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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 Morengaoleifera, (surface drip irrigation, D, buried drip, BD and mini-sprinkler, MS), as well for irrigating a magic crop like Morenga (Morengaoleifera) 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 respectivly), more over threes soil conditioners (Compost, C, Farm manure, FM, Mud, M). The experiment was carried out inShalatien 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 onmorphological and chemical characterizes 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 chlorophyll, 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 Jiru*et 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 35ºC. It is highly susceptible to frost and high temperature exceeding 40ºC causes flower shedding. Under water deficit conditions, Moringacould 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 does an essential component for the plants life owes 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 resolves 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 circumstance 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.**Manuringof 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 unmannered trees.**Seemanthani (1964).**Usually moringa receives no horticultural attention, but mulching and fertilizing will produce better growth and result in quality of products.**(Sundararaj 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 characterizesresponses 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,
W_1 : 100% of ETa, applied water,
W_2 : 80% of ETa, applied water,
W_3 : 60% of ETa, applied water,
C : Compost,
FM : Farm Manure,
M : and 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, TypicTorripsamments, Mixed, Hyperthermic and TypicCalciorthents, 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 (1_a&$_b$).

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, (18.34Me/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

$$IR = \left[\frac{K_c \times Et_o \times A \times C_F}{10^7 \times Ea}\right] + LR$$

Where:

IR = Irrigation water requirements, m^3/ha/day.
$E\ t_o$ = Potential evapotranspiration, mm day^{-1}
Kc = Crop factor of apple,
Ea = Application efficiency, %, where 90% for used irrigation systems.
A = Area irrigated, (m^2)
LR = Leaching requirements.
C_F = Covering factor, of Moringa trees45%.

Irrigation systems and control head:
The drip irrigation system was used to irrigate Moringa trees. The system consists of a diesel pump ($18m^3/h$, flow rate) which takes water from open sub-surface tank ($75m^3$ capacity) through two filter units, the first one is screen (130 mesh) and the other is gravel filter.

Table1$_a$:- Soil physical properties of the studied **aera**

Depth, cm	Particle size distribution%				Textural Class	Bd ($Mg.m^{-3}$)	Moisture content,102KPa	
	Coarse Sand	Fine Sand	Silt	Clay			0.06	15
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		1.67	13.89	5.39

L.S = Loamy Sand

Table 1$_b$:-Soil chemical properties of the studied area

Depth, Cm	CaCO3, %.	EC, dS/m	PH	% O.M	Cations me/l				Anions me/l			
					Na+	K+	Ca++	Mg++	CO_3=	HCO_3-	Cl -	SO_4=
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+	CO_3=	HCO_3-	Cl-	SO_4=	
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 theexperimental 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 PVCpipeline with 50 mm end plug for flushing. Thedrippers flow rate of 4 L/h (GR), the space of two drippers is 50cm. Theywere 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, (m^3/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 m^3/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 ET_o 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 m^3/ha/ year; under drip irrigation system as mentioned above.ET_{crop} can be found by the equation that aforementioned that **Allen et al. (1998)** reported that crop coefficient is "The ratio of the actual Evapotranspiration (ET_a) occurring with a specific crop at a specific stage of growth to potential Evapotranspiration at the same time, i.e.

KC = ETa / ET_o

Where:

KC : Crop coefficient.
ET_a : Actual Evapotranspiration, mm/day.
ET_o : Potential Evapotranspiration, mm/day.

Morphological and chemical characterizes measurements:
TheMoringa*oleifera* 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 contentof*Moringaoleifera* plants, in two studied seasons, (2017-2018/2018-2019).

Water use efficiency (kg/m^3):
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=Biological yield (kg/ha) / Applied water amounts (m^3/ha), according to

Table 4:- Irrigation schedule for Moringaplantations 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	31
Crop coefficient	0.40	0.40	0.50	0.50	0.55	0.55	0.55	0.4
(liters/tree)	30	40	50	60	60	60	50	30
m^3/ha.	338.7	912.0	1315.4	1359.8	1330.6	1186.4	898.1	437.5
m^3/ha/day	22.56	29.424	104.4	43.872	44.352	38.28	29.9376	14.112
* *Moringa* – annual irrigation rate: 7778.4 m^3/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 systemsaccording to **Batty et al. (1975),** according to the followingformula:
- Power consumption for pumping water (Bp) was calculated as follows:

$$Bp = \frac{Q * TDH}{Ei * 75}$$

Where:

Bp	=	Power conumption for pumping water (Hp)
Q	=	Total system flow rate (m^3/h)
TDH	=	Total dynamic head (m)
E_i	=	Total system efficiency

Irrigation was operated at total dynamic head (1.0m) for all of planted season.
Pumping energy requirements (Er) (Hp.h) were calculated as follows:

$$Er = Bp * It$$

Where:
It = Irrigation time per season (h).
Pumping energy applied efficiency (EAE) was calculated as follows:

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

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 burialof 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 s, **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 1005 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 andsoilconditioners (2017-2018/2018-2019).

Irrigation system	SC / WR	**Trunk Diameter cm**			**Pods Tree Quantity**		
		C	**FM**	**Mud**	**C**	**FM**	**Mud**
D	**W_1**	31.87B	30.87D	27.56F	53.23F	47.02J	43.42N
	W_2	25.14H	23.75I	25.32H	46.75K	42.25O	40.45S
	W_3	18.65M	16.75N	22.77J	41.22Q	30.60W	37.31U
BD	**W_1**	74.53A	28.36E	31.45C	78.63A	65.40C	56.52D
	W_2	28.55E	27.22F	30.55D	65.85B	55.51E	51.36H
	W_3	21.99K	26.41G	28.63E	47.24I	45.12L	44.41M
MS	**W_1**	22.47J	20.14L	25.33H	52.36G	46.87JK	42.12O
	W_2	20.02L	16.54N	23.85I	40.64R	41.56P	36.62V
	W_3	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) responsesof *Moringa* to the irrigation systems, water restriction andsoilconditioners (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	**W_1**	543.7F	521.6E	465.9M	321.4O	442.4D	398.6I
	W_2	521.5E	503.6H	410.5Q	296.5R	410.0G	362.5K
	W_3	429.9P	452.4N	382.2S	253.2V	326.4N	375.6J
BD	**W_1**	682.1A	652.5B	510.4G	452.3C	485.6A	425.7E
	W_2	557.5C	500.6I	482.6L	425.7E	468.4B	405.3H
	W_3	485.4K	411.5Q	354.3U	300.6Q	410.2G	351.5L
MS	**W_1**	544.2D	499.0J	442.8O	271.4D	342.9M	280.8T
	W_2	497.8J	411.2Q	400.9R	252.6W	310.5P	264.6V
	W_3	351.3V	365.6T	312.5W	165.1Y	283.4S	216.8X

Table 7:-Oil yields per tree (g) and oil yields per/ Acer (kg) responsesof *Moringa* to the irrigation systems, water restriction andsoilconditioners (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	**W_1**	247J	265H	284F	216F	189K	233D
	W_2	214.0L	188N	**263H**	175M	172N	182L
	W_3	196.0M	145S	198M	122R	122R	141P
BD	**W_1**	350B	342C	350B	253B	260A	248C
	W_2	310E	338D	357A	188K	214G	231E
	W_3	215L	276G	149R	128Q	196J	175M
MS	**W_1**	213L	236K	251I	175M	174M	211H
	W_2	178O	156Q	174P	129Q	155O	198I
	W_3	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 light10. 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 Moringaoleifera 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 Moringaoleifera plants:
Analyses clear that the highest values of Nitrogen, Calcium, iron and Zinc is 100, 80, and 605 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).**

Table 8:- Chlorophyll A- Bresponses of *Moringa* to the irrigation systems, water restriction andsoil conditioners(2017-2018/2018-2019).

Irrigation system	**Irrigation water deficit as a depletion**	**Soil conditioners**		
		C	**FM**	**Mud**
D	**W_1**	35.19BC	32.63D	14.99A
	W_2	35.19BC	32.37B	14.99A
	W_3	34.36A	32.11B	14.79AB
BD	**W_1**	37.65A	34.07CD	15.67A
	W_2	35.94B	33.75CD	15.02A
	W_3	35.81A	32.73D	15.08A
MS	**W_1**	34.29A	31.83B	14.74AB
	W_2	34.19A	31.83B	14.73AB
	W_3	34.13CD	30.96B	14.69A

Table 9:-Total chlorophyll and carotenoidsresponses of *Moringa* to the irrigation systems, water restriction andsoil conditioners(2017-2018/2018-2019)

Irrigation system	SC WR	Total Chlorophyll (mg/g FW)			Carotenoids (mg/g FW)		
		C	**FM**	**Mud**	**C**	**FM**	**Mud**
D	**W_1**	50.30A	50.28A	47.75BC	2.46A	2.42A	2.42A
	W_2	49.87A	49.37AB	47.18BC	2.44A	2.10AB	1.89B
	W_3	49.37AB	48.79B	46.85CD	2.31AB	2.08ABC	1.87B
BD	**W_1**	50.30A	50.30A	50.28A	2.46A	2.42A	2.42A
	W_2	50.28A	50.28A	47.75BC	2.44A	2.22AB	1.99AB
	W_3	49.99A	49.12AB	47.25C	2.42A	2.22AB	1.92BC
MS	**W_1**	50.30A	50.28A	46.82C	2.46A	2.42A	2.42A
	W_2	50.28A	48.56B	46.56CD	2.34A	2.03ABC	1.78B
	W_3	49.21AB	47.86BC	45.74D	2.26AB	2.03ABC	1.78C

Table 10:-Total carbohydrates and vitamin Cresponses of *Moringa* to the irrigation systems, water restriction andsoil conditioners(2017-2018/2018-2019)

Irrigation system	SC WR	Total Carbohydrate (% DW)			Vitamin C (mg/100g)		
		C	**FM**	**Mud**	**C**	**FM**	**Mud**
D	W_1	21.9A	21.9A	21.9A	210.0A	210.0A	210.0A
	W_2	21.9A	21.9A	15.3E	190.0BC	180.0BC	173.3BC
	W_3	17.9D	17.9D	14.9F	190.0BC	180.0BC	170.0C
BD	W_1	17.6D	17.6D	21.9A	210.0A	210.0A	210.0A
	W_2	21.9A	21.9A	18.1D	210.0A	190.0B	180.0BC
	W_3	19.8C	19.8C	15.9E	200.0AB	185.0B	180.0BC
MS	W_1	19.3C	19.3C	21.9A	210.0A	210.0A	210.0A
	W_2	21.9A	21.9A	14.9F	190.0B	180.0B	170.0C
	W_3	16.6E	16.6E	13.8F	190.0	180.0B	160.0C

Table 11:-Nitrogen and calciumcontentresponsesof *Moringa* to the irrigation systems, water restriction andsoil conditioners(2017-2018/2018-2019).

Irrigation system	SC WR	**Nitrogen content (% DW)**			**Calcium content (ppm DW)**		
		C	**FM**	**Mud**	**C**	**FM**	**Mud**
D	W_1	4.70A	4.70A	4.70A	2833A	2833A	2833A
	W_2	3.56A	3.30AB	3.30AB	1730A	1570AB	1450BC
	W_3	3.49A	3.06AB	3.06AB	1673BC	1523C	1523C
BD	W_1	4.70A	4.70A	4.70A	2833A	2833A	2833A
	W_2	4.48A	3.39AB	3.39AB	2126B	1660BC	1563AB
	W_3	4.38A	3.38AB	3.38AB	1766BC	1620AB	1456BC
MS	W_1	4.70A	4.70A	4.70A	2833A	2833A	2833A
	W_2	4.39A	2.93B	2.93B	1660BC	1513C	1523C
	W_3	4.39A	2.93B	2.93B	1650A	1463C	1346C

Table 12:- Fe and znic content, (ppm DW) responseof *Moringa* to the irrigation systems, water restriction andsoil conditioners(2017-2018/2018-2019)

Irrigation system	SC WR	**Fe content (ppm DW)**			**Zn content ppm DW)**		
		C	**FM**	**Mud**	**C**	**FM**	**Mud**
D	W_1	430.00A	430.00A	430.00A	183.33A	183.33A	183.33A
	W_2	370.00AB	275.00C	241.67C	171.33AB	151.33C	134.00D
	W_3	301.67BC	271.67C	228.33CD	169.33AB	146.67CD	119.33D
BD	W_1	346.67B	430.00A	430.00A	183.33A	183.33A	183.33A
	W_2	431.67A	415.00A	260.00C	180.00A	158.67BC	135.33D
	W_3	430.00A	300.00BC	248.33CD	178.67A	156.00BC	135.32D
MS	W_1	430.00A	430.00A	430.00A	183.33A	183.33A	183.33A
	W_2	370.00AB	265.00C	225.00C	165.33AB	146.00CD	119.33E
	W_3	301.67BC	261.67C	188.33D	160.67BC	141.33D	116.00E

Water use efficiency of Moringaoleifera 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 conditionersit'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, Henggeler, 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).**

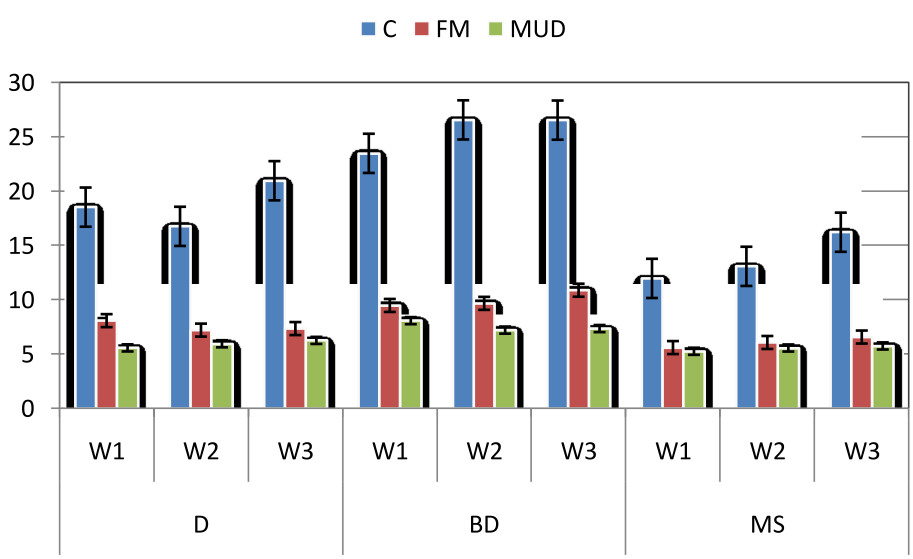

Figure (1):-Crop water use efficency, CWUE (kg/m^3) and Field water use efficency, FWUE (kg/m^3) response of *Moringa* to the irrigation systems, water restriction andsoil conditioners(2017-2018/2018-2019)

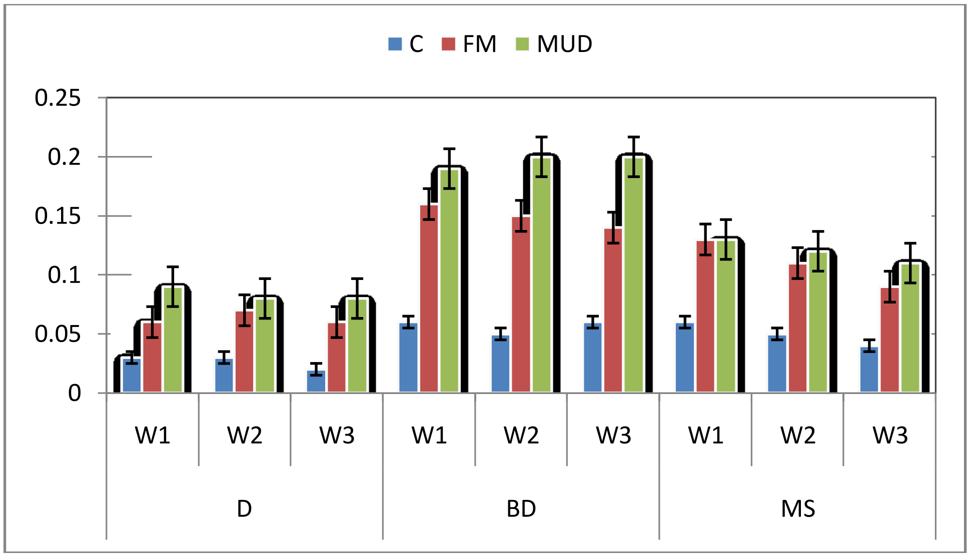

Figure (2):-Irrigation cost of unite production (LE/kg) response of *Moringa* to the irrigation systems, water restriction andsoil conditioners(2017-2018/2018-2019)

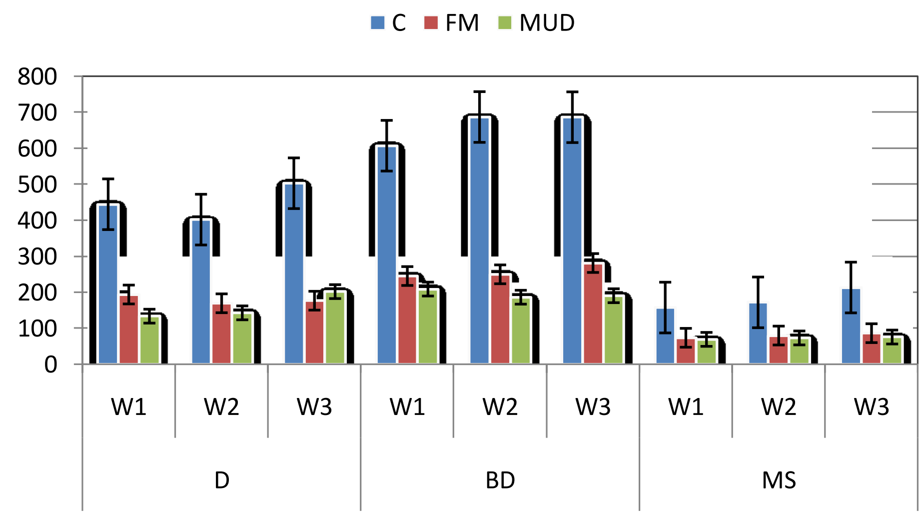

Figure (3):-Pumping energy applied efficiency (EAE)response of *Moringa* to the irrigation systems, water restriction andsoil conditioners(2017-2018/2018-2019)

Table 13:-Crop water use efficencyCWUE (kg/m^3) and Field water use efficency, FWUE (kg/m^3) responseof *Moringa* to the irrigation systems, water restriction andsoil conditioners(2017-2018/2018-2019)

Irrigation system	SCSCSC WR	Crop water use efficencyCWUE (kg/m^3)			Field water use efficency, FWUE (kg/m^3)		
		C	**FM**	**Mud**	**C**	**FM**	**Mud**
D	**W_1**	18.54b	8.09c	5.58c	16.69b	7.28c	5.02c
	W_2	16.77c	7.22ba	5.96b	15.09c	6.50ba	5.36b
	W_3	20.97a	7.36a	6.27a	18.87a	6.62a	5.64a
BD	**W_1**	23.49c	9.49c	8.09c	22.79c	9.21cb	7.85a
	W_2	26.57a	9.68b	7.22b	25.77a	9.39b	7.00c
	W_3	26.55ba	10.89a	7.36a	25.75b	10.56a	7.14b
MS	**W_1**	11.98c	5.61c	5.27c	9.46c	4.43c	4.16c
	W_2	13.09b	6.08b	5.57b	10.34b	4.80b	4.40b
	W_3	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 andsoil conditioners(2017-2018/2018-2019)

Irrigation system	Water restriction	Soil conditioners		
		C	**FM**	**Mud**
D	**W_1**	1.11	1.11	1.11
	W_2	1.11	1.11	1.11
	W_3	1.11	1.11	1.11
BD	**W_1**	1.03	1.03	1.03
	W_2	1.03	1.03	1.03
	W_3	1.03	1.03	1.03
MS	**W_1**	1.27	1.27	1.27
	W_2	1.27	1.27	1.27
	W_3	1.27	1.27	1.27

Table 15:-Irrigation cost of water unite (LE/m^3) and irrigation cost of unite production (LE/kg) responses of *Moringa* to the irrigation systems, water restriction andsoil conditioners(2017-2018/2018-2019)

Irrigation system	SCSCSC WR	irrigation Cost of water unite (LE/m^3)			Irrigation Cost of unite production (LE/kg)		
		C	**FM**	**Mud**	**C**	**FM**	**Mud**
D	**W_1**	0.47a	0.47a	0.47a	0.03a	0.06ba	0.09a
	W_2	0.45ba	0.45ba	0.45ba	0.03ab	0.07a	0.08ba
	W_3	0.43c	0.43c	0.43c	0.02cab	0.06cab	0.08cab
BD	**W_1**	1.46a	1.46a	1.46a	0.06a	0.16a	0.19cab
	W_2	1.40c	1.40c	1.40c	0.05cab	0.15ba	0.20a
	W_3	1.43b	1.43b	1.43b	0.06ba	0.14cb	0.20ba
MS	**W_1**	0.56a	0.56a	0.56a	0.06a	0.13a	0.13a
	W_2	0.52b	0.52b	0.52b	0.05ba	0.11b	0.12ba
	W_3	0.48c	0.48c	0.48c	0.04cb	0.09c	0.11cb

Table 16:- Pumping energy requirements **(E_r) (Hp.h)** andPumping energyappliedefficiency **(EAE)** rsponses of *Moringa* to the irrigation systems, water restriction andsoilconditioners(2017-2018/2018-2019)

Irrigation system	SCSCSC WR	Pumping energy requirements **(E_r) (Hp.h)**			Pumping energyappliedefficiency **(EAE)**		
		C	**FM**	**Mud**	**C**	**FM**	**Mud**
D	**W_1**	324.1a	324.1a	324.1a	444.9b	194.1a	133.9c
	W_2	259.3b	259.3b	259.3b	402.2c	169.7c	143.1b
	W_3	194.5c	194.5c	194.5c	503.3a	176.9b	202.1a
BD	**W_1**	300.7a	300.7a	300.7a	607.6c	245.4c	209.2a
	W_2	240.6b	240.6b	240.6b	687.4ab	250.2b	186.6c
	W_3	180.4c	180.4c	180.4c	686.8b	281.6a	190.7b
MS	**W_1**	590.8a	590.8a	590.8a	157.8cb	73.8c	69.4c
	W_2	472.6b	472.6b	472.6b	172.2b	80.0b	73.4b
	W_3	354.5c	354.5c	354.5c	213.5a	86.6a	75.9a

Conclusion:-

MoringaOlifera 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/ Acer (kg), chlorophyll A- B, total chlorophyll, 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) 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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