Surface, Subsurface Drip and Nano-Oozing Irrigation Effects on Some Physical Characteristics of Tillage and Untilled Soil

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Abstract. A field experiment was conducted in Habbaniyah sub-district / Khalidiya district / Anbar governorate, western Iraq, in silty loam soil during the autumn season 2020, to study the effect of surface and subsurface drip irrigation and nanotechnology spurting on the bulk density, saturated hydraulic conductivity and penetration in plowed and non-Tillage soil. Irrigation was performed upon depletion of 50% of the prepared water, and the treatments were distributed according to the Nested-Factorial Experiments Design with three replications. Corn was planted, (Furat class), on 7/15/2020. The American evaporation basin Class A used for irrigation as a first indicator. The results showed an increase in bulk density after planting in general in surface drip irrigation, it reached 1.45 mg.m³ and 1.38 mg.m³ in subsurface irrigation for both of the tillage systems, while the tillage process didn’t significantly affect the bulk density values. The values of saturated hydraulic conductivity decreased after planting in general compared to before planting, except for the non-tillage irrigation treatment, which increased from 9.28 to 10.31 cm hr⁻¹, penetration decreased from 6.58 kg cm⁻² before planting to 1.83 after cultivation without tillage, while the opposite occurred in non-Tillage soils, which increased from 0.63 kg.cm² before planting to 1.28 kg.cm².

1. Introduction.

The lands that occur within arid and semi-arid regions suffer of the lack of rainfall and other precipitations; so it is necessary to go to irrigative agriculture to secure water requirements for permanent crop production and increase agriculture area to increase production, for the global increase of population. It requires, in turn, to specify more irrigation waters and therefore, the water utilizers and researchers have to manage reducing the use of irrigation water and securing water for these areas planned to culture in a scientific planned way.

Water is one of the most effective force to destroy and dissociate aggregates. It almost functions through quick imbibition and difference in various soil parts extension or quick imbibition that captures air in pores and making the so-called (air explosions) [1].

In a comparative study between oozing irrigation and superficial distill irrigation [2], obtained the highest average value of Saturated hydraulic conductivity conductivity that was 5.56 cm hr⁻¹ at oozing irrigation, compared with 5.21 cm hr⁻¹ for superficial distill irrigative applications. He explained that to the keep of suitable and stable moisture in oozing irrigation applications; so, value of water conductivity have raised in comparison with distill irrigation method at which the bulk density values raised for soil because of successive courses of moisturizing and drying during the irrigation processes to lead to release some soil fine particles which enter the big pores with their flow with water stream to cause closing these pores. Also, [3] has obtained a highest bulk density 1.623 Mg m⁻³ between the irrigation
interspaces and plow patterns for flow irrigation method in the unplowed application with four days
inter-irrigational interval, with 8.19% increase in comparison with the least bulk density value 1.49 Mg
m⁻³ in Tillage application and two days inter-irrigational interval. The aims of this study are to find:

- effect of surface, subsurface irrigation and plow patterns in bulk density bulk density and
water conductivity of saturated soil.
- effect of plow patterns and irrigation methods on soil resistance to penetration.

2. Materials and Methods

A field experiment was done during the autumn season, 2020 in Abu-Fleis District – Al Habanniya
Town – al Anbar Province, West Iraq, Within geographic coordinate 33040'44" N and 43054'92" E. The
farm soil is classified as Typic Torrifluvent, Fine loamy mixed, Calcareous, hyperthermic in accordance
with [4]. recommendations. Sample for farm soil were taken randomly from different spots in 0 – 0.30m
depths and several physical and chemical analyses were made for them (table 1) as in the mentioned
standard methods in [5].

| Table 1. Some physical and chemical properties of the soil before planting. |
|-------------------------------------------------------------|
| Sand             | Silt             | Clay | Bulk density | Turated hydraulic conductivity | pH | EC       |
| (g Kg⁻¹)        | (g Kg⁻¹)        | (mg m⁻³) | (cm hr⁻¹) | (ds. m⁻¹) |       |         |
| 222             | 541             | 237 | 1.29         | 9.28      | 7.5   | 1.25    |
| Cl⁻             | CO₃²⁻           | HCO₃⁻ | SO₄²⁻        | Ca²⁺      | K⁺    | Na⁺     | Mg²⁺   |
| (mmol. L⁻¹)     | (mmol. L⁻¹)     | (mmol. L⁻¹) | (mmol. L⁻¹) | (mmol. L⁻¹) | (mmol. L⁻¹) | |
| Nil             | 2.50            | 1.10 | 5.0          | 0.35      | 1.5   | 4.25    |
|                 |                 |     |              |           |       |         |

The irrigation water characteristics were estimated on the basis of the methods suggested by the
American Lab of Salinity. The Euphrates water has been used to irrigate yellow corn crop which
chemical characteristics are stated in table (2).

| Table 2. chemical properties of irrigation water. |
|------------------------------------------------|
| Class | S | AR | NO₃⁻ | Ions dissolved(meq. L⁻¹) | pH | EC       |
|-------|---|----|------|--------------------------|----|---------|
|       |   |    |      |                          |    |         |
| C3S1  | 1.15 | 2.10 | 0.0  | 2.0                      | 3.5 | 4.0     | 0.14 | 2   | 2.89 | 4.1 | 7.4 | 0.98 |
|       |     |     |      |                          |    |         |

The experiment included studying the effect of three different irrigation systems with nanodistillers.
They are superficial distill, sub-superficial distil and nano irrigation systems. The irrigation was timed
depending on the American evaporation basin class A as a primary indicator for superficial distill, sub-
superficial distill systems irrigation is done when 50% of the available water finishes. It was actually
measured with gravity way in the farm. Also the irrigation water was added to the nano-oozing
irrigation system as a continuous ooze along with the season with regarding the increase and decrease of
quantity added by growth stage, depending on the average plant water consumption for yellow corn in the autumn season. In every system, a couple of plow pattern was put: zero and traditional plow.

A land spot with dimensions 52.2m length and 21.5m width has been selected and divided into three equal partitions with dimensions 14.5m X 17.5m with interspace 2.5m between partitions as a guard zone. Each one of the three irrigation methods was put aside, vertically with dominant wind stream to form the main panels. In addition, each irrigation method separately included three replications where the both plow applications have been placed in each replication to include plowing a line with 1.5m length and 1.5m width using the moldboard to plow, then the soil was softened and 1.5m space was left from the plow application, followed by the unplowed application (it was done a spare to avoid soil interference, beside smoothing the tractor motion during the studied application plow, and to avoid disturbing the untilled application). The distillation line were extended for each experimental unit, separated with 0.5m space, thus we have six experimental units in each irrigation system, as 18 experimental units for the whole experiment. A couple of meters was left around the experiment zone to separate it from the guard areas and planted on both experiment sides (from the wind stream side) to ensure less winds damage and preparing homogenous circumstance for all the applications.

The actual water consumption (ETa) that equals the added water depth (d) and irrigative timing has been calculated depending on the actually exhausted moisture in the field using the gravity method and depending on basin data as a primary indicator, as follows:

\[
d = \frac{\theta_{f.c} - \theta_{w1}}{100} \cdot D
\]  

Whereas:

d = depth of water that must be added to soil (cm), that equals the actual water consumption (ETa).

D= active radical group depth.

Evaporation-reverse transpiration (ET0) has been determined according to equation mentioned in [6] like the following:

\[
ET_0 = \frac{ETa}{Kc}
\]

Whereas:

ET0 : Evaporation-reverse transpiration mm day^{-1} . and ETa: Evaporation-actual transpiration mm.day^{-1}

Kc : theoretic crop factorial depended for different growth stages (0.94, 1.05, 1.69 and 0.82) for germination, vegetative growth, flowering and maturation successively. Mentioned in [7].

The Epan value that equals the basin evaporation percentage has been found according to the equation mentioned in [6] as follows:

\[
Epan = \frac{ET_0}{Kp}
\]

Where:

Epan= water depth (mm) required to evaporate from evaporation basin which informs us about actual soil moisture.

Kp= evaporation basin factorial which differs by basin type, ambient plant cover and soil surface nature [6]. The value 0.8 in this study was depended on the basis of what's mentioned in [8].
The yellow corn seeds Class Furat were planted for the autumn season on July 15, 2020 adding 3-4 seeds per hole. Later they've been decreased to one plant, two weeks after culturing the space between every two lines was 0.5m and 0.25m for every two holes as 58 plants in each agriculture line to make Heavily plant 80000 plant ha-1.

Nitrogen element was obtained from urea fertilizer and added as 400 kg.hec-1 in two loads: the first contained 200 kg.hec-1 with 260 kg.hec-1 super triphosphate before agriculture, then the second load was added five weeks later. The crop service processes were made like periodic grassing for all the applications. Meanwhile, the stem digger pest Sesamia Cretica L. was eradicated using the pesticide (10% active grainy diaxenon) as 6 kg.hec-1, injecting it in plant medulla, 20 days after agriculture, thrice with a time space 10 days.

The bulk density has been estimated taking undisturbed soil samples from depths 0 – 0.20m. as in the mentioned standard methods in [5].

The saturated hydraulic conductivity was determined taking undisturbed soil samples using the same method in taking soil bulk density. Samples were taken to lab and soil was wetted with capillarity for 24 hours after stabilizing the soil probe with a titrate holder and applying a stable apical water column, 0.01m high from soil surface according to the volume of water that flows down to the collecting plate down the soil column within a limited time 15 minutes. Operation was repeated many times until two similar reading are obtained for the same time period. The saturated hydraulic conductivity has been calculated using Darcy law delete as follows:

\[
K = \frac{V L}{At (h+L)}
\]

Where:

- \( K \): saturated hydraulic conductivity (cm.hr⁻¹).
- \( V \): down streaming water size (cm³)
- \( L \): soil column length (cm).
- \( A \): flow section area (cm²)
- \( t \): water collect time (hour).
- \( h \): water column height above the soil surface (cm).

The soil penetrometer has been measured with field (Penetrometer) shown in figure 1, each application before and after agriculture at 20cm depth with sampling each depth to measure its water content in three replication per treatment at percentage 21.89% moisture of soil Volume.

Figure 1. A field pentrometer
Results were analyzed with (Genstat v. 12.1) programming and the averages have been compared by the least significant difference (LSD) test at probability level 0.05.

3. Results and Discussion

3.1. Bulk Density (Mg m$^3$)

Refers to the bulk density increase significantly after agriculture in comparison with its values before agriculture. In addition, the irrigation methods had influence on soil bulk density values. They decreased significantly when oozing irrigated to reach average 1.38 Mg.m$^3$ with decrease percentage 4.16 and 6.44% compared with the two Surface and subsurface irrigation methods for both plow patterns successively. The reason is the efficiency of oozing irrigation system in saving suitable humidity continuously without irrigation brake. This has led to avoid moisture and drying courses succession like in superficial and subsuperficial irrigation that caused soil extension and contraction and precipitation of fine particles in the soil pores, [2].

The same table refers to the effect of both plow patterns on soil bulk density values, but insignificantly. The highest value was 1.437 Mg m$^3$ in unplowed soil with 0.7% increase percentage, in comparison with plowed soil for all the irrigation systems. This increase could be due to soil un-disturbing in case of unplowing and keeping its structure; so, the soil here is stable with no precipitation of fine components in the inter-particular pores when compared with plowed soil, in a hand. In the other, for the activity of saturated irrigation system in saving suitable moisture for soil, which necessary to reduce the succession of moisture and drought cycles, which doesn’t agree with [3].

Table 3. the effect of study parameters on the bulk density of field soil (mg g. m$^3$).

| Irrigation systems | The pattern of tillage | Irrigation Average |
|-------------------|-----------------------|--------------------|
|                   | NT                    | T                  |
| Surface drip irrigation | 1.490               | 1.460              | 1.475               |
| Subsurface drip irrigation | 1.450               | 1.430              | 1.440               |
| Drain irrigation system | 1.370               | 1.390              | 1.380               |
| LSD                | N.S                  |                    | 0.023               |
| Average tillage    | 1.437                | 1.427              |                    |
| LSD                | N.S                  |                    |                    |

3.2. Saturated Hydraulic Conductivity (cm.hr$^{-1}$)

Table 4 refers to the reduced value of soil saturated water conductivity after agriculture significantly when compared with its value before agriculture for all the study applications except oozing irrigative application in unplowed soil, at which, the value increased from 9.28 cm.hr$^{-1}$ to 12.23 cm.hr$^{-1}$ after agriculture. The reason is the oozing irrigation course which provides permanent moisture along with the season in the presence of old plant residues and their residual shoot parts in soil without being Tillage to become more disintegrable and forming passages inside soil (tunnels), plus the role of soil worms in forming these tunnels and turning the to active media to transport water within the soil matrix [9]. The irrigation methods also influenced the character values to dominate significantly at oozing irrigation to reach average 10.31 cm.hr$^{-1}$ with increase percentage 11.09% compared with its value before agriculture, while it increased for 70.69% and 46.27% compared with both distill irrigation methods, superficial and sub-superficial, successively. The reason is the same above.

The same table refers to the two plow patterns effect on soil saturated water conductivity; so, the highest average value for the character reached 8.17 cm.hr$^{-1}$ in untilled soil with increase percentage 10% compared with plowed soil. The reason is un-disturbing the soil with zero plow and keeping its structure stable and not downgrading the fine component to precipitate at the inter-particular pores in comparison with Tillage soil, beside passage formation in soil matrix [9]; [10].
Table 4. The effect of study parameters on Saturated Hydraulic Conductivity (cm.hr⁻¹):

| Irrigation systems          | The pattern of tillage | Irrigation Average |
|----------------------------|------------------------|--------------------|
|                           | NT                     | T                  |                     |
| Surface drip irrigation    | 5.870                  | 6.200              | 6.040              |
| Subsurface drip irrigation | 6.400                  | 7.700              | 7.050              |
| Drain irrigation system    | 12.230                 | 8.400              | 10.310             |
| LSD                       | 1.757                  |                    | 0.023              |
| Average tillage            | 8.170                  | 7.43               |                    |
| LSD                       | N.S                    |                    |                    |

3.3 Soil Penetrometer (kg cm⁻²)

Table 5 refers to soil penetrating forces after agriculture for the unplowed soil and its increase in Tillage soil when compared with its values before the agriculture to reach 6.58 kg.cm⁻² before agriculture and decrease to 1.83 kg.cm⁻² after agriculture at the unplowed soil application. The inverse has happened with Tillage soil is forming passage because of degrading the former crop residues in soil to facilitate soil penetration and its particles slide on each other (FAO, 2005), the reason that soil penetrating forces have increased after agriculture to Tillage soil is disturbing the soil and collapse of its structure due to plow to cause the small particles to move down from higher layers and precipitate in the lower layers to cause the bulk density to increase and blocking the penetrative forces, which agree with [3].

The same table also refers to the significant effect of irrigation methods on the values of soil penetration, where the average values decreased after agriculture with oozing irrigation to 0.655 kg.cm⁻² with 75.04 and 52.70% compared with superficial and sub-superficial distil irrigation successively. The reason for that is the oozing irrigation course which saves continuous humidity along with the season and missing the wetting and drought processes as per the superficial and sub-superficial distil, successively which cause to wash and precipitate the particles that result from soil extension and contraction and bulk density increase, [3].

Table 5 the effect of study parameters on Soil Penetrability (kg cm⁻²).

| Irrigation systems          | The pattern of tillage | Irrigation Average |
|----------------------------|------------------------|--------------------|
|                           | NT                     | T                  |                     |
| Surface drip irrigation    | 3.120                  | 2.130              | 2.625              |
| Subsurface drip irrigation | 1.770                  | 1.000              | 1.385              |
| Drain irrigation system    | 0.600                  | 0.710              | 0.655              |
| LSD                       | 0.113                  |                    | 0.095              |
| Average tillage            | 1.830                  | 1.280              |                    |
| LSD                       | 0.068                  |                    |                    |

4. Conclusion
The treatment of drip irrigation with nanotechnology gave the product the best physical properties.

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