RESEARCH ARTICLE

MORPHOLOGICAL AND CHEMICAL CHARACTERIZES RESPONSES OF MORINGA OLEIFERA YIELD TO LOCALIZED IRRIGATION SYSTEMS, WATER RESTRICTION AND FERTILIZERS

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Abstract

This investigation of both of irrigation system, water restriction and soil conditioners on Moringaoleifera, (surface drip irrigation, D, buried drip, BD and mini-sprinkler, MS), as well for irrigating a magic crop like Morenga (Moringaoleifera) plants. Also, this work includes different irrigation water restriction which represent two three treatments (100, 80 and 60% of calculated applied water, W1, W2 and W3 respectively), more over threes soil conditioners (Compost, C, Farm manure, FM, Mud, M). The experiment was carried out in Shalatien where it lies in the east-west of the Red sea in Egypt. Surface evaporation in this area has a paramount importance because of its aridity hot climate under the circumstances of saline irrigation water usage. The objective of the present work is to study the influences of irrigation system, water restrictions and soil conditioners on morphological and chemical characters of Moringa, for that, the following measurements are taken; Trunk Diameter, Pods Tree Quantity, Seeds Yields (g) per tree, Weight per 1000 seeds (g), oil yields per tree (g), oil Yields per/ Acer (kg), chlorophyll A-B, total carbohydrates, carotenoids, Total carbohydrates, vitamin C, Nitrogen, Calcium, Fe and zinc content of Moringaoleifera plants in addition to Water use efficiency, cost analysis, energy analysis in two studied seasons, (2017-2018/2018-2019). Results show that the most positive influence of irrigation is buried irrigation, drip irrigation and mini-sprinkler respectively, due to the saved water from losses by evaporation under drought conditions. And the most positive influence of water restrictions treatments is 100, 80 and 60% respectively, but the in many measurements the differences between both of 100 and 80% of applied water is not significant, so it’s more economical to approve 80% of applied water under buried drip irrigation, which means about 20% of applied water can be save.

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Introduction:-
Moringa belongs to the family Moringaceae. The family consists of the single genus Moringa and the botanical name of the tree is Moringaoleifera Lam. The family is distinguished by parietal placentation, 3-valved fruit, elongated, non-dehiscent berry and winged seeds. Philips (1951) reported four species; while Pax (1936) and Puri (1942), Moringaoleifera Lam. Belonging to the family Moringaceae is fast growing, drought tolerant and easily adapted to varied ecosystems and farming systems. It occupies a unique and consistent position in the Indian vegetable industry. In lieu of its many uses, free flowering nature and the ease with which it can be cultivated, the demand for its products and hence the area under its cultivation is on the increase. Moringa is a slender, fast growing, deciduous shrub or small tree reaching 9 to 15 m in height, with an umbrella shaped, open crown. It is an exceptionally nutritious tree with a variety of medicinal properties, Anwar et al., (2007) and Jiruet al., (2006). It comes up well in a wide range of soil. A deep sandy loam soil with a pH of 6.5-8.0 is optimum. Highest seedling vigour was noticed in red soil compared to black loam, loamy or sandy soils. It is a tropical plant and grows well in the plains. However, it is found growing in the subtropical climate also. It is predominantly a crop of dry and arid tract. The optimum temperature for better growth is 25 to 35°C. It is highly susceptible to frost and high temperature exceeding 40°C causes flower shedding. Under water deficit conditions, Moringa could be affected and reduced its potential growth, development and functions by a number of biotic and abiotic factors during seedling stage. While among numerous factors, water plays an essential component for the plants life owing to the crucial role that water plays in physiological processes. (Jaleel, and Llorente, 2009). Moringa plants can survive in harsh climatic condition including barren soil without being much affected by drought. It is a plant with exceptional medicinal properties which can resolve the health care needs in several situations. Moringa is an outstanding source for nutritional component necessity. Its leaves contain calcium 4 times that of milk, vitamin C 7 times that of oranges, potassium 3 times that of bananas, iron 3 times that of spinach, vitamin A 4 times that of carrots, and protein 2 times that of milk. Hence, it is considered as a powerhouse of nutritional value. Easy cultivation of Moringa within adverse environmental conditions attracts attention for economic and health related potential in resource limited developing countries (Aslam et al., 2005; Kamal, 2008; Anjorin et al., 2010 and Raja et al. 2013).

However, even though moringa is drought tolerant plant, during prolonged drought stress, there is a reduction in water content, diminished leaf water potential and turgor loss, closure of stomata, inhibit photosynthesis, lead to dehydration, impair metabolism processes, decrease and inhibit cell expansion, enlargement, growth and development of plants especially during early stage. Kamara et al. 2003 and Badran et al. 2013. Manuring of moringa was rarely practiced, as the tree was capable of growing in very poor soils. Muthuswamy (1954). The problems in moringa and stated that application of manures could help to promote larger yields without sacrificing the margin of profit. Research work at the Tamil Nadu Agricultural University has shown that application of 7.5 kg of farmyard manure and 0.37 kg of ammonium sulphate per tree gave three-fold increase in yield over the unmanured trees. Seemanthani (1964). Usually moringa receives no horticultural attention, but mulching and fertilizing will produce better growth and result in quality of products. (Sundarraj et al., 1970). Martin and Ruberte (1979). Drip irrigation system has been demonstrated to improve crop productivity, reduce energy costs, improve irrigation efficiency and reduce water loss by deep percolation. When implementing drip irrigation system, it is important to consider water use efficiency, humidity, temperature, ground water. Irrigation at 60 % water holding capacity and applying mineral nitrogen 60 kg/Acer (Yassen et al., 2006; Eddahhak et al., 2007 and El-Sayed, 2007). There are also some additional practical advantages associated with SSDI. The relatively dry soil surface under SSDI permits farm equipment access and movement during the whole irrigation period and reduces, significantly weed growth (Solomon, 1993). In addition, the permanent installation of SSDI below the ploughing depth provides saving of the labors cost. (Jibin and Foroud, 2007). The highly sophisticated equipment developed to serve drip irrigation systems in the industrialized countries obscures the concept's essential simplicity. The main justification for such a capital-intensive and generally energy-intensive approach is to reduce the costs of labor. Since the relative costs involved in the promotion of irrigation for the developing countries of Africa are often the reverse of those in the industrialized countries, consideration must be given to simplifying drip irrigation systems. Efforts must be directed towards redesigning drip systems so as to facilitate installation and maintenance, while retaining the basic principles of high-frequency, high-efficiency and low-volume irrigation (Daniel H., 1997).

The aim of these investigations is determined the morphological and chemical characterizes responses of Moringaoleifera yield to localized irrigation systems, water restriction and fertilizers under arid and semi-arid area in Egypt and sandy soil in desert environmental conditions.
List of acronyms and nomenclature

- **SC**: Soil conditioners,
- **WR**: Water restriction,
- **D**: Surface drip irrigation systems,
- **BD**: Buried drip irrigation systems,
- **MS**: Mini-sprinkler irrigation system,
- **W1**: 100% of ETa, applied water,
- **W2**: 80% of ETa, applied water,
- **W3**: 60% of ETa, applied water,
- **C**: Compost,
- **FM**: Farm Manure,
- **M**: Mud

Materials and Methods:

Morenga seedlings (15 cm height) are transplanted in successful two seasons 2017/2018 and 2018/2019; the space of plants is 2 m and 2.5 m of the plant row.

A field experiment was carried in an Abo Sfera, Shalatien where it situates in the east-west of the Red sea in Egypt (elevation 12.75 m, Latitude 31°22' 55" N and 29°27’15” E). Soil samples have variable origins and CaCO3 content, Typic Torripsamments, Mixed, Hyperthermic and Typic Calciorthents, loamy mixed, Thermic, respectively according to Soil Taxonomy as described by Soil Survey Staff (1975). The study is conducted to evaluate the interaction effect of some soil organic fertilization, (i.e., Compost, Farm Yard Manure and Filter Mud), in addition to the suitable irrigation water scheduling by 80% and 60% (i.e. 20% and 40% as soil moisture depletion treatments) in addition to 100% (as a control) treatment quantities calculated from Penman – Monteith equation under the modern irrigation system, (i.e. surface and sub-surface drip irrigation systems besides mini sprinkler) on maximizing Morenga production. All treatments repeated three times under statistical design as Split - Split plot design.

The investigation area is characterized as a desert region and the soil of the trial site was deep, well drained sandy which contents of 78.95% sand, 16.95% silt and 4.44% clay, with an alkaline pH 7.9, EC 0.54 dS/m, CaCO3 15.55%, O.M 0.44% as an average shown in table (1a&b).

An irrigation water sample was taken and the chemical properties were determined according to (Black, 1983) of the studied area. The data in table (2) shows the value of EC of irrigation water, which reached 4.23 dS/m and pH 7.65. The highest value of cations was for Na, (18.34 Me/l) and the highest value of anions was for Cl-, (35.67 me/l). This means that the dominant salt is NaCl, which need to spotlight in this trial.

Irrigation requirements:

Irrigation water requirements for moringa were calculated according to the follow equation

\[
IR = \left( \frac{K_c \times E_t \times A \times C_F}{10^7 \times E_a} \right) + LR
\]

Where:
- **IR** = Irrigation water requirements, m³/ha/day.
- **E_t** = Potential evapotranspiration, mm day⁻¹
- **Kc** = Crop factor of apple,
- **Ea** = Application efficiency, %, where 90% for used irrigation systems.
- **A** = Area irrigated, (m²)
- **LR** = Leaching requirements.
- **CF** = Covering factor, of Moringa trees 45%.
Irrigation systems and control head:
The drip irrigation system was used to irrigate Moringa trees. The system consists of a diesel pump (18 m³/h, flow rate) which takes water from an open sub-surface tank (75 m³ capacity) through two filter units, the first one is screen (130 mesh) and the other is gravel filter.

Table 1:- Soil physical properties of the studied area

| Depth, cm | Coarse Sand | Fine Sand | Silt | Clay | Textural Class | Bd (Mg·m⁻²) | Moisture content | 102KPa |
|-----------|-------------|-----------|------|------|------------|-------------|-----------------|--------|
| 0-20      | 12.91       | 61.97     | 20.21 | 4.91 | L.S        | 1.66        | 14.55           | 5.89   |
| 20-40     | 15.22       | 63.58     | 18.21 | 4.99 | L.S        | 1.69        | 13.96           | 5.56   |
| 40-60     | 17.11       | 61.44     | 17.31 | 4.14 | L.S        | 1.68        | 13.58           | 5.45   |
| 60-80     | 14.19       | 66.04     | 15.22 | 4.55 | L.S        | 1.67        | 14.02           | 5.70   |
| 80-100    | 20.15       | 61.55     | 14.11 | 4.19 | L.S        | 1.66        | 13.88           | 4.88   |
| >100      | 23.22       | 56.34     | 16.61 | 3.83 | L.S        | 1.65        | 13.33           | 4.87   |
| Average   | 17.13       | 61.82     | 16.95 | 4.44 | L.S        | 1.67        | 13.89           | 5.39   |

L.S = Loamy Sand

Table 1a:- Soil chemical properties of the studied area

| Depth, Cm | CaCO₃, % | EC, dS/m | PH | % O.M | Cations me/l | Anions me/l | SAR |
|-----------|----------|----------|----|-------|--------------|--------------|-----|
|           |          |          |    |       | Na+ | K+ | Ca++ | Mg++ | CO₃= | HCO₃⁻ | Cl⁻ | SO₄²⁻ |
| 0-20      | 17.25    | 0.76     | 7.9 | 0.32  | 0.7 | 0.3 | 2.8 | 3.8  | 0.0  | 0.30  | 3.2 | 4.08  |
| 20-40     | 14.52    | 0.67     | 7.9 | 0.34  | 0.7 | 0.3 | 2.8 | 2.9  | 0.0  | 0.32  | 3.1 | 3.29  |
| 40-60     | 15.58    | 0.49     | 7.8 | 0.65  | 0.7 | 0.2 | 1.9 | 2.1  | 0.0  | 0.28  | 2.8 | 1.81  |
| 60-80     | 15.08    | 0.50     | 7.8 | 0.54  | 0.6 | 0.3 | 2.7 | 1.3  | 0.0  | 0.28  | 2.8 | 1.87  |
| 80-100    | 16.39    | 0.36     | 8.0 | 0.48  | 0.5 | 0.3 | 1.9 | 0.9  | 0.0  | 0.26  | 1.8 | 1.85  |
| >100      | 14.50    | 0.43     | 8.0 | 0.33  | 0.4 | 0.3 | 1.9 | 1.7  | 0.0  | 0.28  | 1.9 | 2.13  |
| Average   | 15.55    | 0.54     | 7.9 | 0.44  | 0.6 | 0.3 | 2.4 | 2.1  | 0.0  | 0.29  | 2.6 | 2.51  |

Table 2:- Chemical analysis of irrigation water

| EC, dS/m | PH | Cations me/l | Anions me/l | SAR |
|----------|----|--------------|--------------|-----|
|          |    | Ca++ | Mg++ | K+ | Na+ | CO₃= | HCO₃⁻ | Cl⁻ | SO₄²⁻ |
| 4.23     | 7.65 | 11.70 | 8.19 | 4.05 | 18.34 | 0.0 | 6.00 | 35.67 | 0.61 | 5.56 |

Table 3:- Chemical analysis of Compost, farmyard manure and Filter mud added to the experimental field

| Organic Matter Source | Moisture content % | pH (1:10) | EC (1:10) dS.m⁻¹ | N. ppm | C. ppm | C/N Ratio | P. % | K. % | OM % |
|-----------------------|-------------------|----------|-----------------|--------|--------|------------|------|------|------|
| Compost, C            | % 23              | 7.04     | 1.04            | 0.69   | 17.98  | 12.42      | 0.16 | 0.59 | 51.8 |
| Farmyard manure, FM   | % 18              | 7.84     | 5.29            | 1.82   | 10.73  | 19.52      | 0.49 | 0.58 | 34.3 |
| Mud, M                | % 7               | 7.02     | 1.01            | 0.54   | 19.44  | 10.5       | 0.11 | 0.48 | 24.16|

The filtration system is controlled by safety valve, relief valve, four control valves, pressure regulator unit, flow meter unit, air tank (balloon) unit, 6.4 mm pressure meter. The manifold is 50 mm PVC pipeline with 50 mm end plug for flushing. The drippers flow rate of 4 L/h (GR), the space of two drippers is 50cm. They were installed in 16 mm Polyethylene laterals as one and two lines, surface and subsurface systems. Mini sprinklers were installed with each 10 meters apart.

Phenological stages and irrigation schedule for Moringa plantations in the studied area are shown in Table (6) which cleared how much irrigation water need, (m³/ha/day) for every growth stage and when they added besides to the crop coefficient which ranged from 0.4 for the early spring and harvest stages to 0.5 for the other most Moringa growth stages. Also, the table shows that the annual irrigation rate was 7714 m³/ha. Daily rate (liters/tree) as water amounts for Moringa trees is shown in Table (6) which ranged from 30 in the early spring and fall growth stages to
60 in the summer season besides the irrigation interval (days) which ranged from 3 to 7 days. The Evapotranspiration process combined of two processes whereby water is lost from the soil surface by evaporation and on the other hand from the crop by transpiration. (Allen et al., 1998) selected the FAO Penman–Monteith method to estimate ETo as follows:

The irrigation requirements of olive orchards (the most similar tree of Moringa) was calculated based on the Penman -Monteith equation, multiplied by the season-specific crop coefficient (KC) (Table 4). Seasonal crop water requirement: 7714 m³/ha/ year; under drip irrigation system as mentioned above. ETcrop can be found by the equation that aforementioned that Allen et al. (1998) reported that crop coefficient is "The ratio of the actual Evapotranspiration (ETa) occurring with a specific crop at a specific stage of growth to potential Evapotranspiration at the same time, i.e.

\[
KC = \frac{ETa}{ETo}
\]

Where:
- KC : Crop coefficient.
- ETa : Actual Evapotranspiration, mm/day.
- ETo : Potential Evapotranspiration, mm/day.

**Morphological and chemical characterizes measurements:**
The Moringaoleifera plants are harvested and the next morphological and chemical characterizes measurements are taken as follows: Trunk Diameter, Pods Tree Quantity, Seeds Yields (g) per tree, Weight per 1000 seeds (g), oil yields per tree (g), oil Yields per/ Acer (kg), chlorophyll A- B, total chlorophyll, carotenoids, Total carbohydrates, vitamin C, Nitrogen, Calcium, Fe and zinc content of Moringaoleifera plants, in two studied seasons, (2017-2018-2019).

**Water use efficiency (kg/m³):**
It is expressed as the weight of yield (kg/ha). Computed for the different treatment by using the formula of El-Boraie (2006) and Vites (1965) as follow:

\[
WUE = \frac{\text{Biological yield (kg/ha)}}{\text{Applied water amounts (m}^3/\text{ha)}},
\]

**Table 4:- Irrigation schedule for Moringa plantations in the studied area.**

| Growth Stages | Early spring | Spring | Late spring | Early summer | Summer | Late summer | Early fall | Fall |
|---------------|--------------|--------|-------------|--------------|--------|-------------|-----------|------|
| Phenological stage | Flower bud development - bloom | Pod-set | Pod growth stages: cell division -pit hardening | Pod growth stages: cell enlargement | Harvest and fall growth |
| Evaporation (mm/day) | 5.6 | 7.3 | 8.7 | 8.7 | 8.0 | 6.9 | 5.4 | 3.5 |
| No. of days/stage | 15 | 31 | 30 | 31 | 30 | 31 | 30 | 30 |
| Crop coefficient (liters/tree) | 0.40 | 0.40 | 0.50 | 0.50 | 0.55 | 0.55 | 0.55 | 0.4 |
| m³/ha. | 338.7 | 912.0 | 1315.4 | 1359.8 | 1330.6 | 1186.4 | 898.1 | 437.5 |
| m³/ha/day | 22.56 | 29.424 | 104.4 | 43.872 | 44.352 | 38.28 | 29.9376 | 14.112 |

* Moringa – annual irrigation rate: 7778.4 m³/ha

**Cost analysis:**
Cost analysis to evaluate the drip irrigation systems was computed according to Worth and Xin (1983). Fixed cost is calculated according to market price level of 2020 for equipment and operating irrigation process. Cost analysis is based on one hectare.
Pumping energy requirements:
Energy requirements and energy-applied efficiency (EAE) were determined for drip irrigation systems according to Batty et al. (1975), according to the following formula:

\[ B_p = \frac{Q \times TDH}{E_i \times 75} \]

Where:
- \( B_p \) = Power consumption for pumping water (Hp)
- \( Q \) = Total system flow rate (m³/h)
- \( TDH \) = Total dynamic head (m)
- \( E_i \) = Total system efficiency

Irrigation was operated at total dynamic head (1.0 m) for all of planted season.

Pumping energy requirements (Er) (Hp.h) were calculated as follows:

\[ Er = B_p \times I_t \]

Where:
- \( I_t \) = Irrigation time per season (h).

Pumping energy applied efficiency (EAE) was calculated as follows:

\[ EAE \ (kg/Hp.h) = \frac{\text{Total fresh yield}}{\text{Energy requirements}} \]

Statistical analysis:
All the obtained data during the two seasons of study were subjected to analysis of variance method meanwhile; differences among means were compared using Duncan's multiple range tested at a probability of 5 % level according to (Snedecor and Cochran, 1990) and (Duncan, 1955).

Results and Discussion:-

Trunk diameter and pods Tree quantity:
The highest values of trunk diameter is under buried drip irrigation, 100% of applied water and compost according to the zero stress of water restriction and the minimum losses of water by evaporation according to burial of the dripper under the soil surface and the next values which response to the treatments is located under surface drip irrigation, 100% of applied water and compost on the other side the lowest values of trunk diameter of Moringa trees is under mini-sprinkler, 60% of applied water and farm yard manure then under compost and filter mud, and these results are due to the water stress on plant which affected on the biological process which also effect on growth parameters of plants and these results are agreed with Vasconcelos et al. 2019. Table (5).

Data in table (5) illustrated that the highest significant values of pods tree quantity is of buried drip irrigation, 100% of applied water and compost where the lowest significant values is of mini-sprinkler, 60% of applied water and filter mud, but it’s important to mention that the value of buried drip irrigation and 80% of applied water and compost is in the second class of signification, which mean it can be save about 20% of applied water, the last results are agreed to Prabhakar and Hebbar (2007), Adebayo et al. (2011).Table (5).

Seeds yields (g) per tree, and weight per 1000 seeds (g):
The buried drip irrigation effects positively on the both of seeds yields (g) per tree, and weight per 1000 seeds (g) as clear in table (6), moreover the water restriction treatments has the same behavior, and by the same token the compost is the most positively impact factor of both of seeds yields (g) per tree, and weight per 1000 seeds (g) , on the other side the lowest significant values of both of seeds yields (g) per tree, and weight per 1000 seeds (g) is under mini-sprinkler, 60% of applied water and filter mud. These data are according to Kumar et al. 2014.Table (6).

Oil yields per tree (g) and oil Yields per/ Acer (kg):
As clear in table (7), for irrigation system, the highest positive impact on the Oil yields per tree (g) and Oil Yields per/ Acer (kg) is for buried drip irrigation system, surface drip irrigation system and min-sprinkler irrigation respectively, where for water restriction the highest negative impact on Oil yields per tree (g) and Oil Yields per/ Acer (kg) is 60%, 80% and 100% of applied water respectively. And finally for the soil conditioners, the highest positive impact oil yields per tree (g) and oil Yields per/ Acer (kg) is compost, farm yard and filter Mud,
respectively. The last result due to the soil salinity influences of seed production according to Alqudah et al., 2011, Anwar et al, 2006, Simpson, 1981 and Flagella et al. (2004).

Table 5: Trunk Diameter and Pods Tree Quantity responses of *Moringa* to the irrigation systems, water restriction and soil conditioners (2017-2018/2018-2019).

| Irrigation system | SC | WR | Trunk Diameter cm | Pods Tree Quantity |
|-------------------|----|----|-------------------|-------------------|
|                   |    |    | C     | FM | Mud | C     | FM | Mud |
| D                 | W1 | 31.87B | 30.87D | 27.56F | 53.23F | 47.02J | 43.42N |
|                   | W2 | 25.14H | 23.75I | 25.32H | 46.75K | 42.25O | 40.45S |
|                   | W3 | 18.65M | 16.75N | 22.77M | 41.22Q | 30.60W | 37.31U |
| BD                | W1 | 74.53A | 28.36E | 31.45C | 78.63A | 65.40C | 56.52D |
|                   | W2 | 28.55E | 27.22F | 30.55D | 65.85B | 55.51E | 51.36H |
|                   | W3 | 21.99K | 26.41G | 28.63E | 47.24I | 45.12L | 44.41M |
| MS                | W1 | 22.47J | 20.14L | 25.33H | 52.36G | 46.87JK | 42.12O |
|                   | W2 | 20.02L | 16.54N | 23.85I | 40.64R | 41.56P | 36.62V |
|                   | W3 | 15.45O | 13.58P | 18.65M | 38.42T | 32.89X | 30.09Y |

Table 6: Seeds Yields (g) per tree and Weight per 1000 seeds (g) responses of *Moringa* to the irrigation systems, water restriction and soil conditioners (2017-2018/2018-2019).

| Irrigation system | SC | WR | Seeds Yields (g) per tree | Weight per 1000 seeds (g) |
|-------------------|----|----|--------------------------|---------------------------|
|                   |    |    | C     | FM | Mud | C     | FM | Mud |
| D                 | W1 | 543.7F | 521.6E | 465.9M | 321.4O | 442.4D | 398.6I |
|                   | W2 | 521.5E | 503.6H | 410.5Q | 296.5R | 410.5Q | 375.6J |
|                   | W3 | 429.9P | 452.4N | 328.2S | 263.2V | 326.4N | 375.6J |
| BD                | W1 | 682.1A | 652.5B | 510.4G | 452.3C | 485.6A | 425.7E |
|                   | W2 | 557.5C | 500.6I | 482.6L | 425.7E | 468.4B | 405.3L |
|                   | W3 | 485.4K | 411.5Q | 354.3U | 300.6Q | 410.2G | 351.5L |
| MS                | W1 | 544.2D | 499.0J | 442.8O | 271.4D | 342.9M | 280.8T |
|                   | W2 | 497.8J | 411.2Q | 400.9I | 252.6W | 310.5P | 264.6V |
|                   | W3 | 351.3V | 365.6T | 312.6W | 165.1Y | 283.4S | 216.8X |

Table 7: Oil yields per tree (g) and oil yields per Acer (kg) responses of *Moringa* to the irrigation systems, water restriction and soil conditioners (2017-2018/2018-2019).

| Irrigation system | SC | WR | Oil Yields per tree (g) | Oil Yields per Acer (kg) |
|-------------------|----|----|------------------------|------------------------|
|                   |    |    | C     | FM | Mud | C     | FM | Mud |
| D                 | W1 | 247J | 265H | 284F | 216F | 189K | 233D |
|                   | W2 | 214.0L | 188N | 263H | 175M | 172N | 182L |
|                   | W3 | 196.0M | 145S | 198M | 122R | 122R | 141P |
| BD                | W1 | 350B | 342C | 350B | 253B | 260A | 248C |
|                   | W2 | 310E | 338D | 357A | 188K | 214G | 231E |
|                   | W3 | 215L | 276G | 149R | 128Q | 196J | 175M |
| MS                | W1 | 213L | 236K | 251I | 175M | 174M | 211H |
|                   | W2 | 178O | 156Q | 174P | 129Q | 155O | 198I |
|                   | W3 | 141T | 109V | 125U | 88T | 111S | 142P |

Chlorophyll A- B contents, total chlorophyll and Carotenoids contents of *Moringaoleifera* plants:
Data illustrated in both of table (8 and 9) shown that the highest significant difference of chlorophyll A – B, total chlorophyll and carotenoids contents is buried drip irrigation and 100% of applied water and 80% of applied water and finally under the compost and Filter mud. Physiological traits such as photosynthetic pigments (a, b and total chlorophylls), it’s important to clear that the influence of irrigation systems, water restriction and soil conditioners
of Chlorophyll A- B contents, total chlorophyll and Carotenoids contents is a positive influence and significant in the higher levels of contents, photosynthetic rate, transpiration, stomata conductance and stomata traits like aperture, leaf water related like relative water content percentage and water use efficiency are of the most important physiological traits. Photosynthetic pigments are important to plants mainly for harvesting light. Gas exchange of the plants (photosynthetic rate, transpiration rate and stomatal conductance) is the principal plant process responsible for plant biomass production and for plant adaptation to adverse environment, Lawlor 2009.

Compost as a soil conditioner causes the raise the content of total chlorophyll a & b as reported by El-Sayed et al. (2002) and Abo Elazm (2008). Water stress leads to obvious changes in the contents of chlorophyll a & b and carotenoids (Anjum et al. 2003 and Farooq et al. 2009).

**Total carbohydrates Vitamin C contents of Moringa oleifera plants:**
Table (10) clear that the heights significant values of total carbohydrates and vitamin C is surface drip and buried drip and in the last class the mini-sprinkler, and for water restriction is 100, 80 and 60% of applied water respectively, and for soil conditioners the highest influence positively is compost farm yard manure and filter mud respectively, these influence according to the water stress which followed by salinity stress which lead to the physiological process progress or vice versa, according to the desert climate of experimental zone which encourage the water evaporation in addition to evapotranspiration and stressing on growth stages to keep the genus from extinction as a self-adaptation of all-round environment.

**Nitrogen, Calcium, Fe and Zinc contents of Moringa oleifera plants:**
Analyses clear that the highest values of Nitrogen, Calcium, iron and Zinc is 100, 80, and 60% of applied water respectively, and for soil conditioners is compost, farm manure and filter mud due to the ratio of these element in every soil conditioners, on the other hand, there is no strong significant differences of treatments of irrigation systems. The last results are agreed with (Amanullah et al. 2010).

| Irrigation system | Irrigation water deficit as a depletion | Soil conditioners |
|------------------|---------------------------------------|-------------------|
|                  |                                       | C     | FM   | Mud  |
| D                |                                       |       |      |      |
| W₁               | 35.19BC                               | 32.63D| 14.99A|
| W₂               | 35.19BC                               | 32.37B| 14.99A|
| W₃               | 34.36A                                | 32.11B| 14.79AB|
| BD               |                                       |       |      |      |
| W₁               | 37.65A                                | 34.07CD| 15.67A|
| W₂               | 35.94B                                | 33.75CD| 15.02A|
| W₃               | 35.81A                                | 32.73D| 15.08A|
| MS               |                                       |       |      |      |
| W₁               | 34.29A                                | 31.83B| 14.74AB|
| W₂               | 34.19A                                | 31.83B| 14.73AB|
| W₃               | 34.13CD                               | 30.96B| 14.69A|

| Irrigation system | SC | Total Chlorophyll (mg/g FW) | Carotenoids (mg/g FW) |
|-------------------|----|-----------------------------|------------------------|
|                   |    | C  | FM   | C  | FM   | C  | FM   | C  | FM   | C  | FM   | C  | FM   | C  | FM   | C  | FM   |
|                   | WR |     |      |     |      |     |      |     |      |     |      |     |      |     |      |
| D                 |    |    |      |     |      |     |      |     |      |     |      |     |      |     |      |
| W₁               | 50.30A | 50.28A | 47.75BC | 2.46A | 2.42A | 1.89B |
| W₂               | 49.87A | 49.37AB | 47.18BC | 2.44A | 2.10AB | 1.89B |
| W₃               | 49.37AB | 48.79B | 46.85CD | 2.31AB | 2.08ABC | 1.87B |
| BD                |    |    |      |     |      |     |      |     |      |     |      |     |      |     |      |
| W₁               | 50.30A | 50.30A | 50.28A | 47.75BC | 2.46A | 2.42A | 1.99AB |
| W₂               | 50.28A | 50.28A | 47.75BC | 2.44A | 2.22AB | 1.99AB |
| W₃               | 49.99A | 49.12AB | 47.25C | 2.42A | 2.22AB | 1.92BC |
| MS                |    |    |      |     |      |     |      |     |      |     |      |     |      |     |      |
| W₁               | 50.30A | 50.28A | 46.82C | 2.46A | 2.42A | 2.42A |
| W₂               | 50.28A | 48.56B | 46.56CD | 2.34A | 2.03ABC | 1.78B |
| W₃               | 49.21AB | 47.86BC | 45.74D | 2.26AB | 2.03ABC | 1.78C |
Table 10: - Total carbohydrates and vitamin C responses of *Moringa* to the irrigation systems, water restriction and soil conditioners (2017-2018/2018-2019)

| Irrigation system | SC  | WR | Total Carbohydrate (% DW) | Vitamin C (mg/100g) |
|-------------------|-----|----|---------------------------|---------------------|
|                   |     |    | C  | FM | Mud | C  | FM | Mud |
| **D**             |     |    |    |    |     |    |    |     |
| W1                | 21.9A | 21.9A | 21.9A | 210.0A | 210.0A | 210.0A |
| W2                | 21.9A | 21.9A | 15.3E | 190.0BC | 180.0BC | 173.3BC |
| W3                | 17.9D | 17.9D | 14.9F | 190.0BC | 180.0BC | 170.0C |
| **BD**            |     |    |    |    |     |    |    |     |
| W1                | 17.6D | 17.6D | 21.9A | 210.0A | 210.0A | 210.0A |
| W2                | 21.9A | 21.9A | 18.1D | 210.0A | 190.0B | 180.0BC |
| W3                | 19.8C | 19.8C | 15.9E | 200.0AB | 185.0B | 180.0BC |
| **MS**            |     |    |    |    |     |    |    |     |
| W1                | 19.3C | 19.3C | 21.9A | 210.0A | 210.0A | 210.0A |
| W2                | 21.9A | 21.9A | 14.9F | 190.0B | 180.0B | 170.0C |
| W3                | 16.6E | 16.6E | 13.8F | 190.0   | 180.0B | 160.0C |

Table 11: - Nitrogen and calcium content responses of *Moringa* to the irrigation systems, water restriction and soil conditioners (2017-2018/2018-2019).

| Irrigation system | SC  | WR | Nitrogen content (% DW) | Calcium content (ppm DW) |
|-------------------|-----|----|-------------------------|--------------------------|
|                   |     |    | C  | FM | Mud | C  | FM | Mud |
| **D**             |     |    |    |    |     |    |    |     |
| W1                | 4.70A | 4.70A | 4.70A | 2833A | 2833A | 2833A |
| W2                | 3.56A | 3.30AB | 3.30AB | 1730A | 1570AB | 1450BC |
| W3                | 3.49A | 3.06AB | 3.06AB | 1673BC | 1523C | 1523C |
| **BD**            |     |    |    |    |     |    |    |     |
| W1                | 4.70A | 4.70A | 4.70A | 2833A | 2833A | 2833A |
| W2                | 4.48A | 3.39AB | 3.39AB | 2126B | 1660BC | 1563AB |
| W3                | 4.38A | 3.38AB | 3.38AB | 1766BC | 1620AB | 1456BC |
| **MS**            |     |    |    |    |     |    |    |     |
| W1                | 4.70A | 4.70A | 4.70A | 2833A | 2833A | 2833A |
| W2                | 4.39A | 2.93B | 2.93B | 1660BC | 1513C | 1523C |
| W3                | 4.39A | 2.93B | 2.93B | 1650A | 1463C | 1346C |

Table 12: - Fe and zinc content, (ppm DW) responses of *Moringa* to the irrigation systems, water restriction and soil conditioners (2017-2018/2018-2019).

| Irrigation system | SC  | WR | Fe content (ppm DW) | Zn content ppm DW |
|-------------------|-----|----|---------------------|-------------------|
|                   |     |    | C  | FM | Mud | C  | FM | Mud |
| **D**             |     |    |    |    |     |    |    |     |
| W1                | 430.00A | 430.00A | 430.00A | 183.33A | 183.33A | 183.33A |
| W2                | 370.00AB | 275.00C | 241.67C | 171.33AB | 151.33C | 134.00D |
| W3                | 301.67BC | 271.67C | 228.33CD | 169.33AB | 146.67CD | 119.33D |
| **BD**            |     |    |    |    |     |    |    |     |
| W1                | 346.67B | 430.00A | 430.00A | 183.33A | 183.33A | 183.33A |
| W2                | 431.67A | 415.00A | 260.00C | 180.00A | 158.67BC | 135.33D |
| W3                | 430.00A | 300.00BC | 248.33CD | 178.67A | 156.00BC | 135.32D |
| **MS**            |     |    |    |    |     |    |    |     |
| W1                | 430.00A | 430.00A | 430.00A | 183.33A | 183.33A | 183.33A |
| W2                | 370.00AB | 265.00C | 225.00C | 165.33AB | 146.00CD | 119.33E |
| W3                | 301.67BC | 261.67C | 188.33D | 160.67BC | 141.33D | 116.00E |

**Water use efficiency of *Moringa oleifera* plants, (kg/m$^3$):**

The highest values of crop water use efficiency and field water use efficiency is BD, B and MS respectively, while for soil conditioners is compost, farm manure and filter mud respectively, finally for water restrictions, the highest values is 100, 80 and 60% of applied water, it’s important to mention that the highest valued of treatments interaction is BD, 80% and compost, which lead to save about 20% of applied water and this is very sensitive value.
of save water in arid area, as known shalateen area is very arid area and featured by water scarcity, the high significant influence of buried drip on crop and field water use efficiency is due to the saved water in BD comparing with both of surface drip and mini-sprinkler according to the evaporation of surface is high in desert climate zone, moreover, the mini-sprinkler had the lowest values of water use efficiency according to the pressurized water droplets in jet support the water evaporation, which lead to the water losses by evaporation and the converse behavior of buried (subsurface drip irrigation). The last results are agreed with both of (Sakellariou-Makrantonaki, And Papanikolaou 2008, Ayars et al. 2015, Colaizzi et al. 2006, and Camp 1988), Figure (1) and table (13).

Cost analysis of Moringaoleifera plants under irrigation systems:
The data clear that the highest significant difference of values of irrigation cost of unite production (as follow for the irrigation systems is Buried drip, Mini-sprinkler and drip irrigation system respectively, and for water restriction is for 100, 80 and 60% of applied water except under buried drip irrigation system the lowest value under 100% of applied water according to the highest production units of Moringa yield which, and finally for soil conditioners it’s clear that the highest values is filter mud, manure and compost respectively, whatever the irrigation cost of unite production is indicator for the cost of water unite and the production unite during the against relationship, and it can be noted that the buried drip irrigation had the highest costs of unit production according to the incremental costs according to the additional process of installation of irrigation and the hoses burial under the soil surface as a result for the last process the buried drip irrigation is the highest fixed cost comparing with the other irrigation systems, and the mini-sprinkler comes in the second class according to the costs of operating head which is featured all of sprinkler irrigation comparing with the other irrigation systems. The last results are agreed with (Bosch et al., 1998; Phene, 1999, Henggele, 1997; and Camp, 1998). Figure (2) and table (15).

Pumping energy analysis of irrigation systems:
As shown in figure (3), the highest values of pumping energy applied efficiency (EAE) is obtained by buried drip, surface drip and finally mini-sprinkler respectively, it’s need to describe that the highest significant differences between mini-sprinkler and two drip systems are due to the high operating energy of sprinkler comparing with drip irrigation system moreover, the lowest values of Moringa yield as a result to water losses by evaporation from sprinkler, and here the influence of climate changes is clear, where the water losses from sprinkler as a results of direct impact of high temperature, wind and humidity, and for water restriction treatments, it’s logic to be the highest values of applied energy for the highest amount of applied water so that, the highest values of pumping energy applied efficiency (EAE) is 100, 80 and 60% of applied water, respectively according to the positive relationship of both of applied water amounts and applied pumping energy, finally the soil conditioners are related to the Moringa yield, as it is clear the highest significant positive values is compost, filter mud and manure respectively. the last results are logic according to (Zapata et al. 2015, Robles et al. 2017). Figure (3) and able (16).
Figure (2):-Irrigation cost of unite production (LE/kg) response of Moringa to the irrigation systems, water restriction and soil conditioners (2017-2018/2018-2019)

Figure (3):-Pumping energy applied efficiency (EAE) response of Moringa to the irrigation systems, water restriction and soil conditioners (2017-2018/2018-2019)

Table 13:- Crop water use efficiency CWUE (kg/m³) and Field water use efficiency FWUE (kg/m³) response of Moringa to the irrigation systems, water restriction and soil conditioners (2017-2018/2018-2019)

| Irrigation system | SCSCSC WR | Crop water use efficiency CWUE (kg/m³) | Field water use efficiency FWUE (kg/m³) |
|-------------------|-----------|----------------------------------------|----------------------------------------|
|                   |           | C           | FM         | Mud       | C           | FM         | Mud       |
| D                 |           |             |            |           |             |            |           |
| W₁                |           | 18.54b      | 8.09c      | 5.58c     | 16.69b      | 7.28c      | 5.02c     |
| W₂                |           | 16.77c      | 7.22ba     | 5.96b     | 15.09c      | 6.50ba     | 5.36b     |
| W₃                |           | 20.97a      | 7.36a      | 6.27a     | 18.87a      | 6.62a      | 5.64a     |
| BD                |           |             |            |           |             |            |           |
| W₁                |           | 23.49c      | 9.49c      | 8.09c     | 22.79c      | 9.21cb     | 7.85a     |
| W₂                |           | 26.57a      | 9.68b      | 7.22b     | 25.77a      | 9.39b      | 7.00c     |
| W₃                |           | 26.55ba     | 10.89a     | 7.36a     | 25.75b      | 10.56a     | 7.14b     |
| MS                |           |             |            |           |             |            |           |
| W₁                |           | 11.98c      | 5.61c      | 5.27c     | 9.46c       | 4.43c      | 4.16c     |
| W₂                |           | 13.09b      | 6.08b      | 5.57b     | 10.34b      | 4.80b      | 4.40b     |
| W₃                |           | 16.23a      | 6.58a      | 5.76a     | 12.82a      | 5.20a      | 4.55a     |
Table 14: Water uptake efficiency under irrigation systems, (WPE, %) responses of *Moringa* to the irrigation systems, water restriction and soil conditioners (2017-2018/2018-2019)

| Irrigation system | Water restriction | Soil conditioners |
|-------------------|-------------------|-------------------|
|                   | C                 | FM               | Mud               |
| D                 | W₁                | 1.11             | 1.11              | 1.11              |
|                   | W₂                | 1.11             | 1.11              | 1.11              |
|                   | W₃                | 1.11             | 1.11              | 1.11              |
| BD                | W₁                | 1.03             | 1.03              | 1.03              |
|                   | W₂                | 1.03             | 1.03              | 1.03              |
|                   | W₃                | 1.03             | 1.03              | 1.03              |
| MS                | W₁                | 1.27             | 1.27              | 1.27              |
|                   | W₂                | 1.27             | 1.27              | 1.27              |
|                   | W₃                | 1.27             | 1.27              | 1.27              |

Table 15: Irrigation cost of water unite (LE/m³) and irrigation cost of unite production (LE/kg) responses of *Moringa* to the irrigation systems, water restriction and soil conditioners (2017-2018/2018-2019)

| Irrigation system | SCSCSCWR | Irrigation Cost of water unite (LE/m³) | Irrigation Cost of unite production (LE/kg) |
|-------------------|----------|----------------------------------------|---------------------------------------------|
|                   |          | C                                      | FM                                          | Mud          |
| D                 | W₁       | 0.47a                                  | 0.47a                                       | 0.03a        | 0.06ba | 0.09a |
|                   | W₂       | 0.45ba                                 | 0.45ba                                     | 0.03ab       | 0.07a  | 0.08ba |
|                   | W₃       | 0.43c                                  | 0.43c                                      | 0.02cab      | 0.06cab| 0.08cab|
| BD                | W₁       | 1.46a                                  | 1.46a                                      | 0.06a        | 0.16a  | 0.19cab|
|                   | W₂       | 1.40c                                  | 1.40c                                      | 0.05cab      | 0.15ba | 0.20a |
|                   | W₃       | 1.43b                                  | 1.43b                                      | 0.06ba       | 0.14cb | 0.20ba|
| MS                | W₁       | 0.56a                                  | 0.56a                                      | 0.06a        | 0.13a  | 0.13a |
|                   | W₂       | 0.52b                                  | 0.52b                                      | 0.05ba       | 0.11b  | 0.12ba|
|                   | W₃       | 0.48c                                  | 0.48c                                      | 0.04cb       | 0.09c  | 0.11cb|

Table 16: Pumping energy requirements (Eₚ) (Hp.h) and Pumping energy applied efficiency (EAE) responses of *Moringa* to the irrigation systems, water restriction and soil conditioners (2017-2018/2018-2019)

| Irrigation system | SCSCSCWR | Pumping energy requirements (Eₚ) (Hp.h) | Pumping energy applied efficiency (EAE) |
|-------------------|----------|----------------------------------------|-----------------------------------------|
|                   |          | C                                      | FM                                      | Mud          |
| D                 | W₁       | 324.1a                                 | 324.1a                                   | 324.1a        | 444.9b | 194.1a | 133.9c |
|                   | W₂       | 259.3b                                 | 259.3b                                   | 259.3b        | 402.2c | 169.7c | 143.1b |
|                   | W₃       | 194.5c                                 | 194.5c                                   | 194.5c        | 503.3a | 176.9b | 202.1a |
| BD                | W₁       | 300.7a                                 | 300.7a                                   | 300.7a        | 607.6c | 245.4c | 209.2a |
|                   | W₂       | 240.6b                                 | 240.6b                                   | 240.6b        | 687.4ab| 250.2b | 186.6c |
|                   | W₃       | 180.4c                                 | 180.4c                                   | 180.4c        | 686.8b | 281.6a | 190.7b |
| MS                | W₁       | 590.8a                                 | 590.8a                                   | 590.8a        | 157.8cb| 73.8c  | 69.4c |
|                   | W₂       | 472.6a                                 | 472.6a                                   | 472.6a        | 72.6b  | 80.0b  | 73.4b |
|                   | W₃       | 354.5c                                 | 354.5c                                   | 354.5c        | 213.5a | 86.6a  | 75.9a |

Conclusion:
*Moringa Olifera* is very economic plant and medical, grown under desert conditions and arid area; in this investigation data it’s clear the follows measurements and parameters such as morphological and chemical characterizes measurements are taken as follows: Trunk Diameter, Pods Tree Quantity, Seeds Yields (g) per tree, Weight per 1000 seeds (g), oil yields per tree (g), oil Yields per/ Acre (kg), chlorophyll A - B, total chlorophyll, carotenoids, Total carbohydrates, vitamin C, Nitrogen, Calcium, Fe and zinc content of *Moringa oleifera* plants in
addition to Water use efficiency, cost analysis, energy analysis in two studied seasons, (2017-2018/2018-2019) are expose to investage and results show that the most positive influence of irrigation is buried irrigation, drip irrigation and mini-sprinkler respectively, due to the saved water from losses by evaporation under drought conditions. And the most positive influence of water restrictions treatments is 100, 80 and 60% respectively, but the in many measurements the differences between both of 100 and 80% of applied water is not significant, so it’s more economical to approve 80% of applied water under buried drip irrigation, which means about 20% of applied water can be saved without any influence of Moringa yield or morphological and chemical characterizes, moreover the most positive influence are obtained by compost, manure and filter mud. Finally to have the best results of yield and quality parameters which support the economic and environmental feasibility, it’s recommended by using buried drip irrigation, 80% of calculated applied water and compost.

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