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The relationship of tillage pattern and water infiltration under quinoa (*Chenopodium quinoa* Willd) Crop cultivation in western Iraq

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Abstract:

This study aims to identify the relationship of the tillage pattern and water infiltration under quinoa (*Chenopodium quinoa* Willd.) crop cultivation in western Iraq, Hit district, Anbar Governorate. The field experiment is conducted in sandy loam soil during the spring season of 2021, located on longitude 95° 42' 25″ N, and latitude 68° 33' 42″ E at 71 m.asl. The experiment lay-out is a randomized complete block design in three replicates, including three tillage patterns, namely: conventional tillage (T2), minimum tillage (T1), and no-tillage (To), and three irrigation treatments which are ET 0.75, ET 1.00, and ET 1.25. The treatment T2 gives the highest correlation coefficient (R2) value, approached 0.9964, and the highest cumulative water infiltration with 35.7 cm during 4 hours. The highest basic infiltration rate is observed in the T2 treatment with 3.3 cm h-1 when the filtration rate is constant.

Keywords: *quinoa, tillage pattern, accumulative infiltration, basic infiltration rate*.

I. INTRODUCTION

Quinoa is a multi-purpose crop, mainly cultivated due to gluten-free with rich seeds in proteins and essential elements. The quinoa crop is considered one of the most essential irrigated crops in the world and Iraq recently, where it is grown for human and animal consumption at the same time. Balanced fertilization, protection of the crop from diseases and the use of soil water are assumed to be the most important factors to consider when planting (Ruiz et al., 2014 and Jacobsen, 2017). The infiltration rate means the rate of water entry into the soil expressed as a depth of water per unit of time (Hillel, 1971). Water infiltration through the soil surface is fundamental in designing and operating irrigation systems and evaluating their efficiency. The infiltration has a vital role to be gained from its relationship with the time required for determining irrigation water depth to be added to the soil and in the designs of the length of the irrigation track for surface irrigation systems (Willardson and Bishop, 1967). Cattan et al. (2009) showed that the

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infiltration had been affected by crop cover and machinery. Soil texture and soil structure together, plant age and other characteristics such as the height of the water column above the soil surface and the initial moisture content are affecting the water depth penetrate through the soil surface (Kirkham and Powers, 1972), (Philip, 2009), (Sajjadi., et al., 2016), (Leung et al., 2016), and (Buchmann et al. 2020). Tillage is one of the essential operations in dismantling and preparing the soil before planting and preparing a suitable seedbed by breaking up and softening the soil mass with a plow aerating the soil and increasing its porosity. Zero tillage is one of the components of conservation agriculture because it maintains moisture and soil structure and does not form a thick or hard layer under the tillage area due to the lack of movement of machines on the soil, as well it helps to maintain not destroy their colonies in the soil. It was observed that the infiltration rate was much higher when the disc plow was used (Guzha., 2004).

The use of the minimum tillage pattern led to an increase in the infiltration rate of the crusted soil surface compared to the conventional tillage pattern, as well as a decrease in the runoff and increased cumulative infiltration (Zhao et al. 2018), and (Al-Shaibani and Jali, 2010, Zhaoand others.2018). Al-Attar et al. (2009) showed that the use of conventional tillage compared with minimum tillage and zero tillage led to an increase in soil penetration resistance and reduced each of; soil bulk density, average weighted diameter and saturated water conductivity, which caused an increase in the hardness and thickness of the soil surface. The definition of infiltration requires that the downward flow into and through the sediments be no divergent.

The U.S. Salinity Laboratory Staff (1954) pointed out that the effect of divergent flow increases as the infiltration area decreases and becomes pronounced where the permeability decreases with depth. The proportion of lateral flow to vertical flow becomes higher as the permeability of the sediments beneath an infiltrometer decreases. Lewis (1937) found that the uniform soils that used a set of cylinders with at least 6 inches into the soil gave reliable results and that buffer rings were not needed if the infiltrometer was at least 18 inches in diameter. Burgy and Luthin (1956) also found that the difference between rates obtained with the single-ring and double-ring infiltrometers for uniform soils that had been previously wetted above field capacity was not significant. However, Schiff (1953) obtained the opposite effect in using the two types of rings where soils were not uniform and contained subsurface low permeability zones.

II. Materials and method

Experimental site and soil properties:

A field experiment is conducted during the spring season of 2021 at Hit District, Anbar Governorate. The land's topography is almost flat to a slope level close to the plane and the physiographic location within the plateau unit. The material of gypsum and calcareous origin in the soil is well-drained. The site locates at a longitude of 95° 42' 25″ N, and latitude of 68° 33' 42″ E and 71 m sea level. The experiment lay-out is a randomized complete block design in 3 replicates, included three tillage patterns, namely: conventional tillage (T2), minimum tillage (T1), no-tillage (To), and three irrigation treatments which are ET 0.75, ET 1.00 and ET 1.25. The prevailing soil is a loam texture, and the soil is classified as chalky gypsies. Soil samples are

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taken from depths 0.10, 0.20, 0.30, 0.40 and 0.50 m to determine the soil moisture release curve at 0, 33, 100, 500, 1000 and 1500 kPa for samples taken from the depths. Soil available water content equal to 0.192 is calculated from the difference in moisture content at 33 and 1500 kPa. Soil properties are estimated according to standard methods (Black et al., 1965), where pH= 8.1, EC= 2.3 $dS.m^{-1}$, bulk density= 1.67 $\mu g\ m^{-3}$, porosity= 34.5%, the lime= 275 $g\ kg^{-1}$, sandy loam (766 sand, 90 silt and 144 clay $g\ kg^{-1}$), and Volumetric moisture content at 33 kPa = 0.21 $cm^3\ cm^{-3}$ and at 1500 kPa= 0.018 $cm^3\ cm^{-3}$.

Measuring of water infiltration rate:

Field measurements included measuring the infiltrated water into the soil using the double ring method, and the double ring is buried in the soil. The inner and outer ring is filled with water. A ruler is placed inside the inner ring, and a digital clock is used to record the time of infiltrated water, which lasts up to 240 minutes; the height of the water is recorded against the time. The experiment is repeated four times, and the mean is taken. The cumulative infiltration from the field readings of water infiltrated at different times is calculated. These measurements get the accumulated infiltration (cm); these data are arranged and subjected to mathematical analysis to obtain the two constants of the Kostiakov equation.

Predicting the constants of the Kostiakov equation 1932 for the aggregation tip or deep seepage based on the properties of soil and water:

Kostiakov's equation is used to estimate the infiltration rate in the soil as follows:

$$I = kt^{x} \dots (1)$$

Where:

I = cumulative infiltration (cm)

k, x= constants

t = time (min.)

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III. Results and discussion

Water infiltration in the soil and its relationship with the pattern of tillage and evapotranspiration

The linear relationship (Log I = log k + x log t) for the no, minimum and conventional tillage pattern treatments is drowned between the cumulative infiltration logarithm and time logarithm, as shown in Figures 1, 2, and 3, from which the constants of the equation are derived from the Kostiakov equation for the cumulative infiltration. The linear equation is represented as follows:

$$I = k \times t^x \ldots\ldots (2)$$

$$log\ log\ I\ = log\ log\ k\ + log\ log\ t\ \ldots (3)$$

$$k = 10\ log\ log\ k$$

The results in Figures 1, 2 and 3 show that the T2 treatment gives the highest value of the correlation coefficient approached R^2=0.9964, followed by To treatment with R^2=0.9935 and T1 treatment with the lowest value by R^2=0.98, respectively. This means that the T2 treatment is harmonious between the infiltration rate and the tillage pattern used, which agrees with (Meek *et al.*, 1989).

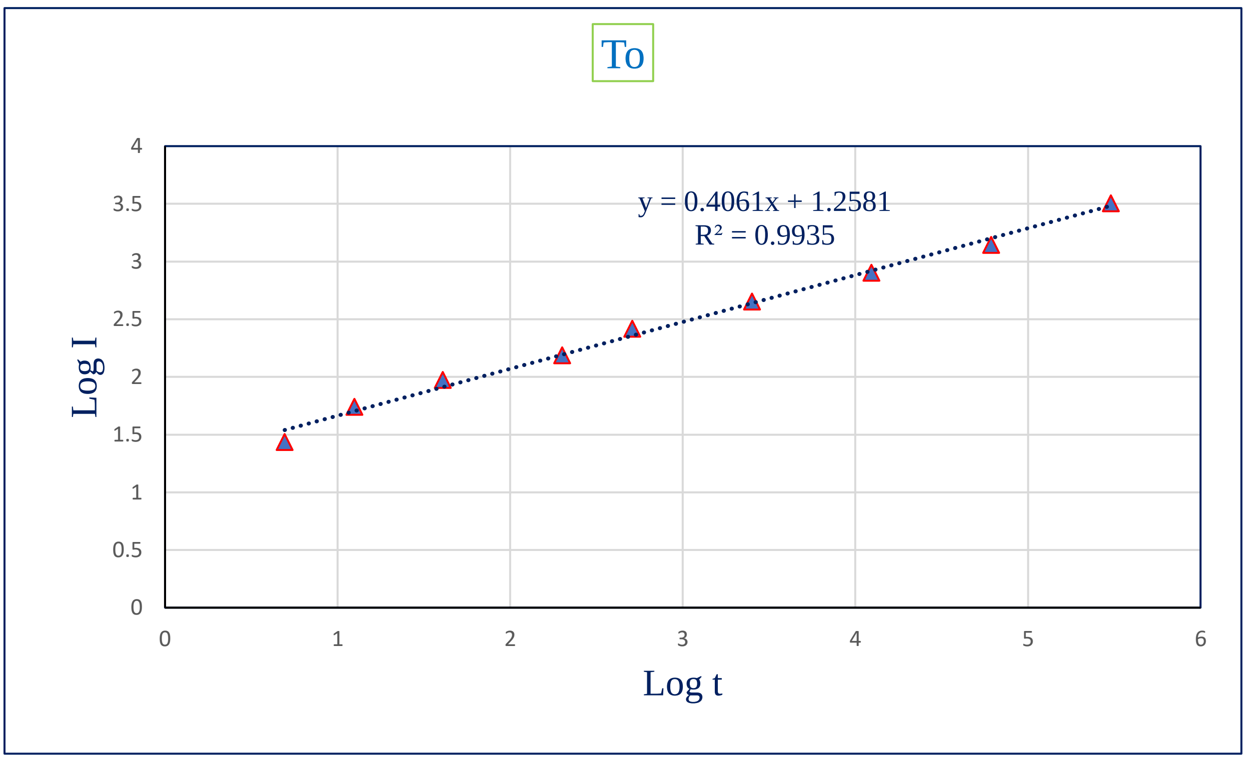

Figure 1. Linear relationship of the accumulative infiltration for To treatment

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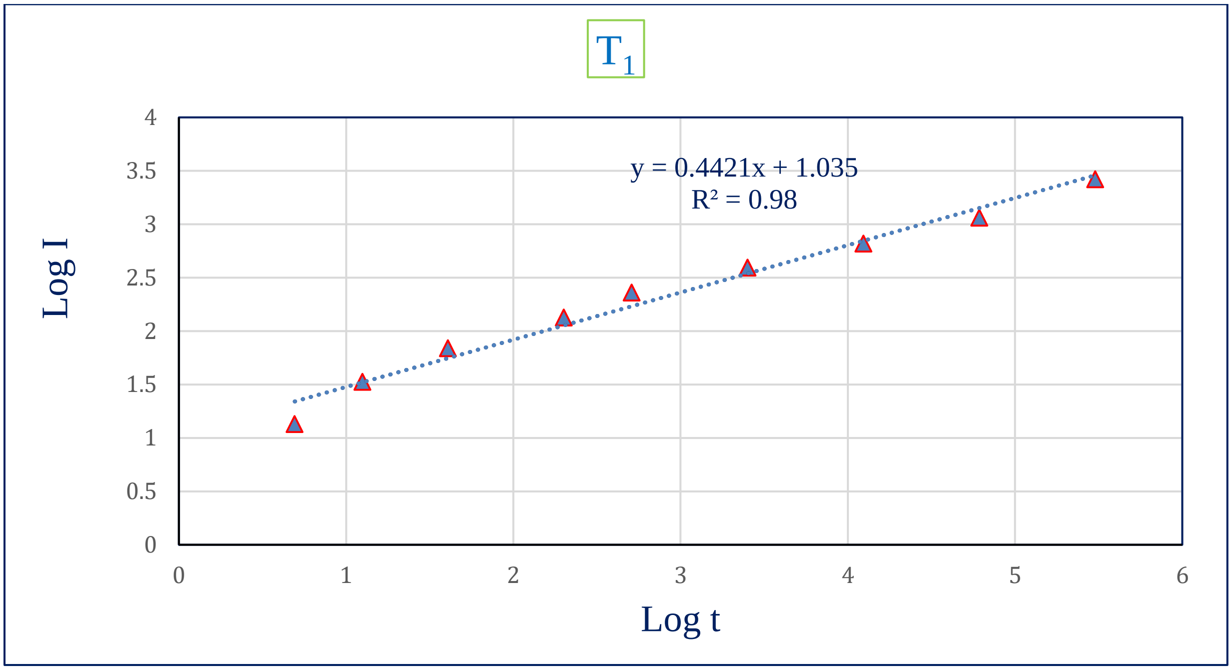

Figure 2. Linear relationship of the accumulative infiltration for T1 treatment

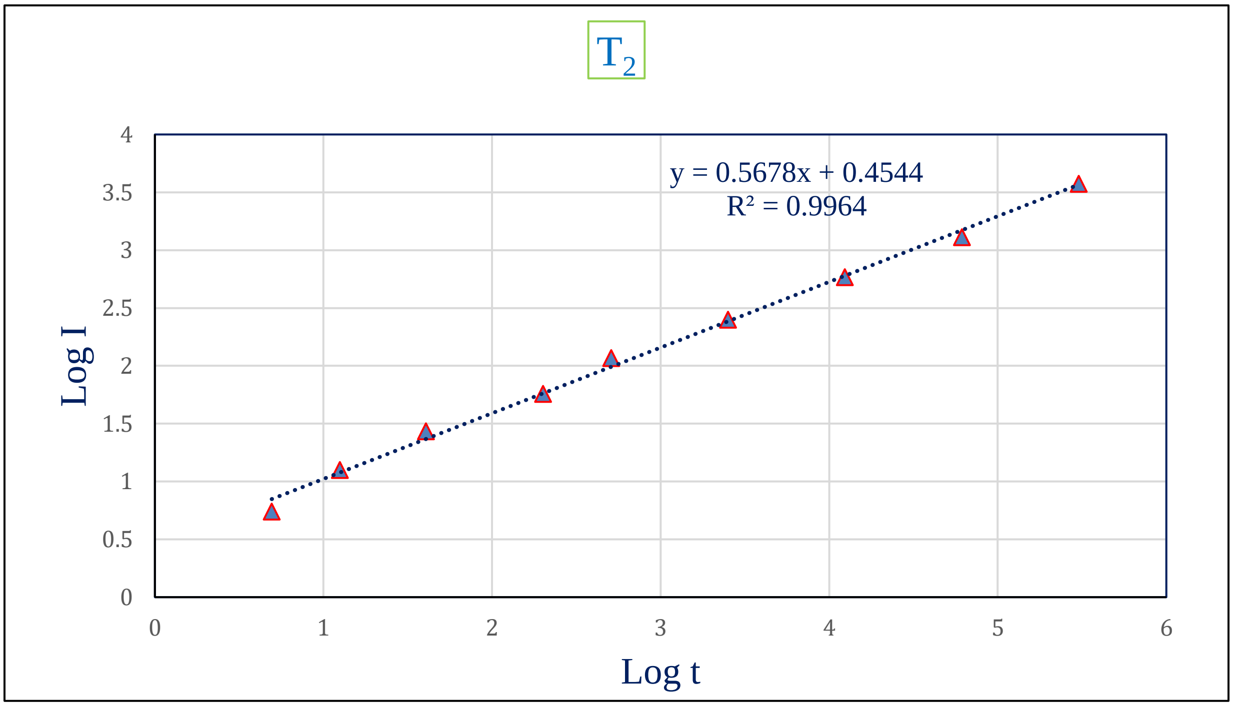

Figure 3. Linear relationship of the accumulative infiltration for T2 treatment

The Kostiakov equation constants' values are shown in Table 1, calculated from the linear equation presented in Figures 1, 2, and 3; all these figures are collected and compared in Figure 4. The T2 treatment assigned the highest linear cumulative infiltration values with time, followed by T1 treatment with low values, and the To treatment achieved the lowest values; the reason of that the conventional tillage increased soil permeability due to improving soil aggregation, which increasing air and water movement, and this agreed with Al-Sabbagh (1990) and (Costamana et al. 1982).

Table 1. Kostiakov equation constants for tillage patterns

tillage pattern	K	X
To (no-tillage)	3.51859	0.40612
T1(minimum tillage)	2.81501	0.442147
T2 (conventional tillage)	1.57527	0.56783

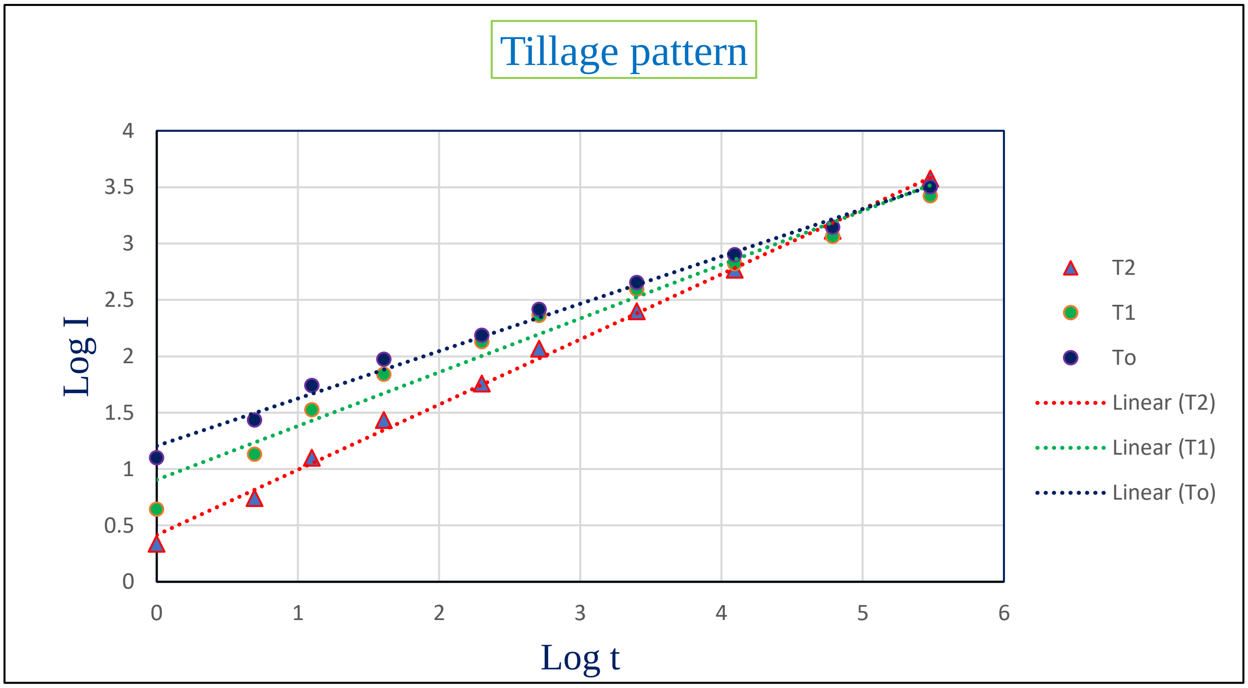

Figure 4. The comparison of the linear relationships for the three tillage patterns

The relationship between the cumulative infiltration with time for the three tillage patterns are shown in Figure 5. The highest cumulative infiltration is observed in the T2 treatment by 35.7 cm during 4 hours, followed with the lowest values of the treatments To and T1 by 33.2 cm and 30.6 cm, respectively, and the reason of that due to the rearranging of soil particles which leads to improving the soil structure.

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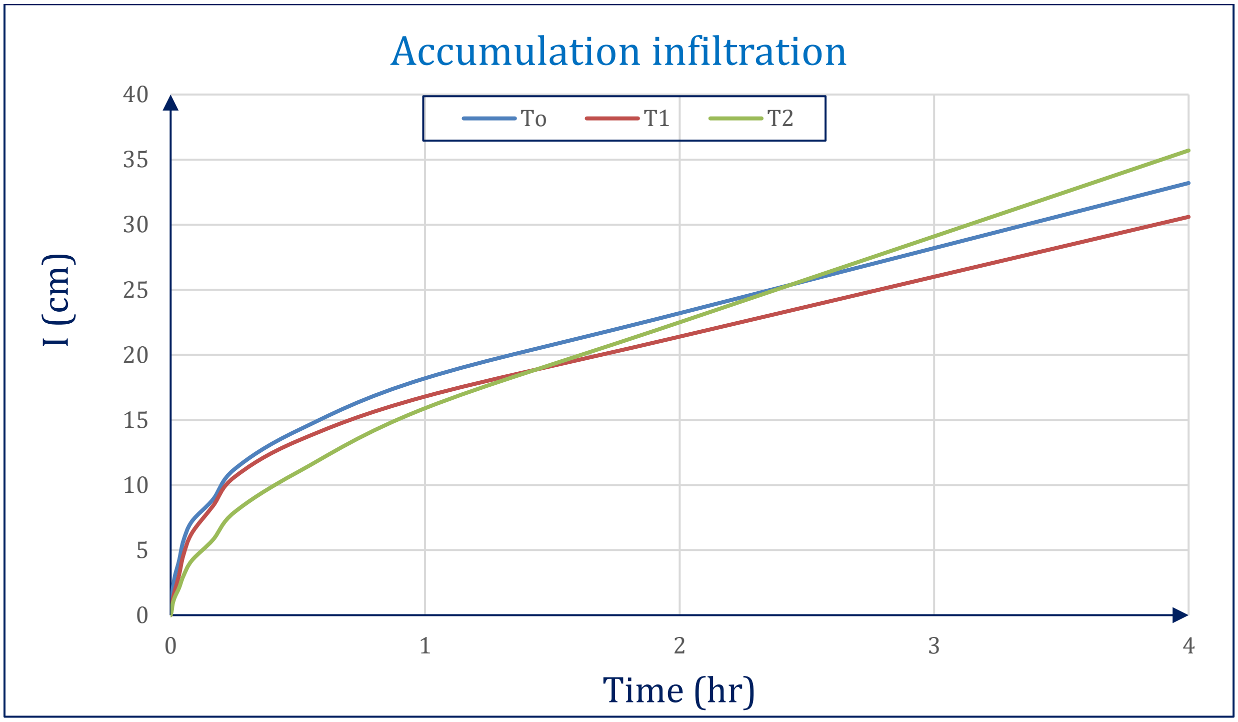

Figure 5: The relationship of the accumulative infiltration with time

The relationship of the infiltration rate with time for the three tillage patterns is shown in Figure 6, and the basic infiltration rate is shown in Figure 7. The last two figures show that the highest basic infiltration is for T2 treatment with 3.3 cm hr^{-1}, followed by To treatment with 2.5 cm hr^{-1}, and then T1 treatment with the lowest value of basic infiltration rate with 2.3 cm h^{-1}. The increase in basic infiltration rate is due to the conventional tillage pattern decreased soil penetration resistance; this agreed with Al-Hadithy and disagreed with Al-Attar et al. (2009). The effect of T1 treatment (minimum tillage) is a limited effect on the soil surface and each of; soil bulk density, average weighted diameter and saturated water conductivity, and it is agreed with (Al-Obaidi, 2019). The T2 treatment significantly changes the soil surface's bulk density and soil structure in-depth.

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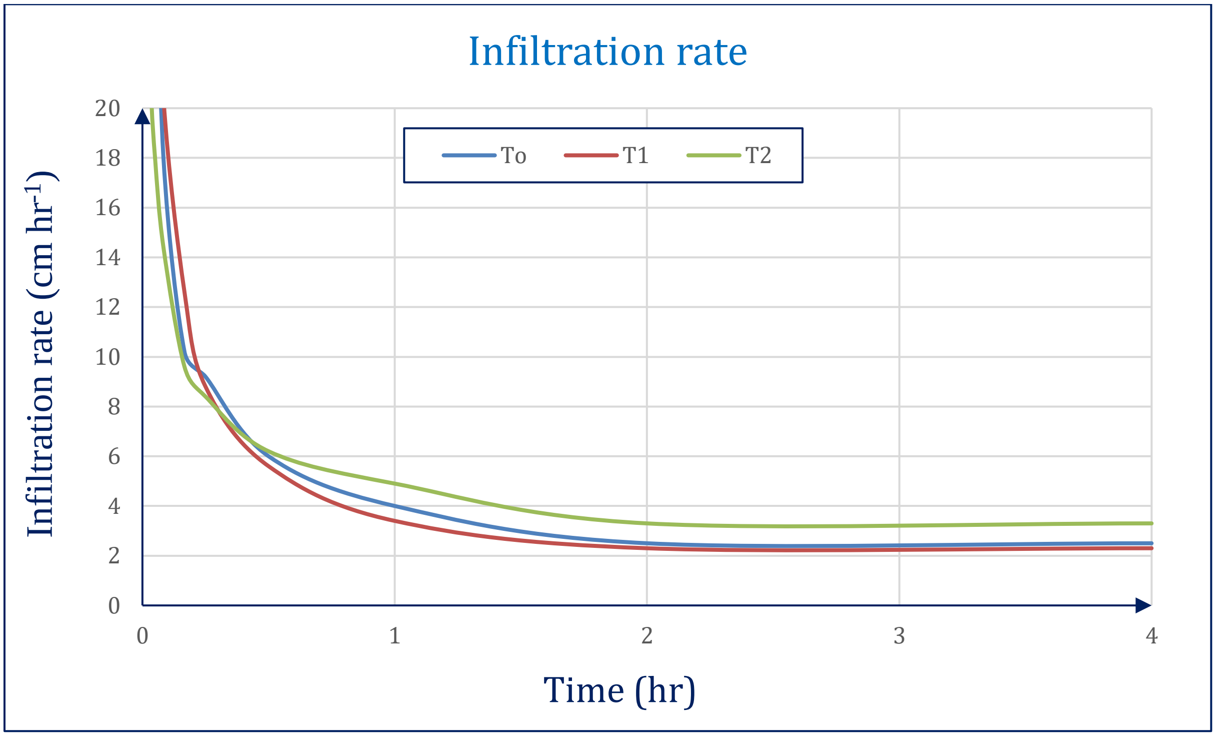

Figure 6. The relationship of the infiltration rate with time

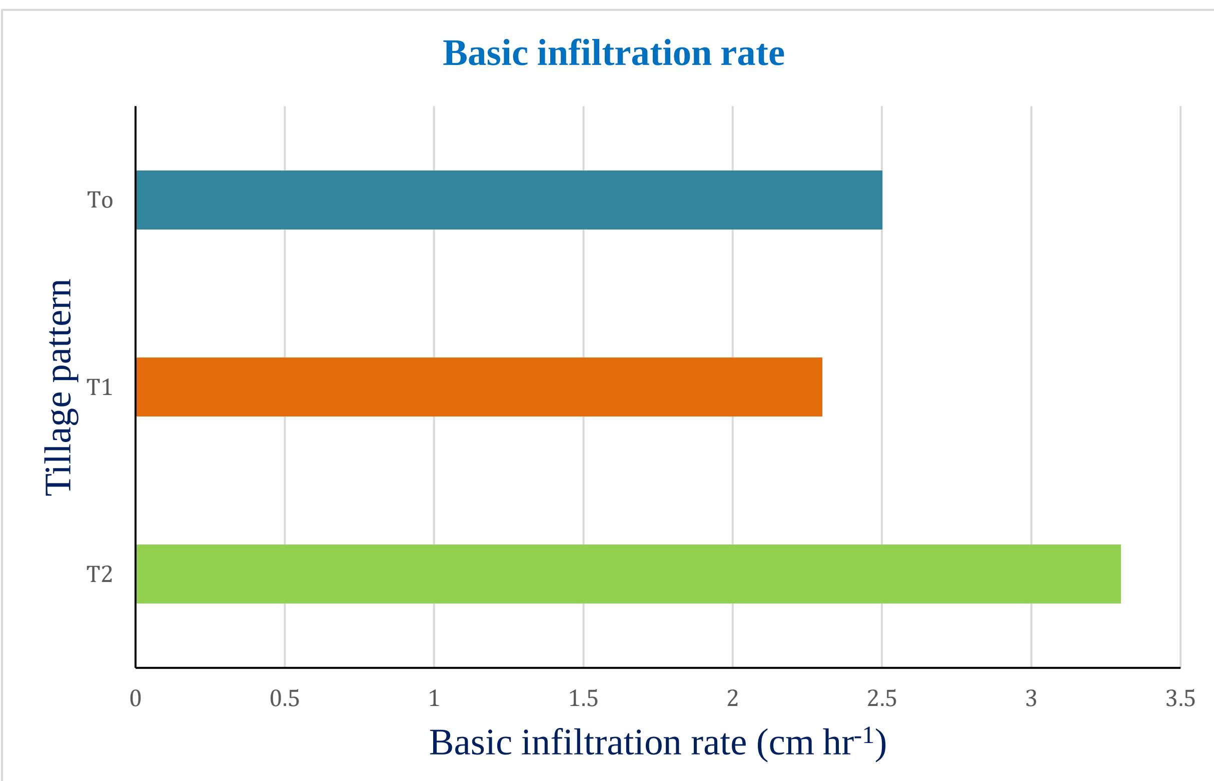

Figure 7: The base infiltration rate for the tillage patterns

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Conclusion

It is concluded from the results that the conventional tillage pattern (T2) achieved an increase in the water infiltration rate in the soil compared with the two treatments T1 and To. The highest accumulation infiltration is observed at treatment T2 with 35.7 cm during 4 hours. When the infiltration rate reaches a constant value, the highest basic infiltration rate is 3.3 cm h^{-1} for the T2 treatment.

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