Response Sunflower crop to drip irrigation tape (T-tape) level and added organic matter and its effect on some physical properties of the soil.

Saqr Mijbil Al-jumaily

Tikrit University, Faculty of Food Science / Al-Shirqat, Department

of Food Science and Technology, 34005, Salah Al Deen, Iraq.

Email : saqer.m.mohammed@tu.edu.iq

Abstract

A field experiment was conducted in Salah al-Din Province , Al-Sharqat District - Ajmeela Island, Al-Nahr Village, during the 2025 agricultural season. The aim was to study the effect of three drip irrigation tape levels (I_1, I_2, I_3) in the first factor, along with the addition of three levels of organic matter (T_1, T_2, T_3) in the second factor, on some physical soil properties, namely bulk density, saturated water conductivity, and soil porosity, in the response of sunflower crops. This was used as an indicator of growth and yield in a sandy loamy soil, according to a completely randomized block design. The most important results showed that the value of saturated water conductivity in the soil decreased with increasing organic matter content, recording a minimum value of (2.38) cm·h^{-1} and a maximum value of (4.52) cm·h^{-1} at a 50% irrigation level. Meanwhile, bulk density values increased with decreasing organic matter content, reaching a maximum value of (1.65), and bulk density increased with increasing irrigation level to 100%, reaching a value of (1.28). The results also showed that soil porosity increases with increasing organic matter content and decreasing irrigation levels, and decreases with decreasing organic matter content and increasing irrigation levels. Regarding the studied plant characteristics, the leaf area of sunflower plants and overall yield increased with increasing organic matter content to 1% and 2%. The highest yield (5361.3 kg ha^{-1}) was achieved at a 75% irrigation level with 1% organic matter. As for leaf area, the highest average leaf area was recorded in treatment T_3 with 434.33 cm² plant^{-1}, a significant increase of 5.92% compared to treatment T_2 with 1% organic matter. Regarding the interaction, the highest leaf area (513.62 cm² plant^{-1}) was recorded in the interaction treatment (I_2T_3), while the lowest (289.79 cm² plant^{-1}) was recorded in treatment I3T1, at 75% of the plant's irrigation level and with a high percentage of organic matter. 2%. As for the effect of the irrigation level and the percentage of added organic matter on the weight of the plant's vegetative mass, the weight of the plant's vegetative mass increased with the increase in the irrigation level from (125.08 g plant^{-1}) to (146.56 g plant^{-1}), and the percentage of organic matter affected the increase in the weight of the vegetative mass from (121.83 g plant^{-1}) to (148.29 g plant^{-1}). Therefore, the study recommends using 75% of the lowest rate of irrigation level for the needs of the sunflower plant within the conditions of the sandy loamy soils of the study area, with an increase in the percentage of added organic matter further to improve the physical properties of the soil on other strategic crops.

Key word: Sunflower, drip irrigation tape, organic matter, bulk density

Introduction

Water in arid and semi-arid regions is an essential part of developing the agricultural sector due to its scarcity and the size of cultivated lands. The scarcity of water and the lack of water rationing through water management are among the most significant problems facing the agricultural sector. Therefore, it is necessary to reduce the amount of water wasted and provide additional

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quantities during drought seasons, through the use of modern and advanced irrigation technologies that help increase production and reduce the volume of water losses ideally, especially in arid and semi-arid regions, which Iraq is located in and currently suffers from a real water crisis due to its location within the boundaries of these regions of the world, which are subject to continuous changes, soil aridity, and fluctuations in climatic conditions. The excessive depletion of water without achieving economic benefit leads to the loss of one of the most important natural resources and the emergence of social problems that threaten the country's food security. With water scarcity, increasing population growth, conflict and occupation of water resources from primary sources, the effects of climate change, and continuous urbanization trends, modern and diverse technologies must be used to contribute to achieving greater water security [19] -[1]. Designing a good irrigation system at different levels is one of the most important factors contributing to increasing the efficiency of moisture distribution in cultivated areas when strategic crops are grown to address the problem of water scarcity and increase production. Therefore, strip irrigation is considered one of the most important and highly efficient irrigation methods in terms of water use, reaching more than 60% compared to other irrigation methods used in the conditions of central Iraq [3] Among the most important advantages of strip irrigation is that it maintains a good percentage of moisture in the root zone of plants, reduces the amount of water evaporating from the soil surface, and prevents the growth and germination of weeds to a certain extent [36]. Agriculture in gypsum soils requires the use of irrigation methods that are appropriate to the type of soil present, as gypsum soils are considered poorly structured soils with continuously deteriorating chemical and physical properties, which is reflected in their weak ability to retain water. The scarcity of nutrients is a significant factor. [7] stated that gypsum soils constitute 27% to 36% of the total land area of Iraq, extending from the Sinjar region to the southern alluvial plain, the Tigris and Euphrates river basins, and scattered areas in the western desert [34] These soils consist of structurally unstable gypsum horizons with weak cohesion, low organic matter content, and are hard when dry but brittle when moistened. They are unstable and have a limited water retention capacity [10] indicated that the low organic matter content in gypsum soils, due to weak vegetation cover and the prevalence of these soils in arid and semi-arid regions, reduces the activity of microorganisms that aid in the decomposition of organic matter. This activity decreases with increasing depth, and their distribution within the soil becomes irregular. Therefore, studying some of the physical properties of gypsum soils is a key objective of this research, particularly regarding the response of sunflower plants and increasing yield. There is a scarcity of studies on this soil type. The amount of gypsum affects water transport functions, permeability, diffusion, and saturated water conductivity, making it an important physical property that determines water availability. The soil's ability to leach salts is defined as the capacity of the porous medium to transport water. Water conductivity is saturated when all pores are filled with water and capable of conducting it [28]. Bulk density is a variable soil characteristic and is directly related to compaction and porosity. Therefore, there is a strong relationship between the organic matter content in the soil and bulk density values. [33] found that adding poultry manure and straw to the soil reduced bulk density and increased porosity, with the effect being largely positive for poultry manure. The type of organic matter used is important in reducing the negative impact of soil compaction and increasing soil air content [5].

Sunflower is considered an important strategic oilseed crop due to its seeds containing a high percentage of healthy vegetable oils, ranging from 40-50% of the seed weight. This is attributed to its high content of unstabilized fatty acids, which help lower blood cholesterol

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and reduce the risk of atherosclerosis and heart disease [22]. Furthermore, the increasing demand for sunflower seeds enhances its economic importance, making its cultivation highly profitable and leading to growing growth, as consumers prefer fat-free vegetable oils [25]. Sunflower is an oilseed crop belonging to the Asteraceae family and is among the leading oilseed crops in Iraq in terms of economic importance and the percentage of total cultivated area. The province s of Babylon, Salah al-Din, Anbar, and Muthanna lead in both production quantity and cultivated area [16].-[23] found that the quantity of water significantly affects the yield, and that water stress resulting from insufficient watering negatively impacts the plant's performance. Proper water distribution during the vegetative growth period limits stem elongation and leaf area expansion. Therefore, methods should be used that minimize water waste while maximizing production. In a study conducted on sunflower cultivation in gypsum soil to determine the effect of thinning during the growth stage, [9] found that using leaf thinning at various growth stages under the gypsum soil conditions of Iraq significantly impacted daily growth rate and overall yield. Furthermore, [4] demonstrated the significant results of a study examining the effects of strip irrigation and biochar on certain properties of gypsum soil in sunflower growth and yield. The study showed that regulating water quantity during alternating irrigation did not negatively affect plant growth; rather, it increased water distribution efficiency and nutrient availability. The alternating strip irrigation method significantly outperformed traditional irrigation, resulting in a 13.95% increase in yield. Regarding the effect of irrigation and biochar on the total yield weight of sunflowers, the highest value was recorded at 5261.4 kg ha^{-1} across all studied treatments. The other increase was 13.8% and 3.39%, respectively.Using different irrigation levels based on plant requirements for agricultural crops is one of the most important modern methods for reducing the amount of water added in agricultural fields in arid and semi-arid regions. [35] found that the moisture content decreases with distance from the water source, reaching an average of 16.5%, 13.3%, and 11.4% when irrigation levels of 50%, 75%, and 100% of the plant's requirements were applied, respectively, in a study he conducted on the effect of organic fertilizers and plant moisture distribution. Similarly, [17] reported on the effect of a strip irrigation system at different distances with three irrigation levels (60%, 80%, and 100% of the plant's requirements) and found that the 100% irrigation level resulted in the best grain yield, reaching 4.289 tons ha^{-1}, surpassing all other treatments. In another study loam conducted by [37] in soil with A sandy mixture texture to demonstrate the effect of adding different levels of organic matter (5, 7.5 and 10 tons ha^{-1}) on the apparent density and of the soil. They found that the apparent density values gradually decreased with increasing levels of addition, giving 1.31, 1.21 and 1.17 mg m^{-3} respectively. This was due to the increase in the total porosity of the soil with respect to the pore volumes, due to the decomposition of organic matter, which leads to an improvement in soil structure.

Materials and Methods

A field experiment was conducted in Salah al-Din Province – Al-Sharqat District – Ajmila Island, Al-Nahr Village, approximately 10 kilometers from the district center, on a sandy loam soil. The purpose was to study the response of sunflower crops, irrigation levels, and the percentage of added organic matter to the soil's physical properties, namely bulk density, saturated water conductivity, and porosity. Sunflowers were planted in July of the 2025 growing season. Soil samples were taken from the field at a depth of 30 cm, at a level appropriate to the root system size, randomly selected from the study area. The soil was dried, ground, and passed through a 2 mm sieve. Chemical and physical analyses were performed on the soil samples before

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planting, as detailed in Table (1). The experiment was implemented according to a completely randomized block design (RCBD). The experiment included two main factors:

1. Irrigation: 50% of the water requirements (I_1)

2. Irrigation: 75% of the water requirements (I_2)

3. Irrigation: 100% of water requirements (I_3)

Work Two: Three levels of organic matter addition

1. 0% T_1

2. 1% T_2

3. 2% T_3

The land was moistened before plowing to eliminate unwanted weeds. The land was plowed perpendicularly and leveled on a 20x20 meter agricultural plot with a total area of 400 m². The experiment included 9 main treatments for irrigation level and percentage of added organic matter. The plants were distributed equally across 3 replicates, totaling 27 experimental units within the field. The area of each experimental unit was 6 m². decomposed organic matter was added to the soil as a percentage at three levels: 0%, 1%, and 2%. It was thoroughly mixed with the soil using a small two-wheeled moldboard plow. Sunflower seeds of a local variety for the autumn season were sown on July 20, 2025, at a rate of 3 seeds per plot. A planting hole 4 cm deep was prepared, and a strip irrigation system was installed within the field for the main and branch lines. The distance between planting and irrigation lines was 70 cm, and between planting holes was 30 cm. The system's discharge rate was 8000 liters per hour. Thinning was carried out after seedling emergence, within 10 days of planting, along with other agricultural operations such as patching and weeding. Irrigation was carried out based on direct assessment of moisture content when 50% of the available water was depleted for the plant. This assessment was conducted using the gravimetric method and a microwave oven, by taking soil samples with an auger. Irrigation was also carried out according to the plant's root depth and its stage of development throughout the growing period.

Table (1) Some chemical and physical properties of the field soil before planting

Unit	Value	Property	Unit	Value	traits
$Mg.m^{-3}$	1.68	Bulk density	$g.kg^{-1}$	609	Sand
$Mg.m^{-3}$	2.65	Particle density	$g.kg^{-1}$	247	Silt
%	0.37	Porosity	$g.kg^{-1}$	153	Clay
ds . m-1	2.63	Ec	Sandy loam	——	Texture
——	7.24	pH	$g.kg^{-1}$	6.4	Organic matter
$C.mol_c.Kg^{-1}$	12.28	CEC	$Cm .h^{-1}$	5.12	Hydraulic conductivity
$g.kg^{-1}$	61.3	Calcium carbonate	$g.kg^{-1}$	84.9	Calcium sulfate

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Soil texture was estimated using the gypsum soil method developed by [31] Organic matter was estimated using the wet digestion method described by [24]. pH and EC were estimated using a 1:1 soil extract as described by [15] Saturated soil water conductivity was measured before planting using Equation (3) and after planting using Equation (4). It was also measured at full seed maturity using the steady-state water column method on undisturbed soil samples. Soil samples were taken from the field for all experimental treatments using a core sampler with a known diameter and reinforced filter paper placed underneath to prevent soil particles from being carried away with the water. The values were determined according to Darcy's law [21] where the water flow density (q) is proportional to the water kinetic force (f), and the soil water conductivity constant (K) is.

q = kf …..(1)

Where the flow density is equal to the amount of water flowing (Q) to the flow area (A) in time (t.(

$$q = \frac{Q}{AT} \quad \text{…….(2)}$$

ΔH) Change in water potential between two points (L) Distance between two points = $\frac{\Delta H}{L}$ F However, f equals

= -k $\frac{\Delta H}{L}$ Multiplying both sides of the equation by the reciprocal$\frac{\Delta H}{L}$ $\frac{Q}{At}$ The Darcy equation

We have the Darcy equation

$\frac{Q}{AT} * \frac{L}{H}$ …..(3) Ks =

….(4) Ks= $\frac{V\,L}{At\,(h+L)}$

The apparent density of the soil was measured before and after planting at the maturity stage after the flowering stage for the experimental treatments according to the paraffin wax method as described by [30] The true density was estimated from the relationship proposed by [11] for gypsum soils. The total porosity was calculated by applying the relationship between the apparent density of the soil and the true density according to the method described by [20].

f = 1- $\frac{Pb}{Ps}$ …..(5)

Where:

f = porosity %

Pb = bulk density $Mg.m^{-3}$

Ps = particle density $Mg.m^{-3}$

Studied Plant traits

Plant characteristics were calculated by randomly selecting (6) plants from each experimental unit, representing one-third of the total number of plants cultivated, and calculating the average for each experimental unit.

Leaf area was calculated using the equation [18]

: $LA = 0.65\sum W^2$

LA = Leaf area (cm^2)

W = Maximum leaf width

W = 0.65 (constant value)

Total seed yield ($kg\ ha^{-1}$): Seed yield was calculated using the equation: Total seed yield ($kg\ ha^{-1}$) = Average seed yield per plant * Plant density ha^{-1}

Note: Plant density = 30,000 plants ha^{-1}

Dry weight of the vegetative growth of the sunflower: The vegetative weight was calculated by cutting the stem at the root attachment point, washing it under a gentle stream of water, and placing the stem, leaves, and lateral branches in a paper-lined oven at 65°C. ◦ It was dried until the weight stabilized,

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then weighed using a sensitive scale after the drying process.

Results and Discussion

Effect of Irrigation Level and Added Organic Matter on Saturated Conductivity

The results in Figure (1) show that water conductivity decreases with increasing organic matter content and irrigation level in the soil when compared to its values before planting. Water conductivity was high for the sandy loamy soil (Table 1). Increasing the irrigation level and organic matter content led to increased cohesion between soil particles and better aggregate stability due to a reduction in soil pore size, creating suitable conditions for plant growth. This was confirmed by [8]. A suitable moisture content was maintained due to the increased irrigation level and increased soil depth. The lowest values for saturated water conductivity were recorded at (2.76, 2.38) cm.h^{-1} for 100% and 75% irrigation levels, respectively, compared to the 50% irrigation level treatment, where water conductivity increased to 3.29 cm.h^{-1}. This is attributed to the soil's exposure to a longer dry period, reducing its water retention capacity due to the decomposition of organic matter and the formation of a barrier layer. Water absorption increases the flow rate within the soil.

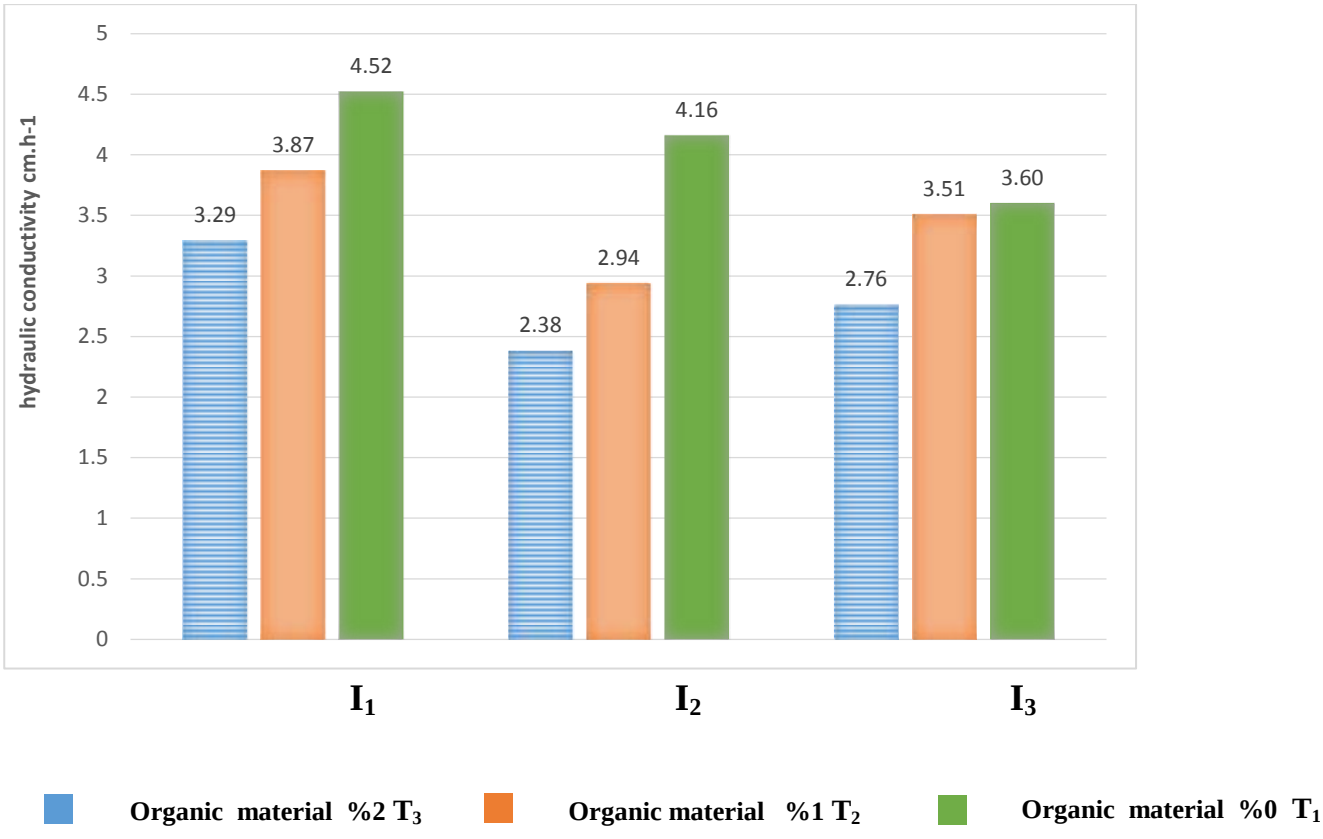


Figure (1) Effect of Irrigation Level and Added Organic Matter on Saturated Water Conductivity

The highest value of saturated water conductivity, as shown in Figure (1), indicates an inverse relationship between organic matter and water conductivity. It reached (4.52 cm·h^{-1}) for the treatment with a 50% irrigation level and 0% organic matter. Saturated water conductivity increases with decreasing organic matter content due to

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reduced cohesion between soil particles, increased pore volume, and decreased surface area. These results are consistent with those found by [6]. Effect of Irrigation Level and Added Organic Matter on Soil Bulk Density

Figure (2) shows that soil bulk density decreases as the organic matter content increases and increases with increased irrigation level. This is a direct relationship resulting from water entering the air pores, reaching saturation, and deteriorating the solid bulk structure. There is also an inverse relationship between bulk density and organic matter content, as soil compaction decreases with increasing organic content, and vice versa [13]. Figure (2) further illustrates this. The lowest values were (1.28, 1.40, 1.34%) Mg.m-3 for the 2% organic matter ratio for all study treatments, which decreased by percentages of (25.37, 20, 31.25) compared to its value before the planting period, as mentioned in Table (1). The reason for this can be attributed to the increased downward movement of water as a result of its absorption and retention by the organic matter. The level of irrigation water addition with the appropriate amount of organic matter raises the soil moisture level without shrinking it and closing its pores, while increasing the improvement of the structural aggregation process and maintaining the size of the medium and large connected pores, which affects the increase in the size of the pores. Therefore, the organic matter maintains the same size because it is not compressible, while maintaining a larger volume for the same weight of soil [26]. Dividing a constant weight by the amount of the larger volume will reduce the value of the apparent density while increasing soil productivity.

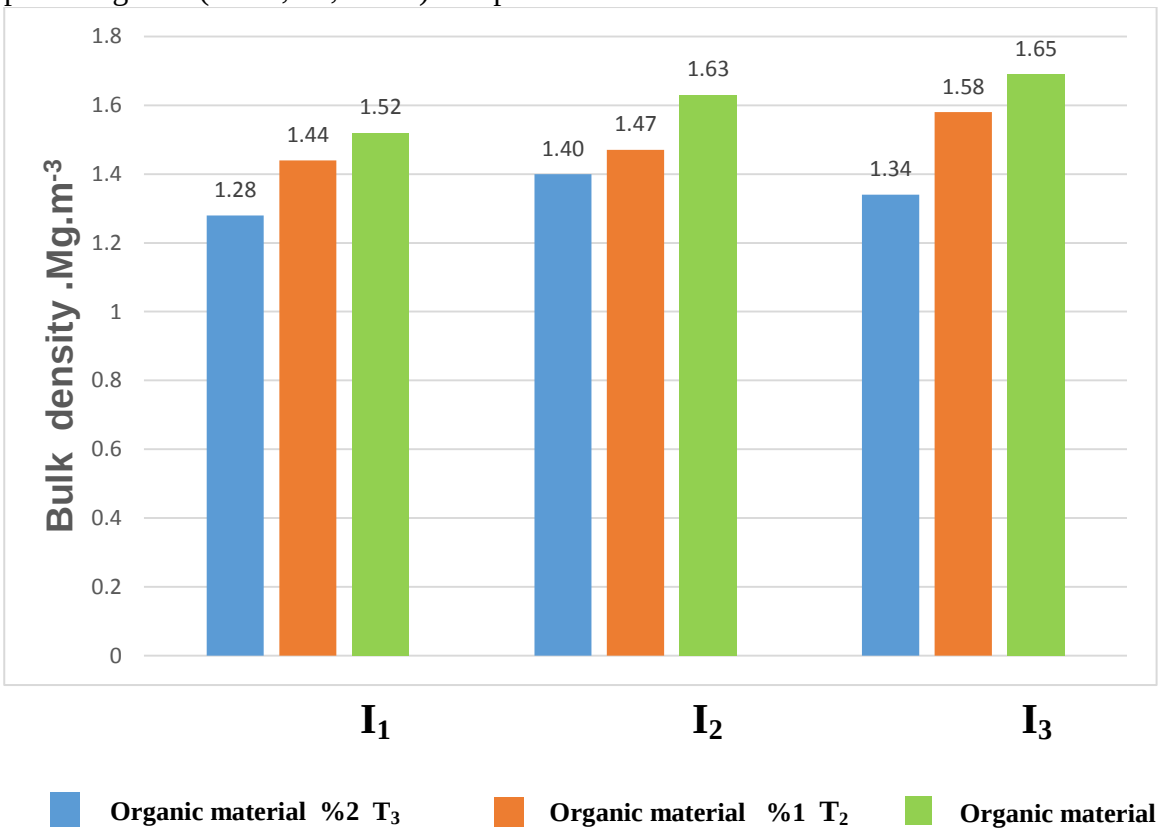


Figure (2) Effect of Irrigation Level and Added Organic Matter on Soil Bulk Density

Effect of Irrigation Level and Added Organic Matter on Soil Porosity

Figure (3) shows that soil porosity values increase with increasing organic matter content and decreasing irrigation levels, and decrease with decreasing organic matter

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content. The highest soil porosity value was recorded at (0.52%) and the lowest value at (0.38%), representing an increase of (36%) and a percentage of (40%), respectively, compared to the porosity before planting, as mentioned in Table (1). The lowest porosity values were recorded for the organic matter content (To) and for all irrigation level treatments, while the highest values were recorded for the organic matter content for all other treatments (T2 and T1). This is explained by the fact that organic matter helped redistribute the pores associated with the amount of gypsum in sandy loam soils, which increases the cross-sectional area that conducts water, facilitates its disintegration, increases its elasticity, and enhances the soil's compressive strength. This is consistent with the findings of [14]

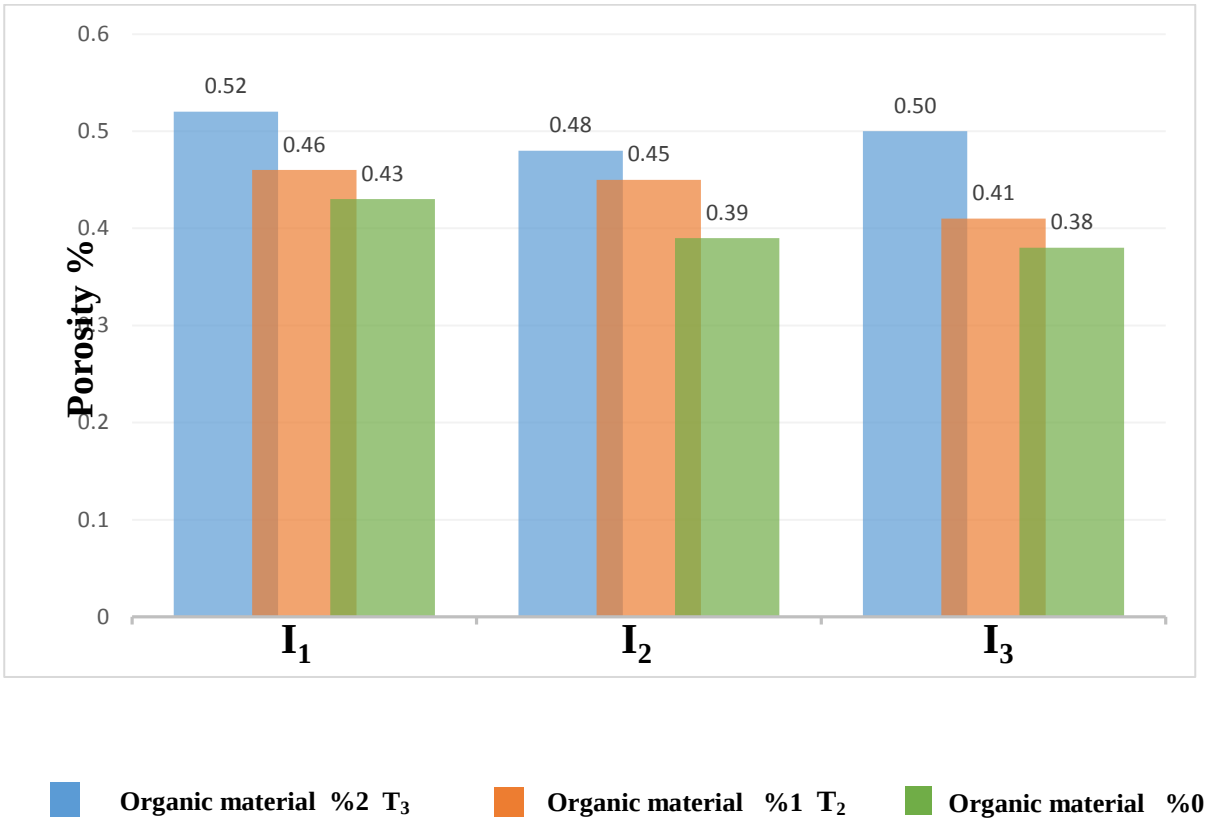


Figure (3) Effect of Irrigation Level and Added Organic Matter on Soil Porosity

Effect of Irrigation Level and Added Organic Matter on Plant Yield (Total Seed Yield kg ha^{-1})

Table (2) shows the effect of irrigation level and organic matter percentage on sunflower seed yield. The 75% irrigation level treatment (I2) resulted in the highest average sunflower seed yield, reaching 4821.4 kg ha^{-1}, with an increase of (10.12% and 21.03%) compared to the I1 and I3 irrigation levels. This can be explained by the fact that regulating the irrigation level to 75% of the plant's requirements is appropriate for the physiological growth stages of the sunflower plant. The plant goes through different growth stages, and the germination stage is the most sensitive to water deficiency. Reducing the added amount of water slows plant growth [29]. As the growth stages progress, the water addition level increases, with irrigation being regulated for other growth stages, especially during the flowering stage and until maturity. This allows the plant to maintain

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photosynthesis for a longer period at an appropriate irrigation level, thus increasing the yield. The yield increased when the irrigation level was raised from 50% with an improvement in soil properties. These results are consistent with those of [2,12] It is also evident that the highest organic matter content, 5019.8 kg ha^{-1}, was achieved in treatment T3. An appropriate organic matter content helped maintain soil moisture levels, enhance water retention between pores, promote cohesive particle aggregation, and facilitate better root penetration and propagation. Table (2) also shows that treatment T3I2 achieved the highest yield, 5361.3 kg ha^{-1}.

Table 2: Effect of Irrigation Level and Added Organic Matter on Plant Yield (Total Seed Yield kg ha^{-1})

I / T	I_1	I_2	I_3	Mean
T_1	3401.3 f	4010.5 d	3721.9 e	3711.2 C
T_2	4038.1 d	5092.6 b	4225.7 d	4452.1 B
T_3	4510.8 c	5361.3 a	5187.4 a	5019.8 A
Mean	3983.4 C	4821.4 A	4378.3 B	

Means with the same letters do not show a statistically significant difference according to Duncan's test at a significance level of 5%.

Effect of Irrigation Level and Added Organic Matter on Plant Leaf Area (cm²):

Table (3) shows the effect of irrigation level and organic matter percentage on plant leaf area. Treatment T3, with the highest organic matter percentage, yielded the highest average leaf area of 449.33 cm² .plant^{-1}, a significant increase (9.58 %) compared to treatment T2. This is due to the fact that the organic matter percentage increased the amount of moisture in the root zone due to the binding of soil particles together, thus retaining water for longer periods. The increased irrigation level also increased the swelling pressure exerted on the plant cell walls, stimulating cell division and expansion, thereby increasing the plant leaf area [27] The lowest average leaf area, 337.73 cm², was observed in irrigation treatment I1. This is attributed to the fact that the plant's leaf area decreases when exposed to prolonged water stress conditions during cultivation. Through this, the plant adapts to and tolerates these arid conditions, and reducing the area of the plant is considered a way to resist this stress [1].

ISSN 2072-3857

Table (3) Effect of irrigation level and added organic matter on the leaf area of the plant (cm^2)

I / T	I_1	I_2	I_3	Mean
T_1	289.79 e	318.84 d	295.11 e	301.24 C
T_2	328.50 d	494.27 a	407.29 c	410.02 B
T_3	394.91 c	513.62 a	439.46 b	449.33 A
Mean	337.73 C	442.24 A	380.62 B	

Means with the same letters do not show a significant difference according to Duncan's test at a significance level of 5%.

Effect of Irrigation Level and Added Organic Matter on the Dry Weight of vegetative growth (g $plant^{-1}$):

Table (4) shows the effect of irrigation level and organic matter on the response of the plant's shoot weight. The irrigation level for treatment I3 recorded the highest average shoot weight, reaching (146.56 g $plant^{-1}$), with a significant increase of (6.04% and 17.17%) compared to the other irrigation level treatments (I1 and I2). This is explained by the fact that the high Dry Weight of vegetative growth sunflower plants was observed at a 100% irrigation level for all treatments due to the increased moisture level and organic matter content in the soil during the growth period. This increases the rate of transpiration, as the plant maintains continuous water uptake by the cells, filling them and increasing the elongation of the stem, leaves, and other vegetative parts. This is due to the increased rate of water loss through the stomata, which the plant utilizes to increase the shoot weight [32] The highest average organic matter percentage for the 2% treatment was (148.29 g $plant^{-1}$). As shown in Table (4), gradually increasing the organic matter percentage helped improve the soil's water retention capacity for longer periods, while also retaining dissolved nutrients and facilitating root expansion within the soil. Regarding the interaction effect, the highest value for shoot weight was recorded for the (I3T3) treatment, reaching (158.07 g plant-1), representing an increase of (4.52) compared to the nearest treatment with a 1% organic matter percentage.

Table (4) Effect of Irrigation Level and Organic Matter Percentage on Dry Weight of vegetative growth (g $plant^{-1}$)

I / T	I_1	I_2	I_3	Mean
T_1	113,28 d	121.84 c	130.39 c	121.83 C
T_2	124.36 c	143.59 b	151.23 a	139.72 B
T_3	137.62 b	149.18 a	158.07 a	148.29 A
Mean	125.08 C	138.20 B	146.56 A	

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Averages with similar letters show no statistically significant difference according to Duncan's test at a significance level of 5%.

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