# Influence of Organic Wastes on Evaporation and Hydraulic Properties of Sandy Soil

Ahmed Farid Saad[1]

## ABSTRACT

**A laboratory experiments were conducted to examine the influence of various organic wastes on evaporation and some of hydro-physical properties of sandy soil collected from Al-Bustan region, Egypt. Five treatments: control, 1% of wheat straw, % clover straw, mixture of wheat & clover, and chicken manure on the basis of air dry weight of sandy soil (0.529 kg/m$^2$) were applied directly on soil surface. The same treatments were done with incorporation of organic wastes. Also, plastic mulch used in the two cases of applications as a tool for maximizing the role of organic wastes for reducing evaporation from surface layer of sandy soil. Soil samples were subjected to wet and dry cycles (1$^{st}$ experiment). In 2$^{nd}$ experiment was conducted to evaluate the role of organic wastes for improving the hydraulic properties of sandy soil. The average values of evaporation reduction percentages in case of addition organic wastes on surface of sandy soil, were 22%, 10.4%, 9.8% and 40%, 21.7%, 16.6% in chicken manure and clover straw(CS) treatments along wet and dry cycles in the first, second and third runs (2, 4 and 6 days intervals), respectively. The average values of evaporation reduction percentages, in case of incorporation organic wastes with sandy soil, were 21.3% and 31.7% in chicken manure and mixture of wheat and clover straw (WS+CS) treatments in the first run (2days intervals), respectively while it were (4.9%, 12.4%) and (1.1%, 5.4%) in chicken manure and (WS+CS) treatments in the second and third runs (4 and 6 days intervals), respectively. Using plastic mulch with surface application of organic wastes treatments (SAOWT) on sandy soil reduced the average daily evaporation rate by 21.54% to 35.97% while it reduced by1% to 15.6% in incorporated organic wastes treatments (IOWT) compared to control treatment. Linear equations with high $R^2$ are given to describe and quantify the relationship between evaporation rate and time in all cases of using plastic mulch. Organic wastes led to decrease the values of hydraulic conductivity in sandy soil. Determined values showed that $K_s$ decreased to 51%, 33% and 16.5%, respectively in WS+CS, CS and WS treatments compared to control. $K_s$ (t) for all treatments were fitted to 2$^{nd}$ order polynomial equation with high $R^2$. Basic infiltration rate values decreased substantially by about 33% in incorporated broad bean straw and chicken manure while it were decreased by about 78% and 50% in case of wheat and clover straw compared to control treatment, respectively. There was a lag time in wet front advance between organic wastes treatments and control treatment. The lag time was ranged between 20 and 7 minutes for clover straw and wheat straw treatments, respectively. Distribution of water content with depth of soil columns appeared the polynomial trend with high values of $R^2$. Incorporated sandy soil columns with clover straw and chicken manure increased the percentage of water holding capacity 20.1 and 15.2%, respectively compared to control treatment. There were highly significant differences between most of treatments.**

**Key words: Organic wastes, plastic mulch, Evaporation, Infiltration rate, wet front advance, water content, hydraulic conductivity.**

## INTRODUCTION

Water loss by evaporation and deep percolation represents the main problems in irrigation of the sandy soil. Hence, reducing evaporation rate and decreasing water loss through infiltration and deep percolation is always targeted in these highly-permeable sandy soils. Infiltration and soil evaporation are among the key processes that determine soil water availability to crops in semi arid agriculture.

Plastic mulches used in drought areas because it works as an insulating barrier which checks evaporation and limit water losses via the soil surface. Hatfield et al. (2001) reported a 34-50 per cent reduction in soil water evaporation as a result of crop residue mulching. Khurshid et al. (2006) and Muhammad et al. (2009) stated that mulching increases soil water contents and reduce infiltration rate. This means the mulch slows down evaporation and reduces the irrigation requirement. Mulches obstruct the solar radiation reaching to soil. The presence of crop residue mulch at the soil-atmosphere interface has a direct influence on infiltration of drip water or rainwater into the soil and evaporation from the soil. Mulch cover holds drip-water or rainwater at the soil surface thereby giving it more time to infiltrate into the soil. Straw mulch conserved higher soil moisture to an extent of 55 per cent more compared to control (Rajput and Singh, 1970). Mulching the soil surface reduce evaporation and increase the amount of water stored in the soil profile (Gardner, 1959). Hence, mulching favors the reduction of evaporation leading to higher soil moisture content. During summer, mulching conserves the soil moisture due to reduced evaporation. An experiment have been done to quantify the effect of three organic wastes

[1]Soil and Water Sciences Department, Faculty of Agriculture, Alexandria University, Alexandria, Egypt
E-mail: afarid.agr@gmail.com
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(shredded date palm leaf (*Phoenix dactylifera*), cereal straw, and pine bark) used as mulch on moisture retention in two soils with different textures, S1 (loam) and S2 (silty loam). The treatments were administered a day after soil saturation with water by covering each soil with 2 cm of mulch. Linear regressions were established to quantify the water loss over time in each treatment. The results show that all three organic by products was effective in reducing water loss in both soils, with significant differences observed between pine bark and the other two materials. The palm leaf was as effective as the cereal straw (Rico et al., 2016).

Field investigation was conducted on the effects of incorporating different rates of poultry waste and green yard manure (GYM) on the porosity and infiltration rates of sandy loam soil at three levels of application, namely: 0.75, 1.25 and 1.75kg, representing 30, 50 and 70T/ha, respectively. The infiltration rates of the samples were measured after one week using the double ring infiltrometer while the porosity was calculated from direct measurements of total and void volumes. The result showed that 30 and 50T/ha of GYM exhibited lower infiltration rates than the ordinary sandy loam soil while samples of poultry wastes had higher infiltration rates than both the control soil and the GYM. The highest mean rate of infiltration (6.03cm/min) was exhibited by the lowest rate of application of poultry waste (30T/ha), while it was the reverse situation for GYM amendment, (2.67cm/min for 30T/ha). Porosity was also highest with the highest level of poultry waste application. From this investigation GYM amendment is recommended to check excessive infiltration while both poultry waste and GYM can be used for the improvement of porosity of compacted sandy loam soil (Essien, 2011).

Mulching has been advocated as an effective means for conserving soil moisture (Bhardwaj and Sarolia, 2012). The conservation of soil moisture through mulching is one of the important purposes. When soil surface is covered with mulch helps to reduce evaporation and increase soil infiltration rate. Plastic mulch helps prevent soil water loss during dry years. Crop residues or mulch at the soil surface act as shade; serve as a vapour barrier against moisture losses from the soil, causing slow surface runoff. Rathore et al. (1998) reported that more water conserves in the soil profile during the early growth period with straw mulch than without it. Higher water use efficiency was caused by lower evaporation in *Rosa indica* by using black polythene sheet (0.18 mm thick) as mulch (Rodrigues et al., 1999).

Recycled organics are applied to soils as either surface applications or through soil incorporation, with mulches (in raw form or as processed products) best applied to soil surfaces. Soil improvement and soil amendment with recycled organics have been associated through changes to soil properties and functions, including: reduced evaporation, increased water infiltration, increased water holding capacity, improved soil structure and promotion of plant growth (Waste Authority Information, 2010).

Where a mulch layer is applied, it changes the rate of evaporation from a soil surface. A mulch layer will partially protect a soil from exposure to solar radiation and air movements, both of which cause evaporative losses. This slowing of soil moisture loss has consequent benefits to other soil properties, including the capacity of a soil to allow infiltration and drainage of water, especially on non-wetting soils and through reducing surface crusting. Mulches can also improve the ability of a soil to support plant growth through improving the topsoil moisture status. Hence, mulch application is more likely to allow higher total water infiltration per unit of land area, when compared to non-mulched areas (Waste Authority Information, 2010).

The capacity to hold water within a soil profile against the force of gravity relates to the texture of a soil and the level of organic matter. Research into the relationship between soil organic matter and water holding capacity is indicates it is difficult to provide general trends for finer textured soils. However, research provides good evidence that organic matter has a positive effect on water holding capacity in sandy soils and under many circumstances this translates into increase water availability for plants (Waste Authority Information, 2010).

Both soil surface application and soil incorporation of suitable recycled organics can affect directly or indirectly the potential for water use efficiency improvements associated with urban and agricultural landscapes. Mulches applied to soil surfaces should reduce evaporation from soil and allow water to pool for longer at the soil surface (to assist water infiltration). Soil incorporation of suitable recycled organics can increase the water holding capacity of courser textured soils (such as sandy soils). (Waste Authority Information, 2010).

Mulching is one cultural practice which can be used to reduce water needs. Using certain agricultural by products as mulch is a sustainable practice which can provide other benefits as well as improving soil. Wheat straw, grass clippings, and leaf debris are fairly abundant byproducts which can be used as mulch. An experiment was conducted to determine which of these readily available mulching materials would be best at conserving soil moisture, and at which thicknesses, 5, 10, and 15 cm. Soil water content was monitored every three days for a duration of three weeks, when no discernable differences were measured. Within the first 3 days, a mulch layer of at least 5 cm reduced surface evaporation to 40% compared to the water losses from bare soil, and all mulch types were equally effective. While there were no differences between the mulch types, the mulching rate did have a significant effect on water loss. Doubling the mulching rate from 5 cm to 10 cm maintained soil moisture 10% higher throughout most of the experiment. However, increasing the rate further to 15 cm had no discernible effect (Michael McMillen, 2013). The main target of the research work presented in this article was to examine the effect of the crop residues on evaporation and some hydraulic properties of sandy soil.

## MATERIALS AND METHODS

### 1. Soil sampling and analyses

The soil of the study area (Al-Bustan region, Egypt) was classified as *Typic torripsamments* (Labib and Khalil, 1977). Undisturbed soil samples were collected from different sites of the study area; air dried and sieved through a 2 mm screen. Soil pH, ECe, $CaCO_3$ and total organic matter values were 8.3, 1.2 $dS.m^{-1}$ , 2.4% and 0.5%, respectively. The textural class was sand with 95% sand, 3% silt, and 2% clay. Dry bulk density was (1.65 $Mg.m^{-3}$) determined by core method (Black and Hartge, 1986). Particle size distribution was determined by the Bouyoucos hydrometer method (Bouyoucos, 1962). Total salt, $_P{}^H$ and calcium carbonate content were determined by the procedures outlined in (Page *et al*., 1982). Soil organic matter (OM) was determined by 'Walkely- Black 'method (Nelson and Sommers, 1982).

### 2. 1st Laboratory experiment (Determination of water losses by evaporation from sandy soil amended with organic materials).

First part of Laboratory experiment has been conducted to reduce evaporation from surface layer of sandy soil under different three runs of wetting and drying cycles. 60 plastic cylinders with 6 inches" diameter and 1.5 inches" height were prepared. Each cylinder packed with 1 kg of air dry sand with bulk density 1.65 $Mg.m^{-3}$. 1% of wheat straw, clover straw, (wheat+ clover straw), and chicken manure, on air dry weight basis (0.529 $kg/m^2$), were applied as mulches on surface of sandy soil to 12 cylinders plus 3 ones as a control treatment (without any addition of organic wastes) for each run of wetting and drying cycles. The thickness of mulch layers were 1, 2, 1.5 and 0.4 cm for wheat straw, clover straw, (wheat+ clover straw), and chicken manure, respectively. Also, another 15 cylinders prepared as mentioned above were covered, tightly with dark plastic sheet placed at a distance of 1.2 cm above soil surface. Plastic mulch was used as a barrier for reducing evaporation and check if it can used also as a support material for maximizing the role of organic wastes in minimizing evaporation rate from sandy soil. In the second part of this experiment was to study the effect of incorporated organic wastes, mentioned above on evaporation rate of sandy soil. For this purpose the same quantities of organic wastes were incorporated into 48 cylinders homogenously plus 12 cylinders were as control treatments (without adding organic wastes for each run). Another 15 cylinders were covered with dark plastic sheet as described, previously. Three replicates for each treatment were done under 2 days, 4 days and six days intervals from saturation represented as 1st, 2nd and 3rd runs, respectively during the study period. Evaporation in cubic centimeter (cc) per kg of sand for each wet and dry cycle was calculated by the difference of weighing after 2, 4 and 6 days intervals from saturation.

### 3. 2nd experiment was for: Determination of hydraulic properties of sandy soil incorporated with organic wastes.

### 3.1. Saturated hydraulic conductivity (Ks)

The first part of the second laboratory experiment was conducted to study the effect of incorporated organic wastes on saturated hydraulic conductivity (Ks). 1% of wheat straw, 1% clover straw, 1% (wheat+ clover straw), and 1% chicken manure, on air dry weight basis incorporated with sandy soil and 12 PVC columns with 2 inches diameter and 4 inches height packed at bulk density 1.65 Mg $m^{-3}$ plus 3 columns packed only with sandy soil as a control treatment. Soil columns were saturated by capillary rise. Ks was determined by the constant head method according to Klute and Dirksen (1986) and calculated by using Darcy's law. Saturated hydraulic conductivity, for each treatment was determined through 12 wetting runs (7days interval).

### 3.2. Infiltration Rate (I), Cumulative Infiltration (Z), Wet Front Advance and Distribution Moisture Content

The 2nd part of the second experiment was conducted to study the effect of incorporated organic wastes on infiltration rate, wet front advance and distribution of moisture content in sandy soil. 1% of wheat straw, 1% clover straw, 1% Bean straw, and 1% chicken manure, on air dry weight basis incorporated with sandy soil and packed in 4 transparent soil columns (3.25 inches diameter and 20 inches height) plus one column for control treatment(packed with sandy soil, only). Infiltration rate was determined as the depth of water infiltrating into the soil column per unit time and cumulative time was calculated. Infiltration curves were constructed and fitted to the infiltration equation described by Kostiakov-Lewis relationships (Kostiakov, 1923; Lewis, 1937). The infiltration rate-time functions were expressed by equations that took the form $I = kt^{a-1}$, Where I is the infiltration rate, measured after a time interval, t, from the start of the infiltration process, and (k and a) are empirical constants. Since a is always less than unity and I approaches zero at infinite time. The simplest approximation of cumulative infiltration (Z) is written as follows: $Z= kt^{a}$. Wet front advance was measured in cm vs. accumulated time in minutes in sandy soil columns. After drainage water ceased the soil columns were divided to 5 cm length and moisture content on weight basis was determined according to (Standards Association of Australia, AS 1289 B1.1-1977).

**4. Data analysis**

The differences between the treatments were analyzed using three-way and two-way analysis of variance (ANOVA) followed by a t-test for least significant differences (LSD) at $P < 0.05$.

## RESULTS and DISCUSSION

**1. Effect of organic wastes (plant residues) as a surface mulching on evaporation rate.**

Effect of applied surface organic wastes (plant residues) on evaporation from sandy soil subjected to 7 of wet and dry cycles (1st run, 2days interval), 6 cycles (2nd run, 4 days interval) and 7 cycles (3rd run, 6 days interval) are illustrated in Table 1 and Figure 1. In general, organic wastes applied as a surface amendment to sandy soil reduced the amount of water loss by evaporation compared to control treatment under all runs of wet and dry cycles. Water lost by evaporation was in ascending order was as follows: clover straw (CS), mixture of wheat and clover straw (WS+CS), wheat straw only (WS) and chicken manure when organic wastes were used as a surface mulching in sandy soil. Evaporation from sandy soil under different treatments has been affected by the change of intervals of wet and dry cycles in the runs as shown in Table 1. The results showed that when, the sandy soil exposed to wet and dry cycles with 6 days interval (3rd run) the function of organic wastes applied as surface barrier to reduce water loss by evaporation can be negligible. The variations and fluctuations in values of evaporation inside each run were due to changes in weather conditions in the laboratory during the period of experiment. The average values of evaporation reduction percentage ranged between about 22%, 10.4%, 9.8% and 40%, 21.7%, 16.6% in chicken manure and clover straw(CS) treatments along wet and dry cycles in the first, second and third runs (2, 4 and 6 days intervals), respectively.

**2. Effect of incorporation of organic wastes (plant residues) on evaporation from sandy soil**

The values of evaporation reduction as a result of incorporation organic wastes (plant residues) to sandy soil which has subjected to runs of wet and dry cycles (1st run, 2days interval, 2nd run, 4 days intervals and 3rd run, 6 days intervals) are shown in Table 2 and Figure 2. In general, organic wastes incorporated with sandy soil reduced the amount of water loss by evaporation compared to control treatments under all runs of wet and dry cycles. Reduction of evaporation was in descending order as follows: chicken manure, wheat straw only (WS), clover straw (CS) and mixture of wheat and clover straw (WS+CS) when organic wastes were incorporated with sandy soil. Evaporation from sandy soil under different treatments has been affected by the change of intervals of wet and dry cycles in the runs as shown in table 2. The results showed that the effect of incorporated organic wastes in reducing evaporation were very close together in the 3rd run as the sandy soil exposed to alternative wet and dry cycles of 6 days interval (Figure 2: C). The average values of evaporation reduction percentage were ranged between 21.3% and 31.7% in chicken manure and mixture of wheat and clover straw (WS+CS) treatments in the first run (2days intervals), respectively while it were ranged between (4.9%, 12.4%) and (1.1%, 5.4%) in chicken manure and (WS+CS) treatments in the second and third runs (4 and 6 days intervals), respectively. It was concluded that irrigation intervals should be not more than 2 days to extend the effective role duration of organic wastes (plant residues) when it used as surface mulch or incorporated to reduce the evaporation from sandy soil. This means that the addition of organic wastes as a barrier to delay and reduce evaporation from surface layer of sandy soil will be more useful under drip irrigation and green houses than surface irrigation.

**3. Effect of plastic mulch on evaporation from sandy soil**

The effect of plastic mulch on evaporation in case of surface application and incorporation organic wastes in sandy soil are given in Table2. The data in Table2 show that small amount of water lost by evaporation when plastic mulch was used as barrier cover soil surface in all treatments includes control treatment.

Data in Table 2 and Figure 3 showed the effect of using transparent plastic sheet as a mulch and barrier on reduction of evaporation from surface layer of sandy soil in control treatments (without addition of organic wastes). The Figure 3 shows that there was high regular reduction rate in evaporation over the period of one month,

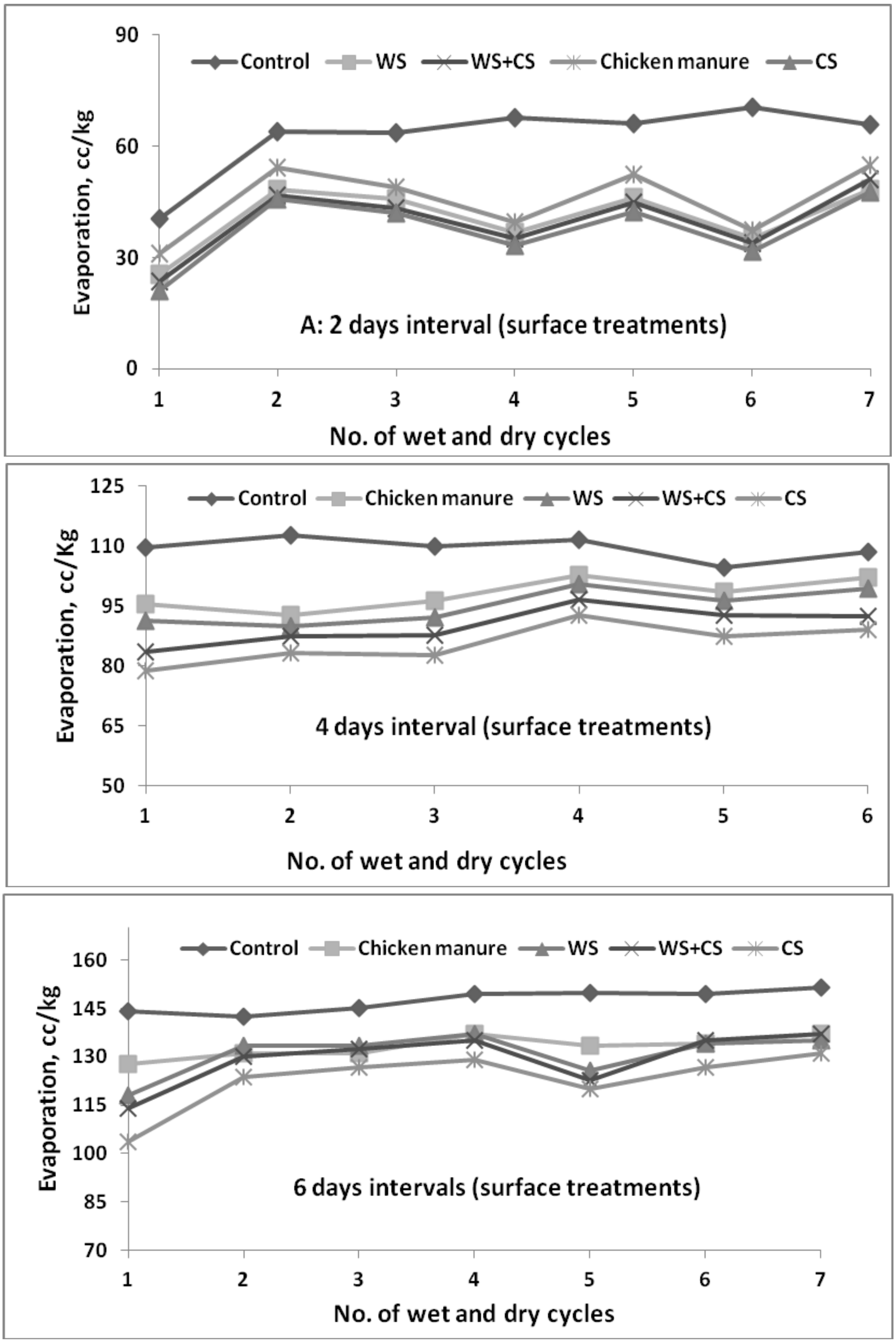


**Fig. 1 . Effect of surface addition of organic wastes on evaporation: A (2days interval), B (4 days intervals) and C (6 days interval)**

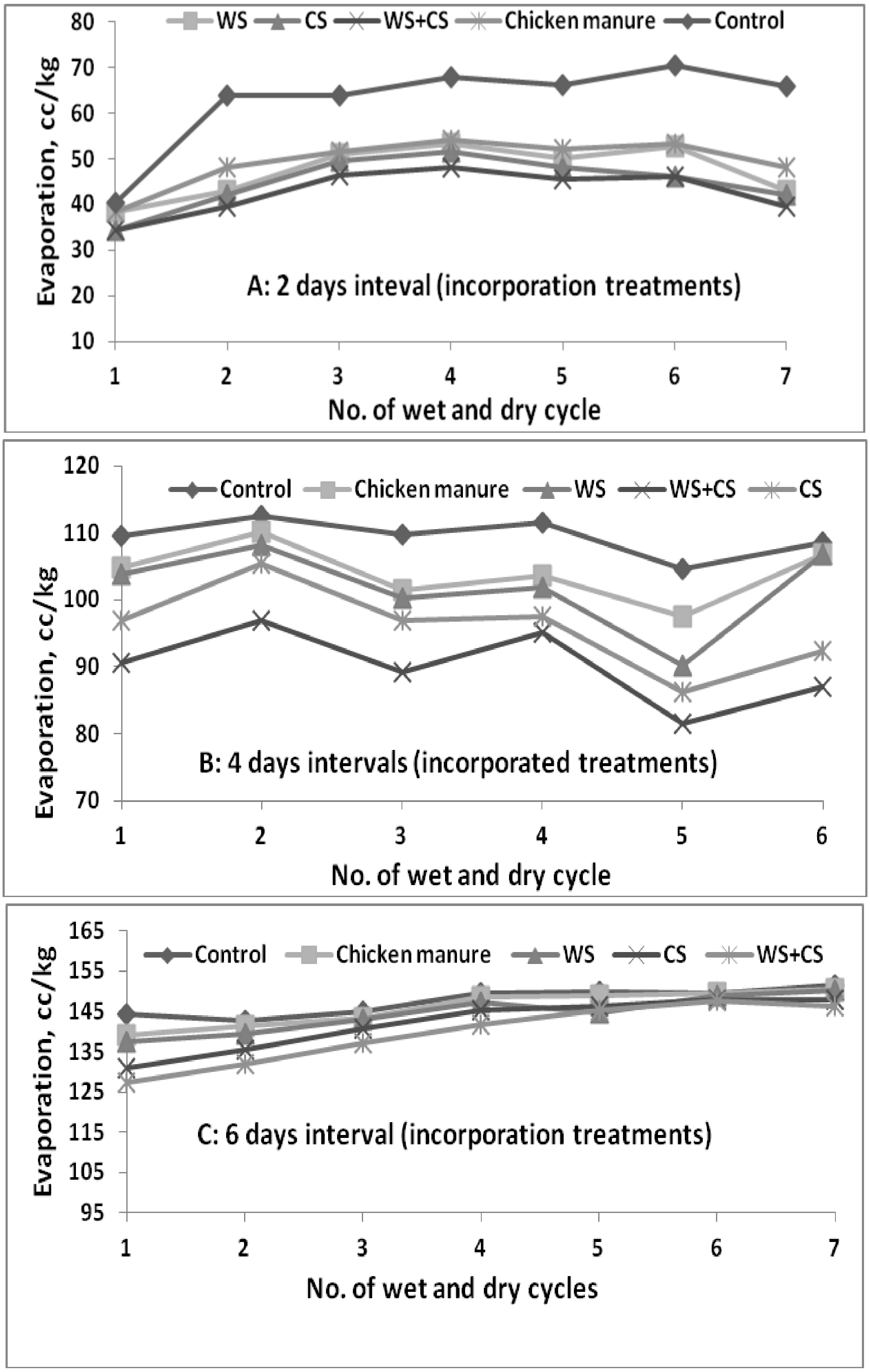


**Fig.2. Effect of incorporated organic wastes on evaporation: A (2days interval), B (4 days intervals) and C (6 days interval)**

**Table 1. Effect the type and application of organic materials (plant residues) on evaporation from sandy soil subjected to wet and dry cycles with different time intervals**

| Evaporation, cc/kg | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **application of organic materials** | | | | | | | | | | |
| **First run, 2 days intervals** | | | | | | | | | | |
| | **Surface applications** | | | | | **Incorporation** | | | | |
| **N.of cycles** | **Con.** | **Ch.M.** | **WS** | **WS+CS** | **CS** | **Con.** | **Ch.M.** | **WS** | **WS+CS** | **CS** |
| 1 | 40.4 | 31 | 25.4 | 23.6 | 21 | 40.4 | 38.4 | 38.4 | 34.4 | 34.4 |
| 2 | 64.4 | 54.4 | 48.4 | 46.8 | 45.8 | 64.4 | 48 | 43 | 39.6 | 42 |
| 3 | 63.8 | 49 | 45.8 | 43.4 | 42 | 63.8 | 51.6 | 51 | 46.4 | 49.6 |
| 4 | 67.8 | 39.4 | 36.8 | 35 | 33.4 | 67.8 | 54 | 53.2 | 48 | 51.6 |
| 5 | 66.2 | 52.4 | 46 | 45 | 42.4 | 66.2 | 52 | 50 | 45.4 | 48 |
| 6 | 70.6 | 74.8 | 35 | 34 | 31.8 | 70.6 | 53.2 | 52.8 | 46 | 46 |
| **2nd run, 4 days intervals** | | | | | | | | | | |
| **No. of cycles** | **Con.** | **Ch.M.** | **WS** | **WS+CS** | **CS** | **Con.** | **Ch.M.** | **WS** | **WS+CS** | **CS** |
| 1 | 109.6 | 95.6 | 91.4 | 83.6 | 78.8 | 109.6 | 104.8 | 103.8 | 96.8 | 90.6 |
| 2 | 112.6 | 92.6 | 90 | 87.4 | 83.4 | 112.6 | 110.2 | 108.2 | 105.4 | 96.8 |
| 3 | 109.8 | 96.4 | 92.2 | 87.6 | 82.6 | 109.8 | 101.4 | 100.2 | 96.8 | 89.2 |
| 4 | 111.6 | 102.6 | 100.4 | 96.6 | 92.8 | 111.6 | 103.6 | 101.8 | 97.4 | 95.2 |
| 5 | 104.6 | 98.4 | 96.2 | 92.6 | 87.4 | 104.6 | 97.4 | 90.2 | 86.2 | 81.4 |
| 6 | 108.6 | 102.2 | 99.4 | 92.4 | 89.2 | 108.6 | 106.8 | 106.8 | 92.4 | 87 |
| **3rd run, 6 days intervals** | | | | | | | | | | |
| **No. of cycles** | **Con.** | **Ch.M.** | **WS** | **WS+CS** | **CS** | **Con.** | **Ch.M.** | **WS** | **WS+CS** | **CS** |
| 1 | 144.2 | 127.6 | 118.2 | 114.2 | 103.6 | 144.2 | 139 | 137.4 | 127.4 | 131 |
| 2 | 142.6 | 131.2 | 133.6 | 130.2 | 123.6 | 142.6 | 141.2 | 139.4 | 131.8 | 135.6 |
| 3 | 145 | 131 | 133.6 | 132.6 | 126.6 | 145 | 143.4 | 143 | 137 | 140.6 |
| 4 | 149.6 | 137 | 137 | 135.2 | 129 | 149.6 | 148.6 | 147.4 | 141.6 | 145.4 |
| 5 | 149.8 | 133.6 | 125.8 | 122.6 | 120.2 | 149.8 | 149 | 144.6 | 145.2 | 146.2 |
| 6 | 149.6 | 134.2 | 134.2 | 135.2 | 126.6 | 149.6 | 149.6 | 149 | 147.6 | 148 |
| $LSD_{0.05}$ | Application methods =1.73 | | | Organic materials= 2.73 | | | Intervals = 2.11 | | | |

| ANOVA | F-test | ANOVA | F-test |
|---|---|---|---|
| Main Effects: | | Interaction: | |
| Application methods (A.M.) | *** | A.M. x O.M. | *** |
| Organic materials (O.M.) | *** | A.M. x I | *** |
| Intervals (I) | *** | O.M. x I | * |
| | | A.M. x O.M. x I | ns |

WS= Wheat straw, CS= Clover straw, Ch.M. = Chicken manure, Control= Unameneded treatments
*, **, ***: significant at 0.05, 0.01, and 0.001, respectively. ns: non significant

as an one run, from moist to dry situation in treatment was covered with plastic mulch, only compared to the amount of evaporation from control treatment without using plastic mulch and subjected to alternative runs of wet and dry cycles (1st run, 2days interval, 2nd run, 4 days intervals and 3rd run, 6 days intervals),as previously mentioned.

The evaporation rate was increased with time so, there was a significant difference between the two control treatments particularly, when the interval period was increased. It's better to use plastic mulch as a barrier for reducing evaporation from surface sandy soil than using organic wastes (plant residues) if the irrigation interval was more than two days. Using plastic mulch saved about 42%, 51% and 58% of soil moisture lost by evaporation from surface layer of sandy soil compared to control without using plastic mulch and unameneded with organic wastes under 2, 4, 6 days of wet and dry cycles, respectively.

**Table 2. The effect of plastic mulch on evaporation, cc/kg under two application methods of organic wastes**

**Evaporation, cc/kg using plastic mulch**

**A: surface application method**

| Time, days | Control Uncovered | Control Covered | WS+CS | CS | Ch.M. | WS |
|---|---|---|---|---|---|---|
| 2 | 40.4 | 21 | 2.6 | 4 | 4 | 7.4 |
| 4 | 64.4 | 26 | 4.4 | 7.4 | 5.6 | 10.6 |
| 6 | 63.8 | 30.8 | 6.6 | 9 | 7.4 | 12.6 |
| 8 | 67.8 | 32.4 | 8.4 | 10.6 | 9 | 13.8 |
| 10 | 66.2 | 35 | 10.6 | 14.4 | 11 | 15.4 |
| 12 | 70.8 | 37 | 12.4 | 16 | 11.6 | 20 |
| 14 | 65.8 | 44.2 | 14.4 | 17.8 | 14.4 | 21.8 |
| 16 | 112.6 | 48.4 | 15.6 | 19.4 | 16 | 23.4 |
| 18 | 109.8 | 50.2 | 17.4 | 21 | 17.8 | 25.8 |
| 20 | 111.6 | 51.8 | 19 | 22.8 | 20 | 29.4 |
| 22 | 104.6 | 55.2 | 21 | 23 | 22.8 | 31.8 |
| 24 | 108.6 | 57.4 | 22.8 | 27.8 | 24.4 | 35.6 |
| 26 | 142.6 | 59.4 | 24.4 | 30 | 27.4 | 36 |
| 28 | 145 | 62.4 | 26 | 32.4 | 30 | 38.4 |
| 30 | 149.8 | 62.8 | 27.8 | 34 | 31.8 | 39.4 |

**B: Incorporation method**

| Time, days | Control Uncovered | Control Covered | WS+CS | Ch.M. | CW | WS |
|---|---|---|---|---|---|---|
| 2 | 40.4 | 21 | 18.1 | 18.7 | 20.8 | 22.6 |
| 4 | 64.4 | 26 | 22.9 | 23.4 | 26 | 26.2 |
| 6 | 63.8 | 30.8 | 27.1 | 27.4 | 30.4 | 31 |
| 8 | 67.8 | 32.4 | 28.2 | 28.9 | 32.1 | 33.2 |
| 10 | 66.2 | 35 | 30.8 | 31.2 | 34.7 | 37 |
| 12 | 70.8 | 37 | 32.3 | 33.1 | 36.8 | 37.9 |
| 14 | 65.8 | 44.2 | 39.1 | 39.6 | 44.0 | 44.8 |
| 16 | 112.6 | 48.4 | 43 | 43.3 | 48.1 | 48.4 |
| 18 | 109.8 | 50.2 | 44.2 | 44.9 | 49.9 | 50.4 |
| 20 | 111.6 | 51.8 | 45.7 | 46.2 | 51.3 | 51.9 |
| 22 | 104.6 | 55.2 | 48.3 | 49.1 | 54.6 | 55.4 |
| 24 | 108.6 | 57.4 | 51.0 | 51.3 | 57.0 | 58.1 |
| 26 | 142.6 | 59.4 | 52.1 | 52.6 | 58.4 | 60.2 |
| 28 | 145 | 62.4 | 54.3 | 55.1 | 61.2 | 62.8 |
| 30 | 149.8 | 62.8 | 55.1 | 55.6 | 61.8 | 63.7 |

$LSD_{0.05}$ Application methods = 0.48 OM = 0.83 Time = 1.31

| ANOVA | F-test | ANOVA | F-test |
|---|---|---|---|
| Main Effects: | | Interaction: | |
| Application methods (A.M.) | *** | A.M. x O.M. | *** |
| Organic materials (O.M.) | *** | A.M. x T | *** |
| Time (T) | *** | O.M. x T | *** |

Uncovered: Control treatment without using organic materials or plastic mulch.

Covered: Control treatment covered by transparent plastic sheet ( using plastic mulch only).

***: significant at 0.001.

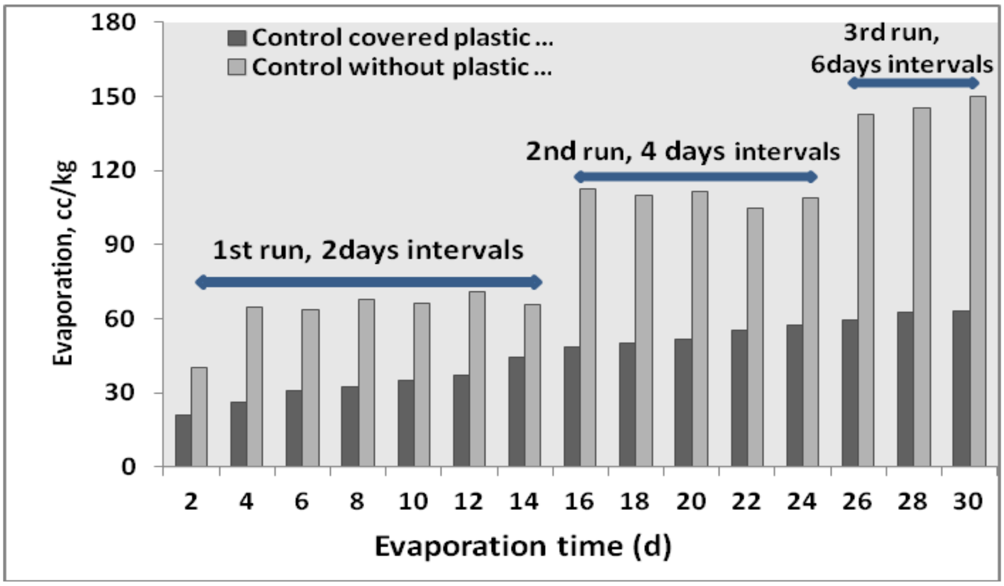


**Fig.3. Effect of plastic mulch on evaporation in case of control treatments**

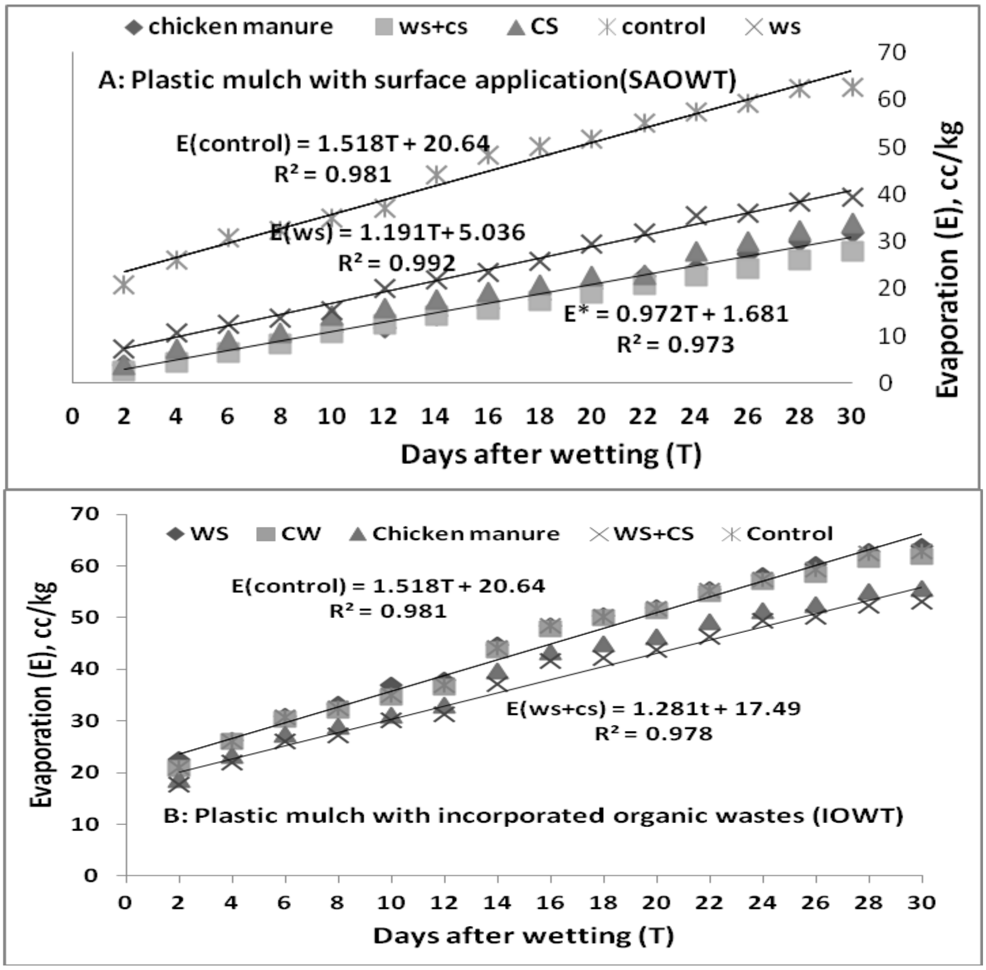


**Fig.4. Effect of plastic mulch on evaporation under surface application (A) and incorporated organic wastes (B) in sandy soil**

The reduction of evaporation was more pronounces in surface application of organic wastes treatments than incorporated treatments as shown in Figure 4, A and B. The results in Figure 4:B demonstrate that there was a little differences in evaporation rate between incorporated treatments covered with transparent plastic sheet and control treatment (only, using plastic mulch). Linear equations printed on Figure 4 (A and B) with high $R^2$ described and quantify the relationship between evaporation in cc per kg of sandy soil and time in days. Using plastic mulch with surface application of organic wastes treatments (SAOWT) on sandy soil reduced the average daily evaporation rate in wheat straw (WS) treatment and other three treatments together (clover straw (CS), (WS+CS) and chicken manure) by 21.54% to 35.97%, respectively compared to control treatment as shown in Figure 4:A. E* refers to average daily evaporation from CS, (WS+CS) and chicken manure treatments. The using of plastic mulch with incorporated organic wastes treatments (IOWT) in sandy soil reduced the average daily evaporation rate from 1% to 15.6% compared to control treatment as shown in Figure 4:B.

**Effect of incorporated organic wastes on the saturated hydraulic conductivity (ks)**

Effects of incorporation of agriculture wastes on saturated hydraulic conductivity (Ks) through 12 runs are depicted in Table 3 and illustrated in Figure 5. Determined values showed that Ks decreased to 51%, 33% and 16.5%, respectively in WS+CS, CS and WS treatments compared to control. Organic wastes leading to lowering the hydraulic conductivity in sandy soil due to the formation of soil micro-aggregates. Improving the structure of coarse-textured soils plays an important role in reducing their permeability to water. This process results in the formation of micro-pores within the aggregates and consequently leads to decreasing the amount and the sizes of the large voids which are naturally abundant in sands. Upon the formation of aggregates, particles are combined together and spaces between the particles become smaller and thus do not allow the flow of water as readily as it would under the normal conditions of sand. Ks (t) for all treatments were fitted to 2nd order polynomial equation with high R2 as shown in Table 4. The decrease in hydraulic conductivity in sand upon the application of organic wastes means- in practical terms- that amending sandy soils with the organic wastes will be expected to improve the water-holding characteristic of sand and lower its high tendency of loosing irrigation water by drainage. This should benefit the grown plants in sandy soils, especially in arid and semi-arid regions where saving water and controlling rapid drainage losses are very important constraints.

**Table 3. Effect of organic wastes on saturated hydraulic conductivity of sandy soil through 12 runs of wet and dry cycles**

| Average hydraulic conductivity, m/day | | | | | |
|---|---|---|---|---|---|
| | Treatments | | | | |
| **Runs, weeks** | **Control** | **Wheat straw (WS)** | **Clover straw (CS)** | **WS + CS** | **Ch.M.** |
| 0 | 5.73 | 5.16 | 4.53 | 3.82 | 4.78 |
| 1 | 5.03 | 4.58 | 3.53 | 3.13 | 4.13 |
| 2 | 4.34 | 3.82 | 3.02 | 2.57 | 3.43 |
| 3 | 3.67 | 3.12 | 2.28 | 2.04 | 2.78 |
| 4 | 3.12 | 2.53 | 1.84 | 1.46 | 2.06 |
| 5 | 2.53 | 1.92 | 1.46 | 1.18 | 1.80 |
| 6 | 2.18 | 1.59 | 1.26 | 1.01 | 1.70 |
| 7 | 1.86 | 1.43 | 1.18 | 0.91 | 1.60 |
| 8 | 1.68 | 1.31 | 1.08 | 0.91 | 1.60 |
| 9 | 1.57 | 1.31 | 1.08 | 0.91 | 1.60 |
| 10 | 1.57 | 1.31 | 1.05 | 0.91 | 1.57 |
| 11 | 1.57 | 1.31 | 1.05 | 0.91 | 1.57 |
| 12 | 1.57 | 1.31 | 1.05 | 0.91 | 1.57 |
| $LSD_{0.05}$ | OM = 0.18 | | Run = 0.29 | | |
| ANOVA | | | | F-test | |
| Organic materials (O.M.) | | | | *** | |
| Runs (7 days intervals) | | | | *** | |

***: significant at 0.001

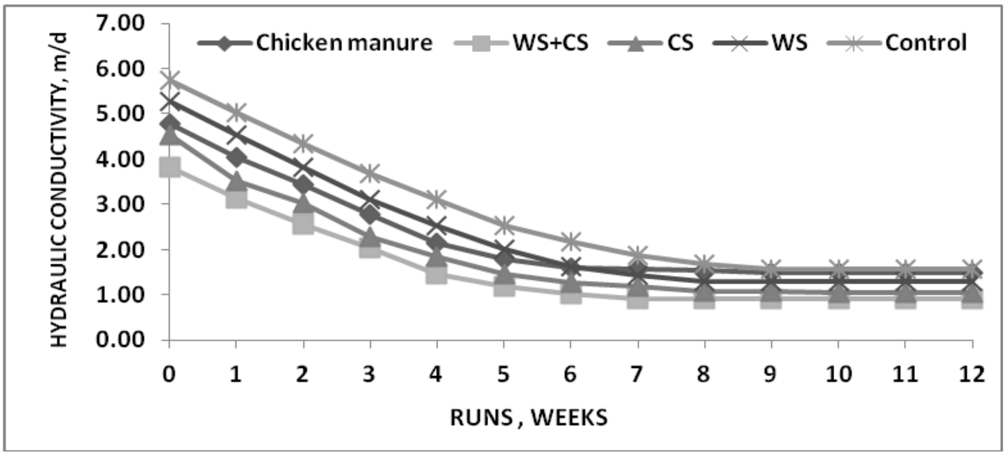


**Fig. 5 . Average hydraulic conductivity of sandy soil incorporated with organic wastes**

**Table 4. Ks *vs.* T relationshipes of sandy soil treated with organic wastes**

| Mulches treatments | Fitting equations | Determination coefficient ($R^2$) |
|---|---|---|
| (control) | $Ks = 0.041T^2 - 0.929T + 6.687$ | 0.998 |
| (WS+CS) | $Ks = 0.037T^2 - 0.748T + 4.449$ | 0.985 |
| (Clover, CS | $Ks = 0.041T^2 - 0.837T + 5.124$ | 0.985 |
| (Chicken manure) | $Ks = 0.042T^2 - 0.838T + 5.501$ | 0.984 |
| (Wheat straw, WS) | $Ks = 0.045T^2 - 0.955T + 6.205$ | 0.996 |

**Effect of incorporated organic wastes on infiltration rate and cumulative infiltration of sandy soil**

The effect of organic wastes incorporated into sandy soil on the infiltration rate is illustrated in Fig.5. The instantaneous- as well as the final (basic or steady state) infiltration rate decreased upon the application of different organic wastes to the sandy soil. The decrease in infiltration rate was more pronounced in bean straw and chicken manure treatments compared to control. This trend is reflected in the IR-time curves shown in the graphs designed in Fig.6. Basic infiltration rate values decreased substantially by about 33% in bean and chicken manure in case of surface application while it were decreased by about 78% and 50% in case of incorporated wheat and clover straw, respectively compared to control treatment as shown in Table 5. Clearly, a decrease in the infiltration rate in sand is a favorable effect as it improves the water-holding capacity of the soil, and decreases water loss through excessive drainage and deep percolation. The effect of organic wastes on the infiltration rate in the sandy soil is caused by several mechanisms such as reducing macro-pores, enhances the process of sealing the soil surface. Soil surface sealing was often reported as one of the principal causes of deterring water entry into the soil from the surface, i.e. reducing the infiltration rate (Hillel and Gardner, 1969; Singer et al., 1992, Bedaiwy, 2008) and improving the structure of the soil where the organic wastes function as a bridging or cementing material. These materials bind individual particles together (Hillel, 1982, Hillel, 1998, Marshall and Holmes, 1988) which results in a better aggregated soil with many micropores within the formed aggregates. It is inside these micropores that the water is retained in the treated sandy soil. Decreasing infiltration rate in the sandy soil means decreased water loss via excessive drainage and deep percolation, and hence more efficient water use by plants and better growth. Among soils of similar mineralogy and particle size, a linear relationship was reported between mean weight diameter and both soil organic carbon and microbial biomass carbon (Carter, 1992). The I- time functions, $I_{(t)}$ for all treatments were fitted to power equation with high $R^2$ as shown in Table 6. Effects of organic wastes on cumulative infiltration (Z) are given in Figure 7. The results revealed the same trend of effecting organic wastes on infiltration rate (I) as shown in Figure 6. Power relations with high $R^2$ between Z (cm) and time (T, min) are depicted in Table7.

**Effect of organic wastes on wet front advance in sandy soil columns**

The effect of organic wastes on wet front advance in sandy soil column were recorded and depicted in Table 7. The results demonstrated that the clover straw appeared the highest retardation of downward flow of water along sandy soil column whereas the advance of wet front was so slowly through the soil columns compared to all treatments.

**Table 5. Effect of incorporated organic wastes on infiltration rate (I) and cumulative infiltration of sandy soil**

| Infiltration Rate (I), cm/min<br>Cumulative Infiltration (Z), cm | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Treatments** | **Control** | | **Wheat straw** | | **Clover straw** | | **Broad bean straw** | | **Chicken M.** | |
| **T, min** | **I, cm/ min** | **Z, cm** | **I, cm/min** | **Z, cm** | **I, cm/min** | **Z, cm** | **I, cm/min** | **Z, cm** | **I, cm/min** | **Z, cm** |
| 1 | 5.4 | 5.4 | 5.3 | 5.3 | 3.3 | 3.3 | 2.1 | 2.1 | 3.0 | 3.0 |
| 2 | 3.2 | 8.6 | 3.2 | 8.5 | 2.4 | 5.7 | 1.8 | 3.9 | 1.9 | 4.9 |
| 3 | 2.3 | 10.9 | 2.1 | 10.6 | 1.7 | 7.4 | 1.5 | 5.4 | 1.2 | 6.1 |
| 4 | 1.9 | 12.8 | 1.6 | 12.2 | 1.5 | 8.9 | 1.2 | 6.6 | 1.1 | 7.2 |
| 5 | 1.5 | 14.3 | 1.2 | 13.4 | 1.1 | 10 | 1.1 | 7.7 | 1.1 | 8.3 |
| 6 | 1.2 | 15.5 | 0.9 | 14.3 | 0.9 | 10.9 | 0.9 | 8.6 | 0.9 | 9.2 |
| 7 | 1.1 | 16.6 | 0.8 | 15.1 | 0.8 | 11.7 | 0.8 | 9.4 | 0.6 | 9.8 |
| 8 | 1 | 17.6 | 0.6 | 15.7 | 0.6 | 12.3 | 0.6 | 10 | 0.6 | 10.4 |
| 9 | 0.9 | 18.5 | 0.6 | 16.3 | 0. 5 | 12.8 | 0.6 | 10.6 | 0.6 | 11 |
| 10 | 0.9 | 19.4 | 0.5 | 16.8 | 0. 5 | 13.3 | 0.6 | 11.6 | 0.6 | 11.6 |
| 11 | 0.9 | 20.3 | 0.5 | 17.3 | 0. 5 | 13.8 | 0.6 | 12.2 | 0.6 | 12.2 |
| 15 | 0.9 | 21.2 | 0.5 | 17.8 | 0.5 | 14.3 | 0.6 | 13.8 | 0.6 | 12.8 |
| 20 | 0.9 | 22.1 | 0.5 | 18.3 | 0.5 | 14.8 | 0.6 | 14.4 | 0.6 | 13.4 |
| $LSD_{0.05}$ (I) | | | | OM = 0.36 | | | | Time = 0.58 | | |
| $LSD_{0.05}$ (Z) | | | | OM = 0.72 | | | | Time = 1.16 | | |
| ANOVA | | | | | | | | F-test | | |
| Organic materials (O.M.) | | | | | | | | *** | | |
| Time | | | | | | | | *** | | |

***: significant at 0.001

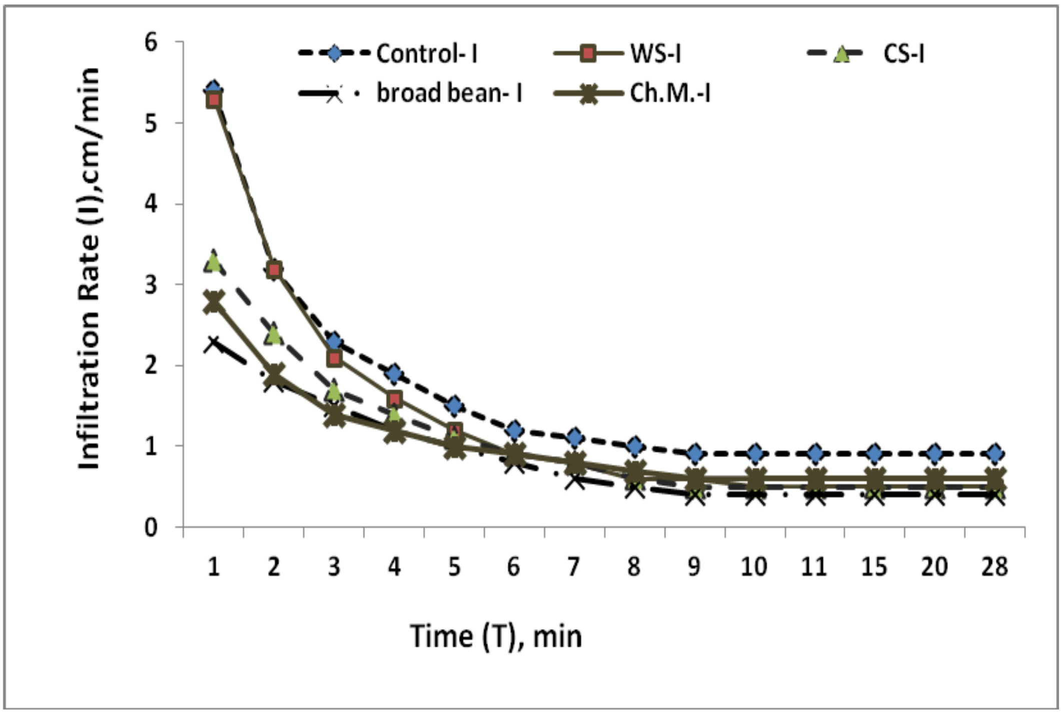


**Fig. 6 . Infiltration rate (I) curves of sandy soil incorporated with organic wastes compared to control**

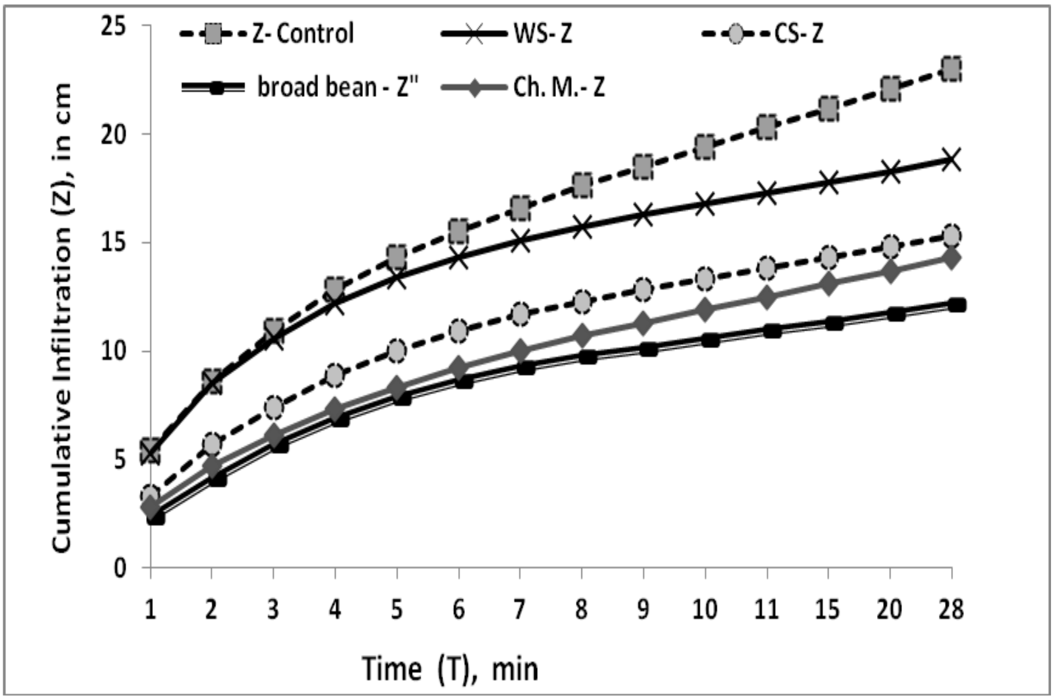


**Fig.7. Cumulative infiltration (Z) in cm *vs*. time for sandy soil incorporated with organic materials**

**Table 6. Power models describe the relationship between I and Z *vs*. Time In sandy soil incorporated with organic wastes**

| Treatments | Fitting equations | $R^2$ | Treatments | Fitting equations | $R^2$ |
|---|---|---|---|---|---|
| Control | $I = 5.021T^{-0.72}$ | 0.968 | Clover straw | $I= 3.853T^{-0.82}$ | 0.966 |
| | $Z = 5.871T^{0.526}$ | 0.992 | | $Z = 3.814T^{0.551}$ | 0.976 |
| Wheat straw | $I= 5.763T^{-0.99}$ | 0.980 | Broad bean straw | $I = 2.980T^{-0.80}$ | 0.938 |
| | $Z = 5.076T^{0.449}$ | 0.971 | | $Z = 2.701T^{0.599}$ | 0.973 |
| Chicken manure | $I= 2.801T^{-0.63}$ | 0.980 | Chicken manure | $Z = 3.049T^{0.597}$ | 0.993 |

Z= Cumulative infiltration, cm T= Time, minutes I= Infiltration rate, cm/min

**Table 7. Effect of organic wastes on wet front advance in sandy soil**

| Time consumed in advancing wet front, (minutes) | | | | | |
|---|---|---|---|---|---|
| **depth, cm** | **Control** | **Clover Straw** | **Broad bean Straw** | **Chicken Manure** | **Wheat Straw** |
| 0-5 | 2 | 4 | 3 | 3 | 2 |
| 5-10 | 5 | 10 | 6 | 6 | 5 |
| 10-15 | 6 | 16 | 9 | 8 | 6 |
| 15-20 | 8 | 23 | 11 | 11 | 9 |
| 20-25 | 10 | 27 | 14 | 15 | 12 |
| 25-30 | 12 | 30 | 18 | 19 | 14 |
| 30-35 | 16 | 34 | 22 | 22 | 18 |
| 35-40 | 18 | 38 | 26 | 26 | 25 |
| $LSD_{0.05}$ | OM = 2.67 | | depth = 3.37 | | |
| ANOVA | | | | F-test | |
| Organic materials (O.M.) | | | | *** | |
| Runs (7 days intervals) | | | | *** | |

***: significant at 0.001

Therefore, there was a lag time in wet front advance (40 cm) between organic wastes treatments and control treatment. The lag time was 20, 8 and 7 minutes for clover straw, (broad bean straw and chicken manure) and wheat straw treatments, respectively. This might be due to the relative changes in pore size distribution, inkbottle effect and tortuous water paths along sandy soil columns as a result of incorporation of different types of organic wastes.

**Effect of organic wastes on distribution water content of sandy soil columns**

The results related to vertical distribution of water content of sandy soil columns under different treatments of organic wastes illustrated in Table 8 and Figures 8. The results indicated that the percentages of saved water were 20.1, 17.7, 16.5 and 15.2% in clover straw, beans straw, wheat straw and chicken manure treatments, respectively as shown in Table 8. Distribution of water content with depth of soil columns appeared the polynomial relationships with high values of $R^2$ as shown in Table 9.

**Table 8. Distribution of soil water content under incorporated organic wastes**

| | | Θw, % | | | |
|---|---|---|---|---|---|
| **Depth, cm** | **Control** | **Wheat straw** | **Clover straw** | **Broad bean straw** | **Chicken manure** |
| 0-5 | 13.77 | 15.21 | 14.6 | 14.41 | 13.51 |
| 5 - 10 | 14.34 | 16.6 | 17.49 | 17.19 | 16.78 |
| 10-15 | 16.26 | 18.95 | 19.11 | 19.24 | 19.08 |
| 15-20 | 17.28 | 19.25 | 19.89 | 19.11 | 20.23 |
| 20-25 | 18.44 | 20.4 | 22.39 | 21.71 | 20.84 |
| 25-30 | 18.81 | 20.63 | 21.88 | 21.41 | 20.53 |
| 30-35 | 16.96 | 21.3 | 21.3 | 20.99 | 20.76 |
| 35-40 | 15.57 | 20.57 | 21.13 | 20.59 | 19.57 |
| ∑ | 131.43 | 152.91 | 157.79 | 154.65 | 151.3 |
| average | 16.4 | 19.1 | 19.7 | 19.3 | 18.9 |
| Δ, % | 0 | 2.7 | 3.3 | 2.9 | 2.5 |
| saved water,% | - | 16.5 | 20.1 | 17.7 | 15.2 |
| $LSD_{0.05}$ | | M = 0.72, | | depth = 0.92 | |
| ANOVA | | | | F-test | |
| Organic materials (O.M.) | | | | *** | |
| Depth | | | | *** | |

***: significant at 0.001

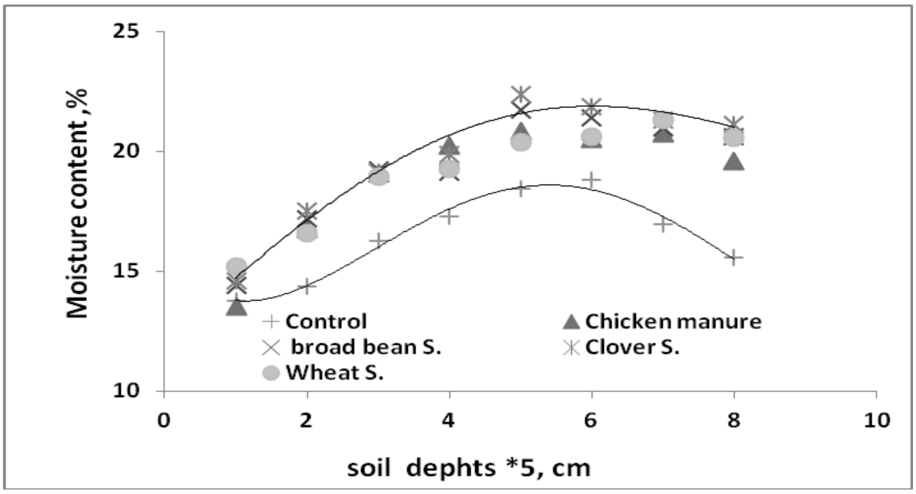


**Fig. 8. Vertical distribution of water content of sandy soil columns under different types of organic wastes**

**Table 9. 4th order polynomial equations describe the relationship between moisture content and depth along sandy soil columns incorporated with organic wastes**

| Treatments | Fitting equations | $R^2$ |
|---|---|---|
| Control | $\theta w,\%= 0.014d^4-0.306d^3+1.982d^2-3.387d +15.47$ | 0.980 |
| Chicken manure | $\theta w,\% = - 0.005d^4+0.123d^3-1.269d^2+6.459d +8.163$ | 0.995 |
| Broad beans straw | $\theta w,\% = - 0.005d^4+0.103d^3-0.906d^2 +4.707d+10.57$ | 0.957 |
| Clover straw | $\theta w,\% = 0.003d^4-0.058d^3+0.086d^2+2.504d +12.18$ | 0.967 |
| Wheat straw | $\theta w\% = - 0.003d^4+0.067d^3-0.555d^2+3.154d +12.44$ | 0.979 |

## CONCLUSION

It was concluded that irrigation intervals should be not more than 2 days to extend the effective role duration of organic wastes (plant residues) when it used as surface mulch or incorporated to reduce the evaporation from sandy soil. The addition of organic wastes as a barrier to delay and reduce evaporation from surface layer of sandy soil will be more useful under drip irrigation and green houses than surface irrigation. Plastic mulch can be used as a support material for increasing the performance of surface addition of some organic wastes (plant residues) to minimize evaporation because of it was acting as a regulator of evaporation from surface layer of sandy soil. Linear equations with high $R^2$ are given to describe and quantify the relationship between evaporation and time in all cases of using plastic mulch. Organic wastes leading to lowering the hydraulic conductivity in sandy soil due to the formation of soil micro-aggregates. $K_s$ (t) for all treatments were fitted to 2nd order polynomial equations with high $R^2$. The decrease in infiltration rate was more pronounced when broad bean straw and chicken manure incorporated with sandy soil compared to control. Clover straw appeared the highest retardation in advance of wet front along soil column compared to control treatments (20 minutes lag time). Distribution of water content with depth of soil columns appeared the 4th order polynomial trend with high values of $R^2$. Incorporated sandy soil columns with clover straw and chicken manure increased percentage of water holding capacity 20.1 to 15.2% compared to control treatment, respectively. From the study the response of hydraulic properties to the corporation of organic wastes with sandy soil was more beneficial for increasing water holding capacity and decreasing water lost by percolation than its role as used as mulch for reduction evaporation. From this investigation surface amendment and plastic mulch can be used for the reducing evaporation while incorporation organic wastes are recommended to check excessive infiltration of sandy soil.

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## الملخص العربي

# تأثير المخلفات العضوية علي البخر والخواص الهيدروليكية للتربة الرملية

أحمد فريد سعد

اجريت تجارب معملية بهدف اختبار تأثير انواع مختلفة من البقايا العضوية علي معدل البخر وبعض الخواص الهيدروفيزيائية للاراضي الرملية بمنطقة البستان بجمهورية مصر العربية. استخدمت خمس معاملات هي الكنترول واضافة ١% علي اساس الوزن من تبن القمح وتبن البرسيم وخليط متساوي من تبن القمح وتبن البرسيم وكذلك مخلفات مزارع الدواجن. وتمت الاضافة بطريقتين احدهما سطحية واخري خلط بالتربة خلطا متجانسا. كما استخدمت الاغطية البلاستكية كأحد الوسائل في تقليل البخر وايضا اختبارها كعامل مساعد في تعظيم دور المخلفات العضوية في هذا المجال (التجربة الاولي). اما بالنسبة للتجربة الثانية فتم دراسة تاثير المخلفات العضوية علي الخواص الهيدروليكية للتربة الرملية (معامل التوصيل الهيدروليكي- معدل الرشح-الرشح التجميعي- تقدم جبهة الابتلال- قدرة التربة علي الاحتفاظ بالماء).

أوضحت نتائج التجربة بأن الاضافات السطحية للمخلفات النباتية قللت من كمية المياة المفقودة بالبخر بنسب تتراوح بين (٢٢%،١٠,٤% و٩,٨%) و(٤٠% و٢١,٧% و١٦,٦%) في معاملة مخلفات مزارع الدواجن وتبن البرسيم عند تعرضها لدورات ابتلال وتجفيف متعاقبة لمدة ٢و٤و٦ أيام علي التوالي. بينما تراوحت هذه النسب بين (٢١,٣% ، ٣١,٧%) عند خلط التربة بالمخلفات العضوية في تعاقب دورات الابتلال والجفاف الاولي كل ٢ يوم، بينما بلغت (٤,٩% الي ١٢,٤%) ونسب تتراوح بين (١,١%، ٥,٤%) عند تعاقب دورات الابتلال والجفاف لمدة ٤،٦ أيام علي التوالي وذلك في معاملات (مخلفات مزارع الدواجن وخليط تبن القمح والبرسيم) واضافة تبن البرسيم فقط.

أوضحت النتائج ايضا ان استخدام الاغشية البلاستكية داكنة اللون مع معاملات الاضافات السطحية للمخلفات النباتية للتربة الرملية أدت الى انخفاض معدل البخراليومي بنسبه تتراوح بين ٢١,٥٤%- ٣٥,٩٧%. بينما انخفض معدل البخر اليومى بنسب تتراوح من ١% الي ١٥،٦% في معاملة خلط المخلفات النباتية مع التربة الرملية وتغطيتها بالاغشية البلاستكية مقارنة بمعاملة الكنترول. كما ان هناك علاقة خطية بين معدل البخر وزمن التبخير في جميع معاملات استخدامات الاغشية البلاستكية.وفيما يخص تأثير المخلفات العضوية علي الخواص الهيدروليكية للتربة فانه لوحظ انخفاض قيم معامل التوصيل الهيدروليكي بنسب وصلت الي ٥١%، ٣٣%، ١٦،٥% في معاملات (خليط تبن القمح والبرسيم)، تبن البرسيم وتبن القمح، بالترتيب مقارنة بمعاملة الكنترول، كما وجد أن هناك علاقة متعددة الحدود من الدرجة الثانية بين معامل التوصيل الهيدروليكي ودورات الجفاف والابتلال. كما انخفضت قيم معدل الرشح النهائي الاساسي Basic infiltration rate بنسب ٧٨%، ٥٠% في حالة (خليط تبن القمح وتبن البرسيم معاً) ثم تبن البرسيم علي التوالي. لوحظ ان هناك Lag-time بين تقدم جبهة الابتلال في معاملات المخلفات النباتية ومعاملة الكنترول حيث تراوحت قيمته بين ٢٠، ٧ دقائق لكل من معاملة تبن البرسيم وتبن القمح بالتربة الرملية علي التوالي. كما وجد علاقة متعددة الحدود من الدرجة الرابعة بين التوزيع الرأسي للرطوبة مع العمق وأن خلط الرمل بتبن البرسيم ومخلفات مزارع الدواجن أدي الي زيادة في الرطوبة تتراوح بين ٢٠,١% ١٥,٢% مقارنة بمعامل الكنترول، كما وجد تأثير معنوي لمعاملات المخلفات النباتية علي معدل البخر والخواص الهيدروليكية للتربة الرملية.