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Effect of Clay Minerals and Organic Matter Injection in El-Salhia Soil on Water Use Efficiency of Cucumber

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FIELD experiments were performed during two summer successive seasons of 2017 and 2018, at a private farm in El- Salhia El-Gedida area, El- Sharqia Governorate, Egypt, to determine the best treatment of sandy soil injection with different rates, from clay and humic acids additive through different doses. In addition to studying the effect of injecting sandy soil by clay and humic acids (IS), different irrigation water levels (IR=100, 90, 80, 70, 60, 50 and 40% calculated based on crop evapotranspiration) and three mineral fertilizer rates (MFR=100, 70 and 40% of recommended chemical fertilizer N, P, K rates) on the marketable yield (MY), crop quality parameters, seasonal actual evapotranspiration (ETa), water use efficacy (WUE) and irrigation water use efficiency (IWUE) for summer cucumber fruits "*Cucumis sativus*" were investigated. The results reported that; 1) the marketable yield and studied quality parameters except total soluble solid (TSS) and vitamin C (VC) of summer cucumber fruits gave the highest values under IS, IR and MFR =100% treatments for both seasons. 2) Seasonal ETa gave the lowest values: 155.01 and 142.23 mm for both seasons, respectively, under IS, IR and MFR= 40% treatments. 3) The maximum values of summer cucumber fruits WUE and IWUE were 22.03 and 16.63 kg/m^3; 26.34 and 18.12 kg/m^3 for both seasons, respectively, under IS, IR=60% and MFR=70% treatment. This study concluded that the cultivation of summer cucumber under IS, IR= 60% and MFR= 70% treatment can possibly save about 40% of the applied irrigation water, 30% of the total mineral fertilizers rates additive and increased marketable yield of the summer cucumber fruit about 27 and 36% for both seasons, respectively, compared with that under the control treatment (UIS, IR=100% and MFR=100%).

Keywords: Actual evapotranspiration, Bentonite clay, Cucumber, Humic acids, Irrigation water use efficiency, Water use efficiency

Introduction

The sandy soil in arid area is comparatively poorly character and their physical and chemical properties are very low. Therefore, the irrigation water loaded with mineral fertilizer is lost by deep leakage. Some authors reported that the clay amendments are highly effective in improving the physical and chemical properties of these soils and hence increased their fertility and productivity. Clay amendment in sandy soil increases fertility with the essential macro- and micronutrients when bentonite percentage in sandy soils is more than 5% (Karbout et al., 2015). Sandy soils have low cation exchange capacity (CEC), therefore low nutrient retention capacity and organic matter content Walpola and Arunakumara (2010) and low water holding capacity resulting in low yield. Clay-rich soils on the other hand, have high CEC as well as high water and nutrient retention capacity (Hamarashid et al., 2010). On the other hand, the Bentonite ore often contains more than 75% of Montmorillonite mineral. Bentonite swelled extremely when exposed to water, labour it perfect for conserving formations from overrun by dig fluids. Sodium Bentonite achieved specifications the dig-clay

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and civil engineering due to its superb colloidal and rheological characteristics El-Mahllawy et al. (2013). The clay (Bentonite) particles has thousands of times more surface area than sand particles and therefore it progress nutrient holding ability of soils and assist supply a best residence for soil microorganisms. So that, addition calcium Bentonite to sandy soil keeps and releases water much easier than other sorts of clays (Croker, 2004). Also, calcium Bentonite can carry from 1 to 5 times its weight with water and is used in horticulture as it is more steady (Wahab et al., 2010). Adding clay (Bentonite) to coarse sandy soils is a promising technique to raise biomass production and reform the cation exchange capacity properties of these poor soils concerning to its fraction and economic implementation rates. Also, clay (Bentonite) addition at high rates will provide barley plants substantial amounts of irrigation water (El-Dardiry and El-Hady, 2015). Adding clay soil rich in nutrients to sandy soils increases their mineral content and crop production in it. In addition to that, sub-clay soil contains low nutrient content (Hall et al., 2010) and Lawrence et al., 2015). Adding high rates of the clay (Bentonite), which contains 10% of the various HCl forms (Ca, Mg, Na, K), significantly reduces the acidity of sandy soil during the period of plant cultivation and in the long run. Moreover, adding high rates of clay (Bentonite) increases the cation exchange capacity values of sandy soils due to the formation of stable mineral groupings on the structure of the metal particles of clay (Bentonite). Actual results confirm the need add clay (Bentonite) to improve sandy soil fertility (Czaban and Siebielec, 2013). The humic acids extracted from organic fertilizers contain a percentage of organic carbon ranging from 20-30%, the CEC values vary between 60 - 156 meq/100g, pH value is about 6.0, HA features black colour and slow soluble in water. The addition of 400 mL of humic acids to 5 kg of soil significantly reduced the values of both the bulk density and soil pH, also increased the values of CEC for soil (Ali and Mindari, 2015). The potassium humate is potentially effective as a soil conditioner in beneficent aggregate stabilization of sodic and acidic soils versus inverse effects of periodic seasonal wetting and drying cases (Imbufe et al., 2005). Adding the humic acids can progress the stability for soil structure and thus improve physical and chemical characteristic of soil. In addition, level of organic carbon and nitrogen in soil and aggregate stability were improved through soil amendment by adding HA. The results reported that the HA (K-Humate) has possibility to be used as an effective conservation and management tool for sustainability of the soil environment (Gümüs and Seker, 2015). Egypt is one of the countries suffering from water poverty. So, the use of the deficit strategy of irrigation water is aimed at rationalizing the consumption water and saved it to cultivation more reclaimed lands. Although deficit irrigation leads to increased efficiency of the use of irrigation water, it may have a negative effect on plant growth, productivity and quality. So that, it is necessary to well fertilize the plants well when applying deficit strategy of irrigation water until plants not to suffer from double stress. When cultivating tomatoes in the open field, adding three levels of N P K fertilizers and four levels of added irrigation water, the results showed that full fertilization of the plant can save about 20% of the added irrigation water as well improved yield productivity and quality of fruits (Abdelhady et al., 2017). The cucumber yield decreased with increasing water deficit in significantly linear relationship. Moreover, the results recorded no significant effect when applied irrigation water above ETc 100% (Amer et al., 2009). The seasonal ETc values were major through reproduction growth stage in the crop (Agele et al., 2011). The water management in xeric regime and under water shortage contains various policies. In general, policies should goal at provision irrigation water in excess the need of plants, especially those identical ling to water consumption and to the no-reusable part of transferred water. However, completely reconnoitring these notions, especially for farmers at the field level, requires favourable steps to be developed. On the other hand, the deficit irrigation at 80% of ETc was more effective in saving irrigation water with a perfect marketable yield of cucumber compare to traditional irrigation and 100% ETc. Moreover, the deficit drip irrigation assist in rationalization and forbidding immoderate use of fertilizers and pesticides subsequently decrease economic depletion and environmental pollution (Alomran and Luki, 2012). The injector unit can be installed as one unit or as several units in the head of the irrigation system and before the filtration system. Chemical fertilizers should be injected in the water flow centre and slowly to ensure dilution rates and therefore systematic distribution of fertilizers (Evans and Waller, 2007). It is important to obtain a uniform distribution of fertilizers injected through the irrigation network and to understand the hydraulic processes that occur in the central fertigation system in order to obtain optimum fertigation management this helps improve the distribution of fertilizers by 10.5% (Jimenez-Bello et al.,`` 2011).

This study aimed to investigate the effect of the best treatment of injected sandy soil by clay and humic acids under different irrigation water levels and mineral fertilizer rates on cucumber crop production, quality growth parameters, actual evapotranspiration, water use efficiency and irrigation water use efficiency.

Materials and Methods

Experiments

Field experiments were performed in El- Salhia El-Gedida area, El- Sharqia Governorate, Egypt, at (30° 18` 25`` N: 31° 23`09``E.; 28 m a.s.l.) during the summer seasons 2017 and 2018. In a split-split plot design with three replicates, the experimental was divided into 45 m2 plots; each bounded by 1.5 m wide barren to avoid horizontal infiltration. The obtained data were subjected to statistical analysis according to Snedecor and Cochran (1989), using Co-state software program. The first field experiment studied the injection of sandy soil at 45 cm depth with, four clay injection rates (as bentonite) (CIR= 5, 10, 15 and 20 ton/fed) and three humic acids rates (HAR= 2, 4 and 8 kg/fed)It is soaked it in the fertilizer tank for four hours with good stirring before injecting it through the fertilizer injector Venturi 1" at three different injection doses (CHID= 1, 2 and 3 doses) through surface drip irrigation network, taking into account periods of drought (5 days) after each injection dose to allow the clay mineral negatively charged to aggregated of soil particles which helps to form a good and stable soil construction thus prevent the migration of clay from the effective roots zone targeted by injection technique as a result of continuous soil service and irrigation operations. The cation exchange capacity (CEC), free swell index (FSI) and available water (AW) will be measured after applied the previous injection treatments for both seasons. Then the second experiment was carry out to compare between the best injected sandy soil (IS) treatment and un-injected soil (UIS) treatment when cultivating the summer cucumber (Cucumissativus) by added seven levels of irrigation water (IR=100, 90, 80, 70, 60, 50 and 40% calculated based on crop evapotranspiration) and three mineral fertilizer rates (MFR=100, 70 and 40% of recommended chemical fertilizer N, P, K rates). The length (L) cm, diameter (D) cm, total soluble solid TSS (%), vitamin C (VC) mg/100 g FW and marketable yield (MY) ton/fed were determined for summer cucumber fruits. While, the seasonal actual evapotranspiration (ETa) mm, water use efficiency (WUE) kg/m3 and irrigation water use efficiency (IWUE) kg/m3 were calculated for all applied irrigation water stress and mineral fertilizer rates under injected and un-injected sandy soil treatments for all summer cucumber plant plots.Soil characteristics.

2. How to injection bentonit rates in sandy soil

The results of the analysis showed that the melt rate of bentonite in water exceeds 98%. Thus, during injection sandy soil with bentonit through drip irrigation network (dripper discharge 4 L/h) the clay takes the same movement of irrigation water and distributes and spread it to the required depth of injection under all drippers the depth of the injection, taking into account the drought period between each dose and the other5 days in the case of the addition bentonite in different doses so as not to migrate away from addition areas. Also, can be controlled in injection depth by knowing the field capacityand the wilting point for sandy soil. In this study the injection was done at a depth of 45 cm by applying the following equation:

Total available water TAW = 1000 (θFC –θPWP) .Zrmm Allen et al., (1998)

Where: θFC: Average water content at file capacity, % (Table 1).

θPWP: Average water content at permanent wilting point, % (Table 1).

Zr: rooting or injection depth, 0.45m

- TAW loaded with bentonite (m3) at depth 0.45 m = TAW loaded with bentonite (m) at depth 0.45 m * the area to be injected with bentonite below each dripper (m2)

- TAW loaded with bentonite (m) at depth 0.45 m = 1000 * [(10.72/100(–)4.44/100)] * 0.45 = 28.26 mm………… 0.0283 m

- The area to be injected with bentonite below each dripper (m2) = π. r2 = 3.14 * (0.40)2 = 0.5024 m2

- TAW loaded with bentonite (m3) at depth 0.45 m = 0.0283 m * 0.5024 m2 = 0.014198 m3………… 14 L/dripper

So, injection process needs 14 L of irrigation water loaded with bentonite to hold it in area and depth required under all drippers showed that in Fig. 1.

To calculate the number of drippers/Feddan = Feddan area (m2) / (distance between irrigation lines (m) * distance between drippers (m))

Number of drippers = 4200 m2 / (1 m * 0.5 m) = 8400 drippers/Feddan

Fig. 1.Calculated TAW loaded with bentonite (m3) and the area to be injected with bentonite below each dripper.

Figure 2 showed that the four rates of bentonite were injected through irrigation water by a tank with capacity 10 m3 equipped with electric mold to dissolved bentonite in water. As well the tank connected to pump with capability 1.5Hp for pumping irrigation water loaded with bentonite into a drip irrigation network for injection into sandy soil through drippers with discharge4 L/h. The water loaded with bentonite is pumped to the area and depth to be injected below each dripper as follows:

- 8400 drippers/fed * 0.6 kg bentonite dissolved in 14 L of irrigation water required for the area to be injected under each dripper at depth 0.45m = 5 ton/fed.

- 8400 drippers/fed * 1.2 kg bentonite dissolved in 14 L of irrigation water required for the area to be injected under each dripper at depth 0.45m = 10 ton/fed.

- 8400 drippers/fed * 1.8 kg bentonite dissolved in 14 L of irrigation water required for the area to be injected under each dripper at depth 0.45m = 15 ton/fed.

- 8400 drippers/fed * 2.4 kg bentonite dissolved in 14 L of irrigation water required for the area to be injected under each dripper at depth 0.45m = 20 ton/fed.

Where the dripper is discharge 4 L/h and the number of drippers 8400 dripper/Feddan and where the area under each dripper at depth 0.45 m need 14 L / bottom of each dripper dissolved different rates of bentonite becomes the injection time per feddan3.5 hours, in the case of injecting all rates in one dose.

Finally, the added bentonite does not decompose and does not migrate areas added; the passage of successive planting seasons helps in Improvement some physical and chemical properties of sandy soils and thus improves the ground construction of it, which helps to provide more irrigation water and mineral fertilizers.

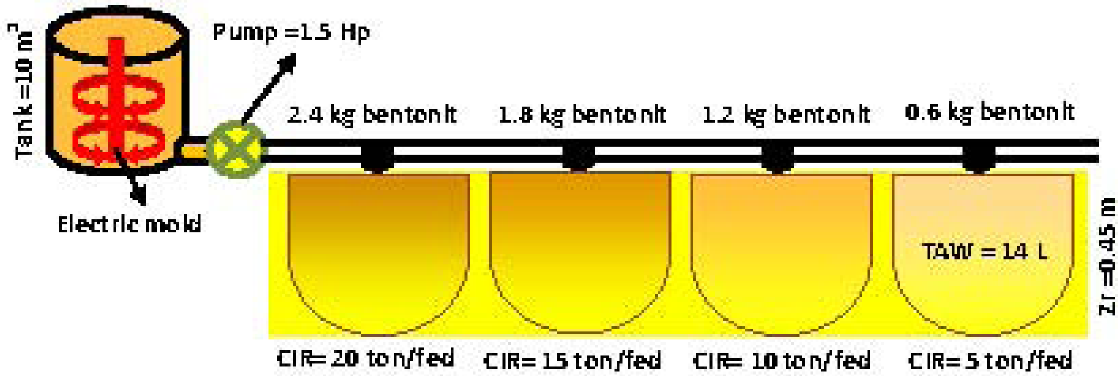

Fig. 2. How to inject bentonit and humic acids rates in sandy soil

Soil characteristics

Soil samples were collected to determine the physical and chemical soil characteristics. The methodological procedures followed the methods described by Page et al. (1982) and Klute (1986) as shown in Tables 1 & 2.

Quality of irrigation water

Chemical analyses of the irrigation water were performed according to the methods described by Ayers and Westcot (1994) and are presented in Table 3.

TABLE 1. Physical characteristics of the experimentalsoil.

Soil depth (cm)	Particle size distribution % Sand	Silt	Clay	Textural class	OM %	ρ_b g/cm^3	Ks cm/h	FC %	WP %	AW %	FSI* %
0-20	91.57	5.24	3.19	S	0.41	1.54	15.72	11.36	4.64	6.72	5
20-40	91.45	5.32	3.23	S	0.35	1.57	16.34	10.61	4.47	6.14	3
40-60	91.32	5.41	3.27	S	0.23	1.59	16.96	10.19	4.21	5.98	2

*FSI= Free swellindex.

TABLE 2.Chemical characteristics of the experimental soil.

Soil depth (cm)	EC(dS/m)	pH	$CaCO_3$ %	CEC Cmole/kg	Soluble ions (meq/l) in saturated soil paste extract: Na^+	K^+	Ca^{++}	Mg^{++}	Cl^-	HCO_3^-	CO_3^{--}	SO_4^{--}
0-20	2.37	7.54	5.19	3.41	10.73	1.39	7.01	4.57	9.34	2.87	-	11.49
20-40	2.49	7.42	4.75	3.83	11.29	1.51	7.26	4.84	10.12	2.93	-	11.85
40-60	2.54	7.36	4.61	3.97	11.47	1.63	7.34	4.96	10.26	3.11	-	12.03

TABLE 3. Chemical analysis of irrigation water.

pH	EC dS/m	SAR	Soluble cations, meq/l				Soluble anions, meq/l			
			Na^+	K^+	Ca^{++}	Mg^{++}	CL^-	HCO_3^-	$CO_3^=$	$SO_4^=$
7.68	1.65	1.02	2.58	1.31	12.45	0.36	6.57	1.84	-	8.29

Clay (Bentonite) characteristics

The sample of clay (Bentonite) used in this study was taken from inconsiderable exploited quarry located at KomOshim area, El-Fayoum province, Egypt. The studied quarry was situated 30 km north of El-Fayoum city at latitude 290 32" N and longitude 300 54" E. The clay (Bentonite) sample was dried at 6000 C for 48 h and then crushed using a jaw crusher to 100% below 5 mm size. Then grind well to100% pass through 200 µm sieve diameter using a porcelain mill to avoid the sample contamination. This sieved sample was used for mineralogical, chemical and physical analyses. The mineralogical analyses were performed using X-ray diffraction (XRD) apparatus was an X'Pert PRO PW3040/60 (PANalytical) diffractmeter equipped with a Cu-Ka radiation source showed in Figure 1 to arrange clay minerals, descending according to their availability, as follows, Montmorillonite, Kaolinite and Illite. Also, quartz and calcite minerals were found in minor amounts as non-clay components. While, using X-ray fluorescence (XRF) were estimating the semi-quantitative percentage of detected clay minerals with respect to all fraction sizes of the studied sample. Where the mainstream clay minerals in the sample used were 85% for Montmorillonite and 15% for Kaolinite minerals. As was performed the physical and chemical analyses for Bentonite clay by using the methods described by Page et al. (1982), Klute (1986) and Holtz and Gibbs (1956) as shown in Tables 4 & 5.

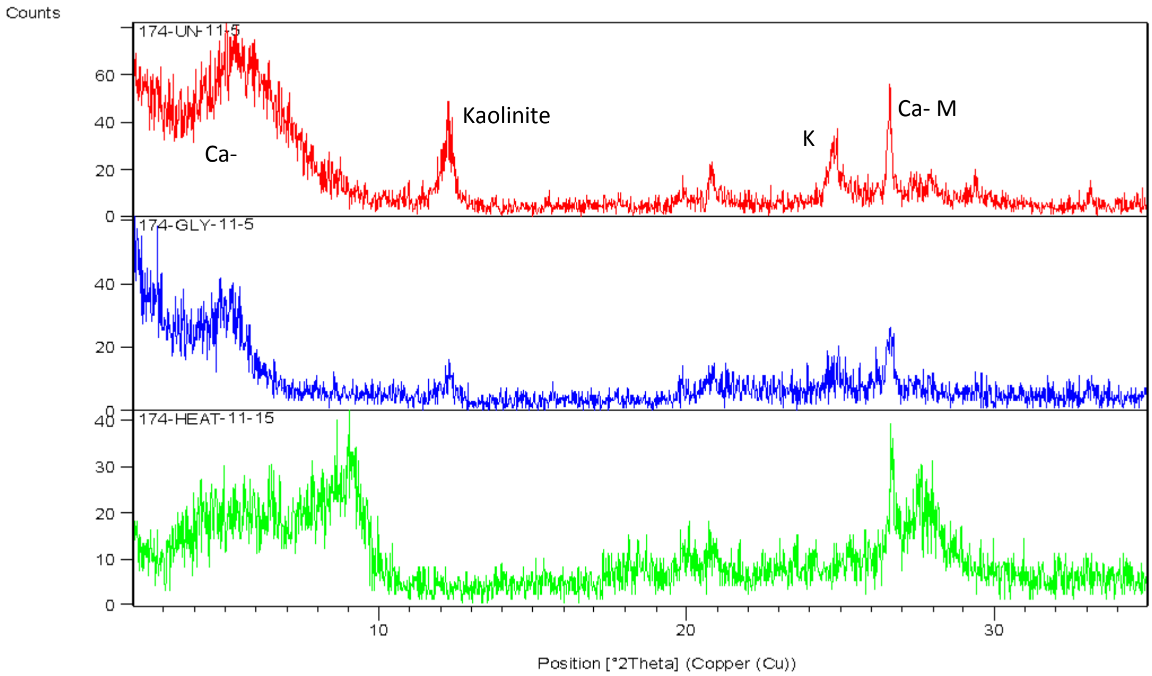

Fig. 3. X-ray diffractograms of the powder and treated calcic Bentonite clay fraction of sample

Table 4. Physical characteristics of the clay (Bentonite) sample

Particle size distribution %			ρ_b g/cm^3	FC %	WP %	AW %	FSI %
Sand	**Silt**	**Clay**					
7.56	14.31	78.13	0.58	45.42	16.75	28.67	109

TABLE 5. Chemical characteristics of the clay (Bentonite) sample

EC (dS/m)	pH	CEC Cmole/kg	Cations and anions of soluble salts, %							
			Na^+	K^+	Ca^{++}	Mg^{++}	Cl^-	HCO_3^-	CO_3^{--}	$SO4^{--}$
0.76	7.62	94.35	0.51	0.23	4.07	2.79	0.81	2.53	-	4.26

TABLE 6. Oxides content of the clay (Bentonite) sample by used X-Ray Fluorescence analysis

Oxide content	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	CaO	MgO	Na_2O	K_2O	MnO	P_2O_5	LOI
%	58.95	17.29	8.20	1.19	3.80	0.86	0.40	1.72	0.08	0.02	7.49

Mineral (chemical) fertilizer rates

All plots were fertilized as percentages of the recommended rates in the Ministry of Agriculture:

1- Ammonium sulfate (NH4)2SO4 as a source of nitrogen with three rates of N100%= 250 kg/fed, N70%= 175 kg/fed and N40%= 100 kg/fed was added during vegetative stage as liquid form by injection in irrigation water.

2- Super phosphate (P2O5) as a source of phosphoruswith three rates of P100%= 100 kg/fed, P70%= 70 kg/fed and P40%= 40 kg/fed was added to the soil before cultivation.

3- Potassium sulfate (K2O) as a source of potassium with three rates of K100%= 100 kg/fed, K70%= 70 kg/fed and K40%= 40 kg/fed wereadded during vegetative stage as liquid form by injection in irrigation water.

Reference evapotranspiration ETo

The reference evapotranspiration (ETo) shown in Table 7 was calculated by using Penman-Monteith equation FAO 56 method Allen et al.(1998).

Crop evapotranspiration ETc:

The crop evapotranspiration ETc shown in Table 8 was calculated by using the equation:

• $ETc = K_{cFAO}.ETo$ (mm / period) Allen et al. (1998)

where: K_{cFAO} :crop coefficient from FAO No.(56).

ETo: reference crop evapotranspiration, mm /period.

TABLE 7. Calculated reference evapotranspiration (mm/day)through summercucumber plant growth period

Month	Feb	Mar	Apr	May
ETo(mm/day)	3.35	4.49	6.17	6.83

TABLE 8. Calculated crop evapotranspiration (ETc), mm through summercucumber plant growth period

Stages	Initial	Develop.	Mid	Late	Seasonal
Planting date	14/2 to 5/3	6/3 to 4/4	5/4 to 14/5	15/5 to 29/5	to 29/5 14/2
Period length (day)	20	30	40	15	105
Kc_{FAO} (-)	0.60	0.80	1.00	0.75	--------
ETo (mm)	72.70	141.42	256.04	102.45	572.61
$ETc_{100\%}$ (mm)	43.62	113.14	256.04	76.84	489.64
Eff. Rainfall (mm)	0	0	0	0	0

Applied irrigation water IR

The amounts of applied irrigation water (IR) for summer cucumber plant shown in Table 9 were calculated by using the equation:

• $IR_{100, 90, 80,70, 60, 50,40}$=(ETc - pe)Kr / Ea) + LR (mm /period) Keller and Karmeli (1974)

where: Kr: correction factor for limited wetting at cucumber percent round coverage by canopy 80%, Kr = 0.90. (Smith, 1992).

Ea: irrigation efficiency for drip, 90% (Allen et al., 1998).

Pe: effective rainfall, 0 mm/season.

LR: leaching requirements, under salinity levels of irrigation water (0.15 x ETc), mm.

TABLE 9. Calculated applied irrigation water (IR), mm through summer cucumber plant growth period

IR (%)	Applied Irrigation water (mm) Growth Stages				
	Initial	Development	Mid	Late	Seasonal
100	50.35	130.58	295.52	88.69	565.14
90	45.32	117.52	265.97	79.82	508.63
80	40.28	104.46	236.42	70.95	452.11
70	35.25	91.41	206.86	62.08	395.60
60	30.21	78.35	177.31	53.21	339.08
50	25.18	65.29	147.76	44.35	282.58
40	20.14	52.23	118.21	35.48	226.06

• Actual evapotranspiration ETa = (M2 % – M1 %) /100. db . D(mm) (Doorenbos and Pruitt, 1984)
where: M2: moisture content after irrigation %.
M1: moisture content before irrigation %.
db: specific density of soil .
D: mean depth, mm.

• Water use efficiency WUE = MY / ETa (kg/m3) (Howell, 2001)
where: MY: marketable yield of cucumber plant, (kg/fed).

• Irrigation water use efficiency IWUE = MY / IR (kg/m3) (Michael, 1978)
where:IR :seasonal applied irrigation water, m3, (Table 6).

Results And Discussion

Effect of clay and humic acids injection rates on some physical and chemical characteristics of sandy soil

Data in Table 10 indicated that the values of some physical and chemical characteristics for sandy soilsuch as free swell index (FSI) %,available water (AW) % and cation exchange capacity (CEC) cmole/kgincreased with increasing clay and humic acids injection rates (CIR), (HAR)at different clay and humic acids injection doses (CHID)for all treatments.Also, data reported that the values of FSI, AW and CEC significantly affected by changing CIR between 5, 10,15 and 20 ton/fed. While, there is no significant difference between CIR15 and 20 ton/fed for all treatments. On the other hand, data reportedno significant superiority of HARbetween 4 and 8 kg/fed these results when appliedCIR=15 ton/fed treatment. In addition, data revealed that the values of FSI, AW and CEC significantly affected by changing CHID between 1, 2 and 3 doses. There is no significant difference between CHID 2 and 3 doses for all treatments.The results recorded the same trend for both seasons 2017 and 2018. The highest values of some physical and chemical characteristics for sandy soil FSI, AW and CEC were (99 %,24.21 % and 65.21cmole/kg) for the 1st season; (114%, 27.89 % and 73.45cmole/kg) for the 2nd season respectively, under CIR=20 ton/fed, HAR=8 kg/fed and CHID=3doses treatment. Meanwhile, the lowest values of some physical and chemical characteristics for sandy soil FSI, AW and CEC were (14 %, 6.53 % and 5.79cmole/kg) for the 1st season; (16 %, 7.49 % and 6.53cmole/kg) for the 2nd season respectively, under CIR=5 ton/fed, HAR=2 kg/fed and CHID=1 doses treatment. So it's recommended to applied the best treatments of injected sandy soil (CIR=15 ton/fed, HAR=4 kg/fed and CHID=2 doses) and compared it with un-injected sandy soil. These results may be attributed to be used clay and humic acids complex injection technique in sandy soil leads to distributed it well in the effective roots spread zone and thus be a good construction of the sandy soil as well as improved the physical and chemical properties its, therefore provision of the large quantities of irrigation water and mineral fertilizers added as well as increased marketable yield productivity. These results are in agreement with that found by Hamarashidet al. (2010), El-Mahllawyet al. (2013),Gümüs and Seker (2015) and Karboutet al. (2015).

Effect of IR and MFR onquality parameters for cucumber under IS and UIS treatments

Data in Table 11illustrate that the values of quality parameters for summer cucumber fruits such as length (L) cm and diameter (D) cm increased with increasing applied irrigation water levels (IR) and mineral nitrogen fertilizer rates (MFR) for all treatments except total soluble solid (TSS) % and vitamin C (VC) mg/100 g FW decreased with increasing IR and MFR. In addition, injected sandy soil (IS) had a clear effect on all treatments compared to un-injected sandy soil (UIS). The results record the same trend for both seasons 2017 and 2018. The highest values of summer cucumber fruits L and D were (19.87 and 14.87 cm) for the 1st season; (21.76 and 16.35 cm) for the 2nd season respectively, except TSS and VC were (3.31% and 3.58mg/100 g FW) for the 1st season; (3.65 % and 3.94 mg/100 g FW) for the 2nd season, respectively,under IS, IR=100% and MFR=100% treatment. While, the lowest values of cucumber fruits L and D were (4.26 and 2.36 cm) for the 1st season; (4.38 and 2.42 cm) for the 2nd season respectively, except TSS and VC were (8.75 % and 9.31 mg/100 g FW) for the 1st season; (9.01 % and 9.49 mg/100 g FW) for the 2nd season, respectively, under UIS, IR=40% and MFR=40% treatment. These results are in agreement withAmeret al.(2009) and Abdelhadyet al.(2017).

Effect of IR and MFR on MYfor cucumber under IS and UIS treatments

Data in Table 12 report that the values of marketable yield (MY) ton/fed for summer cucumber fruits increased with increasing applied irrigation water levels (IR) and mineral fertilizer rates (MFR) for all treatments. In addition, injected sandy soil (IS) had a clear effect on all treatments compared to un-injected sandy soil (UIS). The results indicated the same trend for both seasons 2017 and 2018. The highest values of MY for summer cucumber fruits were (21.13 and 23.17

ton/fed) for both seasons respectively, under IS, IR=100% and MFR=100% treatment. While, the lowest values were (1.25 and 1.28 ton/fed) for both seasons respectively, under UIS, IR=40% and MFR=40% treatment. These results may be attributed to the injection of sandy soil by clay and humic acids were helps to improved soil structure and soil texture, which helps to improve the physical and chemical properties of sandy soil therefore, maximizing plant utilization from the water and fertilizer units, which is reflected in the productivity of the crop, these results are in accordance with Jimenez-Bello et al. (2011), Alomran and Luki (2012), Lawrence et al. (2015) and Abdelhady et al.(2017).

Effect of IR and MFR under IS and UIS treatments on ETaof cucumber fruits

Data in Table 12indicate that the values of seasonal actual evapotranspiration (ETa) mm for summer cucumber fruits decreased with decreasing applied irrigation water levels (IR). It is also, there was no significant effect of the addition mineral fertilizers rates on the results of seasonal ETa. In addition, injected sandy soil (IS) had a clear effect on all treatments compared to un-injected sandy soil (UIS). The results indicated the same trend for both seasons 2017 and 2018. The lowest values of seasonal ETa were (155.01 and 142.23mm) for both seasons respectively, under IS, IR=40% and MFR=40% treatment. While, the highest values were (487.71 and 477.04mm) for both seasons respectively, under UIS, IR=100% and MFR=100% treatment.These results may be attributed to the injection of sandy soil by clay and humic acids were contributed to increase values both of free swell index and available water. Thus increase the storage capacity of sandy soils which reduces seasonal ETa. Also, the water stress of the irrigation water added reduces the actual water consumption; these results are in agreement with that found by Amer et al.(2009),Agele et al.(2011) andAbdelhady et al.(2017).

Effect of IR and MFR under IS and UIS treatments on WUE and IWUE of cucumber fruits

Data in Table 12 show that the highest values of water use efficiency (WUE) and irrigation water use efficiency (IWUE) for summer cucumber fruits were (22.03 and16.63 kg/m3); (26.34 and 18.12 kg/m3) for both seasons respectively, under IS, IR=60% and MFR=70% treatment. While, the lowest values were(1.91 and 1.54 kg/m3); (1.99 and 1.57 kg/m3) for both seasons respectively, under UIS, IR=40% and MFR=40% treatment. Meanwhile, the values of WUE and IWUE under IS, IR=60% and MFR=70% treatment were increased significantly by about (143 and 112 %); (162 and 177 %) for both seasons, respectively, compared to that under the control treatment (UIS, IR=100% and MFR=100 %). These results may be attributed to that the Injection of sandy soil by clay and humic acids In addition to water stress were contributed to decrease surface soil evaporation, consequently, increasing the storage capacity in the sandy soil led to increase marketable yield with decrease in water consumption, these results were similar to those indicated by Amer et al.(2009), Alomran and Luki (2012) and Abdelhady et al. (2017).

Economic study for injection of sandy soil by Bentoniteand humic acids

There is no doubt that apply the injection technique of sandy soil by used clay and humic acids at applied irrigation level 60% and mineral fertilizers rates 70% was very economical because the costs of injection soil by clay and humic acids at depth of 45 cm needed about 15 ton of clay (cost ton =1000EGP) and 4 kg of humic acids (cost kg =100 EGP) so that the costs of injection soil by clay and humic acids / fed = (15 ton * 1000 EGP = 15000 EGP) and (4 kg * 100 EGP = 400 EGP). The total cost of this technique 15400 EGP / fed. Although the life span of injected sandy soil by clay forever, because the added clay gives permanent fertility to the sandy soil where it does not decompose and do not leave the areas added to it. However, if imposed sandy soil injection every five years to increase its fertility, the cost of applying the injection technique is divided on five years (15400 EGP / 5 years = 3080 EGP / year is the cost of using the farmer for this technique will remain very economical because the cucumber is cultivated three times per year and the increase in marketable yield were about 5800 kg/fed, compared to that under traditional treatment (applied irrigation level 100% and mineral fertilizers rates 100% under Un-injected soil) and on the assumption that the average price of 1 kg cucumber was 2 EGP. Therefore, the profit of application injection soil by clay and humic acids at applied irrigation level 60% and mineral fertilizers rates 70% transaction on year was (5800 kg/fed * 3 times / year *2 EGP = 34800 EGP / fed / year). Also, this treatment save about 30% of mineral fertilizers rates on the assumption that the cost of mineral fertilizers / fed / year = 20000 EGP/ fed /year thus, this treatment save about 6000 EGP / fed from the total cost of mineral fertilizers annually. Thus the total profit becomes (34800 increase marketable yield + 6000 save mineral fertilizers costs = 40800 EGP / fed / year) the cost of sandy soil injection treatment (7900 EGP) is deducted to become the net profit during = (40800 –15400 = 25400 EGP fed / year). In addition to, this treatment provides about 40% of the amount of irrigation water added that can be used to reclaim more desert land and cultivate it with the same crop.

TABLE 10. Effect of CIR and at HAR on FSI, AW and CEC under 3 CHID for seasons 2017- 2018

CIR ton/fed	HAR Kg/fed	CHID doses	FSI %		AW %		CEC cmole/kg	
	Seasons		S1	S2	S1	S2	S1	S2
5	2	1	14	16	6.53	7.49	5.79	6.53
		2	25	29	7.58	8.66	14.51	16.45
		3	27	31	7.91	9.08	16.83	18.97
	4	1	24	27	9.51	10.94	14.31	16.17
		2	39	45	10.75	12.37	23.07	26.13
		3	42	48	11.13	12.83	24.53	27.65
	8	1	29	33	11.14	12.84	19.03	21.46
		2	42	48	11.71	13.43	26.29	29.54
		3	45	52	12.16	13.94	28.07	31.73
10	2	1	46	53	10.97	12.61	17.25	19.41
		2	57	65	12.23	14.01	26.43	29.69
		3	59	68	12.68	14.49	27.57	31.13
	4	1	59	68	14.77	17.00	33.83	38.09
		2	73	84	16.37	18.82	38.14	42.91
		3	75	86	16.61	19.15	39.81	45.02
	8	1	64	74	16.29	18.67	38.42	43.28
		2	76	88	17.05	19.58	40.42	45.78
		3	78	90	17.48	20.13	42.34	47.57
15	2	1	62	71	16.15	18.53	29.53	33.35
		2	74	85	17.46	19.94	37.95	42.87
		3	78	89	17.95	20.58	39.72	44.69
	4	1	76	88	21.35	24.61	54.16	61.32
		2	92	105	22.89	26.39	59.91	67.54
		3	94	108	23.25	26.71	60.27	68.31
	8	1	81	93	22.76	26.15	58.37	65.72
		2	94	107	23.43	26.85	61.37	69.32
		3	97	111	23.84	27.37	63.19	71.35
20	2	1	64	73	17.28	19.78	31.07	35.13
		2	76	87	18.61	21.39	39.29	44.51
		3	81	94	18.87	21.65	41.29	46.71
	4	1	79	92	21.59	24.92	56.28	63.50
		2	94	108	23.11	26.51	60.76	68.49
		3	96	110	23.49	27.09	62.39	70.49
	8	1	85	97	23.02	26.48	60.51	68.34
		2	97	112	23.79	27.29	63.61	71.79
		3	99	114	24.21	27.89	65.21	73.45
LSD (0.05)	CIR		**4.25**	**4.31**	**2.17**	**2.19**	**2.67**	**2.83**
	HAR		**6.67**	**6.83**	**1.89**	**1.97**	**4.21**	**4.25**
	CHID		**5.89**	**5.95**	**1.32**	**1.40**	**3.14**	**3.17**
	CIR X HAR X CHID		**4.93**	**5.07**	**2.24**	**2.31**	**2.92**	**3.01**

TABLE 11. Effect of IR and MFRon quality parameters of cucumberunder IS and UIS for seasons 2017-2018

Injection	MFR %	IR %	L cm		D cm		TSS %		VC mg/100 g FW	
	Seasons		S1	S2	S1	S2	S1	S2	S1	S2
UIS	100	100	16.89	17.35	12.49	12.83	3.57	3.68	3.94	4.05
		90	16.35	16.78	12.35	12.67	3.89	4.00	4.06	4.49
		80	15.93	16.32	11.93	12.25	4.45	4.57	4.72	4.96
		70	13.67	13.96	9.87	10.12	5.02	5.15	5.39	5.57
		60	12.14	12.43	8.34	8.56	5.63	5.79	5.76	5.93
		50	10.91	11.21	7.01	7.19	6.31	6.50	6.68	6.85
		40	8.58	8.79	5.18	5.31	6.86	7.04	7.23	7.46
	70	100	14.93	15.28	11.43	11.73	4.34	4.46	4.61	4.67
		90	14.71	15.12	11.35	11.65	4.83	4.98	5.03	5.11
		80	12.98	13.31	10.07	10.32	5.37	5.52	5.54	5.63
		70	11.85	12.16	8.65	8.87	5.89	6.07	6.36	6.39
		60	10.74	11.00	7.32	7.52	6.63	6.81	6.72	7.33
		50	9.56	9.83	5.76	5.89	7.21	7.42	7.48	7.77
		40	6.82	6.97	3.82	3.92	7.76	7.98	8.23	8.47
	40	100	12.67	12.97	9.27	9.51	5.43	5.59	5.59	5.85
		90	11.43	11.73	8.23	8.42	6.02	6.21	6.28	6.71
		80	10.18	10.42	6.95	7.14	6.54	6.73	6.81	6.93
		70	9.16	9.38	5.76	5.91	7.08	7.30	7.35	7.58
		60	7.89	8.11	4.59	4.72	7.61	7.82	7.87	8.42
		50	6.31	6.46	3.41	3.49	8.16	8.39	8.73	8.98
		40	4.26	4.38	2.36	2.42	8.75	9.01	9.31	9.49
IS	100	100	19.87	21.76	14.87	16.35	3.31	3.65	3.58	3.94
		90	19.69	21.57	14.85	16.31	3.35	3.69	3.62	3.98
		80	19.51	21.35	14.79	16.23	3.39	3.72	3.76	4.13
		70	19.28	21.08	14.63	16.08	3.47	3.80	3.84	4.21
		60	18.52	20.29	14.16	15.56	3.56	3.91	4.13	4.54
		50	15.94	17.46	12.04	13.21	4.39	4.83	4.76	5.23
		40	12.76	13.98	9.28	10.17	5.13	5.62	5.62	6.19
	70	100	19.39	21.25	14.39	15.79	3.39	3.72	3.67	4.03
		90	19.23	21.10	14.32	15.74	3.43	3.76	3.72	4.09
		80	18.97	20.84	14.27	15.61	3.46	3.81	3.76	4.14
		70	18.62	20.38	13.32	14.57	3.51	3.86	3.98	4.38
		60	15.93	17.46	11.93	13.08	4.67	5.13	5.04	5.54
		50	12.51	13.68	9.81	10.75	5.59	6.15	5.96	6.56
		40	9.29	10.19	6.79	7.45	6.81	7.48	7.18	7.87
	40	100	14.31	15.69	11.31	12.37	4.65	5.12	5.02	5.52
		90	14.23	15.64	11.28	12.33	4.68	5.15	5.05	5.56
		80	13.97	15.26	11.12	12.19	4.73	5.19	5.13	5.63
		70	12.15	13.31	9.75	10.65	5.58	6.12	5.75	6.31
		60	10.21	11.17	8.21	8.98	6.31	6.94	6.58	7.25
		50	8.54	9.34	6.34	6.95	7.26	7.98	7.53	8.29
		40	6.19	6.79	4.19	4.59	8.15	8.97	8.72	9.57
LSD (0.05)	Inj		**1.73**	**1.79**	**1.61**	**1.67**	**1.15**	**1.19**	**1.21**	**1.24**
	MFR		**1.21**	**1.25**	**1.17**	**1.20**	**0.57**	**0.61**	**0.68**	**0.72**
	IR		**0.05**	**0.07**	**0.03**	**0.05**	**0.01**	**0.03**	**0.01**	**0.03**
	Inj X MFR X IR		**1.47**	**1.51**	**1.39**	**1.43**	**0.83**	**0.87**	**0.92**	**0.96**

TABLE 12. Effect of IR and MFR on MY, ETa, WUE and IWUE of cucumber under IS and UIS for seasons 2017-2018

Injection	MFR %	IR %	MY Ton/fed		ETa mm/season		WUE Kg/m³		IWUE Kg/m³	
	Seasons		S1	S2	S1	S2	S1	S2	S1	S2
UIS	100	100	15.89	16.26	487.71	477.04	9.08	9.49	7.83	8.01
		90	15.65	16.04	441.50	431.12	9.87	10.36	8.57	8.78
		80	14.93	15.31	389.74	380.36	10.67	11.21	9.20	9.43
		70	12.37	12.65	335.71	328.58	10.26	10.72	8.71	8.91
		60	9.21	9.41	281.54	275.87	9.11	9.50	7.57	7.73
		50	6.72	6.87	238.28	233.36	7.86	8.20	6.62	6.77
		40	4.28	4.38	190.36	186.30	6.26	6.54	5.27	5.39
	70	100	12.67	12.94	475.15	465.69	7.43	7.74	6.24	6.38
		90	12.49	12.81	438.95	428.32	7.93	8.33	6.84	7.02
		80	9.83	10.06	383.11	374.72	7.15	7.48	6.06	6.20
		70	8.18	8.39	329.07	320.92	6.92	7.29	5.76	5.91
		60	6.36	6.52	278.37	271.95	6.36	6.67	5.22	5.35
		50	4.24	4.35	234.12	228.64	5.04	5.29	4.18	4.28
		40	2.75	2.81	186.30	182.59	4.11	4.28	3.39	3.46
	40	100	7.94	8.14	471.01	460.08	4.70	4.93	3.91	4.01
		90	6.21	6.35	434.34	425.50	3.98	4.15	3.40	3.47
		80	4.89	4.99	379.87	372.52	3.59	3.73	3.01	3.08
		70	4.00	4.10	324.45	316.93	3.43	3.60	2.82	2.89
		60	3.12	3.20	273.69	266.77	3.18	3.34	2.56	2.63
		50	2.04	2.09	229.71	224.74	2.47	2.59	2.01	2.06
		40	1.25	1.28	182.47	178.78	1.91	1.99	1.54	1.57
IS	100	100	21.13	23.17	409.75	376.12	14.00	16.71	10.15	11.12
		90	20.98	22.79	372.05	341.42	15.10	18.05	11.05	12.12
		80	19.93	21.89	337.30	309.60	16.46	19.69	12.28	13.49
		70	19.87	21.79	294.96	271.89	18.76	22.32	13.99	15.34
		60	19.51	21.24	249.71	232.96	21.76	25.39	16.03	17.45
		50	16.04	17.53	206.72	187.63	21.61	26.02	15.81	17.28
		40	11.37	12.79	164.31	149.94	19.28	23.76	14.01	15.76
	70	100	20.59	22.56	413.81	374.43	14.22	17.24	10.41	11.42
		90	20.17	22.13	375.47	343.60	15.56	18.48	11.49	12.48
		80	20.71	22.61	340.64	309.86	16.94	20.33	12.76	13.93
		70	20.56	22.25	297.31	273.29	19.26	22.68	14.48	15.67
		60	20.24	22.06	255.89	233.27	22.03	26.34	16.63	18.12
		50	15.75	17.02	210.56	190.44	20.84	24.89	15.53	16.78
		40	10.85	11.82	167.29	151.35	18.07	21.75	13.37	14.56
	40	100	13.85	15.19	399.33	361.26	9.66	11.71	6.83	7.49
		90	13.37	14.69	365.13	329.58	10.20	12.42	7.32	8.05
		80	12.73	13.87	328.95	299.95	10.78	12.88	7.84	8.55
		70	9.26	10.14	289.39	262.15	8.91	10.78	6.52	7.14
		60	6.91	7.56	237.24	215.21	8.11	9.79	5.68	6.21
		50	5.29	5.75	199.97	182.97	7.37	8.75	5.21	5.67
		40	3.25	3.52	155.01	142.23	5.84	6.90	4.00	4.34
LSD (0.05)	Inj		1.13	1.17	6.31	6.39	-	-	-	-
	MFR		0.35	0.39	8.17	8.21	-	-	-	-
	IR		0.09	0.11	3.53	3.56	-	-	-	-
	Inj X MFR X IR		1.87	1.93	5.89	5.94	-	-	-	-

Conclusion

This study identified the best treatment of apply injected technique for sandy soil by clay and humic acids rates additive at different doses. As well, these study evaluated the effectiveness of the injected sandy soil under different irrigation water levels and rates of mineral fertilizers additive on quality parameters yield, marketable yield, seasonal ETa, WUE and IWUE of summer cucumber fruits compared to un-injected sandy soil treatment, under sandy soil conditions of New Salhia Area. The study concluded that the marketable yield and studied quality parameters for summer cucumber fruits gave the highest values under IS, IR=100% and MFR=100% treatment. On the other hand, the seasonal ETa for cucumber fruits gave the lowest values under IS, IR= 40% and MFR=40% treatment. Finally, the values of summer cucumber fruits WUE and IWUE under IS, IR= 60% and MFR=70% treatment increased significantly by about (143 and 112 %); (162 and 177 %) for both seasons, respectively, compared with that under the control treatment (UIS, IR= 100% and MFR=100%).

So, it is recommended to apply sandy soil injection treatment (CIR=15 ton/fed, HAR= 4kg/fed and 2 doses) under IR= 60% and MFR=70% to cultivate cucumber under El- Salhia El-Gedida conditions to save about 40% of applied irrigation water, save about 30% of the total mineral fertilizers rates additive. In addition to increase the marketable yield of summer cucumber fruits by about 27 and 36 % for both seasons respectively, compared to that under control treatment (i.e. UIS, IR= 100% and MFR=100%).

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تأثير حقن معادن الطين والمادة العضوية بأراضى الصالحية على كفاءة الأستهلاك المائى لنبات الخيار

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أجريت هذه التجارب فى منطقة الصالحية الجديدة بمحافظة الشرقية – جمهورية مصر العربية وكانت أحداثياتها كالتالى (٠٣° ٨١´ ٥٢´´ شمالا : ١٣° ٣٢´ ٩٠´´شرقا) وأرتفاع ٨٢ مترفوق مستوى سطح البحرخلال موسمين زراعة صيفية ٢٠١٧-٢٠١٨ بأستخدام التصميم الأحصائى القطع المنشقة مرتين وثلاثة مكررات لكل معاملة. التجربة الحقلية الأولى تم فيها حقن التربة الرملية لعمق ٤٥ سم بأربع معدلات من طين (البنتونيت)٥ , ١٠ , ١٥ , ٢٠طن/فدان وثلاثة معدلات من الأحماض الدبالية ٢ , ٤ , ٨ كجم / فدان تم حقنها من خلال شبكة الرى بالتنقيط السطحى بجرعات مختلفة (١,٢, ٣) مع مراعاة فترة الجفاف بين كل جرعة والأخرى ٥ أيام بعد الحقن للمساعدة فى تكوين تجمعات أرضية ثابتة وقد تم دراسة تأثيرهذه المتغيرات على كل من معامل الأنتفاخ(ISF) والماء الميسر(WA) والسعة التبادلية الكاتيونية (CEC) للتربة الرملية المحقونة لكلا الموسمين. التجربة الحقلية الثانية تم فيها المقارنة بين أفضل معاملة لحقن التربة الرملية بالغير محقونة عند زراعة نبات الخيار الصيفى بأضافة سبعة مستويات من مياه الرى ١٠٠ , ٩٠ , ٨٠ , ٧٠ , ٦٠ , ٥٠ , ٤٠ ٪ محسوبة على أساس البخرنتح المحصولى و٣ معدلات من الأسمدة الكيميائية المضافة ١٠٠ , ٧٠ , ٤٠ ٪ من معدلات الأسمدة الكيميائية الموصى بها وقد تم دراسة تأثيرهذه المتغيرات على كل من أنتاجية وقياسات الجودة لنبات الخيار الصيفى وكذلك الأستهلاك المائى الفعلى وكفاءة الأستهلاك المائى للري تحت ظروف التجربة وقد أوضحت النتائج المتحصل عليها الأتى :

١- سجلت التربة الرملية المحقونة بالطين أعلى قيم لمعامل الأنتفاخ ٩٩ و ١١٤ ٪ لكلا الموسمين على الترتيب عند حقن التربة الرملية ٢٠ طن/فدان من الطين و ٨ كجم/فدان من الأحماض الدبالية المضافة من خلال شبكة الرى على ٣ جرعات .

٢- كما سجلت التربة الرملية المحقونة بالطين أعلى قيم للماء الميسر ٢٤,٢١ و ٢٧,٨٩ ٪ لكلا الموسمين على الترتيب عند حقن التربة الرملية ٢٠ طن/فدان من الطين و ٨ كجم/فدان من الأحماض الدبالية المضافة من خلال شبكة الرى على ٣ جرعات .

٣- كما سجلت التربة الرملية المحقونة بالطين أعلى قيم للسعة التبادلية الكاتيونية ٦٥,٢١ و ٧٣,٤٥سنتمول/كجم تربة لكلا الموسمين على الترتيب عند حقن التربة الرملية ٢٠ طن/ فدان من الطين و ٨ كجم/فدان من الأحماض الدبالية المضافة من خلال شبكة الرى على ٣ جرعات .

٤- أوضحت النتائج أن قيم معامل الأنتفاخ والماء الميسر والسعة التبادلية الكاتيونية للتربة الرملية المحقونة لم تسجل زيادة معنوية عند تطبيق المعاملة (٢٠ طن/فدان طين – ٨ كجم/ فدان أحماض دبالية – ٣ جرعات أضافة) مقارنة بالمعاملة (١٥ طن/فدان طين – ٤ كجم/فدان أحماض دبالية – جرعتين أضافة) لذا نوصى بتطبيق الأخيرة كأفضل معاملة حقن للتربة الرملية لتوفيرها٥ طن/فدان من الطين و٤ كجم/فدان وتقلل أيضا فى زمن الأضافة.

٥- سجلت ثمارالخيارأعلى قيم لقياسات الجودة فيماعدا المواد الصلبة الذائبة و فيتامين سى عند تطبيق المعاملة (التربة المحقونة بالطين مع أضافة ١٠٠٪ من مياه الرى و١٠٠٪ من الأسمدة الكيميائية).كما سجلت أعلى أنتاجية لثمارالخيار(٢١,١٣و٢٣,١٧ طن/فدان)لكلاالموسمين على الترتيب تحت نفس المعاملة.

٦- سجلت ثمارالخيار أدنى قيم للأستهلاك المائى الفعلى(١٥٥,٠١ و ١٤٢,٢٣ مم/موسم) لكلا الموسمين على الترتيب عند تطبيق المعاملة (التربة الغيرمحقونة بالطين مع أضافة ٤٠٪ من مياه الرى و٤٠٪ من الأسمدة الكيميائية).

٧- سجلت ثمارالخيارأعلى قيم لكفاءة الأستهلاك المائى وكفاءة الأستهلاك الأروائى (٢٢,٠٣ و١٦,٦٣ كجم/م٣) و(٢٦,٣٤ و ١٨,١٢ كجم/م٣) لكلا الموسمين على الترتيب عند تطبيق المعاملة (التربة المحقونة بالطين مع أضافة ٦٠٪ من مياه الرى و٧٠٪ من الأسمدة الكيميائية).

لذا يمكن التوصية بتطبيق أفضل معاملة لتقنية حقن التربة الرملية بالطين والأحماض الدبالية (١٥ طن/ فدان طين – ٤ كجم/ فدان أحماض دبالية مضافة على جرعتين) مع أضافة ٦٠٪ من مياه الرى و٧٠٪ من الأسمدة الكيميائية لزراعة نبات الخيارالصيفى تحت ظروف الصالحية الجديدة وذلك لأن هذه المعاملة توفر٤٠٪ من مياه الرى المضافة وكذلك توفر٣٠٪ من الأسمدة الكيميائية المضافة كما تؤدى الى زيادة أنتاجية ثمارالخياربحوالى ٢٧ و٣٦ ٪ لكلا الموسمين على الترتيب مقارنة بالمعاملة التقليدية (التربة الغيرمحقونة بالطين مع أضافة ١٠٠ ٪ من مياه الرى و١٠٠٪ من الأسمدة الكيميائية).