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# IMPROVING WATER CHARACTERISTIC OF SANDY SOIL TO MAXIMIZING CUCUMBER YIELD PRODUCTION UNDER DRIP IRRIGATION SYSTEM *

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## ABSTRACT

*This field study was conducted to improve water characteristic of sandy soil at El- Salhia El-Gedida area, El- Sharqia governorate during season 2011-2012. The parameters under study were: soil compression rates CR (Passes), organic matter rates OMR ($m^3$/fed) and organic matter decomposition OMD (weeks). The results of this study revealed that the available water AW increases with the increase of CR and OMD but decreases with the increase of OMR for sandy soil depth D of 0-30 cm. The maximum value of AW was 19.55 % at compressed treatment CM; OMR of 10 $m^3$/fed, OMD of 2 weeks and CR of 6 Passes if compared with that under control treatment CN; OMR of 30 $m^3$/fed, OMD of 0 weeks and CR of 0 passes for soil depth of 0-15 cm the maximum value was 9.90 %. Bulk density $?_b$ (g/$cm^3$) increases with the increase of OMR, OMD and CR for soil depth of 0-30 cm, on the other hand there was no effect on depth of 30-45 cm. Meanwhile saturated hydraulic conductivity Ks and total porosity $P_t$ (%) decreases with the increase of OMR, OMD and CR for soil depth of 0-30cm. Cucumber growth parameters: leaf area LA ($cm^2$), total soluble solid TSS (%), fruit length L (cm) and fruit diameter D (cm) at CM decreases with the increase of irrigation intervals Int (days) and increases with the increase of applied irrigation water IR (%). meanwhile, the pH of juice pH (-) at CM increases with the increase of irrigation intervals Int (days) and decreases with the increase of applied irrigation water IR (%).*


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*The maximum value of actual yield (marketable cucumber fruit weight) Ya was 27.71 Ton/fed under CM at 1 day Int and 100 % IR if compared with that under CN the maximum value was 21.95 Ton/fed at the same treatment. The maximum values of water use efficiency WUE and irrigation water use efficiency IWUE (kg/m$^3$) were 26.33 and 18.08 kg/m$^3$ respectively, at 75% IR and 1 day Int if compared with that at CN the maximum values were 14.67 and 11.03 kg/m$^3$ at 100% IR and 1 day Int.*

**Notation & Key words:** ***OMR***: organic matter rates, ***OMD***: organic matter rates, ***CR***: compression rates, ***CM***: compressed soil treatment, ***CN***: control soil treatment, ***Int***: irrigation intervals, ***IR***: applied irrigation water, ***AW:*** available water, ***Ks***: saturated hydraulic conductivity, $?_b$: soil bulk density, $P_t$: total porosity, ***LA***: leaf area, ***TSS***: total soluble solid, ***pH***: pH of juice, ***L***: fruit length, ***D***: fruit diameter, ***Ya***: actual yield, ***ETa***: actual evapotranspiration, ***WUE***: water use efficiency, ***IWUE***: irrigation water use efficiency.

## INTRODUCTION

Sandy soils are often considered as soils with physical properties that easy to define: weak structure or no structure, poor water retention properties, high permeability, highly sensitivity to compaction with many adverse consequences. However, analysis of the literature shows that their physical properties are far from simple. This is particularly true in the tropics where sandy soils are subjected to a cycle of wetting and drying.

The compaction in sandy soils was improving water retention properties and reducing nutrient leaching. Indeed, compaction that reduces the volume and continuity of large pores would increase water retention and reduce water infiltration and saturated hydraulic conductivity in highly permeable deep sandy soils. Compaction would save irrigation water by 15–36 %. **(Arora et al., 2005)**

**Gomez et al. (2002)** showed that compaction reduced total soil porosity in the upper 45 cm by an average of 9% sandy loam to 20% clay. Although compaction caused the greatest $?_b$ increase in the loam 30%, 15–30cm, this corresponded to only 14% loss in total porosity. The greatest porosity loss was at 15 to 30 cm in the clayey soil 27%. For all soils, porosity losses were greater at 15 to 30 cm than at any other depth.

**Balai et al. (2009)** studied the effect of compaction on bulk density, hydraulic conductivity and moisture content of soil during autumn seasons of the year 2002 and 2003.The experiment was consisting of three compaction levels of 0, 2 and 4 passing of 500 kg iron roller. The results revealed that four passing of 500 kg iron roller increase the bulk density and moisture retention at all stages and decreased saturated hydraulic conductivity of soil having maximum values in 15–30 cm soil layer.

The soil compaction increased available water content (AWC) at 0-10 cm depth by 24-59 % compared to non-compacted soil. At both 0-10 and 10-20 cm depths of the non-compacted soil, AWC was lower compared to the compacted soil. On highly fertile soils, the effect of compaction on yields was due to moisture and aeration effects. The soil compaction reduces total porosity and usually creates more fine pores, perhaps increasing both Fc and PWP with variable effects on AWC. Also compaction in clay textured soils caused the expected effect of reducing AWC, but in a sandy loam soil, compaction caused greater increases in Fc than in PWP, thus increasing AWC and tree growth. Thus, compaction can actually improve soil quality. **(Yahya et al., 2010 and Johnson, 2010)**

**Gromyko and Trmasov (1970)** showed that water loss by evaporation from soils was less for the compacted surface than the friable surface layer.

**EL-Gindy et al. (1991)** stated that actual daily, monthly and seasonal consumptive use of squash and cucumber were determined by the soil moisture depletion method. The seasonal consumptive use was 267.7, 242.4 and 226.0 mm under soil moisture tension of 0.35, 0.42 and 0.55 bar, respectively for cucumber which grown under Marryout, Egypt conditions.

**Mady and Derees (2010)** showed that increasing water use efficiency WUE of cucumber crop affected by water stress (irrigation at 40, 60, 80 and 100 % of field capacity). Compost levels were; control, 0.68, 1.36, 2.05, 2.73 and 3.41 kg/m$^2$. The main results of this study indicated that there were significant differences in the cucumber yield, quality (TSS) and its water relations (e.g. (water consumptive use (m) and water use efficacy kg/m$^3$). It could be concluded that in other to produce higher yield, high quality of cucumber water saving, water consumptive use and water use efficiency at 80% from field capacity irrigation with 2.05 kg/m$^2$ of compost under trickle irrigation system and plastic house in both seasons.

**Simsek et al. (2005)** conducted a study to determine the effects of different drip irrigation regimes on yield and yield components of cucumber (*Cucumbis sativus L.*) and to determine a threshold value for crop water stress index (CWSI) based on irrigation programming. Four different irrigation treatments as 50, 75, 100 and 125% of irrigation water applied/cumulative pan evaporation (IW/CRE) ratio with 3-day-period were studied. The irrigation water use efficiencies (IWUE) were between 7.02 and 9.93 kg/m$^3$ in 2002 and between 6.11 and 8.82 kg/m$^3$ in 2003. Results of this study demonstrate that 1.00 IW/CRE water applications by a drip system in a 3-day irrigation frequency would be optimal for growth in semiarid regions.

The main objective of the present study was to reduce saturated hydraulic conductivity and increase available water to improve water characteristic of sandy soil at effective root zoon.

## MATERIALS AND METHODS

### 1. First Field Experimental Design:

The first field study was carried out at El- Salhia El-Gedida area, El-Sharqia governorate during season of 2011–2012 in split–split plot design 4 way completely randomized design with three replicates. The area of experiment of 35 × 40 m was divided into 12 × 13 m plots. Sandy soil mixed with three organic matter rates (*OMR*) of 10, 20 and 30 m$^3$/fed. Three organic matter decomposition (*OMD*) of 0, 2 and 4 weeks and five sandy soil compression treatments (*CR*) of 0, 2, 4, 6, 8 passes of 10 ton weight and 2.17 m width smooth-wheel roller were applied. The bulk density, total porosity, saturated hydraulic conductivity and available water were measured at three depths of 0-15, 15-30 and 30-45.The best treatment which have high available water was determined and comparison with control soil treatment (*OMR* 30 m$^3$/fed, *OMD* 0 Weeks and *CR* 0 passes).

**2. Second Field Experimental Design:**

The second field experimental was carry out to compare between best compressed soil treatment (*CM*) and control soil treatment(*CN*) at three amounts of irrigation water of *IR* 50, 75 and 100 % and different irrigation intervals of 1, 2 and 4 days under surface drip irrigation system. The cucumber (***Cucumis sativus Hayle***) was planted its yield was measured on two soil treatments as indicator. The leaf area meter *LA* ($cm^2$), total soluble solid *TSS* (%), pH of juice *pH* (-), fruit length *L* (cm), fruit diameter *D* (cm), actual yield (marketable fruit weight) *Ya* (ton/fed), actual evapotranspiration *ETa* (mm), water use efficiency *WUE* ($kg/m^3$) and irrigation water use efficiency *IWUE* ($kg/m^3$) were measured.

**3. Soil characteristics:**

Some physical characteristics of the soil studied were listed in Table (1); it was measured in the Laboratory of Physical and Chemical Department in Agricultural Research Center, Ministry of Agriculture, El-Doky, Cairo, Egypt. The methodological procedures were deduced from **Klute (1986).**

**Table (1):** physical characteristics of the soil under study.

| Soil depth (cm) | Particle size distribution % | | | | | Textural class | $CaCO_3$ % | OM % | $?_b$ $g/cm^3$ | Ks cm/h | FC % | WP % | AW % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | C. sand | M. sand | F. sand | Silt | Clay | | | | | | | | |
| 0-15 | 3.22 | 79.35 | 13.31 | 2.64 | 1.48 | S | 2.45 | 0.47 | 1.61 | 15.41 | 9.06 | 3.19 | 5.87 |
| 15-30 | 5.15 | 75.41 | 14.13 | 3.78 | 1.53 | S | 2.41 | 0.43 | 1.63 | 15.18 | 9.11 | 3.22 | 5.89 |
| 30-45 | 5.45 | 69.87 | 18.75 | 4.32 | 1.61 | S | 2.39 | 0.41 | 1.65 | 14.82 | 9.19 | 3.28 | 5.91 |

C = coarse, M = medium, F = fine, S = sand, OM = organic matter ratio, $?_b$ = Bulk density ($g/cm^3$), Ks = Hydraulic conductivity (cm/h), FC = Field capacity (0.1 atm.), WP = Permanent wilting Percentage (15atm) and AW = Available water.

**4. Organic matter:**

Farmyard manure was applied by rates of 10, 20 and 30 $m^3$/fed and the soil was plowed at a depth of 0-20 cm by chisel plow. The farmyard manures analysis is presented in Table (2). It was measured in the same above laboratory. The methodological procedures were deduced from **(Gomaa et al., 2010).**

**Table (2):** Some chemical analysis of applied farmyard manure.

| Organic manure | pH | EC (dS/m) | OM (%) | C/N ratio | Nutrients | | |
|---|---|---|---|---|---|---|---|
| | | | | | Total (%) | Available (ppm) | |
| | | | | | N | P | K |
| Farmyard manure | 7.93 | 6.14 | 27.32 | 9.37 | 1.71 | 29.56 | 109.12 |

**5. Determinations:**

At the end of the experiment, all plots were analyzed and the following determinations were done:

- **Soil bulk density**
- **Total porosity (%) = 1-** $\left(\frac{\textbf{Bulk density}}{\textbf{Particle density}}\right)$ **X 100** **(Brady, 1974)**
- **Available water** $AW = \theta_{fc} - ?_{wp}$ **(%)** **(Fidalski et al., 2010)**

**Where:** $?_{fc}$ : field capacity at (- 0.33 bar) of suction pressure, (%).
$?_{wp}$ : wilting point at (- 15 bars) of suction pressure, (%).

- **Saturated hydraulic conductivity** $Ks = Q.L / ?H$ **(cm/h)** **(Zeineldin and Aldakheel, 2006)**

**Where:** $Q$ : steady state discharge, cm$^3$/h.
$L$ : distance between upper and lower points of the sample, cm.
$?H$ : change of the hydraulic head, cm.

- **Reference evapotranspiration** $ET_o = K_p\, E_{pan}$ **(mm/day)** **(Allen et al., 1998)**

**Where:** $K_p$ : pan coefficient ( $K_p$ = 0.6) at light wind speed < 2 m/s .
$E_{pan}$ : pan evaporation mm/day.

- **Crop evapotranspiration** $ETc = Kc_{FAO} \cdot ETo$ **(mm/day)** **(Allen et al., 1998)**

**Where:** $Kc_{FAO}$ : crop coefficient from FAO No.(56).
$ETo$ : reference crop evapotranspiration, mm/day.

Table (3) illustrate the growth periods (day) of the cucumber crop as established on initial stage, vegetative or development stage, flowering or mid-season and yield formation or late-season(**Allen et al., 1998**). They also showed the crop coefficient ($Kc_{FAO}$) and reference evapotranspiration (ETo) for different growth stages and total cucumber growth season.

**Table (3):** Period length (day), FAO crop coefficient ($Kc_{FAO}$), reference evapotranspiration (ETo) and crop evapotranspiration (ETc) of cucumber growth stages and total season. (Allen et al., 1998)

| Stages | Initial | Develop | Mid | Late | Total |
|---|---|---|---|---|---|
| **Period length (day)** | 20 | 30 | 40 | 15 | 105 |
| **$Kc_{FAO}$ (dimensionless)** | 0.60 | 1.00 | >> | 0.75 | -------- |
| **ETo (mm)** | 98.08 | 136.31 | 155.25 | 50.95 | 440.59 |
| **ETc (mm)** | 58.85 | 136.31 | 155.25 | 38.21 | 388.62 |

- **Leaching requirement** $LR = EC_w / (5\ (EC_e) - EC_w) \times 100$ **(%)** **Allen et al. (1998)**

**Where:** $ECw$ : electrical conductivity of the irrigation water, dS/m.
$ECe$ : average electrical conductivity of the soil solution extract, dS/m.

The amounts of applied irrigation water shown in Table (4) was calculated by using the equation:

- Applied irrigation water $IR_{1,2,3} = (ETo \,.\, Kc_{FAO} \,.\, Kr) / (Ea - R) + LR$ **(mm / period) (Doorenbos and Pruitt, 1984)**

**Where:** $Kr$ : correction factor for limited wetting at cucumber percent round coverage by canopy 80%, $Kr$ = 0.90. **(Smith, 1992).**
$Ea$ : irrigation efficiency for surface drip (85%) **(Allen et al., 1998).**
$R$ : effective rainfall, mm.
$LR$ : leaching requirements, (16%) (0.16 x ETc), mm.

- **Actual evapotranspiration** $ETa = (M_2\,\% - M_1\,\%) / 100 \,.\, d_b \,.\, D$ **(mm)** **(Doorenbos and Pruitt, 1984)**

**Where:** $M_2$ : moisture content after irrigation %.
$M_1$ : moisture content before irrigation %.
$d_b$ : specific density of soil .
$D$ : mean depth, mm.

**Table (4):** The amounts of applied irrigation water *IR* (mm/period) at different irrigation intervals *Int* (days) for all cucumber *(Cucumis sativus)* growth stages and total season under surface drip irrigation system.

| IS | IR (%) | Stages | | | | | | | | Seasonal | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Initial | | Develop. | | Mid season | | Late season | | | |
| | | from | to | from | to | from | to | from | to | from | to |
| | | 23/9 | 12/10 | 13/10 | 11/11 | 12/11 | 21/12 | 22/12 | 5/1 | 23/9 | 5/1 |
| Drip | $IR_1$ | 35.86 | | 83.07 | | 94.61 | | 23.29 | | 236.83 | |
| | $IR_2$ | 53.79 | | 124.60 | | 141.92 | | 34.93 | | 355.24 | |
| | $IR_3$ | 71.73 | | 166.14 | | 189.22 | | 46.57 | | 473.66 | |

$IR_1$ **(50%)** = ($IR$ x 0.50), $IR_2$ **(75%)** = ($IR$ x 0.75) and $IR_3$ **(100%)** = ($IR$ x 1.00)

- **Water use efficiency** $WUE = Ya / ETa$ **kg/m³** **(Giriappa, 1983)**

**Where:** $Ya$ : actual yield of the crop, (kg/fed).

- **Irrigation water use efficiency** $IWUE = Ya / IR$ **kg/m³ (Howell, 2001)**

**Where:** $IR$ : seasonal amounts of applied irrigation water, (m³),Table(4).

**6. Statistical analysis:**

Co-state software program & SPSS software program were used to analyse the data. **(Snedecor and Cochran, 1982).**

## RESULTS AND DISCUSSION

The values of bulk density $?_b$ (g/cm³), Total porosity $P_t$ (%), saturated hydraulic conductivity *Ks* (cm/h) and available water *AW* (%) at different organic matter rates *OMR*, organic matter decomposition *OMD* and compression levels *CR* are listed in table (5) for sandy soil depth of 0-15 cm and in table (6) for sandy soil depth of 15-30 cm.

### 1. Soil bulk density $?_b$ (g/cm³)

Table (5) shows that the bulk density $?_b$ (g/cm³) increases with the increase of organic matter rates. *OMR* for all compression levels *CR* and organic matter decomposition *OMD* while it decreases with the increase of *OMR* for non-compressed treatments. This decreases due to that the mass of organic matter lighter than sand. The data revealed that the values of ?$_b$ were significantly affected by changing *OMD* between 0 and 2 or 4 weeks. While, there were no significant difference between *OMD* 2 and 4 weeks these results at soil depth of 0-15 cm. the same trend was obtain at soil depth of 15-30 cm table (6). While, at soil depth of 30-45 cm *CR*, *OMR* and *OMD* has no effect on ?$_b$. This may be due to using a smooth roller to compressed soil.

**2. Saturated hydraulic conductivity *Ks* (cm/h)**

Tables (5&6) show that the saturated hydraulic conductivity *Ks* cm/h decreases with the increase of organic matter rates *OMR* for all compression levels *CR* and organic matter decomposition *OMD*. Also, the data revealed that the values of *Ks* were significantly affected by changing *OMD* between 0 and 2 or 4 weeks. While, there were no significant difference between *OMD* 2 and 4 weeks these results at soil depth of 0-15 cm. At soil depth of 30-45 cm *CR*, *OMR* and *OMD* has no effect on *Ks*.

**3. Available water *AW* (%)**

Table (5) shows that the relation between available water *AW* (%) and organic matter rates *OMR* ($m^3$/fed) at different compression levels *CR* (passes) and different organic matter decomposition *OMD* (weeks). Table (5) illustrate that the *AW* increases from 5.86 to 13.91 % at increase of *CR* from 0 to 8 passes at *OMR* 10 $m^3$/fed, at 20 $m^3$/fed *OMR* the maximum value of *AW* was 15.03 % at *CR* 6 passes and at 30 $m^3$/fed *OMR*.

The maximum value of *AW* was 15.95 % at *CR* 4 passes these results at *OMD* 0 weeks. While, at 2 weeks the results were differ, the maximum value of *AW* was 19.55 % at *CR* 6 passes and *OMR* 10 $m^3$/fed, at 20 $m^3$/fed *OMR* the maximum value of *AW* was 16.58 % at *CR* 4 passes and at 30 $m^3$/fed *OMR* the maximum value of *AW* was 16.04 % at *CR* 2 passes. Also, the data revealed that the values of *AW* were significantly affected by changing *OMD* between 0 and 2 or 4 weeks. While, there were no significant difference between *OMD* 2 and 4 weeks these results at soil depth of 0-15 cm. Table (6) show the same trend was obtund at soil depth of 15-30 cm. While, at soil depth 30-45 cm *CR*, *OMR* and *OMD* has no effect on *AW*. These results agreement with **Johnson (2010)** and **Yahya et al. (2010)**.

**Table (5): Bulk density $\rho_b$ (g/cm$^3$), total porosity $P_t$ (%), saturated hydraulic conductivity *Ks* (cm/h), and available water *AW* (%) at different organic matter rates *OMR* (m$^3$/fed), organic matter decomposition *OMD* (weeks) and compression levels *CR* (passes) for sandy soil depth of 0-15 cm.**

| *OMD* (weeks) | *CR* (Passes) | $\rho_b$ (g/cm$^3$) | | | $P_t$ (%) | | | *Ks* (cm/h) | | | *Aw* (%) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *OMR* (m$^3$/fed) | | | | | | | | | | | |
| | | 10 | 20 | 30 | 10 | 20 | 30 | 10 | 20 | 30 | 10 | 20 | 30 |
| 0 | 0 | 1.57 | 1.51 | 1.46 | 40.18 | 42.27 | 43.54 | 14.95 | 11.31 | 7.85 | 5.86 | 8.83 | 9.90 |
| | 2 | 1.69 | 1.80 | 1.92 | 35.87 | 30.91 | 25.71 | 10.97 | 8.58 | 2.47 | 7.58 | 10.67 | 13.36 |
| | 4 | 1.76 | 1.87 | 1.97 | 33.08 | 28.35 | 23.52 | 7.42 | 4.35 | 0.31 | 9.53 | 12.73 | 15.95 |
| | 6 | 1.82 | 1.95 | 2.04 | 30.80 | 25.16 | 21.06 | 4.69 | 1.87 | 0.09 | 11.65 | 15.03 | 10.62 |
| | 8 | 1.89 | 2.02 | 2.12 | 28.01 | 22.60 | 17.96 | 2.24 | 0.61 | 0.02 | 13.91 | 9.72 | 6.42 |
| 2 | 0 | 1.53 | 1.46 | 1.42 | 41.83 | 44.19 | 45.09 | 11.89 | 8.96 | 5.14 | 7.62 | 10.12 | 13.52 |
| | 2 | 1.75 | 1.83 | 1.94 | 33.59 | 30.01 | 24.80 | 7.52 | 5.41 | 1.32 | 10.36 | 13.08 | 16.04 |
| | 4 | 1.84 | 1.92 | 2.03 | 29.91 | 26.31 | 21.45 | 3.61 | 1.98 | 0.10 | 12.47 | 16.58 | 11.52 |
| | 6 | 1.93 | 2.03 | 2.12 | 26.49 | 22.35 | 17.96 | 1.15 | 0.19 | 0.02 | 19.55 | 14.31 | 8.73 |
| | 8 | 2.02 | 2.11 | 2.19 | 23.19 | 19.29 | 15.24 | 0.13 | 0.03 | 0.02 | 13.35 | 7.98 | 5.06 |
| 4 | 0 | 1.51 | 1.44 | 1.41 | 42.59 | 44.83 | 45.22 | 11.87 | 8.93 | 5.11 | 7.61 | 10.13 | 13.51 |
| | 2 | 1.76 | 1.85 | 1.95 | 33.08 | 29.25 | 24.55 | 7.50 | 5.39 | 1.29 | 10.36 | 13.07 | 16.04 |
| | 4 | 1.86 | 1.93 | 2.03 | 29.41 | 25.92 | 21.45 | 3.58 | 1.95 | 0.10 | 12.46 | 16.57 | 11.51 |
| | 6 | 1.94 | 2.05 | 2.14 | 26.24 | 21.46 | 16.92 | 1.12 | 0.19 | 0.02 | 19.56 | 14.30 | 8.74 |
| | 8 | 2.03 | 2.12 | 2.21 | 22.81 | 18.64 | 14.21 | 0.11 | 0.03 | 0.01 | 13.34 | 7.99 | 5.07 |
| LSD (0.05) | *OMR* | | 0.03 | | | 1.00 | | | 0.05 | | | 0.13 | |
| | *OMD* | | 0.03 | | | 1.00 | | | 0.05 | | | 0.13 | |
| | *CR* | | 0.03 | | | 1.30 | | | 0.07 | | | 0.17 | |
| | *OMR* OMD*CR* | | 0.18 | | | 6.74 | | | 0.34 | | | 0.86 | |

| ) | 20 | 30 | 10 | 20 | 30 | 10 | 20 | 30 | 10 | 20 | 30 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 51 | 1.56 | 1.50 | 38.91 | 40.23 | 41.86 | 14.83 | 11.26 | 7.82 | 5.79 | 8.81 | 9.85 |
| 55 | 1.72 | 1.81 | 37.39 | 34.10 | 29.72 | 10.91 | 8.51 | 2.43 | 7.52 | 10.57 | 13.31 |
| 71 | 1.79 | 1.89 | 34.85 | 31.55 | 26.87 | 7.34 | 4.29 | 0.29 | 9.43 | 12.66 | 15.92 |
| 78 | 1.87 | 1.98 | 32.19 | 28.48 | 23.38 | 4.62 | 1.83 | 0.08 | 11.57 | 14.95 | 10.44 |
| 32 | 1.94 | 2.06 | 30.80 | 25.67 | 20.03 | 2.18 | 0.59 | 0.02 | 13.87 | 9.64 | 6.38 |
| 57 | 1.49 | 1.45 | 40.18 | 42.78 | 43.67 | 11.85 | 8.89 | 5.09 | 7.55 | 10.04 | 13.46 |
| 70 | 1.78 | 1.86 | 35.36 | 31.93 | 27.91 | 7.46 | 5.37 | 1.27 | 10.29 | 13.01 | 15.98 |
| 79 | 1.87 | 1.94 | 31.94 | 28.35 | 24.93 | 3.52 | 1.91 | 0.09 | 12.41 | 16.51 | 11.46 |
| 37 | 1.95 | 2.05 | 29.03 | 25.16 | 20.67 | 1.08 | 0.14 | 0.02 | 19.49 | 14.25 | 8.71 |
| 96 | 2.06 | 2.14 | 25.48 | 20.94 | 17.18 | 0.10 | 0.01 | 0.01 | 13.24 | 7.92 | 4.99 |
| 58 | 1.47 | 1.43 | 39.92 | 43.55 | 44.45 | 11.83 | 8.87 | 5.07 | 7.56 | 10.04 | 13.45 |
| 72 | 1.79 | 1.87 | 34.73 | 31.29 | 27.65 | 7.42 | 5.34 | 1.25 | 10.29 | 13.00 | 15.98 |
| 31 | 1.89 | 1.95 | 31.18 | 27.46 | 24.55 | 3.49 | 1.89 | 0.08 | 12.40 | 16.51 | 11.44 |
| 39 | 1.96 | 2.06 | 28.27 | 25.03 | 20.03 | 1.09 | 0.14 | 0.02 | 19.48 | 14.27 | 8.69 |
| 98 | 2.08 | 2.15 | 24.84 | 20.31 | 16.79 | 0.08 | 0.01 | 0.01 | 13.24 | 7.91 | 4.98 |
|  | **0.03** |  |  | **1.03** |  |  | **0.05** |  |  | **0.14** |  |
|  | **0.03** |  |  | **1.03** |  |  | **0.05** |  |  | **0.14** |  |
|  | **0.04** |  |  | **1.33** |  |  | **0.06** |  |  | **0.18** |  |
|  | **0.18** |  |  | **6.89** |  |  | **0.33** |  |  | **0.94** |  |

**4. Cucumber actual yield and growth parameters:**

Figures. (1)-(9) show that the leaf area *LA* ($cm^2$), total soluble solid *TSS* (%), pH of juice *pH*, cucumber fruit length *L* (cm), cucumber fruit diameter *D* (cm) and actual yield (marketable cucumber fruit weight) *Ya* (ton/fed), Vs. intervals *Int* at different applied irrigation water *IR* for control and compressed soil treatments under surface drip irrigation system.

**4.1. Leaf area *LA* ($cm^2$):**

Fig.(1) revealed that the leaf area *LA* decreases with the increase of irrigation intervals *Int* while increases with the increase of applied irrigation water *IR* for control *CN* and compressed *CM* soil treatments. The maximum value of *LA* was 145.69 $cm^2$ at 100 % *IR* and 1 day *Int* if compared with that at control soil treatment *CN* the maximum value of *LA* was 139.25 $cm^2$ at 100 % *IR* and 1 day *Int*. These increasing may be attributed to the compression case produces good moisture distribution in the soil profile. The data revealed that the values of *LA* at *CM* treatment were significantly affected by changing *IR* between 50 and 75 or 100 %. While there was no significant difference between *IR* 75 and 100 % for all conditions under study. On the other hand the values of *LA* at *CN* treatment were significantly affected by changing applied irrigation water between 50, 75 and 100 %.

Also, the data revealed that the values of *LA* at *CM* treatment were significantly affected by changing *Int* between 1 or 2 and 4 days. While, there was no significant difference between *Int* 1 and 2 days. On the other hand the values of *LA* at *CN* treatment were significantly affected by changing *Int* between 1, 2 and 4 days.

**4.2. Total soluble solid *TSS* (%):**

Fig.(2) shows that the total soluble solid *TSS* decreases with the increase of irrigation intervals *Int* and increases with the increase of applied irrigation water *IR* for *CN* and *CM* soil treatments. The maximum value of *TSS* was 6.69 % at 100 % *IR* and 1 day *Int* if compared with that at *CN* treatment the maximum value of *TSS* was 6.42 % at 100 % *IR* and 1 day *Int*.

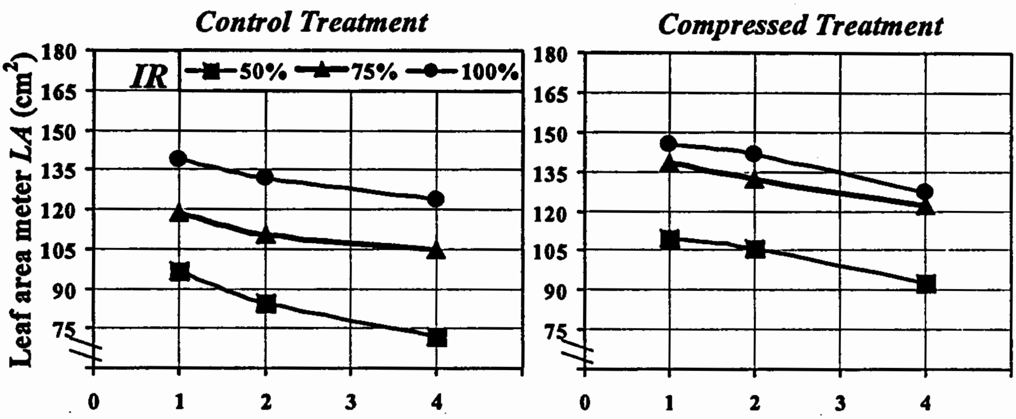


Fig.(1): Leaf area (*LA*, cm²) Vs. intervals (*Int*, days) at different applied irrigation water (*IR*, %) under control and compressed treatments *T* for surface drip irrigation system.

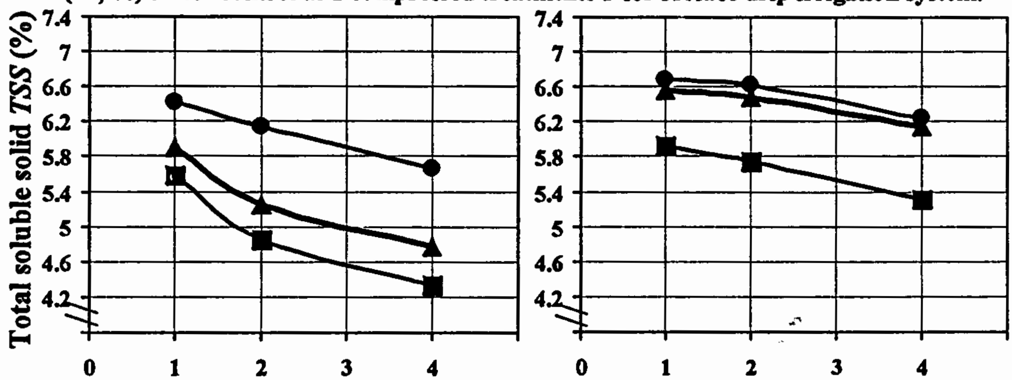


Fig.(2): Total soluble solid (*TSS*, %) Vs. intervals (*Int*, days) at different applied irrigation water (*IR*, %) under control and compressed treatments *T* for surface drip irrigation system.

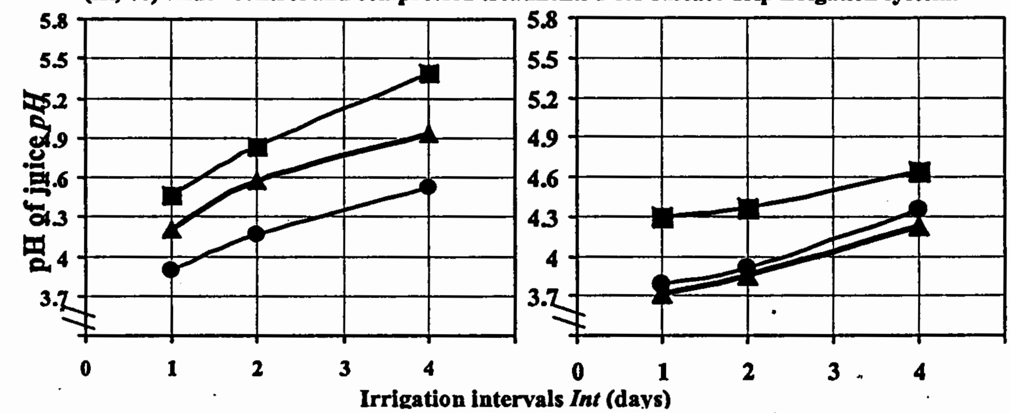


Fig.(3): pH of juice *pH* Vs. intervals (*Int*, days) at different applied irrigation water (*IR*, %) under control and compressed treatments *T* for surface drip irrigation system.

The data revealed that the values of *TSS* at *CM* treatment were significantly affected by changing *IR* between 50 and 75 or 100 %. While there was no significant difference between *IR* 75 and 100 % for all conditions under study. On the other hand the values of *TSS* at *CN* treatment were significantly affected by changing applied irrigation water between 50, 75 and 100 %. Also, the data revealed that the values of *TSS* at *CM* treatment were significantly affected by changing *Int* between 1 or 2 and 4 days. While, there was no significant difference between *Int* 1 and 2 days. On the other hand the values of *TSS* at *CN* treatment were significantly affected by changing *Int* between 1, 2 and 4 days. These results agreement with **Mady and Derees (2010).**

**4.3. pH of juice *pH* (-):**

Fig.(3) pointed out that the pH of juice *pH* increases with the increase of irrigation intervals *Int* and decreases with the increase of applied irrigation water *IR* for *CN* and *CM* soil treatments. The minimum value of *pH* was 3.72 at 75 % *IR* and 1 day *Int* if compared with that at *CN* treatment the minimum value of *pH* was 3.89 at 100 % *IR* and 1 day *Int*. The data revealed that the values of *pH* at *CM* treatment were significantly affected by changing *IR* between 50 and 75 or 100 %. While there was no significant difference between *IR* 75 and 100 % for all conditions under study. On the other hand the values of *pH* at *CN* treatment significantly affected by changing applied irrigation water between 50, 75 and 100 %. Also, the data revealed that the values of *pH* at *CM* treatment were significantly affected by changing *Int* between 1 or 2 and 4 days. While there was no significant difference between *Int* 1 and 2 days. On the other hand the values of *pH* at *CN* treatment were significantly affected by changing *Int* between 1, 2 and 4 days. These results according to **Granberry et al. (1994).**

**4.4. Cucumber fruit length *L* (cm):**

Fig.(4) shows that the cucumber fruit length *L* decreases with the increase of irrigation intervals *Int* and increases with the increase of applied irrigation water *IR* fot *CN* and *CM* soil treatments. The maximum value of *L* was 19.48 cm at 100 % *IR* and 1 day *Int* if compared with that at *CN* treatment the maximum value of *L* was 17.73 cm at 100 % *IR* and 1 day *Int*. The data revealed that the values of *L* at *CM* treatment were significantly affected by changing *IR* between 50 and 75 or 100 %. While there was no significant difference between IR 75 and 100 % for all conditions under study. On the other hand the values of *L* at *CN* treatment were significantly affected by changing applied irrigation water between 50, 75 and 100 %. Also, the data revealed that the values of *L* at *CM* treatment were significantly affected by changing *Int* between 1 or 2 and 4 days. While there is no significant difference between *Int* 1 and 2 days. On the other hand the values of *L* at *CN* treatment were significantly affected by changing *Int* between 1, 2 and 4 days.

**4.5. Cucumber fruit diameter *D* (cm):**

Fig.(5) mention that the cucumber fruit diameter *D* decreases with the increase of irrigation intervals *Int* and increases with the increase of applied irrigation water *IR* for *CN* and *CM* soil treatments. The maximum value of *D* was 13.05 cm at 100 % *IR* and 1 day *Int* if compared with that at *CN* treatment the maximum value of *D* was 11.83 cm at 100 % *IR* and 1 day *Int*. The data revealed that the values of *D* at *CM* treatment were significantly affected by changing *IR* between 50 and 75 or 100 %. While there was no significant difference between *IR* 75 and 100 % for all conditions under study.

On the other hand the values of *D* at *CN* treatment were significantly affected by changing applied irrigation water between 50, 75 and 100 %. Also, the data revealed that the values of *L* at *CM* treatment were significantly affected by changing *Int* between 1 or 2 and 4 days. While there was no significant difference between *Int* 1 and 2 days. On the other hand the values of *L* at *CN* treatment were significantly affected by changing *Int* between 1, 2 and 4 days. These results according to **Mady and Derees (2010).**

**4.6. Actual yield (marketable cucumber fruit weight) *Ya* (Ton/fed):**

Fig.(6) revealed that the actual yield *Ya* decreases with the increase of irrigation intervals *Int* and increases with the increase of applied irrigation water *IR* for *CN* and *CM* soil treatments. The maximum value of *Ya* was 27.71 ton/fed at 100 % *IR* and 1 day *Int* if compared with that at *CN* treatment the maximum value of *Ya* was 21.95 ton/fed at 100 % *IR* and 1 day *Int*. These increasing may be attributed to the soil compression case produces good moisture distribution in the soil profile.

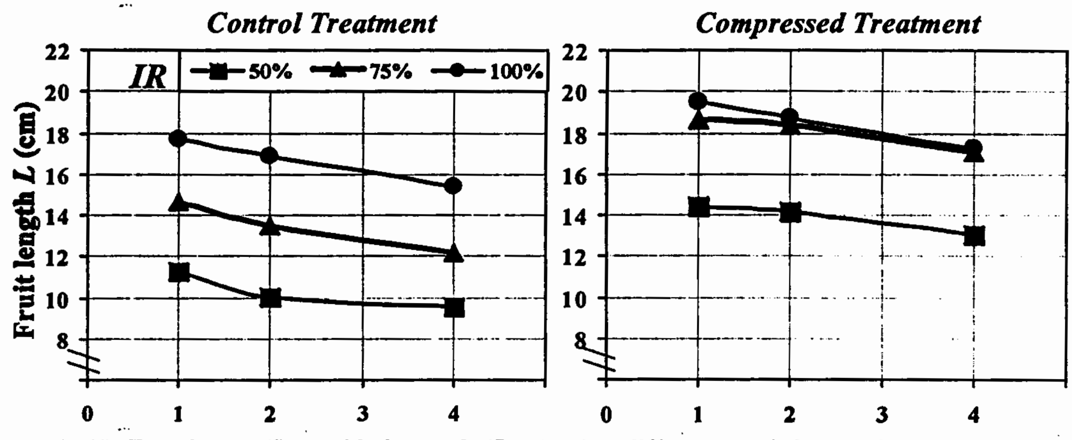


Fig.(4): Fruit length (*L*, cm) Vs. intervals (*Int*, days) at different applied irrigation water (*IR*, %) under control and compressed treatments *T* for surface drip irrigation system.

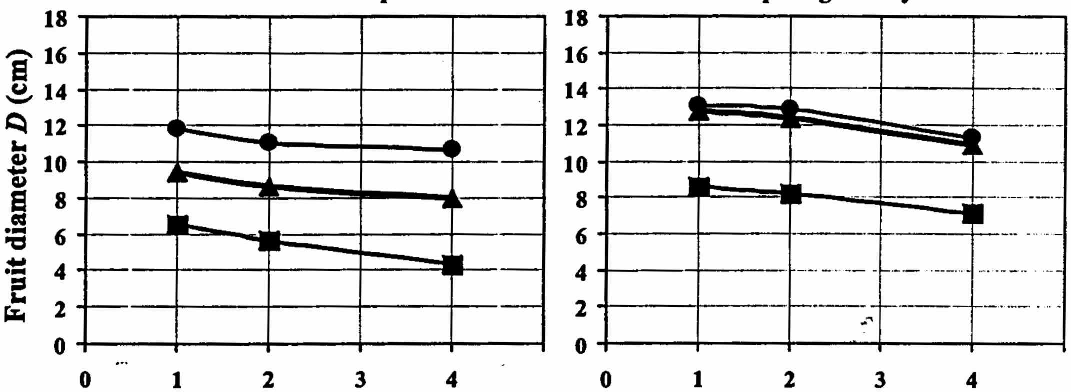


Fig.(5): Fruit diameter (*D*, cm) Vs. intervals (*Int*, days) at different applied irrigation water (*IR*, %) under control and compressed treatments *T* for surface drip irrigation system.

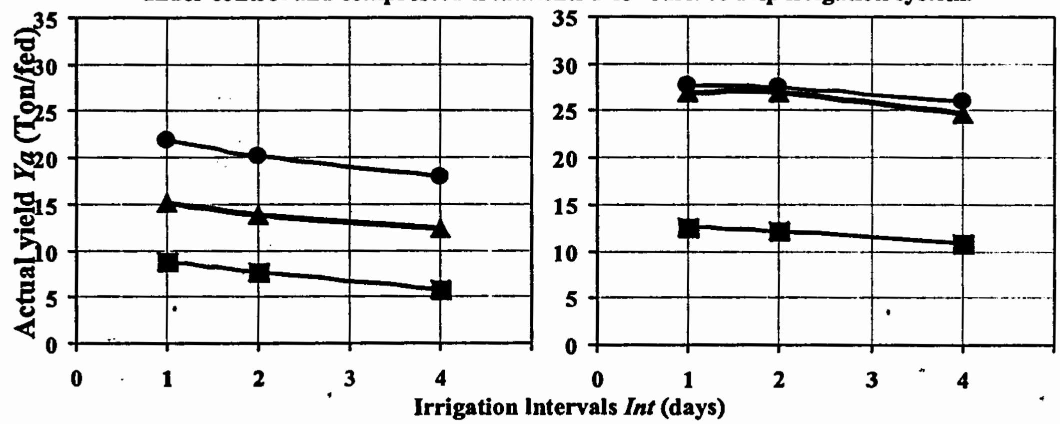


Fig.(6): Actual yield (marketable fruit weight) (*Ya*, Ton/fed) Vs. intervals (*Int*, days) at different applied irrigation water (*IR*, %) under control and compressed treatments *T* for surface drip irrigation system.

The data revealed that the values of *Ya* at *CM* treatment were significantly affected by changing *IR* between 50 and 75 or 100 %. While there was no significant difference between *IR* 75 and 100 % for all conditions under study. On the other hand the values of *Ya* at *CN* treatment were significantly affected by changing applied irrigation water between 50, 75 and 100 %. Also, the data revealed that the values of *Ya* at *CM* treatment were significantly affected by changing *Int* between 1 or 2 and 4 days. While there was no significant difference between *Int* 1 and 2 days. On the other hand the values of *Ya* at *CN* treatment were significantly affected by changing *Int* between 1, 2 and 4 days. These results agreement with **Arora et al. (2005) and Mady and Derees (2010).**

**5. Actual evapotranspiration *ETa* (mm):**

Fig.(7) shows that at *CM* treatment the maximum value of seasonal actual evapotranspiration *ETa* was 334.30 mm at 100 % *IR* and 4 days *Int* if compared with that at *CN* treatment the maximum values of seasonal *ETa* was 389.93 mm at 100 % *IR* and 4 days *Int*. These decreasing may be attributed to the water loss by evaporation from soils was less for the compacted surface than the friable surface layer. These results agreement with **Gromyko et al. (1970)** and **EL-Gindy et al. (1991).**

**6. Water use efficiency *WUE* (kg/m$^3$):**

Fig.(8) pointed out that the maximum value of water use efficiency *WUE* was 26.33 kg/m$^3$ at 75 % *IR* and 1 day *Int*, this result under *CM* treatment if compared with that at *CN* treatment the maximum value of *WUE* was 14.67 kg/m$^3$ at 100 % *IR* and 1 day *Int*. These results may be attributed to the increasing values of actual yield *Ya* (Ton/fed) and decreasing values of seasonal actual evapotranspiration *ETa* at *CM* treatment if compared with that at *CN* treatment. These results agreement with **Mady and Derees (2010).** The data revealed that the values of *WUE* at both treatment *CM* and *CN* were significantly affected by changing *IR* between 50, 75 and 100 %. Also, the data revealed that the values of *WUE* at *CM* treatment were significantly affected by changing *Int* between 1 or 2 and 4 days. While there was no significant difference between Int 1 and 2 days. On the other hand the values of *WUE* at *CN* treatment were significantly affected by changing *Int* between 1, 2 and 4 days. These results agreement with **Camp (1998).**

**7. Irrigation water use efficiency *IWUE* (kg/m$^3$):**

Fig.(9) mention that the maximum value of irrigation water use efficiency *IWUE* was 18.08 kg/m$^3$ at 75 % *IR* and 1 day *Int*, this result under *CM* treatment if compared with that at *CN* treatment the maximum value of *IWUE* was 11.03 kg/m$^3$ at 100 % *IR* and 1 day *Int*. The data revealed that

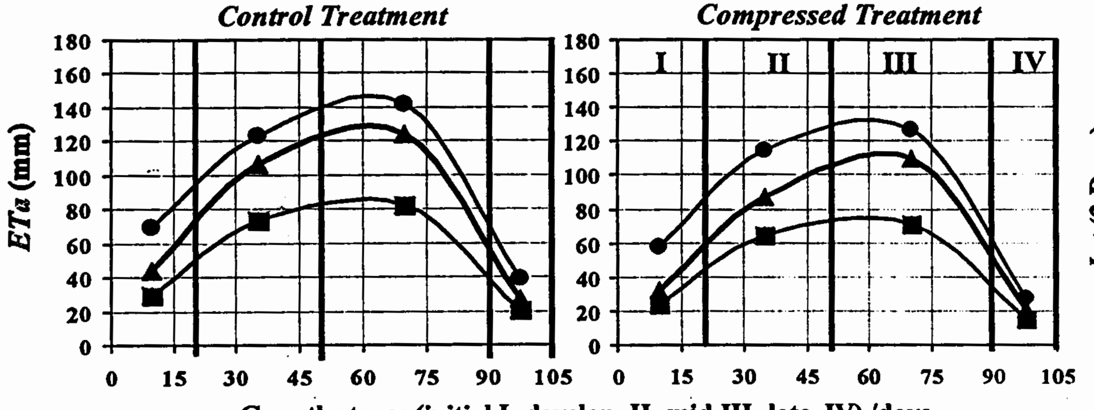


**Fig.(7): Actual evapotranspiration (*ETa*, mm) for all Growth stages (initial I- develop. II- mid III- late. IV) /days Vs. Intervals (*Int*, days) at different applied irrigation water (*IR*, %) under control and compressed treatments *T* for surface drip irrigation system.**

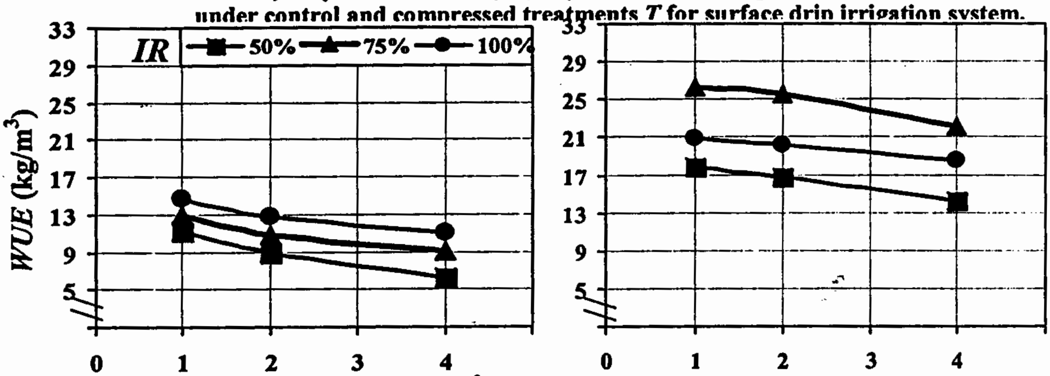


**Fig.(8): water use efficiency (*WUE*, kg/m$^3$) Vs. intervals (*Int*, days) at different applied irrigation water (*IR*, %) under control and compressed treatments *T* for surface drip irrigation system.**

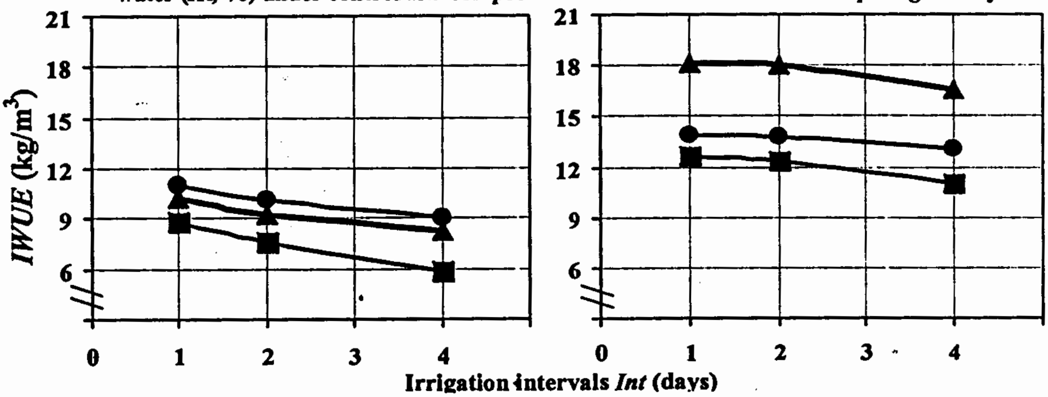


**Fig.(9): Irrigation water use efficiency (*IWUE*, kg/m$^3$) Vs. intervals (*Int*, days) at different applied irrigation water (*IR*, %) under control and compressed treatments *T* for surface drip irrigation**

the values of *IWUE* at both treatment *CM* and *CN* were significantly affected by changing *IR* between 50, 75 and 100 %. Also, the data revealed that the values of *IWUE* at *CM* treatment were significantly affected by changing *Int* between 1 or 2 and 4 days. While there was no significant difference between *Int* 1 and 2 days. On the other hand the values of *IWUE* at *CN* treatment were significantly affected by changing *Int* between 1, 2 and 4 days. These results according to **Simsek et al. (2005).**

## CONCLUSIONS

**It will be concluded that:**

1- Compressed soil treatment *CM*; 10 $m^3$/fed *OMR*, 2 weeks *OMD* and 6 passes *CR* double the *AW* compared with that at control soil treatment *CN*; 30 $m^3$/fed *OMR*, 0 passes *CR* and 0 weeks.

2- Such increase reached of *Ya* was 26.24 % under *CM* at 1 day *Int* and 100 % *IR* if compared with that under *CN* at the same treatment.

3- Such increase reached of *WUE* and *IWUE* were 79.41 and 63.92% respectively, under *CM* at 1 day *Int* and 75% *IR* if compared with that at *CN* at 1 day *Int* and 100% *IR*.

- So, it is recommended to use the compressed soil treatment *CM* at 2 days *Int* and 75% *IR* to save 20 $m^3$ *OMR* and save about 25% from *IR* to cultivate more sandy soil and increases interval frequency to 2 days instead of every day to save power.

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## الملخص العربي

## "تحسين الخواص المائية للتربة الرملية لمعظمة أنتاجية محصول الخيار تحت نظام الرى بالتنقيط "*

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أجريت هذه الدراسة خلال الموسم ٢٠١١ ــ ٢٠١٢ بمنطقة الصالحية الجديدة (الشرقية) والتى تهدف الى تحسين الخواص المائية للتربة الرملية وذلك بتقليل التسرب العميق (التوصيل الهيدروليكى المشبع) وزيادة نسبة الماء الميسرفى التربة الرملية وذلك بهدف زيادة أنتاجية محصول الخياروذلك بتطبيق ثلاثة معدلات أضافة من المادة العضوية (سماد المزرعة) (١٠ و ٢٠ و ٣٠ م٣/ فدان) وثلاث فترات تحلل للمادة العضوية (٠ و ٢ و ٤ أسابيع) تحت خمس مستويات من الأنضغاط (٠ و ٢ و٤ و٦ و ٨ مرات مرور) بهراس وزنه ١٠ طن وذلك لثلاث أعماق (٠-١٥ و ١٥-٣٠ و ٣٠-٤٥) وتم مقارنة أفضل معاملة يمكنها الأحتفاظ بأعلى نسبة من الماء المتاح بالمعاملة الكنترول (طريقة الزراعة العادية بدون أنضغاط أو فترات تحلل للمادة العضوية) وذلك بزراعتهما بمحصول الخيارتحت نظام الرى بالتنقيط السطحى وثلاث نسب (٥٠ و ٧٥ و ١٠٠ %) من كميات مياه الرى المضافة وثلاثة فترات رى ( ١ و ٢ و٤ أيام) لتحديد أنسب كمية مياه رى مضافة وأنسب فترة بين الريات تعطى أعلى أنتاجية للخيار بأقل أستهلاك مائى ممكن وتحديد أعلى كفاءة أستهلاك مائى وأعلى كفاءة أستهلاك أروائى تحت ظروف منطقة التجربة.

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١- أستاذ القوى والآلات الزراعية ــ كلية الهندسة الزراعية ــ جامعة الأزهر.
٢- أستاذ نظم المياه والرى - كلية الهندسة الزراعية ــ جامعة الأزهر.
٣-أستاذ باحث الأحتياجات المائية والأرصاد ــ مركز بحوث الصحراء- المطرية ــالقاهرة
٤- مهندس رى وصرف بشركة الفتح (*من الرسالة المقدمة للحصول على درجة الدكتوراه فى هندسة نظم المياه والرى - كلية الهندسة الزراعية ٢٠١٢).

وكانت أهم النتائج المتحصل عليها هي:

١- وجد أن الماء المتاح يزداد بزيادة الأنضغاط (عدد مرات مرور الهراس) وفترات تحلل المادة العضوية (بالأسابيع) بينما تقل قيمه بزيادة معدلات المادة العضوية (م٣/فدان) وذلك التأثيرعند الأعماق من (٠ – ١٥ & ١٥-٣٠ سم) فقط بينما لا يؤثر على العمق من (٣٠-٤٥ سم) وربما يكون السبب فى ذلك يرجع الى أستخدام هراس ذو أسطوانة ملساء وهذا النوع من المداحل يدمك الطبقة السطحية من التربة فقط دون العميقة مما يرفع من السعة الحقلية ومعامل الذبول للتربة وكانت أقصى قيمة للماء المتاح ١٩،٥٥ % وذلك عند معدل أضافة للمادة العضوية ١٠ م٣/فدان وفترة تحلل للمادة العضوية أسبوعين ومستوى أنضغاط ٦ مرات مرور بالهراس على التربة الرملية وتحت العمق (٠- ١٥ سم).

٢- وجد أن الكثافة الظاهرية تزاد بزيادة كل من معدلات المادة العضوية وفترات التحلل وعدد مرات مرور الهراس (أنضغاط التربة) وخاصة عند العمق (٠-١٥سم) والذى وجد أن الفرق كان معنويا بينه وبين العمق (١٥-٣٠ سم) وأنعدم التأثير على العمق (٣٠-٤٥ سم). ومن ناحية أخرى تقل قيم كل من التوصيل الهيدروليكى المشبع والمسامية الكلية بزيادة كل من معدلات المادة العضوية وفترات التحلل مرات و أنضغاط التربة .

٣- وبعد زراعة المعاملتين بمحصول الخيار وجد ان مساحة سطح الورقة ونسبة المواد الصلبة الذائبة الكلية وطول الثمرة وقطر الثمرة سجلوا أعلى قيمهم ١٤٥،٦٩ سم٢ و ٦،٦٩ % و ١٩،٤٨ سم و ١٣،٠٥ سم على الترتيب وذلك تحت معاملة التربة المضغوطة عند اضافة كمية مياه الرى ١٠٠ % وعند الرى كل يوم أذا ماقورنت بمعاملة التربة الغير الكنترول التى كانت أعلى قيمها ١٣٩،٢٥ سم٢ و ٦،٤٢ % و ١٧،٧٣ سم و ١١،٨٣ سم على الترتيب. بينما سجلت المعاملة المضغوطة أدنى قيمها عند قياس درجة الحموضة فى عصير الثمرة ٣،٧٢ عند كمية مياه ٧٥ % والرى كل يوم أذا ماقورنت بالمعاملة الكنترول كانت الحموضة ٣،٨٩ وذلك عند اضافة كمية مياه رى ١٠٠ % والرى يوميا .

٤- حققت معاملة التربة المضغوطة أعلى أنتاجية لمحصول الخيار ٢٧،٧١ طن/ فدان أذا ما قورنت بالمعاملة الغير منضغطة ٢١،٩٥ طن/ فدان وذلك عند اضافة كمية مياه رى كاملة ١٠٠ % والرى يوميا .

٥- سجل محصول الخيار أقصى أستهلاك مائى فعلى ٣٣٤،٣٠ مم /موسم تحت معاملة التربة المضغوطة وذلك عند اضافة كمية مياه رى ١٠٠ % والرى كل أربع أيام أذا ماقورنت بمعاملة التربة الكنترول والتى كان الأستهلاك المائى الفعلى عندها ٣٨٩،٩٣ مم /موسم عند تطبيق نفس المعاملة .

٦- سجل محصول الخيار أعلى كفاءة فى أستهلاك المياه وفى كفاءة أستهلاك مياه الرى ٢٦،٣٣ و ١٨،٠٨ كجم/ م$^{٣}$ على الترتيب تحت معاملة التربة المنضغطة وذلك عند اضافة كمية مياه رى ٧٥ % والرى يوميا أذا ماقورنت بالتربة الغير منضغطة ١٤،٦٧ و١١،٠٣ كجم/ م$^{٣}$ على الترتيب عند أضافة كمية مياه الرى كاملة ١٠٠ % والرى يوميا.

٧- وجد أن هناك زيادة معنوية فى قيم المحصول ومكوناته وكفاءة الأستهلاك المائى والأستهلاك الأروائى للمحصول نتيجة لتغييرفترات الرى من ١ و ٢ و٤ أيام وذلك تحت ظروف التربة الغير منضغطة بينما ليس هناك زيادة معنوية بين أستخدام فترة الرى ١ و٢ يوم وذلك تحت ظروف التربة المنضغطة.

- لذا ينصح بأستخدام أعلى معاملة يمكنها رفع نسبة الماء المتاح مع تقليل قيمة التوصيل الهيدروليكى المشبع للحد المناسب عند هذه القيمة وأفضل معاملة أنضغاط تم التوصل اليها من التجربة الحقلية الأولى هى (معدل أضافة للمادة العضوية ١٠ م$^{٣}$/فدان وفترة تحلل للمادة العضوية أسبوعين ومستوى أنضغاط ٦ مرات مرور بالهراس على التربة الرملية) وتسمى معاملة الأنضغاط والتى لا تصل الى حالة الدمك ويتم مقارنتها بالمعاملة الكنترول (معاملة الزراعة العادية) (معدل أضافة للمادة العضوية ٣٠ م$^{٣}$/فدان بدون فترة تحلل للمادة العضوية وبدون أى أنضغاط بالهراس) وزراعتهما بمحصول الخيار ومن الجدير بالذكر أن افضل معاملة أنضغاط لاتوفر نسبة أعلى من الماء المتاح فى قطاع التربة فحسب وانما توفر حوالى ٢٠ م$^{٣}$/فدان من المادة العضوية وهذا مايرفع من أقتصاديات هذه المعاملة.
- وينصح أيضا بأستخدام معاملة التربة المنضغطة عند كمية مياه رى ٧٥ % والرى كل يومين لأنها أقتصادية وأعطت أعلى أستهلاك مائى وأروائى حيث تقوم بتوفير ٢٥ % من ماء الرى المضاف مما يتيح للمزارع أستصلاح المزيد من الأراضى الصحراوية والحصول على أعلى أنتاجية بأقل أستهلاك مائى ممكن.