenhouse tomato production in soil, but in soilless culture, the IWUE value was 29 kg/m<sup>3</sup>. However, in controlled greenhouses WUE of tomato may reach 65 kg/m<sup>3</sup>. **Tuzel *et al.* (1994)** reported WUE values ranging from 21.05 to 62.46 kg/m<sup>3</sup>.

## MATERIALS AND METHODS

### 3.1. Experimental layout:

Two field experiments were performed during the two successive summer seasons (2012/2013 and 2013/2014) at El-dolify farm in Katatba zone, Monofaya Government. Location of the experimental site was as follows: latitude  $30^{\circ} 37'31''$  N, longitude  $30^{\circ} 07' 30''$  E and 26 m above sea level. Soil in this experimental site is sandy soil in texture with pH 7.5 and EC 4.68 ds/m. Chemical analysis of water and soil before and after adding soil conditioners are shown in Table 1.

**Table 1: Chemical analysis of soil and water**

	pH	EC dS/m	Chemical analysis								CaCO <sub>3</sub> %
			Anions (Meq/L)				Cations (Meq/L)				
			Cl <sup>-</sup>	HCO <sub>3</sub> <sup>-</sup>	CO <sub>3</sub> <sup>-</sup>	SO <sub>4</sub> <sup>-</sup>	Na <sup>+</sup>	K <sup>+</sup>	Ca <sup>++</sup>	Mg <sup>++</sup>	
Water	7.4	0.51	2.0	1.3	-	0.9	1.85	0.19	1.9	1.6	--
Soil before conditioners	7.5	4.68	36.6	5.9	*	--	20.5	1.5	14	9	3.00
Hundz soil	7.1	2.18	17.1	3.7	*	--	10.2	0.9	6.5	3.4	2.00
Olygo plus	7.2	3.1	27.2	2.8	*	--	15.2	1.2	10.0	6	2.75
Bioconditioner	7.3	3.96	33	2.6	*	--	21.5	0.74	10	7	3.25

### 3.2 Soil samples:

The chemical properties of the experimental soil are shown in Table (1). The following properties were determined:

Soil reaction (pH) was determined in soil water suspension (1:2.5) using pH meter, with glass electrode according to **Jackson (1967)**.

Calcium carbonate content was determined volumetrically using Collins calcimeter according to **Piper (1950)**.

Electrical conductivity (EC) as well as soluble ions was determined in soil paste extract as describe by **Jackson (1967)**.

Soluble Na and K were determined by flame photometer.

Soluble Ca and Mg were determined by using Versenta method and soluble anions, namely; Cl and HCO<sub>3</sub> were determined volumetrically according to **Black (1969)**.

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The current study was conducted with three level (100%, 80% , 60%) of water requirements each of 400m<sup>2</sup> (10m width, 40m length) to investigate the growth and productivity of tomato plants under using four different soil conditioners (Oligo plus, Bioconditioner, Hundz soil, control):

1. Oligo plus: it is a soil conditioners extracted from seaweed it contents 10% carbohydrates, 20% alginic acid, 5% manitol and organic humate.
2. Bioconditioner: it is a soil amendment content natural polymer CMC (carboxy methyl cellulose) designed to reduce plant waterings. It is environmentally friendly soil conditioner which can save water.
3. Hundz soil: it is a natural soil conditioner that made out of cellulose after processing artificial treatments.
4. Control (without soil conditioner)

### **3.3. Nursery materials:**

In this study the seeds of tomato (*Lycoperscon esculentum* Mill.) were belong to Yara F1 hybrid. Seeds were sown on 15<sup>th</sup> of July during both seasons of 2012 and 2013, in multi-pot transplant trays. These trays were filled with a mixture of peat-moss and vermiculite media (1:1 v/v). Chemical fertilizers and fungicides were added to the mixture according to the recommendation of the Ministry of Agriculture. After sowing, trays were covered by black plastic mulching for four days. Then they were moved to high tables and were cared by irrigation, fertilization and pest management in the nursery. After 35 days from sowing, seedlings were transplanted to the open field (on August 20<sup>th</sup> during both seasons of 2012 and 2013). Seedlings were arranged in rows. Each row was 1.5 m in width and 40 m in length. The distance between transplants was 50cm within the row. Irrigation system was drip irrigation.

### **3.4. The experimental treatments:**

The treatments comprised three water regimes were tested as follow: 100, 80, 60% of water requirements for tomato plants estimated

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by Penman Monteith equation Allen *et al.*, (1998). Also, there were three different soil conditioners which tested and compared to control treatment (four treatments). Soil conditioners were Oligo plus, Bioconditioner, Hundz soil. The Hundz soil conditioner was added with soil preparing (5-6 m<sup>3</sup>/feddan). While, Oligo plus and Bioconditioner were added twice in the season. First time was after 20 day from planting and the second time was after 20 day from the first adding with starting the plant flowering (20 liter/feddan). The properties of tested soil conditioners are shown in Table 1.

### 3.4.1 Calculations of water regimes:

Calculations of irrigation levels were done whereas the irrigation control was practiced via manual valves for each experimental plot. The total amount of water irrigation was calculated by Food and Agricultural Organization (FAO) Penman- Monteith (PM) procedure, FAO 56 method Allen *et al.*, (1998). The potential evapotranspiration was calculated as follows:

$$ET_o = \frac{0.408\Delta (R_n - G) + \gamma \frac{900}{T + 273} u_2 (e_s - e_a)}{\Delta + \gamma(1 + 0.34 u_2)} \dots (1)$$

Where:

$ET_o$  = Daily reference evapotranspiration [mm d<sup>-1</sup>].

$R_n$  = Net radiation at the crop surface (MJ m<sup>-2</sup> day<sup>-1</sup>),

$G$  = Soil heat flux density (MJ m<sup>-2</sup> day<sup>-1</sup>),

$T$  = Mean daily air temperature at 2 m height (°C),

$U_2$  = Wind speed at 2 m height (m s<sup>-1</sup>),

$e_s$  = Saturation vapor pressure (kPa),

$e_a$  = Actual vapor pressure (kPa),

$\Delta$  = The slope of vapor pressure curve (kPa °C<sup>-1</sup>)

$\gamma$  = The psychrometric constant (kPa °C<sup>-1</sup>).

The second step was done to obtain values of crop water consumptive use ( $ET_{crop}$ ) as described by Doorenbos and Pruitt (1977), since the crop

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evapotranspiration ( $ET_{crop}$ ) was calculated as the following **Doorenbos and Pruitt (1977)**:

$$ET_{crop} = ET_o \times Kc \quad \dots \dots \text{mm / day} \quad \dots (2)$$

Where:

$ET_o$  = The rate of evapotranspiration from an excessive surface of green cover of uniform height (8 to 15 cm), actively growing, completely shading the ground and did not suffer water shortage.

$Kc$  = Crop coefficient (between 0.6 to 1.2).

- Water requirements (WR) for each treatment were calculated as following:

$$WR = ET_{crop} \times LR \% \quad \dots \dots \text{mm / day} \quad \dots (3)$$

Where:

LR% =Leaching requirement percentage (22% of the water requirement based on the Leaching Fraction equation – according to equation5).

- Irrigation requirement (IR) was calculated as follows:

$$IR = WR \times R * 4200/1000 \text{ (m}^3/\text{feddan / day)} \quad \dots \dots (4)$$

Where:

R = Reduction factor for drip irrigation that only covers a part of land and the rest dry leaves. It was recommend by **Doorenbos and Pruitt (1977)** to use R value which ranges between 0.25 and 0.9 for drip irrigation system.

The total amount of irrigation water was measured by water flow-meter for each treatment. Table (2) shows the seasonal irrigation quantities for tomato under different irrigation treatments at El-Khatatba site during the two seasons. Plants were irrigated by using drippers of 2 l/hr capacity. The fertigation technique was used. Leaching requirements was calculated based on **Allen *et al.*, (1998)**.

$$LF = EC_{iw} / EC_d \quad \dots \dots (5)$$

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Where:

LF = leaching fraction

$EC_{iw}$  = Electrical conductivity of irrigation water (0.35 dS/m).

$EC_d$  = Electrical conductivity of drainage water salinity threshold.

### **3.4.2. Amount of used water:**

Total amount of the added water through the drip irrigation system was measured by giger for each water regime treatment (Table, 2)

**Table 2: Average amounts of applied water (liter/plant) in each treatment of both summer seasons**

Month	Irrigation treatments (l)		
	60%	80%	100%
Sep.	1250	1666	2083
Oct.	2953	3937	4921
Nov.	4368	5824	7279
Dec.	2600	3466	4333
Jan.	2503	3337	4171
Total	13672	18229	22787

### **3.4.3. Water use efficiency (WUE):**

Water use efficiency was calculated for the different water regimes treatments using the following equation Srinivas *et al.*, (1989).

$$WUE = \text{Total yield (kg/ fed.)} / \text{Total water consumption (m}^3 \text{ /fed.)}.$$

### **3.5. Experimental design:**

The experimental treatments were arranged by applying the split plot design with three replicates. Water regimes treatments were arranged in the main plots and soil conditioners treatments were randomly arranged in the sub plots.

### **3.6. Measurements:**

#### **3.6.1 Vegetative growth:**

Five plants were labeled from each experimental plot and the following data were recorded:



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Plant height, number of leaves per plant, number of branch and stem diameter (10cm from the soil surface) were recorded at three times (after 30, 60 and 90 days from transplanting).

The leaf area of the fifth leaf from the top was recorded two times after 60 and 120 days after transplanting by using a digital leaf area meter (LI-300 Portable Area Meter Produced by LI. COR, Lincoln, Nebraska, U.S.A).

A representative sample of three plants from each experimental unit was taken two times during the growth period, 90 and 180 days from transplanting to measure fresh and dry weight.

### **3.6.2 Chemical analysis of leaves:**

#### **3.6.2.1 Total chlorophyll reading**

It was measured in leaves two times during the growth period (60 and 120 days from transplanting) by using digital chlorophyll meter (model Minolta chlorophyll meter SPAD-501).

#### **3.6.2.2 Minerals content (%):**

Dry samples of plant foliage were ground and then 0.2 g of each sample was digested in sulphuric and perchloric acids at ratio 2:1 by volume and then used for determining the following chemical constituents.

- **Nitrogen:** It was determined in leaves by the distillation in a Macro-Kjeldahle apparatus ADAS/MAFF (1987).
- **Phosphorus:** It was determined colorimetrically in leaves in the acid digest using ascorbic acid and ammonium molybdate as described by Watanabe and Olsen (1965).
- **Potassium:** It was determined flame-photometrically as described by ADAS/MAFF (1987).
- **Calcium:** It was determined spectrometrically using Phillips Unicam Atomic Absorption spectrophotometer as described by Chapman and Pratt (1961).

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### **3.6.3. Yield and its components:**

At red stage (75 days from transplanting) fruits were harvested and recorded for each harvest and the early yield, marketable and unmarketable as well as total fruit yield were recorded. Early yield was determined on the basis of the first two harvests.

Marketable yield includes all healthy with good quality parameters, while unmarketable fruit includes misshape, cricked and infected fruits from the total harvest collections.

### **3.6.4. Fruit characters:**

Representative samples of 10 fruits from each replicate at each picking were collected to determine the averages of the following:

### **3.6.5. Physical fruit characters**

- Fruit weight.
- Fruit number.
- Fruit firmness (mg/cm<sup>2</sup>)

It was determined by using Penetrometer (Fruit Pressure Tester) mod. FT 327.

### **3.6.6. Chemical fruit properties:**

- **L.Ascorbic acid content:** Ascorbic acid (mg/100 cm<sup>3</sup> juice) was determined in the fresh fruits by using the 2, 6 Dichlorophenolindophenol method described in A. O. A. C. (1990).
- **Total acidity** was determined as mg/ liter of juice by titration with NaOH as described in the A.O.A.C. (1990).

### **3.7. Statically analysis procedure:**

The obtained data were statistically analyzed using the analysis of variance method according to Snedecor and Cochran (1980). L.S.D values at the 5% level of probability were used to compare means of treatments.

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### **4.1. Vegetative growth:**

Impacts of both of soil conditioners and water regimes, as well as their interaction on the vegetative growth parameters of tomato plants were studied through studying plant length, number of leaves and shoots, chlorophyll content, stem diameter, leaf area, and total fresh and dry weight of plant.

#### **4.1.1. Plant length and number of leaves per plant:**

Illustrated data in Tables (3, 4, 5, 6, 7 and 8) indicated that, soil conditioners are significantly able to enhance plant length and number of leaves of tomato after 30, 60 and 90 days after cultivation. After 30 days from cultivation no significant differences on plant length was observed between the three tested types of soil conditioners. All used soil conditioners had a significant differences compared to control treatment (without soil conditioners). At the same time, there were a significant different between the used soil conditioners in number of leaves.

Hundz soil and Oligo plus were recorded the highest significant values of the two discussed characters (plant length and number of leaves). While, there was an insignificant difference between them for plant length after 30 days from cultivation. There were significant differences between soil conditioners treatments after 60 and 90 days from transplanting. Moreover, a significant effect was detected in number of leaves after 30, 60 and 90 days. Control treatment (without conditioners) was significantly recorded the lowest plant length and number of leaves during the crop life cycle. The same result was found during the second season.

Highlighting effect of irrigation regime, the highest significant value of plant length as well as number of leaves was detected when 100% was used in irrigation, followed by 80% without significant different between them after 30 and 60 days after cultivation. After 90 days there was a significant difference between them in plant length.

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**Table (3):** Effect of different irrigation treatments and soil conditioners on plant length (cm) of tomato after 30 days from transplanting during the two seasons of 2012/2013 and 2013/2014.

<b>2012-2013</b>				
	<b>W.R 60%</b>	<b>W.R 80%</b>	<b>W.R 100%</b>	<b>Mean</b>
<b>Hundz soil</b>	55.33 c	61.00 b	64.67 a	<b>60.33 A</b>
<b>Oligo plus</b>	53.67 c	60.66 b	61.3 ab	<b>58.55 A</b>
<b>Bioconditioner</b>	53.00 c	60.00 b	62.67 a	<b>58.55 A</b>
<b>Control</b>	50.00 c	59.33 b	61.00 b	<b>56.78 B</b>
<b>Mean</b>	<b>53.00 B</b>	<b>60.25 AB</b>	<b>62.42 A</b>	
<b>2013-2014</b>				
<b>Hundz soil</b>	63.33 b	63.67 b	67.33 a	<b>64.78 A</b>
<b>Oligo plus</b>	61.67 b	62.60 b	65.33 a	<b>63.20 A</b>
<b>Bioconditioner</b>	57.67 c	62.33 b	64.33 a	<b>61.44 A</b>
<b>Control</b>	57.00 c	57.33 c	63.33 b	<b>59.22 B</b>
<b>Mean</b>	<b>59.92 B</b>	<b>61.48 AB</b>	<b>65.08 A</b>	

**Table (4):** Effect of different irrigation treatments and soil conditioners on plant length (cm) of tomato after 60 days from transplanting during the two seasons of 2012/2013 and 2013/2014.

<b>2012-2013</b>				
	<b>W.R 60%</b>	<b>W.R 80%</b>	<b>W.R 100%</b>	<b>Mean</b>
<b>Hundz soil</b>	57.67 cd	68.33 a	69.67 a	<b>65.55 A</b>
<b>Oligo plus</b>	64.67 ab	66.33 ab	68.33 a	<b>66.44 A</b>
<b>Bioconditioner</b>	57.67 d	62.00 bc	68.00 a	<b>62.56 BC</b>
<b>Control</b>	56.67 d	61.67 bcd	66.67 ab	<b>61.67 C</b>
<b>Mean</b>	<b>59.17 B</b>	<b>64.56 A</b>	<b>68.16 A</b>	
<b>2013-2014</b>				
<b>Hundz soil</b>	70.70 cd	74.00 a	74.70 a	<b>73.11 A</b>
<b>Oligo plus</b>	69.00 cd	70.00 cd	73.30 ab	<b>70.76 B</b>
<b>Bioconditioner</b>	68.33 de	68.60 cd	71.70 bc	<b>69.53 B</b>
<b>Control</b>	65.33 f	66.00 ef	70.70 cd	<b>67.33 C</b>
<b>Mean</b>	<b>68.34 B</b>	<b>69.65 B</b>	<b>72.60 A</b>	

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**Table (5):** Effect of different irrigation treatments and soil conditioners on plant length (cm) of tomato after 90 days from transplanting during the two seasons of 2012/2013 and 2013/2014.

<b>2012-2013</b>				
	<b>W.R 60%</b>	<b>W.R 80%</b>	<b>W.R 100%</b>	<b>Mean</b>
<b>Hundz soil</b>	62.67 de	75.33 ab	76.30 a	<b>71.44 A</b>
<b>Oligo plus</b>	70.67 bc	71.67 bc	73.00 abc	<b>71.78 A</b>
<b>Bioconditioner</b>	58.00 e	67.33 cd	70.70 bc	<b>65.33 B</b>
<b>Control</b>	58.67 e	65.67 d	71.00 ab	<b>65.11 B</b>
<b>Mean</b>	<b>62.50 C</b>	<b>70.00 B</b>	<b>72.75 A</b>	
<b>2013-2014</b>				
<b>Hundz soil</b>	71.33 ef	75.33 ab	76.00 a	<b>74.22 A</b>
<b>Oligo plus</b>	71.67 fg	73.67 def	75.00 ab	<b>73.44 A</b>
<b>Bioconditioner</b>	70.00 bcd	71.33 ef	74.00 cde	<b>71.77 B</b>
<b>Control</b>	68.67 g	69.67 fg	70.56 bc	<b>69.63 C</b>
<b>Mean</b>	<b>70.41 C</b>	<b>72.5 B</b>	<b>73.89 A</b>	

**Table (6):** Effect of different irrigation treatments and soil conditioners on number of leaves of tomato plants after 30 days from transplanting during the two seasons of 2012/2013 and 2013/2014.

<b>2012-2013</b>				
	<b>W.R 60%</b>	<b>W.R 80%</b>	<b>W.R 100%</b>	<b>Mean</b>
<b>Hundz soil</b>	78.67 c	92.33 a	93.00 a	<b>88.00 A</b>
<b>Oligo plus</b>	74.67 c	84.00 b	90.67 a	<b>83.11 A</b>
<b>Bioconditioner</b>	72.00 cd	74.67 c	76.33 c	<b>74.33 B</b>
<b>Control</b>	61.67 d	62.33 d	74.67 c	<b>66.22 C</b>
<b>Mean</b>	<b>71.75 C</b>	<b>78.33 B</b>	<b>83.67 A</b>	
<b>2013-2014</b>				
<b>Hundz soil</b>	76.00 bcd	91.67 ab	95.66 a	<b>87.78 A</b>
<b>Oligo plus</b>	75.33 bcd	86.60 ab	91.67 ab	<b>84.53 A</b>
<b>Bioconditioner</b>	74.00 bcd	75.33 bcd	80.33 abc	<b>76.55 B</b>
<b>Control</b>	63.00 d	63.67 d	76.67 ab	<b>67.78 C</b>
<b>Mean</b>	<b>72.08 B</b>	<b>79.32 B</b>	<b>86.08 A</b>	

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**Table (7):** Effect of different irrigation treatments and soil conditioners on number of leaves of tomato plants after 60 days from transplanting during the two seasons of 2012/2013 and 2013/2014.

<b>2012-2013</b>				
	<b>W.R 60%</b>	<b>W.R 80%</b>	<b>W.R 100%</b>	<b>Mean</b>
<b>Hundz soil</b>	89.33 cde	100.33 abc	109.70 a	<b>99.79 A</b>
<b>Oligo plus</b>	87.67 cde	93.33 bcd	99.33 bcd	<b>93.50 A</b>
<b>Bioconditioner</b>	85.33 def	86.00 def	88.00 cde	<b>86.55 B</b>
<b>Control</b>	75.00 ef	80.75 ef	83.00 def	<b>81.17 B</b>
<b>Mean</b>	<b>84.33 B</b>	<b>90.10 A</b>	<b>95.00 A</b>	

<b>2013-2014</b>				
<b>Hundz soil</b>	91.33 bc	103.0 ab	106.3 a	<b>98.54 A</b>
<b>Oligo plus</b>	90.33 bc	97.3 ab	100 ab	<b>95.88 A</b>
<b>Bioconditioner</b>	80.00 cd	88.67 bcd	96.00 ab	<b>88.22 B</b>
<b>Control</b>	74.33 d	80.67 cd	93.67 abc	<b>87.17 B</b>
<b>Mean</b>	<b>83.99 B</b>	<b>92.41 A</b>	<b>98.82 A</b>	

**Table (8):** Effect of different irrigation treatments and soil conditioners on number of leaves of tomato plants after 90 days from transplanting during the two seasons of 2012/2013 and 2013/2014.

<b>2012-2013</b>				
	<b>W.R 60%</b>	<b>W.R 80%</b>	<b>W.R 100%</b>	<b>Mean</b>
<b>Hundz soil</b>	101.0 bcd	111.3 ab	116.3 a	<b>109.53 A</b>
<b>Oligo plus</b>	106.0 abc	107.70 abc	110.7 ab	<b>108.83 A</b>
<b>Bioconditioner</b>	94.67 de	99.67 cde	101.3 bcd	<b>98.56 B</b>
<b>Control</b>	90.33 e	91.67 de	95.00 cde	<b>92.67 B</b>
<b>Mean</b>	<b>98 B</b>	<b>102.58 A</b>	<b>105.82 A</b>	

<b>2013-2014</b>				
<b>Hundz soil</b>	99.67 bc	108.7 ab	112.7 a	<b>108.0 2 A</b>
<b>Oligo plus</b>	106.3 ab	103.0 bc	103.7 bc	<b>105.67 A</b>
<b>Bioconditioner</b>	95.67 bc	100.7 bc	102.7 bc	<b>99.69 B</b>
<b>Control</b>	93.33 c	98.67 bc	101.7 bc	<b>97.92 B</b>
<b>Mean</b>	<b>98.74 B</b>	<b>102.77 A</b>	<b>105.2 A</b>	

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However, 60% irrigation regime recorded the lowest significant plant length and leaves number after 30, 60 and 90 days after cultivation. The mentioned trend of a result was true in the second studied season.

Regarding the interaction between soil conditioners and irrigation regime, performance of the highest significant interaction was the same during the crop life cycle. Interaction between Hundz soil and 100% irrigation regime recorded the highest value of plant length and number of leaves after 30, 60 and 90 days from cultivation. On the contrary, interaction between control (without conditioners) and irrigation regime 60% were obviously the lowest significant in both discussed characters. The obtained result was confirmed during the second season.

### **4.1.2. Number of shoots per plant:**

It was concluded from data in Tables (9, 10 and 11) that the different irrigation regimes, soil conditioners and their interactions were affected significantly on the number of shoots of tomato plants. After 30 days from transplanting, the results indicated that there were no significant differences between the different irrigation regimes in the first season. In the second season there was a significant difference in number of shoots after 30 days from transplanting. The highest significant value was obtained by 100% irrigation level followed by 80% and the lowest significant value was obtained from 60% treatment after 90 days from transplanting date.

Concerning to the soil conditioners treatments, there was no significant differences in number of shoots between tested soil conditioners after 30 days from transplanting in the first season. While, in the second season there was a significant difference between the Hundz soil and control, the highest significant value of number of shoots resulted from Hundz soil treatment. However, after 60 and 90 days from transplanting, there was a significant difference between the tested types of soil conditioners compared to control treatment. The Hundz soil was recorded the highest significant value during the first season compared to

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**Table (9):** Effect of different irrigation treatments and soil conditioners on number of shoots of tomato plants after 30 days from transplanting during the two seasons of 2012/2013 and 2013/2014.

<b>2012-2013</b>				
	<b>W.R 60%</b>	<b>W.R 80%</b>	<b>W.R 100%</b>	<b>Mean</b>
<b>Hundz soil</b>	4.00 bc	4.67 abc	5.33 a	<b>4.66 A</b>
<b>Oligo plus</b>	4.67 abc	4.67 abc	5.00 ab	<b>4.89 A</b>
<b>Bioconditioner</b>	4.00 bc	4.43 abc	5.00 ab	<b>4.44 A</b>
<b>Control</b>	3.67 c	4.67 abc	4.33 abc	<b>4.22 A</b>
<b>Mean</b>	<b>4.08 A</b>	<b>4.58 A</b>	<b>4.91 A</b>	
<b>2013-2014</b>				
<b>Hundz soil</b>	3.67 bcd	5.33 a	5.33 a	<b>4.78 A</b>
<b>Oligo plus</b>	3.33 cd	4.67 ab	5.16 a	<b>4.38 AB</b>
<b>Bioconditioner</b>	3.00 d	4.33 abc	4.66 ab	<b>4.33 AB</b>
<b>Control</b>	3.33 cd	4.33 abc	4.33 abc	<b>3.89 B</b>
<b>Mean</b>	<b>3.50 B</b>	<b>4.66 A</b>	<b>4.87 A</b>	

**Table (10):** Effect of different irrigation treatments and soil conditioners on number of shoots of tomato plants after 60 days from transplanting during the two seasons of 2012/2013 and 2013/2014.

<b>2012-2013</b>				
	<b>W.R 60%</b>	<b>W.R 80%</b>	<b>W.R 100%</b>	<b>Mean</b>
<b>Hundz soil</b>	6.00 abc	7.67 a	7.33 ab	<b>7.00 A</b>
<b>Oligo plus</b>	6.33 abc	6.33 abc	6.67 abc	<b>6.44 A</b>
<b>Bioconditioner</b>	6.33 abc	6.33 abc	6.33 abc	<b>6.33 A</b>
<b>Control</b>	5.33 c	5.33 c	5.67 bc	<b>5.44 B</b>
<b>Mean</b>	<b>6.00 A</b>	<b>6.42 A</b>	<b>6.50 A</b>	
<b>2013-2014</b>				
<b>Hundz soil</b>	6.33 abc	7.00 a	7.67 a	<b>7.00 A</b>
<b>Oligo plus</b>	6.00 abc	6.67 ab	7.33 a	<b>6.67 A</b>
<b>Bioconditioner</b>	6.00 abc	6.33 abc	6.33 abc	<b>6.22 A</b>
<b>Control</b>	4.33 c	5.33 bc	5.67 abc	<b>5.11 B</b>
<b>Mean</b>	<b>5.66 A</b>	<b>6.33 A</b>	<b>6.75 A</b>	



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**Table (11):** Effect of different irrigation treatments and soil conditioners on number of shoots of tomato plants after 90 days from transplanting during the two seasons of 2012/2013 and 2013/2014.

<b>2012-2013</b>				
	<b>W.R 60%</b>	<b>W.R 80%</b>	<b>W.R 100%</b>	<b>Mean</b>
<b>Hundz soil</b>	7.00 cd	9.00 a	9.33 a	<b>8.44 A</b>
<b>Oligo plus</b>	7.00 cd	8.67 ab	8.67 ab	<b>8.11 A</b>
<b>Bioconditioner</b>	6.67 cd	6.67 cd	7.67 bc	<b>7.01 AB</b>
<b>Control</b>	5.67 d	5.667 d	7.67 bc	<b>6.33 B</b>
<b>Mean</b>	<b>6.58 C</b>	<b>7.50 B</b>	<b>8.33 A</b>	
<b>2013-2014</b>				
<b>Hundz soil</b>	6.33 cd	8.33 ab	9.20 a	<b>7.95 A</b>
<b>Oligo plus</b>	6.33 cd	8.67 ab	8.64 ab	<b>7.76 A</b>
<b>Bioconditioner</b>	6.33 cd	6.67 cd	7.67 bc	<b>6.89 B</b>
<b>Control</b>	5.67 d	6.33 cd	7.61 bc	<b>6.53 B</b>
<b>Mean</b>	<b>6.16 B</b>	<b>7.41 AB</b>	<b>8.28 A</b>	

control treatment. In the second season, the Hundz soil and Oligo plus treatments gave the highest significant values of shoots number comparing with other soil conditioners treatments.

Regarding to the interaction between irrigation and soil conditioners treatments, after 30 days from transplanting data was showed that the highest significant number of shoots resulted from using 100% irrigation level and both of Hundz soil and Oligo plus soil conditioners. The lowest number was obtained by using 60% irrigation regime and control treatment in the first season. Moreover, in the second season the highest significant values were obtained from using both of 100 and 80% irrigation levels with Hundz soil. The lowest significant value resulted from using 60% irrigation regime with control treatment. After 60 and 90 days from transplanting data showed that the highest significant number of shoots resulted by using 80% irrigation level with Hundz soil. The lowest values were obtained from interaction between 60% irrigation regime with control treatment in the two studied seasons.

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### **4.1.3. Chlorophyll reading:**

Illustrated data in Tables (12 and 13) indicated the effect of different irrigation levels, soil conditioners and their interactions on chlorophyll reading of tomato plants. After 60 days from transplanting, the result showed no significant difference between the different irrigation levels in the two studied seasons. After 120 days from transplanting date, there was a significant difference on chlorophyll reading. The highest significant value was obtained from the 100% and the lowest significant value was obtained from 60% treatment.

Concerning the effect of soil conditioners, a significant difference on chlorophyll reading after 60 and 120 days from transplanting was recorded. The highest significant chlorophyll reading resulted from Oligo plus treatment, while the lowest significant value was obtained from control treatment in the both studied seasons.

Referring to the interaction effect between the irrigation regimes and soil conditioners treatments, after 60 days from transplanting data showed that the highest significant value of chlorophyll reading resulted from using 100% irrigation regime combined with Oligo plus in the first season. In the second season, the interaction between 100% irrigation regime and Hundz soil was presented the highest significant reading. On the contrary, the lowest value was obtained by using 60% irrigation level combined with Bioconditioner treatment in the first season. In the second season, the lowest value was obtained from using 60% irrigation regime with control treatment.

### **4.1.4. Leaf area:**

After 120 days from transplanting, data showed that the highest significant chlorophyll reading resulted from interaction between 100% irrigation regime and Oligo plus soil conditioner during the two studied seasons. However, the lowest significant value was obtained from interaction between 60% irrigation level and control treatment in both of two studied seasons.

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**Table (12):** Effect of different irrigation treatments and soil conditioners on chlorophyll reading (SPAD) of tomato after 60 days from transplanting during the two seasons of 2012/2013 and 2013/2014.

<b>2012-2013</b>				
	<b>W.R 60%</b>	<b>W.R 80%</b>	<b>W.R 100%</b>	<b>Mean</b>
<b>Hundz soil</b>	53.77 cd	64.80 a	64.80 a	<b>61.12 AB</b>
<b>Oligo plus</b>	62.83 ab	63.50 a	65.23 a	<b>63.71 A</b>
<b>Bioconditioner</b>	50.23 d	57.67 bc	64.57 a	<b>57.49 BC</b>
<b>Control</b>	51.23 d	57.33 bc	61.13 ab	<b>56.57 C</b>
<b>Mean</b>	<b>54.52 A</b>	<b>60.83 A</b>	<b>63.93 A</b>	
<b>2013-2014</b>				
<b>Hundz soil</b>	55.25 cd	65.23 a	65.80 a	<b>62.27 AB</b>
<b>Oligo plus</b>	62.83 ab	63.50 a	64.80 a	<b>63.71 A</b>
<b>Bioconditioner</b>	51.75 d	57.67 cd	64.57 a	<b>57.49 BC</b>
<b>Control</b>	51.23 d	57.33 cd	61.13 ab	<b>56.57 C</b>
<b>Mean</b>	<b>54.52 A</b>	<b>60.93 A</b>	<b>63.83 A</b>	

**Table (13):** Effect of different irrigation treatments and soil conditioners on chlorophyll content (SPAD) of tomato after 120 days from transplanting during the two seasons of 2012/2013 and 2013/2014.

<b>2012-2013</b>				
	<b>W.R 60%</b>	<b>W.R 80%</b>	<b>W.R 100%</b>	<b>Mean</b>
<b>Hundz soil</b>	55.20 abc	56.57 bcd	60.33 ab	<b>57.37 AB</b>
<b>Oligo plus</b>	56.40 abcd	57.33 ab	61.33 a	<b>58.36 A</b>
<b>Bioconditioner</b>	51.40 cd	57.83 ab	57.80 ab	<b>55.68 AB</b>
<b>Control</b>	51.23 d	55.57 bcd	57.77 ab	<b>54.86 B</b>
<b>Mean</b>	<b>53.55 B</b>	<b>56.82 AB</b>	<b>59.31 A</b>	
<b>2013-2014</b>				
<b>Hundz soil</b>	63.53 ab	62.77 b	65.50 ab	<b>63.93 AB</b>
<b>Oligo plus</b>	62.73 b	63.80 ab	67.50 a	<b>64.68 A</b>
<b>Bioconditioner</b>	57.77 c	62.33 b	64.57 ab	<b>61.56 BC</b>
<b>Control</b>	57.10 c	57.43 c	63.33 ab	<b>59.29 C</b>
<b>Mean</b>	<b>60.28 B</b>	<b>61.58 AB</b>	<b>65.22 A</b>	

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The obtained results in Tables (14 and 15) showed the effect of different irrigation regime treatments, soil conditioners and their interactions on leaf area of tomato plants. Obtained results after 60 and 120 days from transplanting showed that there was a significant difference between the irrigation levels. The highest significant value was recorded by 100% irrigation level. The lowest significant value was obtained from 60% treatment during the both studied seasons.

Concerning the soil conditioner treatments, a significant different was detected after 60 days from transplanting. Hundz soil and Oligo plus treatments were caused significantly increased in leaf area values comparing with the other treatments of soil conditioner in both tested seasons. Moreover, there were significant differences among treatments after 120 days from transplanting. Hundz soil recorded the highest significant value. Control treatment recorded the lowest significant value in the two studied seasons.

Regarding to the interaction between irrigation level and soil conditioner treatments, data showed that after 60 days from transplanting date, the highest significant interaction in leaf area was detect with 100% irrigation level combined with Hundz soil conditioner. The lowest interaction was found by using 60% irrigation level combined with control treatment. The same result was found during the second season.

After 120 days from transplanting, the highest values of leaf area were obtained by 100% irrigation level combined with Oligo Plus soil conditioner, in the first seasons. Hence, there was another trend in the second season the highest significant value of leaf area gained by 100% irrigation level combined with Hundz soil conditioner. However, the lowest significant value was obtained by 60% irrigation level combined with control treatment during the two studied seasons.

### **4.1.5. Stem diameter:**

Data in Tables (16, 17 and 18) indicated that, the stem diameter affected significantly by using the soil conditioners and interaction between soil

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**Table (14):** Effect of different irrigation treatments and soil conditioners on leaf area of tomato plants after 60 days from transplanting during the two seasons of 2012/2013 and 2013/2014.

2012-2013				
	W.R 60%	W.R 80%	W.R 100%	Mean
Hundz soil	31.13 gh	48.83 cd	58.10 a	<b>46.02 A</b>
Oligo plus	36.10 fg	46.23 de	57.40 ab	<b>46.58 A</b>
Bioconditioner	25.90 h	41.20 ef	57.17 ab	<b>41.43 B</b>
Control	17.17 i	36.57 f	52.77 bc	<b>35.50 C</b>
Mean	<b>27.58 C</b>	<b>43.21 B</b>	<b>56.36 A</b>	
2013-2014				
Hundz soil	37.73 de	46.63 bc	59.40 a	<b>47.93 A</b>
Oligo plus	33.93 e	50.83 b	59.37 a	<b>48.04 A</b>
Bioconditioner	28.03 f	42.23 cd	58.83 a	<b>43.03 B</b>
Control	19.17 g	37.83 de	56.40 a	<b>37.80 C</b>
Mean	<b>29.72 C</b>	<b>44.38 B</b>	<b>58.50 A</b>	

**Table (15):** Effect of different irrigation treatments and soil conditioners on leaf area of tomato plants during after 120 days from transplanting the two seasons of 2012/2013 and 2013/2014.

2012-2013				
	W.R 60%	W.R 80%	W.R 100%	Mean
Hundz soil	52.77 ef	70.80 bc	82.70 a	<b>68.75 A</b>
Oligo plus	57.57 def	65.17 cd	84.53 a	<b>69.09 A</b>
Bioconditioner	47.93 f	61.60 cde	82.33 a	<b>63.96 AB</b>
Control	36.50 g	57.20 def	80.27 ab	<b>57.99 B</b>
Mean	<b>48.69 C</b>	<b>63.69 B</b>	<b>82.46 A</b>	
2013-2014				
Hundz soil	59.23 d	66.93 bcd	84.60 a	<b>70.25 A</b>
Oligo plus	54.90 d	82.37 ab	84.53 a	<b>73.93 A</b>
Bioconditioner	51.00 de	63.67 cd	82.83 ab	<b>65.83 AB</b>
Control	37.97 e	59.47 d	76.30 ab	<b>57.91 B</b>
Mean	<b>50.78 C</b>	<b>68.11 B</b>	<b>82.07 A</b>	

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**Table (16):** Effect of different irrigation treatments and soil conditioners on stem diameter of tomato plants after 30 days from transplanting during the two seasons of 2012/2013 and 2013/2014.

<b>2012-2013</b>				
	<b>W.R 60%</b>	<b>W.R 80%</b>	<b>W.R 100%</b>	<b>Mean</b>
<b>Hundz soil</b>	0.8333 ab	0.8555 ab	1.0333 a	<b>0.9072 A</b>
<b>Oligo plus</b>	0.8111 ab	0.9000 ab	0.9667 ab	<b>0.8926 A</b>
<b>Bioconditioner</b>	0.8233 ab	0.8667 ab	0.9333 ab	<b>0.8744 A</b>
<b>Control</b>	0.7667 b	0.8100 ab	0.8333 ab	<b>0.8033 A</b>
<b>Mean</b>	<b>0.8086 A</b>	<b>0.8580 A</b>	<b>0.9415 A</b>	
<b>2013-2014</b>				
<b>Hundz soil</b>	0.8667 ab	0.9667 ab	1.0477 a	<b>0.9601 A</b>
<b>Oligo plus</b>	0.8111 ab	0.8667 ab	0.9667 ab	<b>0.8815 A</b>
<b>Bioconditioner</b>	0.8000 b	0.8333 ab	0.9667 ab	<b>0.8666A</b>
<b>Control</b>	0.8000 b	0.8325 ab	0.9333 ab	<b>0.8664 A</b>
<b>Mean</b>	<b>0.8244 A</b>	<b>0.8748 A</b>	<b>0.9784 A</b>	

**Table (17):** Effect of different irrigation treatments and soil conditioners on stem diameter of tomato plants after 60 days from transplanting during the two seasons of 2012/2013 and 2013/2014.

<b>2012-2013</b>				
	<b>W.R 60%</b>	<b>W.R 80%</b>	<b>W.R 100%</b>	<b>Mean</b>
<b>Hundz soil</b>	0.933 bc	1.067 abc	1.133 ab	<b>1.044 A</b>
<b>Oligo plus</b>	1.067 abc	1.100 abc	1.233 a	<b>1.133 A</b>
<b>Bioconditioner</b>	0.866 c	0.9667 abc	1.167 ab	<b>1.000 A</b>
<b>Control</b>	0.933 bc	1.00 abc	1.067 abc	<b>1.001 A</b>
<b>Mean</b>	<b>0.9583 A</b>	<b>1.033 A</b>	<b>1.15 A</b>	
<b>2013-2014</b>				
<b>Hundz soil</b>	0.9333 b	1.067 ab	1.167 ab	<b>1.055 A</b>
<b>Oligo plus</b>	0.9600 ab	1.100 ab	1.233 a	<b>1.097 A</b>
<b>Bioconditioner</b>	0.9500 ab	0.9667 ab	1.167 ab	<b>1.027 A</b>
<b>Control</b>	0.9100 b	0.9800 ab	1.067 ab	<b>0.985 A</b>
<b>Mean</b>	<b>0.938 A</b>	<b>1.028 A</b>	<b>1.158 A</b>	

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**Table (18):** Effect of different irrigation treatments and soil conditioners on stem diameter (cm) of tomato plants after 90 days from transplanting during the two seasons of 2012/2013 and 2013/2014.

<b>2012-2013</b>				
	<b>W.R 60%</b>	<b>W.R 80%</b>	<b>W.R 100%</b>	<b>Mean</b>
<b>Hundz soil</b>	1.567 ab	1.610 ab	1.667 ab	<b>1.611 A</b>
<b>Oligo plus</b>	1.422 ab	1.767 ab	1.815 a	<b>1.668 A</b>
<b>Bioconditioner</b>	1.325 b	1.533 ab	1.700 ab	<b>1.519 A</b>
<b>Control</b>	1.333 ab	1.467 ab	1.567 ab	<b>1.455 A</b>
<b>Mean</b>	<b>1.411 A</b>	<b>1.594 A</b>	<b>1.687 A</b>	
<b>2013-2014</b>				
<b>Hundz soil</b>	1.167 ef	1.569 bc	1.622 b	<b>1.452 AB</b>
<b>Oligo plus</b>	1.295 de	1.470 cd	1.780 a	<b>1.515 A</b>
<b>Bioconditioner</b>	1.067 f	1.335 de	1.467 bcd	<b>1.289 B</b>
<b>Control</b>	1.067 f	1.310 de	1.412 cd	<b>1.263 B</b>
<b>Mean</b>	<b>1.149 A</b>	<b>1.421 A</b>	<b>1.570 A</b>	

conditioners and irrigation regime. However, stem diameter of tomato plants was not significantly affected by irrigation regimes at different sampling dates 30, 60 and 90 days after transplanting.

Concerning to the soil conditioners treatments, results after 30, 60 and 90 days from transplanting indicated that there was no significant difference between the soil conditioners treatments in the both tested seasons. Hence, after 90 days from transplanting during the second season, there were significant differences between the tested types of soil conditioners and control. Oligo Plus was recorded the highest significant values while the control treatment was recorded the lowest values.

Concerning the interaction effect among irrigation level and soil conditioner treatments, after 30 days from transplanting the highest significant value of stem diameter resulted by using 100% irrigation level combined with Hundz soil. The lowest significant value was obtained by using 60% irrigation regime combined with control treatment in the both studied seasons.

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After 60 and 90 days from transplanting date, obtained data showed that the highest significant values of stem diameter were resulted by using 100% irrigation level combined with Oligo Plus soil conditioner. The lowest significant values were obtained from using 60% irrigation level combined with Bioconditioner treatment. After 60 days from transplanting during the second seasons, the lowest significant value was obtained from the interaction between 60% irrigation level with control treatment.

### **4.1.6. Total fresh weight:**

Data in Tables (19 and 20) showed the effect of different irrigation levels and soil conditioner treatments and their interactions on total fresh weight of tomato plants. Obtained results after 90 and 180 days showed that there was a significant difference among the different irrigation levels. The highest significant value was obtained by 100% irrigation level. The lowest value was obtained from 60% treatment during both studied seasons.

Concerning the effect of soil conditioner treatments, there were significant different on the total fresh weight after 90 and 180 days from transplanting date. Hundz soil and Oligo plus treatments were significantly increased total fresh weight in comparison with the other treatments in the two studied seasons.

Regarding the interaction effect between irrigation level and soil conditioner treatments, the highest values of total fresh weight resulted by using 100% irrigation level combined with Oligo plus after 90 and 180 days from transplanting. The lowest total fresh weight values were obtained by using 60% irrigation level combined with control treatment in the both studied seasons. However, the highest values of total fresh weight resulted from using 100% irrigation level combined with Hundz soil treatment after 90 days from transplanting date in the second seasons.

### **4.1.7. Total dry weight:**

Illustrated data in Tables (21 and 22) showed that the total dry



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**Table (19):** Effect of different irrigation treatments and soil conditioners on total fresh weight (g) of tomato plants after 90 days from transplanting during the two seasons of 2012/2013 and 2013/2014.

<b>2012-2013</b>				
	<b>W.R 60%</b>	<b>W.R 80%</b>	<b>W.R 100%</b>	<b>Mean</b>
<b>Hundz soil</b>	90.00 bcd	124.7 b	215.0 a	<b>143.2 A</b>
<b>Oligo plus</b>	104.0 bcd	118.7 bc	217.0 a	<b>146.6 A</b>
<b>Bioconditioner</b>	86.67 bcd	107.0 bcd	213.3 a	<b>135.6 A</b>
<b>Control</b>	68.67 d	80.33 cd	207.0 a	<b>118.6 B</b>
<b>Mean</b>	<b>87.33 B</b>	<b>107.7 B</b>	<b>213.07 A</b>	
<b>2013-2014</b>				
<b>Hundz soil</b>	102.3 bcd	117.7 bc	217.3 a	<b>145.7 A</b>
<b>Oligo plus</b>	89.00 cd	126.0 b	216.0 a	<b>143.6 A</b>
<b>Bioconditioner</b>	85.00 cd	101.7 bcd	210.3 a	<b>132.3 A</b>
<b>Control</b>	69.33 d	81.33 d	208.0 a	<b>119.5 B</b>
<b>Mean</b>	<b>86.42 B</b>	<b>106.7 B</b>	<b>212.9 A</b>	

**Table (20):** Effect of different irrigation treatments and soil conditioners on total fresh weight (g) of tomato plants after 180 days from transplanting during the two seasons of 2012/2013 and 2013/2014.

<b>2012-2013</b>				
	<b>W.R 60%</b>	<b>W.R 80%</b>	<b>W.R 100%</b>	<b>Mean</b>
<b>Hundz soil</b>	332.7 de	491.7 ab	521.7 a	<b>448.7 A</b>
<b>Oligo plus</b>	416.7 bcd	438.3 abc	524.3 a	<b>459.6 A</b>
<b>Bioconditioner</b>	241.7 f	381.7 cd	511.1 a	<b>378.1 B</b>
<b>Control</b>	229.3 f	295.0 ef	487.6 ab	<b>337.3 C</b>
<b>Mean</b>	<b>305.1 C</b>	<b>401.7 B</b>	<b>511.1 A</b>	
<b>2013-2014</b>				
<b>Hundz soil</b>	333.0 d	491.3 ab	520.0 a	<b>448.1 A</b>
<b>Oligo plus</b>	400.0 c	439.7 bc	526.0 a	<b>455.2 A</b>
<b>Bioconditioner</b>	239.3 e	399.7 c	523.7 a	<b>387.6 B</b>
<b>Control</b>	215.3 e	300.7 d	521.3 a	<b>345.8 C</b>
<b>Mean</b>	<b>296.9 C</b>	<b>407.8 B</b>	<b>522.8 A</b>	

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**Table (21):** Effect of different irrigation treatments and soil conditioners on total dry weight (g) of tomato plants after 90 days from transplanting during the two seasons of 2012/2013 and 2013/2014.

<b>2012-2013</b>				
	<b>W.R 60%</b>	<b>W.R 80%</b>	<b>W.R 100%</b>	<b>Mean</b>
<b>Hundz soil</b>	26.87 b	36.43 b	59.20 a	<b>40.83 A</b>
<b>Oligo plus</b>	28.43 b	35.10 b	60.67 a	<b>41.40 A</b>
<b>Bioconditioner</b>	26.40 b	33.40 b	59.27 a	<b>39.69 A</b>
<b>Control</b>	21.43 b	31.43 b	58.77 a	<b>37.21 B</b>
<b>Mean</b>	<b>25.78 C</b>	<b>34.09 B</b>	<b>59.47 A</b>	
<b>2013-2014</b>				
<b>Hundz soil</b>	26.87 b	35.90 b	59.27 a	<b>40.68 A</b>
<b>Oligo plus</b>	28.57 b	34.90 b	60.57 a	<b>41.34 A</b>
<b>Bioconditioner</b>	26.03 b	33.10 b	59.57 a	<b>39.57 A</b>
<b>Control</b>	21.83 b	31.30 b	57.33 a	<b>36.82 B</b>
<b>Mean</b>	<b>25.83 C</b>	<b>33.80 B</b>	<b>59.18 A</b>	

**Table (22):** Effect of different irrigation treatments and soil conditioners on total dry weight (g) of tomato plants after 180 days from transplanting during the two seasons of 2012/2013 and 2013/2014.

<b>2012-2013</b>				
	<b>W.R 60%</b>	<b>W.R 80%</b>	<b>W.R 100%</b>	<b>Mean</b>
<b>Hundz soil</b>	112.6 bcd	130.0 abc	170.7 a	<b>137.8 A</b>
<b>Oligo plus</b>	105.8 bcd	119.7 bc	146.7 ab	<b>124.1 A</b>
<b>Bioconditioner</b>	88.43 cd	108.9 bcd	138.8 ab	<b>112.0 AB</b>
<b>Control</b>	69.03 d	102.1 bcd	125.4 abc	<b>98.86 B</b>
<b>Mean</b>	<b>93.97 B</b>	<b>115.2 AB</b>	<b>145.4 A</b>	
<b>2013-2014</b>				
<b>Hundz soil</b>	118.5 cde	133.3 c	181.2 a	<b>144.3 A</b>
<b>Oligo plus</b>	105.8 def	121.7 cd	167.7 ab	<b>131.7 A</b>
<b>Bioconditioner</b>	88.41 fg	107.9 def	156.1 b	<b>117.5 B</b>
<b>Control</b>	74.00 g	96.13 ef	155.1 b	<b>108.4 B</b>
<b>Mean</b>	<b>96.66 B</b>	<b>114.8 B</b>	<b>165.0 A</b>	

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weight was affected significantly by irrigation levels. The highest significant value was obtained by 100% irrigation level. The lowest value was found in 60% treatment. These results were confirmed in the second season.

Concerning the effect of soil conditioner treatments, there were a significant difference between soil conditioner treatments during both seasons. Oligo plus was recorded the highest dry weight after 90 days from transplanting. While, Hundz soil was recorded the highest dry weight after 180 days from transplanting.

Due to the interaction effect between irrigation level and soil conditioner treatments, it was noticed that after 90 days from transplanting date the highest values of total dry weight resulted by using 100% irrigation level combined with Oligo Plus. The lowest total dry weight values were obtained by using 60% irrigation level combined with control treatment during the two seasons. On the other hand, after 180 days from transplanting date the highest dry weight values were resulted from using 100% irrigation level combined with Hundz soil treatment. The lowest total dry weight values were obtained from using 60% irrigation level combined with control treatment in the two studied seasons.

From the previous results related to the vegetative growth, data indicated that there were significant differences concerning vegetative growth parameters i.e. plant height, number of leaves and shoots, leaf area, chlorophyll reading and total fresh and dry weight of tomato plants grown under different irrigation levels and soil conditioners as well as their interactions.

The soil conditioners caused such mentioned significant difference because it have a potential to increase water holding capacity of sandy soils and delay the onset of permanent wilting where evaporation is intense. In this study, plants grown with Hundz soil and Oligo plus have a better growth of tomato compared to the other soil conditioners

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treatments. It could be attributed to improve soil properties because they can increase soil holding capacity especially in sandy soils which have low water and nutrient holding capacity which improve the physical properties of soil such as structural stability.

That might have utilized nutrients more efficiently and resulted in better plant growth. Plant growth and root growth which might be brought on by soil compaction in sandy soil (control). It could be improved by treating the soil with soil conditioners which imbibes water and improves soil porosity. Such evidence proves that soil amendments alleviate soil compaction by reducing soil bulk density. As a result, plants grown on sandy soil amended with soil amendments experienced less premature leaf senescence than the control (sandy soil). However, the data also indicated a direct correlation between root and above ground growth. In addition, this indicates that a good root growth is considered an important issue for plant growth. The benefits from soil amendments were evident in improved root development and plant growth. Also, soil conditioners have a unique ability to improve the chemical, physical, and biological characteristics of soils. These results agreed with **Johnson (1984); Elias (2004); Maboko (2006); Curtis and Claassen (2005); Sodhi *et al.* (2009); Tejada *et al.* (2009); Lakhdar *et al.* (2009) and Wisconsin and Zuhlke (2002).**

The 100%  $ET_0$  treatments applied in this study increased plant growth characters (plant height, number of leaves, total fresh and dry weight and total leaf area per plant). The effect of 100%  $ET_0$  irrigation level was statistically significant in both seasons compared to other irrigation levels (80 and 60%  $ET_0$ ). Low irrigation level was decreased the plant growth due to a reduction in extension growth and increased leaf thickness. These results were agreed with those obtained by **Bonanno and Mack (1983); Gallardo *et al.* (1996); El-Shinawy (1997), Nahar and Ullah (2012) and Wang and Zhang (2004).**

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On the other hand, the improved vegetative growth as plant height, number of leaves, fresh and dry weight of tomato plants at 100% of irrigation level may be due to proper balance of moisture in plants, which creates favorable conditions for nutrients uptake, photosynthesis and metabolite translocation. Other possibility was increasing available water and nutrient uptake ultimately accelerated the rate of vegetative growth. Moreover, enhancement of soil environmental conditions around plant roots to become more favorable for the encouragement of plant growth. Water acts as a solvent in which all plant nutrients dissolve. It is a translocation agent of food materials to all plant parts besides controlling both plant and soil temperatures at a level that is suitable for plant growth and development. It keeps the plant cell turgid and helps the plant root penetrate the soil. Finally, water is responsible for the activity of the soil micro and macro-organisms (El-Beltagy *et al.*, 1984, El-Nemr, 1997 and Saleh and Ozawa, 2006).

Finally, using the highest level of irrigation water (100% of water requirement) reflected the highest values in all determined growth parameters. Such results are confirmed with those reported by El-Beltagy *et al.* (1984); Fattahallah (1992); Merghaney (1997); Byari and Al-Sayed (1999); Navarrete and Jeannequin (2000); Harmanto *et al.* (2005); Ibrahim (2005); Sibomana *et al.* (2013) and El-Sawy (2014) all working on tomato.

### **4.2. Yield and its components:**

#### **4.2.1. Number of fruits per plant:**

Data in Table (23) showed the effect of different irrigation level, soil conditioner treatments and their interactions on number of fruits per plants. The obtained results showed that there were significant differences between different irrigation levels. The highest values were obtained by 100% and the lowest values were obtained from 60% treatment in the two studied seasons.

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**Table (23):** Effect of different irrigation treatments and soil conditioners on fruits number /plant of tomato plants in the two seasons of 2012/2013 and 2013/2014.

<b>2012-2013</b>				
	<b>W.R 60%</b>	<b>W.R 80%</b>	<b>W.R 100%</b>	<b>Mean</b>
<b>Hundz soil</b>	51.40 bc	64.03 ab	71.43 a	<b>62.28 A</b>
<b>Oligo plus</b>	46.97 c	59.30 abc	67.73 a	<b>58.01 A</b>
<b>Bioconditioner</b>	56.93 abc	64.03 ab	70.83 a	<b>63.93 A</b>
<b>Control</b>	53.07 bc	59.10 abc	68.83 a	<b>60.33 A</b>
<b>Mean</b>	<b>52.09 B</b>	<b>61.62 A</b>	<b>69.71 A</b>	
<b>2013-2014</b>				
<b>Hundz soil</b>	57.07 bc	61.50 abc	69.17 ab	<b>62.58 A</b>
<b>Oligo plus</b>	52.27 c	61.60 abc	63.67 abc	<b>59.18 A</b>
<b>Bioconditioner</b>	55.63 c	61.03 abc	64.90 abc	<b>60.52 A</b>
<b>Control</b>	55.30 c	64.03 abc	72.47 a	<b>63.93 A</b>
<b>Mean</b>	<b>55.07 B</b>	<b>62.04 AB</b>	<b>67.55 A</b>	

Concerning the effect of soil conditioner treatments, there was insignificant differences between soil conditioner treatments in both of two studying seasons.

According to effect of the interaction between irrigation regimes and soil conditioners, the highest number of fruit was found by using 100% irrigation level with Oligo plus in the two seasons. The lowest value was obtained when using 60% irrigation regime with Hundz soil treatment in the first season. However, during the second season the lowest value was found from using 60% irrigation level combined with Oligo plus treatment seasons.

### **4.2.2. Average fruit weight:**

Date in Table (24) showed the effect of irrigation level, soil conditioner treatments and their interactions on average fruit weight of tomato plants. Obtained results showed that there were significant differences between the different irrigation level treatments, the highest average fruit weight

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was obtained with 100% irrigation level. The lowest value was obtained by 60% treatment during the two studied seasons.

**Table (24):** Effect of different irrigation treatments and soil conditioners on average fruit weight (g) of tomato plants in the two seasons of 2012/2013 and 2013/2014.

<b>2012-2013</b>				
	<b>W.R 60%</b>	<b>W.R 80%</b>	<b>W.R 100%</b>	<b>Mean</b>
<b>Hundz soil</b>	53.80 bcde	56.90 abcde	70.36 ab	<b>60.35 A</b>
<b>Oligo plus</b>	54.07 bcde	55.28 abcde	73.60 a	<b>60.98 A</b>
<b>Bioconditioner</b>	45.74 def	50.40 cde	64.66 abcd	<b>53.60 AB</b>
<b>Control</b>	30.32 f	43.63 ef	66.54 abc	<b>46.83 B</b>
<b>Mean</b>	<b>45.99 C</b>	<b>51.55 B</b>	<b>68.79 A</b>	
<b>2013-2014</b>				
<b>Hundz soil</b>	57.39 cd	73.51 ab	80.41 a	<b>70.43 A</b>
<b>Oligo plus</b>	58.23 cd	66.29 bc	81.89 a	<b>68.81 A</b>
<b>Bioconditioner</b>	49.49 de	54.09 d	66.11 bc	<b>56.56 B</b>
<b>Control</b>	39.90 ef	36.05 f	55.43 cd	<b>43.80 C</b>
<b>Mean</b>	<b>51.25 C</b>	<b>57.48 B</b>	<b>70.96 A</b>	

Concerning soil conditioners, there were significant differences between soil conditioners as well as without soil conditioner during both studied seasons. Hundz soil was recorded the highest values while, the lowest values was found by control treatment.

Regarding the interaction effect between irrigation and soil conditioner treatments, data showed that the highest average fruit weight values were resulted from using 100% irrigation level combined with Hundz soil. The lowest values were obtained by using 60% irrigation level combined with control treatment in the both seasons.

### 4.2.3. Early yield:

Date in Table (25) showed that there were significant differences between the tested irrigation levels. Tomato early yield was gradually increased with increasing irrigation level from 60% up to 100% treatment in the two studied seasons.

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**Table (25):** Effect of different irrigation treatments and soil conditioners on early yield/plant (Kg) of tomato plants in the two seasons of 2012/2013 and 2013/2014.

2012-2013				
	W.R 60%	W.R 80%	W.R 100%	Mean
<b>Hundz soil</b>	0.917 cd	1.127 c	1.900 a	<b>1.314 A</b>
<b>Oligo plus</b>	0.843 d	1.177 c	1.737 ab	<b>1.252 AB</b>
<b>Bioconditioner</b>	0.863 d	1.023 cd	1.507 b	<b>1.131 BC</b>
<b>Control</b>	0.540 e	0.857 d	1.523 b	<b>0.973 C</b>
<b>Mean</b>	<b>0.790 C</b>	<b>1.046 B</b>	<b>1.667 A</b>	
2013-2014				
<b>Hundz soil</b>	1.017 ef	1.503 abc	1.74 ab	<b>1.420 A</b>
<b>Oligo plus</b>	1.017 ef	1.373 bcde	1.857 a	<b>1.416 A</b>
<b>Bioconditioner</b>	0.9200 f	1.103 def	1.43 bcd	<b>1.151 B</b>
<b>Control</b>	0.7467 f	0.7767 f	1.34 cde	<b>0.9544 B</b>
<b>Mean</b>	<b>0.925 C</b>	<b>1.189 B</b>	<b>1.592 A</b>	

Referring the effect of soil conditioners on tomato early yield, there were significant differences between the soil conditioners in the both studied seasons. Hundz soil was recorded the highest early yield value while, the lowest value was obtained by control treatment.

Highlighting the effect of interaction between irrigation regimes and soil conditioner treatments, data showed that the highest values of early yield resulted from using 100% irrigation regime with Hundz soil in the first season. While, during the second season the highest value of early yield resulted from using 100% irrigation regime with Oligo plus. On the other hand, the lowest value was found from using 60% irrigation regime combined with control treatment in the both studied seasons.

### 4.2.4. Total yield:

The effect of different irrigation, soil conditioner treatments and their interactions on the total yield of tomato plants is shown in Table (26). The total fruit yield affected significantly by different irrigation



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regimes, the highest value was obtained from the 100% and the lowest value was obtained from 60% treatment during the two studied seasons.

Focusing on effect of soil conditioners, there was a significant difference between the tested types of conditioners. Hundz soil was recorded the highest value, while the lowest value was obtained from control treatment. The same results were found during the second season. Concerning effect of the interaction between irrigation regimes and soil conditioner treatments, data showed that the highest values of total yield resulted from using 100% irrigation level combined with Hundz soil. The lowest total fruit weight values were obtained by using 60% irrigation level combined with control treatment in the two studied seasons.

**Table (26):** Effect of different irrigation treatments and soil conditioners on total yield/plant (Kg) of tomato plants in the two seasons of 2012/2013 and 2013/2014.

<b>2012-2013</b>				
	<b>W.R 60%</b>	<b>W.R 80%</b>	<b>W.R 100%</b>	<b>Mean</b>
<b>Hundz soil</b>	2.765 cd	3.643 c	5.026 a	<b>3.676 AB</b>
<b>Oligo plus</b>	2.539 d	3.278 c	4.985 ab	<b>3.736 A</b>
<b>Bioconditioner</b>	2.604 d	3.227 cd	4.580 b	<b>3.470 BC</b>
<b>Control</b>	1.609 e	2.578 d	4.580 b	<b>2.923 C</b>
<b>Mean</b>	<b>2.379 C</b>	<b>3.182 B</b>	<b>4.793 A</b>	
<b>2013-2014</b>				
<b>Hundz soil</b>	3.275 def	4.521 bcde	5.562 a	<b>4.338 A</b>
<b>Oligo plus</b>	3.044 def	4.084 abc	5.216 ab	<b>4.230 A</b>
<b>Bioconditioner</b>	2.750 ef	3.303 cdef	4.290 bcd	<b>3.446 AB</b>
<b>Control</b>	2.206 f	2.307 f	4.017 bcde	<b>2.844 B</b>
<b>Mean</b>	<b>2.818 C</b>	<b>3.554 B</b>	<b>4.771 A</b>	

### **4.2.5. Marketable yield:**

Data in Table (27) illustrate the effect of different irrigation levels, soil conditioner treatments and their interactions on Tomato marketable yield per plants. The results indicated that there were significant differences among the tested irrigation levels. The highest value of marketable yield

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per plants was obtained by using 100% irrigation level followed by 80 % treatment. The lowest value was obtained from 60% treatment in both of two studying seasons.

**Table (27):** Effect of different irrigation treatments and soil conditioners on Marketable yield of tomato plants during the two seasons of 2012/2013 and 2013/2014.

<b>2012-2013</b>				
	<b>W.R 60%</b>	<b>W.R 80%</b>	<b>W.R 100%</b>	<b>Mean</b>
<b>Hundz soil</b>	2.538 fgh	3.516 bcd	4.919 a	<b>3.657 A</b>
<b>Oligo plus</b>	2.375 efgh	3.164 bcdef	4.888 ab	<b>3.476 A</b>
<b>Bioconditioner</b>	2.070 gh	3.084 bcdef	4.453 abc	<b>3.202 AB</b>
<b>Control</b>	1.000 h	2.044 defg	4.453 abc	<b>2.499 C</b>
<b>Mean</b>	<b>1.995 C</b>	<b>2.952 B</b>	<b>4.678 A</b>	
<b>2013-2014</b>				
<b>Hundz soil</b>	3.085 cde	4.347 ab	5.435 a	<b>4.289 A</b>
<b>Oligo plus</b>	2.890 bcd	3.947 abc	5.099 ab	<b>3.978 A</b>
<b>Bioconditioner</b>	2.360 de	3.103 bcde	4.157 ab	<b>3.206 B</b>
<b>Control</b>	1.686 e	1.833 de	3.817 abcd	<b>2.445 C</b>
<b>Mean</b>	<b>2.505 B</b>	<b>3.307 A</b>	<b>4.627 A</b>	

Concerning the soil conditioner treatments, there were significant differences between the tested types of soil conditioner treatments in the both seasons. Hundz soil was recorded the highest marketable yield per plants followed by Oligo plus without any significant differences between them. The lowest value was obtained from control treatment.

Moreover, the interaction effect among irrigation level and soil conditioner treatments was affected significantly on marketable yield. The highest marketable yield values were resulted from using 100% irrigation level combined with Hundz soil. The lowest value was obtained from using 60% irrigation level combined with control treatment in both of two studying seasons.

Generally, it was clear that the best results of early, total and marketable fruit yields per plant, and average fruit weight of tomato were

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obtained by the application of 100% ETo level. These results might be due to adequate moisture content in the soil which might lead to increase various physiological processes, better plant nutrient uptake, and higher rates of photosynthesis which might be reflected on more number of fruits and higher fruit weight. These results are confirmed with those obtained by *Cetin et al. (2002)*, *Isrefil et al. (2002)*, *Saleh et al. (2007)*, *Birhanu and Tilahun (2010)*, *Panigrahi et al. (2010)*, *Olanik and Madramootoo (2014)* and *Elsawy (2014)*. Also, *Mohammadi-ghahsare et al. (2010)* reported that applied irrigation amount on the watering method significantly affect the crop yield, dry matter content, pH and skin resistance were slightly changed during harvesting period. Increasing the amount of water used significantly enhanced average weight of fruit. Soil moisture content is the most conducive condition for tomato fruit cracking (*Baye, 2011*) and (*Nahar et al., 2012*).

The early, total and marketable tomato fruit yields per plant and average fruit weight under different soil conditioners was increased compared to control treatment in the two studied seasons. Meanwhile, Hundz soil and Oligo plus treatments gave the highest early, total and marketable fruit yield. These results are supported by *Hayati and Ali (2004)*; *Maboko (2006)* and *Boatright et al., (1997)*.

Increased yield could be largely attributed to appropriate which resulted in enhancement of soil condition around roots of tomato plants. This will led to increasing plant growth, and hence increasing nutrient absorption and uptake. Hence, the increasing in early and total yield was found. Adding soil conditioners to growing media had beneficial effects on fruit production. These increases can be due to the fact that available more water which enhances nutrient availability. This will improve the absorption of nitrogen and other macro and microelements as well as enhancing the production and translocation of the dry matter content from source to fruit (*Gonzalez-Altozano and Castel, 2000*) and (*Tuzel et al., 2001*). However, fruit quality was also improved by the application of soil

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conditioners to growing media due to the reduced impact of water stress during the growing cycle. These results were in line with those obtained by **Johnson and Piper (1997)**. Other researchers showed that using soil conditioners as a cultivated media is useful for encouraging high total yield (**Farag *et al.*, 2015**).

### **4.2.6. Unmarketable yield:**

Data in Table (28) showed that there were significant differences between the different irrigation levels. The highest values were obtained by 60% irrigation level followed by 80 % treatment. The lowest values were obtained from 100% treatment in the both seasons.

Concerning the effect of soil conditioner treatments, there was a significant difference between the soil conditioners in the both seasons. The control recorded the highest values while, the lowest values were obtained from Oligo plus treatment.

**Table (28):** Effect of different irrigation treatments and soil conditioners on Unmarketable yield of tomato plants during the two seasons of 2012/2013 and 2013/2014.

<b>2012-2013</b>				
	<b>W.R 60%</b>	<b>W.R 80%</b>	<b>W.R 100%</b>	<b>Mean</b>
<b>Hundz soil</b>	0.2267 b	0.1267 b	0.1067 b	<b>0.1533 BC</b>
<b>Oligo plus</b>	0.1633 b	0.1133 b	0.09667 b	<b>0.1244 C</b>
<b>Bioconditioner</b>	0.5333 a	0.1433 b	0.1267 b	<b>0.2678 B</b>
<b>Control</b>	0.6100 a	0.5333 a	0.1267 b	<b>0.4233 A</b>
<b>Mean</b>	<b>0.3833 A</b>	<b>0.2292 AB</b>	<b>0.1142 B</b>	
<b>2013-2014</b>				
<b>Hundz soil</b>	0.1900 c	0.1733 c	0.1267 c	<b>0.1633 C</b>
<b>Oligo plus</b>	0.1533 c	0.1367 c	0.1167 c	<b>0.1356 C</b>
<b>Bioconditioner</b>	0.3900 b	0.2000 c	0.1333 c	<b>0.2411 B</b>
<b>Control</b>	0.5200 a	0.4733 ab	0.2000 c	<b>0.3978 A</b>
<b>Mean</b>	<b>0.3133 A</b>	<b>0.2458 A</b>	<b>0.1442 B</b>	

According to effect of the interaction between irrigation regimes and soil conditioners, the highest values of unmarketable yield resulted

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from using 60% irrigation regime with control treatment. The lowest values were obtained from using 100% irrigation regime with Oligo plus treatment in both of two studying seasons.

It is evident from data presented that there were significant differences in unmarketable yield under different soil conditioner treatments. It is clear, the highest values obtained by control in the two studied seasons. Meanwhile, Hundz soil and Oligo plus treatments recorded the lowest values of unmarketable tomato yield. These results are supported by Cheryld *et al.* (1997), Emmons and Scott (1997), Peet (1992) and Maboko (2006) they concluded that when soil conditioners used resulting greater tomato plant growth and yield due to enhancement of soil conditions. The fruit cracking would be the result of cell expansion, placing pressure on the epidermis and cuticle. Furthermore, limited elasticity or weakness in the cuticle layer would then lead to fruit cracking. The skin strength of the tomato fruit is mostly affected by changes in soil moisture. A sudden increase in the growing media's water content, reduced the elasticity of the tomato cuticle and increased root pressure. Under higher soil moisture conditions, the water-uptake will also be higher which rapidly increased turgor pressure.

Also data showed that the application of 60% ET<sub>o</sub> level recording high values of unmarketable yield. These results are supported by Peet (1992); Pascual *et al.* (1999); Dorais *et al.* (2004) and Abbott *et al.* (1986) they reported that when the availability of soil moisture surrounding the roots is inconsistent, physiological disorders such as fruit cracking could occur and vice versa.

### 4.2.7. TSS %:

The effect of different irrigation level, soil conditioner treatments and their interactions on TSS % of tomato fruits was tabulated in Table (29). The results indicated that there was a significant difference between the different irrigation levels, the highest TSS values were obtained by

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60% irrigation level followed by 80% treatment. The lowest TSS values were obtained by 100% treatment in the two studied seasons.

Concerning to the soil conditioner treatments, there was no significant difference between the tested soil conditioners during the both studied seasons.

Focusing the effect of interaction between irrigation and soil conditioner treatments, the highest significant TSS % value resulted from using 60% irrigation regime with all tested types of soil treatments in the first season. In the second season the highest value was obtained from using 60% irrigation regime with Hundz soil. On the other hand, the lowest value was obtained from using 100% irrigation regime combined with control treatment in the both seasons.

**Table (29):** Effect of different irrigation treatments and soil conditioners on TSS % fruit of tomato plants in the two seasons of 2012/2013 and 2013/2014.

<b>2012-2013</b>				
	<b>W.R 60%</b>	<b>W.R 80%</b>	<b>W.R 100%</b>	<b>Mean</b>
<b>Hundz soil</b>	5.667 a	5.000 ab	5.000 ab	<b>5.222 A</b>
<b>Oligo plus</b>	5.667 a	5.333 ab	5.000 ab	<b>5.333 A</b>
<b>Bioconditioner</b>	5.667 a	5.000 ab	4.500 b	<b>5.056 A</b>
<b>Control</b>	5.667 a	5.000 ab	4.333 b	<b>5.000 A</b>
<b>Mean</b>	<b>5.667 A</b>	<b>5.083 AB</b>	<b>4.708 B</b>	
<b>2013-2014</b>				
<b>Hundz soil</b>	5.667 a	5.000 b	5.000 b	<b>5.222 A</b>
<b>Oligo plus</b>	5.333 ab	5.000 b	5.000 b	<b>5.111 A</b>
<b>Bioconditioner</b>	5.333 ab	5.000 b	5.000 b	<b>5.111 A</b>
<b>Control</b>	5.333 ab	5.000 b	5.000 b	<b>5.111 A</b>
<b>Mean</b>	<b>5.417 A</b>	<b>5.000 B</b>	<b>5.000 B</b>	

### **4.2.8. Fruits firmness:**

Tabulated data in Tables (30) showed that tomato fruit firmness was affected significantly by irrigation level treatments, the highest values were obtained by the lowest tested irrigation level (60%) followed

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by 80% irrigation level. The lowest values were obtained from 100% treatment in the both seasons.

Concerning the effect of soil conditioners, there was a significant difference between the tested types of soil conditioner treatments in both studying seasons. Oligo plus recorded the highest tomato fruit firmness value. The lowest tomato fruit firmness value was obtained from control treatment.

The interaction between irrigation levels and soil conditioner treatments were affected significantly on tomato fruit firmness. The highest significant fruit firmness value was resulted from using 60% irrigation level combined with Hundz soil treatment in the first season. Second season had a different trend, the highest significant values were obtained from 60% irrigation level combined with Oligo Plus. On the other hand, the lowest value was obtained from using 100% irrigation level combined with control treatment in the both seasons.

**Table (30):** Effect of different irrigation treatments and soil conditioners on firmness (g/cm) of tomato plants in the two seasons of 2012/2013 and 2013/2014.

<b>2012-2013</b>				
	<b>W.R 60%</b>	<b>W.R 80%</b>	<b>W.R 100%</b>	<b>Mean</b>
<b>Hundz soil</b>	866.0 a	800.0 b	720.0 c	<b>795.3 AB</b>
<b>Oligo plus</b>	850.7 a	783.3 b	766.7 b	<b>800.2 A</b>
<b>Bioconditioner</b>	816.7 a	816.7 a	743.3 b	<b>792.2 AB</b>
<b>Control</b>	766.7 b	716.7 c	710.0 c	<b>731.1 B</b>
<b>Mean</b>	<b>825.0 A</b>	<b>779.1 B</b>	<b>735.0 B</b>	
<b>2013-2014</b>				
<b>Hundz soil</b>	833.3 a	800 ab	726.7 c	<b>786.7 AB</b>
<b>Oligo plus</b>	883.3 a	866.7 a	766.7 b	<b>838.9 A</b>
<b>Bioconditioner</b>	816.7 a	810.9 ab	743.3 b	<b>792.2 AB</b>
<b>Control</b>	783.3 c	733.3 b	710.0 c	<b>742.2 B</b>
<b>Mean</b>	<b>829.2 A</b>	<b>804.2 A</b>	<b>736.7 B</b>	

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### **4.3. Chemical fruit properties:**

Data in Tables (31 and 32) showed that, the effect of different irrigation regime treatments and soil conditioners and their interactions on L.Ascorbic acid content and total acidity in tomato fruits. The results shown that there were significant differences between the different irrigation levels, the highest values were obtained by 60% treatment. The lowest values were obtained by 100% treatment in the both seasons.

Concerning the soil conditioner treatments there were significant differences between the soil conditioners in the both seasons. The Hundz soil recorded the highest values. The lowest values were obtained from control treatment.

According the interaction effect between irrigation levels and soil conditioner treatments, data showed that the highest values of L.Ascorbic acid content and total acidity of tomato fruits resulted from using 60% irrigation regime with Hundz soil treatment while the lowest values were obtained from using 100% irrigation regime with control treatment in both of two studying seasons.

### **4.4. Water use efficiency:**

Data in Table (33) showed the effect of different irrigation levels, soil conditioner treatments and their interactions on water use efficiency (WUE) of tomato plants. The obtained results indicated that there were significant differences among different irrigation treatments. The highest water use efficiency was obtained by 80% irrigation level. Hence, the lowest water use efficiency was obtained by 100% treatment. The same trend was obtained in the second season.

Concerning soil conditioner treatments, water use efficiency affected significantly by soil conditioner treatments. Hundz soil in the first season and Oligo plus in the second season were recorded the highest water use efficiency values. The lowest water use efficiency values were obtained by control treatment.



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**Table (31):** Effect of different irrigation treatments and soil conditioners on L.Ascorbic acid content (mg/100g) on fruits of tomato plants during the two seasons of 2012/2013 and 2013/2014.

<b>2012-2013</b>				
	<b>W.R 60%</b>	<b>W.R 80%</b>	<b>W.R 100%</b>	<b>Mean</b>
<b>Hundz soil</b>	28.80 a	28.53 a	25.78 bc	<b>27.70 A</b>
<b>Olygo plus</b>	26.99 b	26.67 b	24.46 d	<b>26.04 AB</b>
<b>Bioconditioner</b>	25.64 c	25.33 c	22.68 e	<b>24.55 B</b>
<b>Control</b>	24.30 d	24.00 d	22.91 e	<b>23.74 C</b>
<b>Mean</b>	<b>26.43 A</b>	<b>26.13 A</b>	<b>23.96 B</b>	
<b>2013-2014</b>				
<b>Hundz soil</b>	35.17 a	34.79 ab	31.29 c	<b>33.75 A</b>
<b>Olygo plus</b>	33.32 bc	32.92 bc	30.21 cd	<b>32.15 AB</b>
<b>Bioconditioner</b>	31.69 bc	31.31 c	28.05 d	<b>30.35 B</b>
<b>Control</b>	29.76 d	29.39 de	28.05 e	<b>29.07 C</b>
<b>Mean</b>	<b>32.48 A</b>	<b>32.10 A</b>	<b>29.40 B</b>	

**Table (32):** Effect of different irrigation treatments and soil conditioners on total acidity on fruits of tomato plants during the two seasons of 2012/2013 and 2013/2014.

<b>2012-2013</b>				
	<b>W.R 60%</b>	<b>W.R 80%</b>	<b>W.R 100%</b>	<b>Mean</b>
<b>Hundz soil</b>	23.89 a	23.5 ab	20.35 c	<b>22.57 A</b>
<b>Olygo plus</b>	23.85 a	23.25 a	20.22 c	<b>22.44 A</b>
<b>Bioconditioner</b>	23.15 a	22.23 b	20.11 c	<b>21.85 B</b>
<b>Control</b>	23.12 a	22.20 b	19.93 d	<b>21.75 B</b>
<b>Mean</b>	<b>23.5 A</b>	<b>22.79 A</b>	<b>20.15 B</b>	
<b>2013-2014</b>				
<b>Hundz soil</b>	24.69 a	23.95 ab	21.71 c	<b>23.31 A</b>
<b>Olygo plus</b>	23.87 ab	23.93 ab	21.02 cd	<b>22.36 B</b>
<b>Bioconditioner</b>	23.38 b	22.85 bc	19.51 d	<b>21.91 B</b>
<b>Control</b>	23.14 b	21.39 c	19.20 d	<b>21.24 C</b>
<b>Mean</b>	<b>23.77 A</b>	<b>23.03 A</b>	<b>20.36 B</b>	

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**Table (33):** Effect of different irrigation treatments and soil conditioners on water use efficiency ( $\text{Kg/m}^3$ ) of tomato plants during the two seasons of 2012/2013 and 2013/2014.

2012-2013				
	W.R 60%	W.R 80%	W.R 100%	Mean
<b>Hundz soil</b>	15.18 a	16.74 a	14.45 ab	<b>15.46 A</b>
<b>Oligo plus</b>	15.17 a	15.22 a	14.51 ab	<b>14.97 AB</b>
<b>Bioconditioner</b>	13.57 ab	14.20 ab	13.09 ab	<b>13.62 AB</b>
<b>Control</b>	12.57 ab	13.89 ab	10.81 b	<b>12.42 B</b>
<b>Mean</b>	<b>14.12 AB</b>	<b>15.01 A</b>	<b>13.22 B</b>	
2013-2014				
<b>Hundz soil</b>	17.67 ab	17.01 ab	15.89 ab	<b>16.86 A</b>
<b>Oligo plus</b>	16.02 ab	19.89 a	14.51 ab	<b>16.81 A</b>
<b>Bioconditioner</b>	13.68 ab	15.41 ab	14.19 ab	<b>14.43 A</b>
<b>Control</b>	12.25 b	14.41 ab	12.11 b	<b>12.92 B</b>
<b>Mean</b>	<b>14.89 B</b>	<b>16.68 A</b>	<b>14.17 B</b>	

Another significant effect was detected as a result for the interaction between irrigation levels and soil conditioner treatments, data showed that the highest water use efficiency of tomato plants resulted from using 80% irrigation level combined with Hundz soil treatment in the first season. In the second season, the highest values were obtained from using 80% irrigation level combined with Oligo plus. On the other hand, the lowest values were obtained from using 100% irrigation level combined with control treatment in the both studied seasons.

From the previous showed data we can concluded that increasing irrigation quantity above 80% of irrigation requirement led to decrease water use efficiency. The highest WUE was obtained by 80% irrigation regime. Meanwhile, Hundz soil and Oligo plus treatments gave the highest WUE. These results are supported by Bailey (1990); Abdrabbo *et al.* (2010); Hashem *et al.* (2011); Novello and de Palma (1997) and El-Sawy (2014) all of them concluded that yield and it's attributed characters as well as water use efficiency was highly affected by the

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applied amount of irrigation water. Also efficiency in water utilization has a marked influence in determining most of the physiological and agronomical performances observed in crop plants, especially vegetable. Irrigation can be important for vegetable crops because many are shallow rooted and therefore sensitive to water shortage. Vegetable production is a high-cost enterprise with a high value end product and many growers feel the need to have irrigation available as an insurance against drought. There are several potential benefits from irrigating vegetables, e.g. yield increase, improvement in plant establishment, continuity of supply to market or processor, and increased quality. As water supplies become scarcer and the cost of water for irrigation increases, irrigation-scheduling methodologies need to be more precise and sustained moisture supply by using proper water quantity with soil conditioners was enhanced plant yield. The irrigation water supplied, irrespective of irrigation methods, was retained in the soil and efficiently distributed for crop growth. This has enabled the crop not to distinguish significantly between the levels of irrigation received, once the crop was added conditioner. Higher water use efficiency is an integral part of conditioner and drip irrigation.

### **4.5. Chemical composition of plant**

#### **4.5.1. Nitrogen percentage:**

Nitrogen percentage in leaves of tomato plants was affected by different irrigation, soil conditioner treatments and their interactions are illustrated in Table (34). The results indicated that there were significant differences among the different irrigation levels. The highest values were obtained by 100% irrigation level followed by 80% treatment. The lowest values were obtained from 60% treatment in the both studied seasons. Highlighting the effect of soil conditioner treatments on nitrogen content, significant differences between the tested types of soil conditioner treatments were found as a result for applying the soil conditioners. Hundz soil recorded the highest nitrogen content while, the lowest values were obtained from control treatment in both of two studying seasons.

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**Table (34):** Effect of different irrigation treatments and soil conditioners on nitrogen (%) of tomato leaves during the two seasons of 2012/2013 and 2013/2014.

2012-2013				
	W.R 60%	W.R 80%	W.R 100%	Mean
<b>Hundz soil</b>	4.220 abc	4.683 ab	4.813 a	<b>4.572 A</b>
<b>Oligo plus</b>	3.693 cde	4.080 abcd	4.643 ab	<b>4.139 A</b>
<b>Bioconditioner</b>	3.367 de	3.920 bcd	4.460 abc	<b>3.916 B</b>
<b>Control</b>	2.933 e	3.747 cde	4.243 abc	<b>3.641 B</b>
<b>Mean</b>	<b>3.553 B</b>	<b>4.108 A</b>	<b>4.540 A</b>	
2013-2014				
<b>Hundz soil</b>	4.303 abc	4.813 ab	5.097 a	<b>4.738 A</b>
<b>Oligo plus</b>	3.747 cde	4.103 bcd	4.497 abc	<b>4.116 B</b>
<b>Bioconditioner</b>	3.383 de	4.023 bcd	4.673 ab	<b>4.027 B</b>
<b>Control</b>	3.057 e	3.740 cde	4.360 abc	<b>3.719 B</b>
<b>Mean</b>	<b>3.622 B</b>	<b>4.170 A</b>	<b>4.657 A</b>	

Regarding the interaction between irrigation regimes and soil conditioners treatments, highest value of nitrogen content of tomato plants was resulted by using 100% irrigation level combined with Hundz soil treatment. The lowest nitrogen content was obtained by using 60% irrigation level combined with control treatment in the two seasons.

### 4.5.2. Phosphorus percentage:

Illustrated data in Table (35) showed that there were significant differences in phosphorus content under different irrigation, soil conditioner treatments and their interactions. The highest tested irrigation level (100%) was recorded the highest significant value of phosphorus percentage. However, the lowest significant value was obtained from 60% treatment. In addition, Hundz soil was recorded the highest significant phosphorus percentage. While, the lowest significant value of phosphorus percentage was obtained from control treatment.

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According to the interaction effect between irrigation level and soil conditioner treatments, data showed that the highest value of phosphorus percentage resulted from using 100% irrigation level combined with Hundz soil treatment. The lowest value was obtained from using 60% irrigation level combined with control treatment. Obtained results were confirmed in the second season.

**Table (35):** Effect of different irrigation treatments and soil conditioners on phosphorus (%) of tomato leaves during the two seasons of 2012/2013 and 2013/2014.

<b>2012-2013</b>				
	<b>W.R 60%</b>	<b>W.R 80%</b>	<b>W.R 100%</b>	<b>Mean</b>
<b>Hundz soil</b>	0.4133 bc	0.5180 ab	0.6253 a	<b>0.5189 A</b>
<b>Oligo plus</b>	0.2800 cd	0.2733 cd	0.6000 ab	<b>0.3844 B</b>
<b>Bioconditioner</b>	0.2593 cd	0.2233 cd	0.5453 ab	<b>0.3427 BC</b>
<b>Control</b>	0.1340 d	0.1433 d	0.4740 ab	<b>0.2504 C</b>
<b>Mean</b>	<b>0.2717 B</b>	<b>0.2895 B</b>	<b>0.5612 A</b>	
<b>2013-2014</b>				
<b>Hundz soil</b>	0.4460 ab	0.5440 ab	0.6807 a	<b>0.5569 A</b>
<b>Oligo plus</b>	0.2860 ab	0.3670 ab	0.6210 a	<b>0.4247 AB</b>
<b>Bioconditioner</b>	0.2470 ab	0.2710 ab	0.6000 a	<b>0.3727 AB</b>
<b>Control</b>	0.1467 b	0.1447 b	0.5270 ab	<b>0.2728 B</b>
<b>Mean</b>	<b>0.2814 B</b>	<b>0.3317 B</b>	<b>0.6072 A</b>	

### **4.5.3. Potassium percentage:**

Effect of different irrigation, soil conditioner treatments and their interactions on potassium percentage of tomato plants are illustrated in Table (36). The results indicated that there was a significant difference as a result for the different irrigation levels, the highest value was found in the 100% followed by 80% treatment. The lowest value was obtained from 60% treatment in both of two studied seasons.

Regarding the soil conditioner treatments, there were significant differences between the tested types of soil conditioner treatments. Hundz

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soil recorded the highest significant value while, the lowest significant value was obtained from control treatment during the two studied seasons.

According the interaction effect between irrigation levels and soil conditioner treatments, data showed that the highest significant value of potassium percentage in tomato plants resulted from using 100% irrigation level combined with Hundz soil treatment. The lowest significant value was obtained from using 60% irrigation level combined with control treatment in the both two studied seasons.

**Table (36):** Effect of different irrigation treatments and soil conditioners on potassium (%) of tomato leaves during the two seasons of 2012/2013 and 2013/2014.

<b>2012-2013</b>				
	<b>W.R 60%</b>	<b>W.R 80%</b>	<b>W.R 100%</b>	<b>Mean</b>
<b>Hundz soil</b>	2.907 bcd	3.383 ab	3.880 a	<b>3.390 A</b>
<b>Oligo plus</b>	2.583 cde	3.057 bc	3.453 ab	<b>3.031 AB</b>
<b>Bioconditioner</b>	2.157 de	2.537 cde	3.157 abc	<b>2.617 BC</b>
<b>Control</b>	1.837 e	2.243 de	3.033 bc	<b>2.371 C</b>
<b>Mean</b>	<b>2.371 C</b>	<b>2.805 B</b>	<b>3.381 A</b>	
<b>2013-2014</b>				
<b>Hundz soil</b>	3.013 cd	3.383 bc	4.043 a	<b>3.480 A</b>
<b>Oligo plus</b>	2.523 de	3.057 cd	3.907 ab	<b>3.162 AB</b>
<b>Bioconditioner</b>	2.257 e	2.537 de	3.553 abc	<b>2.782 BC</b>
<b>Control</b>	1.930 e	2.347 e	3.157 c	<b>2.478 C</b>
<b>Mean</b>	<b>2.431 C</b>	<b>2.831 B</b>	<b>3.665 A</b>	

### 4.5.4. Calcium percentage:

Data in Table (37) indicated that there are significant differences in calcium percentage as a result of using different irrigation levels. The highest significant calcium percentage was obtained from the 100% treatment. The lowest significant values of calcium percentage were obtained by 60% treatment during both of studied seasons.

Concerning effect of soil conditioner treatments, a significant difference between the tested types of soil treatments was found. The

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Hundz soil recorded the highest significant calcium content value while, the lowest significant value was obtained by control treatment in the both studied seasons.

Moreover, interaction between irrigation and soil conditioner treatments recorded a significant effect on calcium content in tomato plants. The highest significant value resulted from using 100% irrigation level combined with Hundz soil treatment. The lowest significant value was obtained from using 60% irrigation level combined with control treatment in the both seasons.

**Table (37):** Effect of different irrigation treatments and soil conditioners on calcium (%) of tomato leaves during the two seasons of 2012/2013 and 2013/2014.

<b>2012-2013</b>				
	<b>W.R 60%</b>	<b>W.R 80%</b>	<b>W.R 100%</b>	<b>Mean</b>
<b>Hundz soil</b>	1.507 e	2.547 bc	2.940 a	<b>2.331 A</b>
<b>Oligo plus</b>	1.263 e	2.247 cd	2.897 ab	<b>2.136 AB</b>
<b>Bioconditioner</b>	1.207 e	2.130 d	2.757 ab	<b>2.031 B</b>
<b>Control</b>	1.230 e	2.08 d	2.647 ab	<b>1.988 B</b>
<b>Mean</b>	<b>1.302 B</b>	<b>2.253 AB</b>	<b>2.810 A</b>	
<b>2013-2014</b>				
<b>Hundz soil</b>	1.530 e	2.733 abc	3.027 ab	<b>2.430 A</b>
<b>Oligo plus</b>	1.257 e	2.353 cd	3.280 a	<b>2.297 AB</b>
<b>Bioconditioner</b>	1.187 e	2.380 cd	2.697 bcd	<b>2.088 B</b>
<b>Control</b>	1.250 e	2.123 d	2.633 bcd	<b>2.002 B</b>
<b>Mean</b>	<b>1.306 B</b>	<b>2.398 A B</b>	<b>2.909 A</b>	

### 4.5.5. Magnesium percentage:

Date in Table (38) showed, the effect of different irrigation levels, soil conditioner treatments and their interactions on tomato plants magnesium percentage. Results showed that there were significant differences between the different irrigation levels. The highest significant value of magnesium percentage was obtained by 100% irrigation level.

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The lowest significant magnesium percentage was obtained from 60% treatment in the two studied seasons.

In addition, Hundz soil recorded the highest significant value of magnesium percentage. The lowest significant magnesium percentage was obtained by control treatment in the two studied seasons.

**Table (38):** Effect of different irrigation treatments and soil conditioners on magnesium (%) of tomato plants during the two seasons of 2012/2013 and 2013/2014.

<b>2012-2013</b>				
	<b>W.R 60%</b>	<b>W.R 80%</b>	<b>W.R 100%</b>	<b>Mean</b>
<b>Hundz soil</b>	0.55 abc	0.5767 ab	0.59 a	<b>0.5722 A</b>
<b>Oligo plus</b>	0.50 bcd	0.5167 abcd	0.5767 ab	<b>0.5311 A</b>
<b>Bioconditioner</b>	0.4067 e	0.48 cde	0.54 abc	<b>0.4756 B</b>
<b>Control</b>	0.40 e	0.4467 de	0.53 abc	<b>0.4600 B</b>
<b>Mean</b>	<b>0.4642 A</b>	<b>0.5050 A</b>	<b>0.5600 A</b>	
<b>2013-2014</b>				
<b>Hundz soil</b>	0.5900 abc	0.6033 ab	0.6333 a	<b>0.6089 A</b>
<b>Oligo plus</b>	0.5200 bcde	0.5167 cde	0.5860 abc	<b>0.5411 A</b>
<b>Bioconditioner</b>	0.4400 ef	0.4800 def	0.5500 abcd	<b>0.4900 B</b>
<b>Control</b>	0.4133 f	0.4433 ef	0.5360 bcd	<b>0.4644 B</b>
<b>Mean</b>	<b>0.4908 A</b>	<b>0.5108 A</b>	<b>0.5767 A</b>	

Concerning the interaction effect of between irrigation levels and soil conditioner treatments, data showed that the highest significant value of magnesium content in tomato plants was resulted from using 100% irrigation treatment combined with Hundz soil treatment. The lowest significant value was obtained by using 60% irrigation level combined with control treatment in the two studied seasons.

Soil conditioners significantly were enhanced the nutrient content percentages (nitrogen, phosphorus, potassium, calcium and magnesium percentages). Hundz soil and Oligo plus treatments gave the highest average values of nutrient content percentages of tomato fourth leaf. The lowest nutrient content percentages were obtained in the fourth leaf by the



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Bioconditioner and control treatments during the two seasons. Increased nutrient content could be largely attributed to proper soil properties due to application of the conditioners. This application resulted in enhancement the soil conditions around tomato roots. These conditions were increased the plant growth and hence increasing nutrient absorption and uptake. Optimal root zone conditions allow for adequate root function including proper uptake of water and nutrients. Plant nutrient uptake, plant growth, and yield under mulch fit a quadratic relationship with root zone temperature these results are in agreement with those obtained by Cheryld *et al.* (1997); Emmons and Scott (1997); Peet (1992) and Maboko (2006).

Data in Table (1) showed that adding soil conditioner reducing pH as may be facilitate of the absorption elements. Nutrient contents were decreased under low irrigation level. Increasing irrigation level up to 60% ET<sub>0</sub> decreased the nutrient percentage significantly in the plant leaves. Results may interpret that under low observation of soil moisture, the concentration of ions decreased in the plant and vise versa is true in the conditions of increasing soil moisture observation. Similar results were reported by Abdrabbo *et al.* (2010); El-Shinawy (1997) and El-Nemr *et al.* (1997), they reported that using optimum water quantity allow plants to use water and nutrients from deep soil. So, there were an efficiency use for water and nutrients and reduction in nitrogen leaching. Excess irrigation not only reduces crop yield, but also increases nutrient leaching.

## SUMMARY AND CONCLUSION

The experiment was performed under open filed at El-dolify Farm in Katatba zone, Monofaya Government, during seasons of 2012/2013 and 2013/2014.

The experiment aimed to

1. Study the effect of soil conditioners at different irrigation regimes.
2. Increasing the efficiency of water use for tomato plants while maintaining production.

Two factors were investigated under experiments as follows:

- As main plot:

Water requirement (100, 80 and 60%)

- As sub plot:

Soil conditioners were Oligo plus, Bioconditioner, Hundz soil and control (without soil conditioner). The Hundz soil conditioner was added with preparing the soil. While, Oligo plus and Bioconditioner were added two times during the season (first time was after 20 day from planting and the second time was after 20 day from the first adding with start flowering the plant).

The experiment was arranged in a split plot design with three replicates. Water requirement levels were allocated in the main plots and soil conditioners were randomly arranged in sub plots.

Plant length, number of leaves, stem diameter, leaf area, total fresh and dray weight of plant, chlorophyll reading, early and total yield, fruit parameters and the mineral analyses of tomato leaf (N, P ,K, Ca and Mg) were measured.

**The obtained results could be summarized as follow:**

### **Vegetative growth:**

1. Plant length and number of leaves did not recorded any significant differences between the 80 and 100% of the applied, but a

## SUMMARY AND CONCLUSION

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significant difference was recorded with 60% of water requirement. There was significant differences between soil conditioners and control; both Hundz soil and Oligo plus were superiority more than Bioconditioner. Interaction between Hundz soil and 100% after 30 days from transplanting date was greater than the rest of the transactions. But after 60 and 90 days from transplanting date there was no significant difference between the 80 and 100% combined with Hundz soil. On the other hand, the lowest value in the interaction has recorded by control treatment combined with 60% irrigation treatment.

2. Number of branches per plant had no significant differences between irrigation and soil conditioner treatments in the first season. While, after 60 and 90 days from transplanting there was a significant difference between the tested types of soil conditioners compared to control treatment. Also, there was no significant difference between soil conditioners combined with 80 or 100% but there was a significant difference between them and 60% combined with control in the both seasons.
3. There were no significant differences among irrigation levels on chlorophyll reading after 60 days from transplanting date in the both seasons. Whereas, there were significant differences on chlorophyll reading after 120 days from transplanting date in the both seasons, a moral difference appeared between (80 and 100%) and 60% of water requirement. There were no moral difference among Hundz soil and/or Oligo plus soil conditioner treatments, but there was significant difference between them and the Bioconditioner and control. The highest chlorophyll reading was obtained by both Hundz soil and Oligo plus soil conditioners combined with 80 and/or 100% irrigation levels. The lowest chlorophyll reading was obtained by control treatment combined with 60% irrigation treatment in the both of seasons.

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4. For total plant leaf area there was a significant difference between the irrigation treatments after 60 and 120 day of transplanting date. The highest leaf area was obtained by 100% irrigation level compared to the other irrigation levels. There was no significant difference between Hundz soil and Oligo Plus, but there was a significant difference between both of them and the Bioconditioner and control in the both seasons. The interaction of 100% combined with Hundz soil gave the highest total plant leaf area; while the lowest values were obtained by control combined 60% irrigation level in the both seasons.
5. Stem diameter of the plant had no significant difference between the irrigation and soil conditioner treatments in the both seasons. On the other hand, the interaction had recorded the highest value by using Hundz soil with 100%; while the lowest value was obtained by control combined with 60% irrigation level in the both seasons.
6. Fresh and dry weight of the plant had a significant difference after 90 and 180 days of transplanting date. The highest tested irrigation level (100%) gave the highest values followed by 80% irrigation level. There was a positive significant difference between soil conditioners and control. The highest fresh and dry weight was obtained by using 100% with all tested soil conditioners followed by 80% irrigation level. Using 60% irrigation with control (without soil conditioner) presented the lowest value in both seasons.

### **Yield:**

1. Irrigation treatments had a clear significant difference on average fruit weight; the highest value was obtained by 100% irrigation treatments. Regarding soil conditioner, there was no significant difference between Hundz soil and Oligo Plus but there was a significant difference among Hundz soil and/or Oligo Plus

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compared to both of Bioconditioner and control. The highest fruit weight value recorded by Hundz soil combined with 100% irrigation level. The lowest values were obtained by control combined with 60% irrigation level in both seasons.

2. Early and total yield were increased significant under 100% irrigation level compared to the other tested irrigation treatments. Hundz soil and Oligo Plus had positive significant values compared to Bioconditioner and control. Hundz soil combined with 100% and Oligo Plus combined with 100% had the highest early and total yield. The lowest value was gained by 60% irrigation level combined with control in both seasons.
3. The highest marketable yield was obtained by 100 and 80% irrigation levels. There was a positive significant difference between tested soil conditioners compared to control treatment. The highest marketable yield was obtained by 100% irrigation level combined with Hundz soil. The lowest marketable yield was obtained by control combined with 60% irrigation level in both seasons.
4. Using 60% irrigation level gave the highest unmarketable yield value. The highest unmarketable yield obtained by control compared to tested soil conditioner treatments. Moreover, the highest value was obtained by control combined with 60% irrigation level. The lowest value was obtained by 100% irrigation level combined with Hundz soil in both seasons.

### **Fruit quality and Chemical properties:**

1. Using 60% irrigation level was led to increase TSS compared to the other irrigation treatments. There was no significant difference between soil conditioner treatments. Interaction effect between irrigation and soil conditioner treatments shown that the highest TSS was obtained by 60% irrigation level combined with Hundz

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soil. The lowest value obtained by 100% irrigation level combined with control.

2. Regarding tomato fruit firmness, there was a significant difference between the irrigation treatments. The highest value was obtained with 60% irrigation level. For soil conditioners there were no significant difference between tested soil conditioners but there was a significantly different compared to control. The highest value was obtained by Hundz soil combined with 60%. The lowest value was obtained by control combined with 100% irrigation level in the two seasons.
3. The highest L. Ascorbic acid content and total acidity on tomato fruits were obtained by 60% irrigation level while the lowest value was gained by 100% irrigation level. Hundz soil was recorded the highest value while; the lowest values were obtained by control treatment in both seasons. The highest L. Ascorbic acid content and total acidity values were obtained by 60% irrigation level combined with Hundz soil. The lowest value obtained by 100% irrigation level combined with control in the both seasons.

### **Mineral content of leaves:**

1. Regarding nitrogen percentage there was no significant difference between 100 and 80% irrigation levels. The lowest nitrogen percentage was obtained by 60% irrigation level. Furthermore, there was no significant difference between Hundz soil and Oligo Plus but there was a difference between them and the Bioconditioner as well as control. The highest nitrogen percentage found by 100% irrigation levels combined with Hundz soil. Control combined with 60% irrigation levels was recorded the lowest value in the both seasons.
2. Regarding phosphorus percentage, there were significant differences among irrigation and soil conditioner treatments. Hundz soil increased the phosphorus percentage compared to the

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other soil conditioner treatments. There were significant differences between Hundz soil, Oligo Plus and Biocondchiner compared to control. The highest phosphorus percentage recorded by 100% irrigation level combined with all the soil conditioner. The lowest phosphorus percentage obtained by control combined with 60% irrigation level in both seasons.

3. Regarding potassium percentage, there were a significant difference between irrigation and soil conditioner treatments. Hundz soil increased potassium percentage compared to the other soil conditioner treatments. There were a significant difference between Hundz soil, Oligo Plus and Biocondchiner compared to control. The highest potassium percentage recorded by 100% irrigation level combined with Hundz soil conditioner. The lowest potassium percentage was obtained by control combined with 60% irrigation level in both seasons.
4. Regarding calcium percentage, there was no significant difference between 100 and 80% irrigation levels. The lowest calcium percentage was obtained by 60% irrigation level. Furthermore, there was no significant difference between Hundz soil and Oligo Plus but there was a difference between them and the Bioconditioner as well as control. The highest calcium percentage was found by 100% irrigation levels combined with Hundz soil in the first season and Oligo Plus in the second season. Control combined with 60% irrigation levels recorded the lowest value in both seasons.
5. Regarding magnesium percentage, there was no significant difference among irrigation and soil conditioner treatments. There is no significant difference between Hundz soil and Oligo Plus but there was a difference between them and the Biocondchiner and Control. Interaction between Hundz soil and 100% were greater than the rest of the transactions in both of seasons. The result has

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recorded the lowest value by using control with 60% water level in both of seasons.

### **Water use efficiency**

There was no significant difference in the efficiency of water use in the first season only between 100 and 80%. In the second season it was a significant difference between 80% and rest of the transactions. There was no significant difference between the Hundz soil, Oligo Plus and Biocondchiner in the first season. While, there was a significant difference between the Hundz soil and control in the second season. Interaction between the Hundz soil and Oligo Plus with 80% (higher value) or less in value was control with 100% in both of seasons gave insignificant difference.

The mentioned results stated that 80% irrigation treatment combined with using Hundz soil and Oligo plus conditioners gave the best water use efficiency of tomato crop under experimental conditions which saved amount of irrigation water evaluated about 48 CM per feddan. No doubt that water in Egypt is becoming scarce. Therefore, saving and conservation of irrigation water is becoming increasingly important and essential to support agricultural activity. Abovementioned questions may affirmed the importance of water economic studies needed to justify irrigation quantity demanded for each crop under its existing environmental conditions and the possibilities of producing a promising yield with less amount of water.



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# أثر استخدام محسنات التربة على كفاءة استخدام المياه وإنتاجية نباتات الطماطم

رسالة مقدمة من

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للحصول على  
درجة دكتور الفلسفة في العلوم الزراعية  
( محاصيل خضر )

قسم البساتين

كلية الزراعة

جامعة عين شمس

2016

صفحة الموافقة على الرسالة

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المياه وإنتاجية نباتات الطماطم  
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## الملخص العربي

أجريت هذه الدراسة خلال موسمي 2013 و 2014 وذلك بمزرعة الضليفي , الخطاطبة , محافظة المنوفية على نباتات الطماطم هجين يارا. تهدف هذه الدراسة

1. زيادة كفاءة استخدام المياه لنباتات الطماطم مع الحفاظ على الانتاجية.  
2. دراسة أثر استخدام محسنات التربة على نمو وانتاجية وجودة ثمار الطماطم.

3. دراسة تأثير التفاعل بين الري ومحسنات التربة على الانتاج وتحسين جودة المنتج لمحصول الطماطم.

وكانت المعاملات كما يلي:-

التجربة تحتوي على عاملين كالتالي:-

(1) استخدام مقنن مائي (60% - 80% - 100%) من الاحتياجات المائية للطماطم .

(2) استخدام محسنات تربة :

- سويل هانز
- اوليجو بلس
- بيو كوندشينر
- وبدون اضافة (كنترول)

وكان التصميم التجريبي المستخدم هو القطع المنشقة مره واحدة حيث كانت المقننات المائية داخل القطع الرئيسية و محسنات التربة المختلفة داخل القطع تحت الرئيسية في ثلاث مكررات.

وكانت أهم النتائج التي أمكن المتحصل عليها كما يلي:

اولا:النمو الخضري

1. بالنسبة للطول النبات وعدد الاوراق لم يسجل فروق معنوية بين 80% و 100% من الاحتياجات المائية وكان هناك فرق معنوية مع 60% من الاحتياج المائي. أما بالنسبة للمحسّنات فكان هناك فرق معنوية بين المحسّنات والكنترول وقد تفوق كلا من السويل هانز والليجو بلس على البيوكوندشينر. أما التفاعل فقد تفوق السويل هانز مع 100% من الاحتياج المائي وذلك بعد 30 يوم على باقى المعاملات. ولكن بعد 60,90 يوم لم يكن هناك فرق معنوى بين 80% , 100% مع السويل هانز وقد سجلت اقل قيمة فى التفاعل مع الكنترول و 60% من من الاحتياج المائي وذلك فى كلا الموسمين .

2. بالنسبة لعدد الافرع لم يكن هناك فرق معنوية بين معاملات الري ومحسنات التربة في الموسم الاول بينما وجد فرق معنوى في الموسم الثانى فقد اعطت المعاملة 100% من أعلى قيمة بالنسبة لمعاملات الري وكذلك محسن التربة السويل هانز بالنسبة للمحسنات. أما في التفاعل فكانت اعلى قراءة هي سويل هانز مع 100% وقد سجلت اقل قراءة مع الكنترول و 60% من الاحتياج المائى فى كلا الموسمين.

3. بالنسبة للمحتوى من الكلورفيل في الموسم الاول لم يكن هناك فرق معنوية بين معاملات الري بعد 120,60 يوم من الزراعة ولكن ظهر فرق معنوية في الموسم الثانى بين (80,100%) وبين 60% من الاحياجات المائية. أما في المحسنات فلم يوجد فرق معنوى بين السويل هانز واليجو بلس ولكن وجد فروق معنوية بينهم وبين البيوكوندشيزر والكنترول. أما بالنسبة للتفاعل فقد تفوق كلا من السويل هانز واوليجو بلس مع (80,100%) على باقى المعاملات وقد سجلت اقل قراءة مع الكنترول و 60% من الاحتياج المائى.

4. بالنسبة لمساحة سطح الورقة كان هناك فرق معنوية بين معاملات الري بعد 120,60 يوم فقد تفوق 100% على باقى المعاملات فى كلا الموسمين. أما بالنسبة للمحسنات فلم يكن هناك فرق معنوى بين السويل هانز والوليجو بلس ولكن هناك فروق معنوية بينهم وبين البيو كوندشيزر والكنترول فى كلا الموسمين. أما بالنسبة للتفاعل فقد تفوق 100% مع السويل هانز على باقى المعاملات وكانت اقل قيمة مع الكنترول و 60% من الاحتياج المائى.

5. بالنسبة لسمك الساق لم يكن هناك فرق معنوية بين معاملات الري ولا محسنات التربة فى كلا الموسمين. أما بالنسبة للتفاعل فقد سجلت أعلى قيمة فى السويل هانز و 100% وأقل قيمة الكنترول و 60% من الاحتياج المائى.

6. بالنسبة للوزن الطازج والجاف للنبات بعد 90,180 يوم كان هناك فروق معنوية بين معاملات الري 100% و 80% و 60% وكذلك بالنسبة للمحسنات فكان هناك فروق معنوية بين المحسنات والكنترول. أما بالنسبة للتفاعل فقد سجل كلا من المحسنين سويل هانز واوليجوبلس مع 100% أعلى قيمة بينما كانت اقل قيمة مع الكنترول و 60% من الاحتياج المائى فى كلا الموسمين.

#### ثانياً: المحصول

1. بالنسبة لعدد الثمار لم يكن هناك فرق معنوى بين المعاملتين 100% و 80% ولكن كان هناك فروق معنوية بينهم وبين 60% من الاحتياج المائى. أما في المحسنات فلم يوجد فروق معنوية بينهما فى كلا الموسمين.

1. يرى الرى معاملات بين معنى فرق هناك فكان الدائنة الصالحة للموادة الصالحة للنسبة بالنسبة  
أما المعاملات المعاملة بالرى على المائنة الخاتج 60% من 60% المعاملة بالرى وقد تفوق المعاملة بالنسبة  
على المعاملة بالنسبة أما بالنسبة على الفرق هنا لم يكن فرق المعاملات المعاملة بالنسبة بالنسبة  
على المعاملة بالنسبة على الفرق هنا لم يكن فرق المعاملات المعاملة بالنسبة بالنسبة على الفرق هنا لم يكن فرق المعاملات المعاملة بالنسبة بالنسبة

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بين السويل هانز والمحسّنات ولكن وجد فرق معنوية بينهم وبين البيو كوندشينز والكنترول أما بالنسبة للتفاعل فقد سجلت أعلى قيمة في السويل هانز مع 60% وأقل قيمة الكنترول مع 100% في كلا الموسمين.

3. بالنسبة لمحتوى الثمار من حمض الاسكوربيك (فيتامين ج) فكان هناك فرق معنوي بين معاملات الري وقد تفوق المعاملة 60% من الاحتياجات المائية على باقي المعاملات أما بالنسبة للمحسّنات فكان هناك فرق معنوي بين كلا من السويل هانز والاوليجوبلس وبين المقارنة أما بالنسبة للتفاعل فقد سجل 60% مع سويل هانز أعلى قيمة في كلا الموسمين.

4. بالنسبة للحموضة الكلية في الثمار فكان هناك فرق معنوي بين معاملات الري وقد تفوق المعاملة 60% من الاحتياجات المائية على باقي المعاملات أما بالنسبة للمحسّنات فكان هناك فرق معنوي بين كلا من السويل هانز والاوليجوبلس وبين المقارنة أما بالنسبة للتفاعل فقد سجل 60% مع جميع المعاملات أعلى قيمة في كلا الموسمين.

#### رابعاً: التحليل الكيماوي للأوراق

1. بالنسبة للنيتروجين لم يكن هناك فرق معنوية بين 100% و 80% من الاحتياجات المائية أما بخصوص المحسّنات فلا يوجد فرق معنوي بين السويل هانز والوليجوبلس وكان هناك فرق بينهم وبين البيوكوندشينز والكنترول أما بالنسبة للتفاعل فلم يوجد فرق معنوي بين 100,80% مع السويل هانز والوليجوبلس وقد سجل وأقل قيمة الكنترول مع 60% في كلا الموسمين.

2. بالنسبة للفسفور فقد وجد فرق معنوي في معاملات الري بين 100% و 80,60% أما بخصوص المحسّنات فقد وجد فرق معنوي بين السويل هانز وباقي المعاملات في الموسم الاول بينما في الموسم الثاني وجد فرق معنوي بين السويل هانز والكنترول فقط. أما بالنسبة للتفاعل فقد سجل أعلى قيمة في 100% مع جميع المحسّنات وأقل قيمة الكنترول مع 60% في كلا الموسمين.

3. بالنسبة للبوتاسيوم فقد وجد فرق معنوي في معاملات الري بين 100% و 80,60% أما بخصوص المحسّنات فقد وجد فرق معنوي بين السويل هانز والوليجوبلس وباقي المعاملات. أما بالنسبة للتفاعل فقد سجل أعلى قيمة في 100% مع السويل هانز وأقل قيمة الكنترول مع 60% في كلا الموسمين.

4. بالنسبة للكالسيوم لم يكن هناك فرق معنوية بين 100% و 80% من الاحتياجات المائية. وكذلك فى المحسنات فلا يوجد فرق معنوى بين السويل هانز والوليجو بلس وكان هناك فرق بينهم وبين البيوكوندشينر والكنترول أما بالنسبة للتفاعل فلم يوجد فرق معنوى بين 100 % مع المحسنات وقد سجلت أقل قيمة للكنترول مع 60% فى كلا الموسمين.

5. بالنسبة للمغنسيوم لم يكن هناك فرق معنوية بين معاملات الرى ام فى المحسنات فلا يوجد فرق معنوى بين السويل هانز والوليجو بلس وكان هناك فرق بينهم وبين البيوكوندشينر والكنترول أما بالنسبة للتفاعل فلم يوجد فرق معنوى بين 100,80% مع السويل هانز والوليجو بلس وقد سجل أقل قيمة مع الكنترول و60% فى كلا الموسمين.

#### خامساً: كفاءة استخدام المياه

لم يكن هناك فرق معنوى فى كفاءة استخدام المياه فى الموسم الاول فقط بين 60% و 80% ولكن كان هناك فرق معنوى بينهم وبين 100% . ام فى الموسم الثانى فقد تفوق 80% على باقى المعاملات. أما بخصوص المحسنات ففي الموسم الاول لم يكن هناك فرق معنوى بين السويل هانز والوليجو بلس و البيوكوندشينر وكان هناك فرق معنوى بين السويل هانز والكنترول وفى الموسم الثانى فقد تفوق المحسنات على الكنترول. أما بالنسبة للتفاعل فلم يكن هناك فرق معنوى بين السويل هانز والوليجو بلس مع 80% (أعلى قيمة) أما أقل قيمة كانت فى الكنترول مع (60%,100%) فى كلا الموسمين.

#### التوصية

اتضح من خلال النتائج المتحصل عليها تحت ظروف التجربة ان معاملة الرى 80% مع كلا من محسنين التربة سويل هانز و الاوليجو بلاس قد أعطت أفضل كفاءة استخدام المياه والتي بدورها ادت الى توفير حوالى 48 متر مكعب من المياه للقدان خلال موسم الزراعة.

مما لا شك فيه ان مصر تشهد عجز فى كمية المياه الصالحة للاستخدام فى النشاط الزراعى، لذلك كان من الاهمية بمكان المحافظة على مياه الرى وذلك لتدعيم خطة التوسع فى النشاط الزراعى تحت الظروف المصرية، وذلك عن طريق رفع كفاءة استخدام المياه الصالحة للرى ومحاولة استغلال المصادر المائية المتاحة استغلالاً اقتصادياً للحصول على اعلى محصول ممكن دون فقد نسبة كبيرة من مياه الرى.