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EVALUATION OF SUBSOILING TILLAGE METHODS AND IRRIGATION SYSTEMS IN POTATO CROP GROWTH AND SOIL DYNAMICS

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ABSTRACT

One This study was conducted in the field of the College of Agriculture and Forestry / University of Mosul during in the spring agricultural season of 2023 to examine the effect of three irrigation systems (drip, sprinkler and furrow irrigation) and the use of the subsoiling plow at depth of 30-35 cm in the method of single-pass tillage and the Cross-Passing tillage on the potato crop, The split-plot design was used once in a Randomized Complete Block Design (RCBD) with three replications. Data were then recorded and statistically analyzed. the results were as follows: The drip irrigation system significantly outperformed the percentage of dry matter in the leaves, and the sprinkler irrigation system significantly outperformed the deviation in the shape of the soil beds, while the number of irrigations decreased significantly. The season, significantly outperformed the Cross-Passing tillage method in the number of air stems, the percentage of dry matter in the leaves, the number of tubers per plant and the total yield of tubers, with an increase of 46.15, 20.88, 15.01 and 23.58%, respectively ,The single-pass tillage method gave the recorded the lowest significant values values in the percentage of deviation in the form of soil beds and the number of irrigations per season, at 29.20 and 4.88%, respectively, The interaction between drip irrigation and the Cross-Passing tillage method recorded the highest significant values in number in air stems and the the percentage of dry matter in the leaves, the number of tubers per plant and the total yield of tubers, while the overlap between sprinkler irrigation and single-pass tillage method gave the highest significant values in the deviation in soil beds shape.

INTRODUCTION

Potatoes are one of the main vegetable crops grown all over the world because their tubers contain nutrients, proteins, calories, amino acids and carbohydrates, which are important in achieving human food security (Elsevier et al. 2016) While global warming, climate change and the decrease in rainfall in recent years is the main reason for the decline in agricultural areas worldwide, which poses a significant risk to human food security (Training et al. 2022)Very sensitive to soil and water conditions during their growth (Djaman et al., 2021), so a balance must be found between increasing the world's population with increasing crop production in addition to finding the best irrigation system in terms of reducing water consumption so that it maintains an increase in yield per unit area and the least amount of water consumed, This is done through the use of the appropriate irrigation system For plants, soil and the surrounding climate, in addition to taking

into account the cost of construction, as the tourist irrigation system is one of the oldest irrigation systems around the world because of its ease of use, simplicity of installation and low pump pressure during use by delivering water directly from the pumping pipe to the soil, causing an increase in the amount of water, excessive moisture of the soil, poor ventilation and cracking of the soil surface (Manik et al., 2019).

Switching from furrow irrigation to sprinkler irrigation has significant benefits because of its great benefit in reducing soil erosion, increasing water use efficiency, improving the physical qualities of the soil, enhancing the presence of nutrients in the soil in fields with soil prone to water erosion and deposition of nutrients as a result of the use of soil beds irrigation (Ippolito et al. 2017) The drip irrigation system is one of the latest systems used irrigation, as it provides water directly to the roots and in a certain amount, which provides appropriate moisture. For root growth and increase plant productivity by maintaining soil construction from collapse and reducing nutrient leaching from the soil (Narayanamoorthy et al. 2018) in addition to reducing water use due to low evaporation and direct water delivery to the plant root zone and regular moisture distribution around the plant (Reyes et al. 2016) It is considered more efficient in saving water at the top of the meadows when planting potatoes compared to the method of sprinkler irrigation when applying similar amounts of water, which keeps the soil building from collapsing, unlike sprinkler irrigation, which causes soil compaction as a result of the collision of water droplets in the soil surface, which leads to an increase in the bulk density of the soil in the topsoil layer and reduce the absorption of water by the at the top of the soil beds and increase soil compaction (Duran et al. 2009), and the drip irrigation system has proven its great effectiveness In increasing the efficiency of water use compared to the tourist irrigation system by reducing the evaporation of water from the soil and providing sufficient water for plant growth, which leads to an increase in the number of aerial stems, the percentage of dry matter in the leaves, the number of tubers of one plant, the yield of one plant and the total yield of the plant (Akram et al. 2020) In addition, the use of plow under the soil leads to breaking the deep soil layers, improving the physical properties of the soil, increasing the drainage of excess water from the soil, which maintains the ideal moisture of the soil, which increases the absorption of nutrients by the roots, increasing the elongation of the roots, providing nutrients in the soil, and increasing soil aeration through different bacterial populations of the soil (Costa et al. 2017), as the movement of gases in the soil decreases in the soil with an increase in bulk density as a result of the decrease in the size of soil pores. (Chen et al. 2016).

The study showed that deep tillage was more suitable for the movement of soil moisture to the deep layers after irrigation or rainfall, and that the water consumption in the treatment with deep soil tillage was greater She also noted that deep tillage can coordinate the relationship between water consumption and production. Better, resulting in an increase in yield by 34.48-38.10% and water use efficiency by 19.57-21.96% (Qiang et al. 2022) As soil compaction in the root zone, especially in the upper soil layers, hinders root growth and reduces root density, which leads to a decrease in the rate of leaf appearance and reduces vegetative growth of the plant, causing a decrease in the total yield of the plant. Adjusting the amount of irrigation helps relieve soil pressure. Increase the efficiency of water and nutrient use from the soil (Stalham et al. 2007) It can also cause pressure Soil in the subsurface layer to the collection of roots in the topsoil layer in a small cavity which causes less absorption of nutrients by the roots (Copas et al. 2009) As a result of hindering the deepening of the roots in the soil, which leads to a reduction and which leads to reducing the supply of nutrients to the plant and delaying the rate of leaf appearance, which leads to a decrease in the rate of plant length and the percentage of dry matter and delaying the vegetative growth of the plant and thus a decrease in the number of tubers per plant and the total yield of tubers (Huntenburg et al. 2021) Therefore, the use of deep plowing of the soil helps to relieve the mechanical stress of the compacted soil, which leads to enhancing the elongation of the roots and improving the ability of the crop to reach water In the deep layers of the soil (Ghosh and Daigh,

2020) in addition, deep tillage of the soil drains excess water and thus provides optimal moisture for root growth in the deep soil layers and keeps the soil building from collapsing (Baumhardt et al. 2008).

METHODOLOGY

Chapter Three: Materials and Methods of Work The study was conducted in the spring season / 2023 in the vegetable field of the College of Agriculture and Forestry / University of Mosul, 5 km north of the center of Mosul, Iraq, with mixed clay soil, and soil samples were taken from the field from the soil surface and at a depth of 30 cm, and these samples were analyzed in the central laboratory of the College of Agriculture and Forestry / University of Mosul as shown in Table (1),

Table (1): shows the physical properties of soil and soil contents.

PH	7.1
EC (mS/cm)	1.80
Field Capacity	19.98%
Sand	25.05
Clay	37.95
Silt	37

Potato tubers of the local variety Lucinda grade A, which were stored in cold stores at a temperature of 4-5 m for a period of six months, and produced from the same class E and purchased from a farmer, were planted on 20/1/2023 with potato planting, which is tied behind the jars, and the distance between one soil beds and another was 0.75 meters, and the distance between one tuber and another was 0.25 meters, at a depth of 0.15 meters, and the soil beds depth of the potato was 0.26 meter Soil moisture was measured using a moisture meter at a depth of 30 cm, and the moisture content was 70% of the soil field capacity.

The study included two factors:

Irrigation systems and included three irrigation systems

A- Drip irrigation: The drip irrigation pipe was installed after planting the tubers at the top of the soil beds and the distance between the dotted and the last 25 cm was calculated by placing a cylinder listed under the dripper and calculating the time it takes to fill the graduated cylinder of the known size at the beginning and end of the drip tape line and taking the rate of discharge of the drippers and the percentage of difference in the discharge of drippers was 5% at each transaction and A lock was placed to prevent water from reaching between the treatments when the appropriate moisture of the soil was reached, and another drip line was opened outside the experiment to compensate for the pressure to maintain the constant drainage of the drippers.

B- Sprinkler irrigation: The sprinklers were installed by two lines and amounted to 18 nozzles and by 9 nozzles for each line to achieve interference in the sprinkler water between the two lines and the outer side of the sprinklers lines was neglected and the discharges of 9 nozzles were calculated only in calculating the amount of water consumed and the discharge of one sprinkler was measured by calculating the amount of water coming out of it at a certain time and by placing plastic hoses in the sprinkler nozzle and placing water in a basin with a capacity of 15 liters and then the discharge of the first sprinkler was calculated And the last and find the exchange rate to achieve balance in the account

C- Tourist irrigation: The field was divided into four sections by placing earthen shoulders to separate the transactions from each other and each treatment was watered individually and

according to the methods of tillage, the water drainage pipe was used directly to distribute water to the meadows, and the pump discharge was measured by measuring the time required to fill a pot of known size.

2- Tillage methods: The land was plowed with a subsoiling tillage in two treatments the distance between the plowing lines was 1 meter and included two treatments:

A- Single-pass tillage:

B- Cross-Passing tillage:

Then the disc plow is used at a depth of 20 cm to turn the soil, and the land is leveled before the planting process.

Study treatments: The study included 6 treatments (2×3), combining irrigation systems and two tillage systems, designed with a splinter cutting system once within the design of the complete random sectors RCBD and with three replicates, irrigation systems were placed in the main plots and tillage systems in the difficult plots Sub plots, then the tubers were taken off at the end of the season and on 1/7/2023, and the following characteristics were recorded:

1- *Number of air stems (stem. plant^{-1}):* I took three plants from each treatment and the number of air stems was calculated for them and the rate was extracted for each plant.

2- *The percentage of dry matter in the leaves*: I took three plants from each treatment and the leaves were collected in paper bags to be weighed to obtain the soft weight of the leaves and then placed in an electric oven at a temperature of 65 m for a period of 72 hours to obtain the dry weight of the sample and according to the equation:

$$\text{Percentage of dry matter in the leaves} = \frac{Dry\ weight\ of\ leaves}{Wet\ weight\ of\ leaves} \times 100$$

3- The number of irrigations per season: according to the number of irrigations during the agricultural season

4- *The percentage deviation of the shape of the soil beds*: The percentage of deviation of the shape of the soil beds is measured by measuring the height of the top of the soil beds from the bottom by measuring tape after placing a wooden board on the top of the rose as well as the width of the soil beds is calculated by measuring the lowest point on both sides of the soil beds and the width of the soil beds was 75 cm The width of the soil beds was divided into two assuming that the shape of the soil beds became rectangular and Area measurement The area of the soil beds was also measured at the end of the season before the harvesting process and in the same way where there was a decrease in the height of the soil beds through the calculations that were reached that the area of the at soil beds the end of the season amounted to less than the area of the soil beds at the beginning of the season and to calculate the percentage deviation of the shape of the soil beds the following relationship uses the area at the end of the season on the area at the beginning of the season.

$$\text{Soil beds area} = \text{Soil beds height} \times \text{Soil beds width}$$

$$\text{Soil beds area at the end of the season} = \frac{\text{Soil beds area at the end of the season}}{\text{Soil beds area at planting}}$$

5- The number of tubers per plant: The number of tubers per plant was calculated at harvest at the end of the season by taking out the tubers by digging a manual iron bale and calculating the tubers.

$$\text{Number of tubers per plant} = \frac{\text{Number of tubers for five plants from each treatment}}{5}$$

6- The total yield of tubers (ton. ha^{-1}): according to the same plants in each treatment and as follows:

$$\text{Total yield ton/ha} = \frac{\text{yield per plant (gm. plant)} \times \text{number of plants (ha)}}{1000000}$$

RESULTS AND DISCUSSION

The results of Table (2) indicate no significant difference in the number in aerial stems of the plant when irrigation systems, with drip irrigation system significantly outperforming in the percentage of dry matter in the leaves, reaching 18.63% This differed significantly from the other two systems, with the lowest value of the percentage of dry matter in the leaves at 16.25 observed in the furrow irrigation system. The reason for this is that due to the delivery of water to the soil directly at the drip irrigation system, which provides optimal moisture to the soil for as long as possible. It is necessary for the growth of plant roots and prevents soil saturation and the leakage of nutrients in the root area in the soil and reduces the appearance of bushes unlike the irrigation systems of the liquid irrigation and irrigation and sprinkler, which work on root rot and filter nutrients and increase the accumulation of salts and increases the bulk density of the soil, which hinders the deepening of the roots in the soil and the absorption of nutrients such as phosphorus nitrogen and calcium and reduce the process of photosynthesis of the plant this is consistent with the study.

Table (2) The effect of irrigation systems on vegetative properties

Treats Irrigation System	* No. of aerial Stems	Leaf dry matter%
Drip	4.58 a	18.63 a
Furrow	3.83 a	16.25 c
Sprinkler	4.08 a	17.02 b

The results of Table (3) indicate a significant difference in the number of irrigation furrow times for the season, where the irrigation system gave the lowest values of 11.5 irrigation. season while values reached 15 irrigations. Season at drip irrigation and sprinkler irrigation systems The results also indicate a significant decrease in the percentage of deviation in the shape of the soil beds before harvest at the drip irrigation system and amounted to 14.10% and differed significantly with both irrigation systems and reached the highest values of 38.78% when the sprinkler irrigation system The reason for this is due to the evaporation of water droplets when exiting the sprinkler nozzles in the form of a spray, which leads to the loss of an amount of water before it reaches the soil in addition to the high pressure required for the irrigation system drip for consistency of water distribution between the drippers, which reduces the amounts of water reaching the soil and provides good control of soil moisture and reduces water wastage, unlike irrigation furrow, which provides water directly from the pump drainage pipe to the soil, it needs a little pressure with a waste of water when irrigating and thus increasing the time period between irrigations and reducing the number of watering times in the season as it also causes compress water droplets on the soil surface and increase soil erosion and collapse of soil construction as a result of saturation of the soil with water this is consistent with the study by *Duran et al. (2009)*.

Table (3) The effect of irrigation systems on mechanical properties

Irrigation System	* No. of irrigation cycle/season	* Deviation in soil beds shape at harvest %
Drip	15.00 a	14.10 c

Furrow	11.50 b	30.12 b
Sprinkler	15.00 a	38.78 a

The results of Table (4) indicate that there are no significant differences in the number of tubers of one plant and total yield of the plant.

Table (4) The effect of irrigation systems on potato crop properties

Irrigation System	No. of tubers/plant	Total yield ton/ha
Drip	9.40 a	48.66 a
Furrow	9.05 a	43.22 a
Sprinkler	8.75 a	41.24 a

The results of Table (5) indicate a significant difference between the tillage methods, where the Cross-Passing tillage system gave the highest significant value to the number of air stems, amounting to 4.94 stems. Plant^{-1} While the number of air stems at the single-pass tillage system was 3.38 stems. Plant^{-1} It is noted that the method of tillage with perpendicular passage gave the highest moral values of the percentage of dry matter in the leaves and amounted to 18.80% and differed significantly with the single-pass tillage system, which gave the lowest percentage of dry matter in the leaves and amounted to 15.80% The reason for this is due to the reduction of soil pressure in the area of extension of root hairs as a result of the increased cracking of deaf soil layers in the Cross-Passing tillage system Orthogonality and increased soil aeration, which causes an increase in the deepening of the roots in the soil and the absorption of nutrients from the soil, which caused an increase in the number of plant tubers and an increase in the number of stems of the plant this is consistent with the study *by (2021) Stalham et al. (2007) Ghosh and Daigh, (2020) (Costa et al. 2017).*

Table (5) The effect of plowing systems by subsoil plow on vegetative properties

Plowing System Levels (B)	* No. of aerial Stems	leaf dry matter%
Single-Pass	3.38 b	15.80 b
Cross-Passing	4.94 a	18.80 a

The results of Table (6) Statistically significant difference in the number of irrigations per season and the percentage deviation in soil beds shape at harvest when using the cross-passing tillage method amounted to 13.50 irrigation. season and 24.14% respectively, with a statistically significant difference with the single-pass tillage method, which amounted to 14.16 riyals. The season and 31.19% respectively, which gave the lowest values in these two qualities, and the reason for this is due to the increase in the ability of the soil to retain moisture for a longer period of time as a result of the increase in the size of soil pores as a result of the disintegration of deep soil layers, which leads to the drainage of excess water from the soil and reduce the accumulation of soil with water, which maintains the construction of the soil from collapse, which thus reduces the distortions in the form of soil beds at the end of the agricultural season this is consistent with the study by *(Baumhardt et al. 2008) (Stalham et al. 2007).*

Table (6) The effect of plowing systems by subsoil plow on mechanical properties

Plowing System	* No. of irrigation cycle/season	* Deviation in soil beds shape at harvest %
Single-Pass	14.16 a	31.19 a
Cross-Passing	13.50 b	24.14 b

The results of Table (7) indicate statistically significant the number of tubers per plant and the total yield of tubers when using the cross-passing and amounted to 9.70 g and 49.05 ton/ha^{-1} compared to the single-pass tillage system, which gave the lowest values of 8.43 g and 39.69

ton/ha^{-1} the reason for this is that the cross-passing system works to increase through the cracking of deep soil layers, which leads to an increase in the size of soil pores, deepening roots, absorbing nutrients, providing the ideal moisture necessary for root growth in the soil by draining excess water from the soil, providing oxygen and preventing the accumulation of roots in the form of a mass in a specific cavity inside the soil or near the soil surface, causing the formation of a larger number of tubers per plant and increasing the size and quality of potato tubers this is consistent with the study by *(Qiang et al. 2022) (Qiang et al. 2022).*

Table (7) The effect of plowing systems by subsoil plow on potato crop properties

Plowing System	**No. of tubers/plant^{-1}**	**Total yield ton/ha^{-1}**
Single-Pass	8.43 b	39.69 b
Cross-Passing	9.70 a	49.05 a

The results of Table (8) indicate the effect of the overlap between irrigation and tillage systems on the vegetative growth characteristics of the potato crop and it is noted that the treatment of drip irrigation system with cross-passing tillage system is superior in the number of aerial stems and the percentage of dry matter in the leaves and amounted to 5.33 stem. Plant^{-1} and 20.66% respectively with a significant difference with some coefficients and the lowest values in this overlap amounted to 3.00 stem. Plant^{-1} and 15.10% in the number of aerial stems and the percentage of dry matter in the leaves.

Table (8) The effect of interaction between irrigation & plowing systems by subsoil plow on vegetative properties

Irrigation System	Plowing System	* No. of Aerial stems	leaf dry matter%
Drip	Single Pass	4.66 ab	16.60 d
	Cross-Passing	5.33 a	20.66 a
Furrow	Single Pass	3.00 b	15.10 f
	Cross-Passing	3.83 ab	17.40 c
Sprinkler	Single Pass	4.83 ab	15.70 e
	Cross-Passing	3.33 ab	18.35 b

The results of Table (9) in the bilateral overlap between irrigation systems and tillage methods indicate a significant decrease in the number of irrigations per season at the sewage irrigation system with the perpendicular traffic tillage method and amounted to 10.50 irrigations. season, with a significant difference with most transactions, and the highest values reached 15.00 riyals. Season at all transactions except for irrigation with the method of tillage with one pass, and notes a significant decrease in the percentage deviation in the form of soil beds in the overlap between the drip irrigation system with the method of tillage with perpendicular passage 9.61% and a significant difference with most of the transactions, and the highest values reached 41.02% when the single-pass tillage overlapped with the sprinkler irrigation system.

Table (9) The effect of interaction between irrigation & plowing systems by subsoil plow on mechanical properties

Irrigation System	**Plowing System Levels (B)**	*** No.of irrigation cycle/season**	*** "Deviation in soil beds shape at harvest" %**
Drip	Single Pass	15.00 a	18.58 d
	Cross-Passing	15.00 a	09.61 e
Furrow	Single Pass	12.5 b	33.97 b
	Cross-Passing	10.50 c	26.28 c
Sprinkler	Single Pass	15.00 a	41.02 a

	Cross-Passing	15.00 a	36.54 ab

The results of Table (10) indicate the bilateral overlap between irrigation systems and tillage methods to indicate that the treatment the overlap between the cross-pass tillage system with the drip irrigation system gave the highest significant values in the number of tubers per plant and the total yield of tubers and amounted to 10.10 tuber. Plant^{-1} and 45.48 ton. ha^{-1} respectively with a significant difference with some coefficients and the lowest values amounted to 8.20 tuber. Plant^{-1} and 37.64 ton. ha^{-1} when the single-pass tillage system overlaps with the sprinkler irrigation system.

Table (10) The effect of interaction between irrigation & plowing systems by subsoil plow on potato crop properties

Irrigation System	Plowing System	No. of tubers/plant	Total yield ton/ha
Drip	Single Pass	8.70 ab	42.85 bc
	Cross-Passing	10.10 a	54.48 a
Furrow	Single Pass	8.40 ab	38.59 bc
	Cross-Passing	9.70 ab	47.85 ab
Sprinkler	Single Pass	8.20 b	37.64 c
	Cross-Passing	9.30 ab	44.83 ab

CONCLUSION

From this study, that using Subsoil at a cross-passing tillage and drip irrigation system was the best in improving the vegetative growth of the plant, increasing number of tubers of one plant the total yield of potato tubers, reducing the percentage of deviation in the shape of the soil beds at harvest while the number of irrigations per season decreased at the furrow irrigation system with the cross-passing tillage system

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