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THE EFFECT OF LASER LAND LEVELLING, TILLAGE AND DISCHARGE ON THE PERFORMANCE INDICATORS OF BORDER STRIP IRRIGATION AND THE REFLECTION OF THAT ON THE DEPTH OF WASTED IRRIGATION WATER

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Abstract

A field experiment was conducted in the field of the national program for wheat development in Iraq-The Ministry of Agriculture in the Al-Rashid-Adwaniyah region, located on latitude 33° 13' 93.59" N, and longitude 44° 37' 91.37" E, at an altitude of 31 m above MSL, during the autumn season of the year 2018 AD, to know the effect of laser land leveling, tillage and discharge on the performance indicators of border strip irrigation and the reflection of that on the depth of wasted irrigation water. The experiment consisted of three treatments. The first was the slope percentage of the soil surface leveling, with three levels: the conventional leveling (L_0), the leveling with the slope percentage of 0.15% (L_1), and the leveling with the slope percentage of 0.30% (L_2). The second was the tillage equipment with two levels: the mold board plow (T_1) and the chisel plow (T_2). The third was the discharge rate with two levels: discharge rate of 16 L sec^{-1} (Q_1), and discharge rate of 24 L sec^{-1} (Q_2). The experiment was designed according to the design of randomized complete block design RCBD with three replicates. The gravimetric method was adopted for measuring soil water. The most important results obtained can be summarized by the irrigation performance indicators: adequacy, Christiansen's coefficient, distribution uniformity and storage efficiency, recorded their highest indicators with the leveling slope ratio treatment, with L_1 level at 86.09, 89.48, 84.51 and 86.09%, Respectively. With the tillage equipment treatment, the highest irrigation performance indicators were recorded, with T_1 level of 87.36, 88.10, 82.07 and 87.36%, respectively. With the discharge rate treatment, the highest percentage was recorded in Christiansen's coefficient and the distribution uniformity with Q_1 level of 88.61 and 83.23%, respectively. And in the adequacy and storage efficiency with Q_2 level of 84.71 and 84.71%, respectively.

Key words : laser leveling, tillage, discharge, performance indicators of irrigation, depth of wasted irrigation water.

Introduction

The gap between water supplies and water demand is increasing in many areas of the world: in those areas already suffering water lacking, increasing drought will be the major constraint to agricultural growth and development. Climate changes will cause, above all, a decrease in annual water availability in many areas of the world. Water availability will decrease more and more due to the continuous decline of summer rainfall and in the face of high water demands for cultivations. More than 60 per cent of irrigation water is lost during the conveyance and application in the field. Farmers either under or over irrigate their fields resulting into loss of yield, low water use productivity and low fertilizer-use efficiencies. The determined crop water requirements indicate that there is enormous potential for water saving if it is applied according to crop's requirement. Understanding the indicators of irrigation performance helps us to know the depth of wasted water and take arrangements to reduce the depth of wasted water. So this review paper was made to know measuring the depth

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of wasted water and the most important indicators of irrigation performance, which leads to increase the depth of wasted water.

The used water does not use 100% beneficially, but there are always some losses by evaporation from the soil surface, transpiration from the leaf surface (evapotranspiration losses range from 1-30%), surface runoff and deep leaching losses (the depth of the water that crosses From the root zone). A number of technical sources refer to Christiansen's coefficient as a measure of uniformity. The authors Merriam and Keller (1978) suggested defining the Distribution Uniformity as the mean of infiltration depth for a quarter of the readings less than the field, divided by the mean depth of the tip in the whole field. This term can be represented by the symbol DU, the same authors also suggest "Absolute Distribution Uniformity" DUa, It is the lowest depth divided by the mean depth. The researcher can choose a scale that fits his perceptions or vision, but it must be clear about what will be used (www.fao.org[a]). Distribution Uniformity (DU) is a measure of the uniformly water application, and Distribution Consistency is a measure of the irrigation system (www.mjc.edu). Adequacy is defined as the ratio of the mean depth of stored water or applied water for the root zone (mm) to the required water depth (mm). Christiansen coefficient tells us the Error rate, and Distribution Uniformity (DU) tells us how bad" The worst quarter"In the irrigated field (konx, 2018).

Ideally, the irrigation system should use the following (konx, 2018):

1. Add the correct amount of water to the soil field.
2. Add the same amount of water in all places.
3. Reducing water losses.

One of the most important problems that come with poor distribution uniformity is that some plants in the field have more than adequacy. This condition is called overwatering. It is the opposite of Underwatering condition. Underwatering is also the result of poor Distribution Uniformity. Which is also due to the poor distribution uniformity, which is caused by irrigation with a water depth less than adequacy, and one of the things that should be noted is that in the case of irrigation with a depth greater than adequacy is the result of the thinking of the person in the irrigation process who wants all plants to have a sufficient amount of irrigation water and the following for not The leveling of the land well has to give more depth to irrigation water (www.mjc.edu).

Through Distribution Uniformity that is not highly valued, increased water waste can be observed, and the picture can be approximated more by applying a simple equation, which is {(Water Consumption (mm)) / (Distribution Consistency (%))} For example let us assume that the water consumption was 40 mm and the distribution uniformity was 75%. The result of the equation is equal to 53.33 mm, and this gives us a perception that there is a need for 53.33 mm to ensure each part in the field to receive 40 mm, and therefore there is wastage in irrigation The amount of 13.33 mm results from the lack of accurate leveling of the surface of the field soil, and therefore there is a decrease in the value of the distribution uniformity, usually the value of the distribution uniformity to 85% in the border strip irrigation, and it can be less if the irrigation system is poorly designed, not suitable or The reason for administration. (www.mjc.edu).

Key performance indicators (konx, 2018):

Adequacy: Have you applied enough adequacy?

Inform Consistency Uniformity: Is Added Water Spread Equal?

Efficiency: Have you wasted any volume of added water?

Without good uniformity of irrigation and soil, it is impossible for the irrigation to be sufficient and efficient. Laser leveling is usually done to provide a smooth soil surface, laser leveling reduces the time and water needed to irrigate the field, and the water distribution and moisture environment is more uniform in the field, and germination and growth is also more consistent (Hoque and Hannan, 2014).

Materials and Methods

The site of the experiment

A field experiment was conducted in the field of the national program for wheat development in Iraq-The Ministry of Agriculture in the Al-Rashid-Adwaniyah region, located on latitude 33° 13' 93.59" N, and longitude 44° 37' 91.37" E, at an altitude of 31 m above MSL, during the autumn season of the year 2018 AD, and the study area is characterized by a flat topography to a semi-level with a slope of less than 0.01%. and the field soils were classified as sedimentary with mud tissue. Silt Clay, classified under the Great Typical torrifluvent group, according to Soil Survey (2014). Soil samples were taken from depth 0-0.30 m and from depth 0.30-0.60 m in a grid way from the intersection of each square with 36 square with a number of 46 locations, to represent the physical and chemical properties of field soil (Table 1 and 2). Soil samples were mixed for each site and a sample was taken from it representing the field. Soil samples were dried in the laboratory antenna, then crushed and sieved with a sieve with a diameter of 0.002

m. Particle size analysis was performed for the soil separations to find the soil texture by pipet method (Day, 1965). The bulk density of the soil was estimated using the Core method and calculated the Blake and Hartge method described in Klute (1986). The relationship between volumetric water content and the water potential of field soil was estimated by taking water content values at different potentials values ranging from 33 to 1500 kPa, by using pressure plate apparatus, according to the method of (Kulte, 1986).

Some soil chemical properties were estimated, the electrical conductivity EC and pH of the soil extract 1:1 were measured. Likewise, cations and anions were estimated according to the methods described in Richards (1954). The organic matter in the soil was estimated by using the potassium di-chromate method according to the method described by Wakelly and Black in Jackson (1958). Carbonate was measured with a Calcimeter according to Hesse (1971) method. Ion exchange capacitance (CEC) was measured according to the method mentioned by Savant (1994). The available nitrogen was extracted by using a 2M solution of potassium chloride according to the Bremner and Keeny method described in Black (1965). The available Phosphorous was extracted by using a solution of sodium bicarbonate 0.5M and then the color was developed with ammonium Moldipides and ascorbic acid according to the method (Sommers and Olsen, 1982). The available potassium was extracted by using 0.5 M calcium chloride and it was estimated by using the Flame Photometer as mentioned in Black (1965).

Experiment Treatments

The experiment consisted of three treatments:

The first: The slope percentage of the soil surface leveling with three levels:

1. The conventional leveling (L_0).
2. The leveling with the slope percentage of 0.15% (L_1).
3. The leveling with the slope percentage of 0.30% (L_2).

The second: The tillage equipment with two levels:

1. The mold board plow (T_1).
2. The chisel plow (T_2).

The third: The discharge rate with two levels:

1. The discharge rate of 16 L sec^{-1} (Q_1).
2. The discharge rate of 24 L sec^{-1} (Q_2).

Table 2: Some chemical properties of field soil before planting.

Property	Unit	Value
Electrical conductivity$_{1:1}$ ($EC_{1:1}$)	ds m^{-1}	1.13
pH		7.11
Organic matter	gm kg^{-1}	0.79
Carbon Minerals		261
Bicarbonate	mmol L^{-1}	0.43
Calcium		8.12
Magnesium		6.88
Sodium		4.90
Sulfate		7.16
Chloride		3.98
Available Nitrogen	mg kg^{-1} Soil	48.30
Available Potassium		97.01
Available Phosphorous		16.02
Cation exchange capacity (CEC)	Cmol $_+$ kg^{-1}	24.71

Describe of Field Experiment

The experiment was carried out on a land area of 20,400 m^2 (170 x 120 m). The experiment area was divided into two main-block. The main-blocks included levels of discharge rate treatment. Each main-block is divided into two sub-block, the sub-blocks included levels of tillage equipment treatment. Each sub-block is divided into three sub-sub-block, the sub-sub-block included levels of the slope percentage of the soil surface leveling treatment. It left 3 m between the main blocks, 3 m between the sub-block and 2 m between the sub-sub-block, in order to prevent treatments from overlapping each other and left a

Table 1: Some physical properties of the soil field before planting.

Property	Units	Depth (0.0-0.3m)	Depth (0.3-0.6m)
Sand	g kg^{-1}	154	150
Loam		407	405
Clay		439	445
Texture of soil		Clay loam	Clay loam
The bulk density of the soil	Mg m^{-3}	1.33	1.31
Porosity	cm^{3}cm^{-3}	0.498	0.505
Volumetric water content of soil of 33 kPa		0.369	0.375
Volumetric water content of soil of 100 kPa		0.296	0.299
Volumetric water content of soil of 300 kPa		0.251	0.253
Volumetric water content of soil of 500 kPa		0.233	0.231
Volumetric water content of soil of 1500 kPa		0.192	0.193
The soil content of available water		0.177	0.182

distance of 3 m between the replicates. Thus the number of experimental units became 36 unit in the experiment.

Estimation of Soil Water Content

The Gravimetric Method was adopted to measure soil water and determined the depth of applied irrigation water after depleting 50% of the ready water (www.fao.org[b]). The soil samples were taken by auger From the area where the effective roots of the plant spread. Estimate water content in soil samples for each stage of growth, dry the samples in the microwave oven at a temperature of 105° C, for 14 minute, after the temperature and drying time are adjusted in the microwave oven. The irrigation application was carried out by added the depth of water needed to reach the volumetric content of the soil water at the field capacity. After the depletion of the specified percentage of available water, the equation of Allen *et al.,* (1998) was used to calculate the depth of the water to be added to compensate for the depth Depleted water.

$$d = (\theta_{FC} - \theta_{I}) \times D \quad \text{.... (1)}$$

where:

d: It is the depth of irrigation water (mm).

θ_{FC}: It is the volumetric water content of soil at field capacity (cm^3 cm^{-3}).

θ_{I}: It is the volumetric water content of soil before irrigation (cm^3 cm^{-3}).

D: It is soil depth, which is equal to the depth of the effective root (mm).

Measuring the performance indicators of irrigation

1. Adequacy (%)

The irrigation adequacy was calculated by using the equation of konx (2018):

$$\text{Adequacy} = \frac{\text{Mean depths of storage water in root zone (mm)}}{\text{Required water depth (mm)}} \times 100 \quad \text{.... (1)}$$

2. Christiansen's coefficient (%)

The Christiansen's coefficient was calculated by using the following equation of konx (2018):

$$CU = \left(1 - \frac{\sum x}{mn}\right) \times 100 \quad \text{.... (2)}$$

where:

CU: It is Christiansen consistency coefficient (%)

$\sum x$: It is the sum of the absolute deviations from the mean (mm) of all the observations.

m: It is the mean application depth of storage water in the root zone (mm)

n: It is number of readings for the depth of irrigation water stored in the root zone.

3. Distribution Uniformity or Irrigation Uniformity

According to the Irrigation Uniformity by using the equation of konx (2018):

$$DU = \left(\frac{m}{m}\right) \times 100 \quad \text{.... (3)}$$

where:

DU: It is distribution Uniformity or irrigation Uniformity (%).

m: It is mean quarter (lowest quarter) depths of storage water in the root zone (mm).

m: It is mean depth of storage water in the root zone (mm).

4. Efficiency of soil storage for irrigation water (%)

The soil storage efficiency for irrigation water was calculated by using the equation of AL-Taeef and Al-Hadithi (1988):

$$ES = \left(\frac{W_s}{W_n}\right) \times 100 \quad \text{.... (4)}$$

ES: It is soil storage efficiency for irrigation water (%).

W_s: It is depth of water stored in the root zone (mm).

W_n: It is required water depth during one irrigation (mm).

Results and Discussion

Performance Indicators of Irrigation and Storage Efficiency

Table 3 shows that the slope percentage of the soil surface leveling treatment, with L_1 level ýrecorded the highest percentage in the adequacy, Christiansen's coefficient, distribution uniformity ýand the storage efficiency of 86.09, 89.48, 84.51 and 86.09%, respectively. Whereas, L_0 level recorded the lowest percentage in the adequacy, Christiansen's coefficient, distribution uniformity and storage efficiency of 80.98, 85.23, 76.86, and 80.98%, respectively. The tillage equipment treatment with T_1 level recorded the highest percentage in the adequacy, Christiansen's coefficient, distribution uniformity and the storage efficiency of 87.36, 88.10, 82.07 and 87.36%, respectively. With T_2 level recorded the lowest percentage in ýadequacy, Christiansen's coefficient, distribution uniformity ýand storage efficiency of 81.26, 85.33, 79.50, and 81.26%, respectively. The discharge rate treatment with Q_1 level recorded the highest percentage in the Christiansen's coefficient and distribution uniformity of 88.61 and 83.23%, respectively. And it recorded the lowest percentage in adequacy and storage efficiency of 83.91 and 83.91%, respectively. Whereas the Q_2 level recorded the lowest percentage in the Christiansen's coefficient and the distribution uniformity of 84.82 and 78.34%, respectively. And it recorded the highest percentage in adequacy and storage efficiency was 84.71 and 84.71%, respectively.

The interference between the slope percentage of the soil surface leveling treatment and tillage equipment treatment with T_1L_1 level recorded the highest percentage in adequacy, Christiansen's coefficient, distribution Uniformity and storage efficiency of 89.32, 90.49, 86.40 and 89.32%, respectively. The T_2L_0 level recorded the lowest percentage in adequacy, Christiansen's coefficient, distribution Uniformity, and storage efficiency of 78.42, 83.70, 75.65, and 78.41%, respectively. The interference between the slope percentage of the soil surface leveling treatment and the discharge rate treatment with Q_2L_1 level recorded the highest percentage in adequacy, storage efficiency of 86.85 and 86.85%, respectively. and Q_1L_1 level recorded the highest percentage in the Christiansen's coefficient and distribution uniformity of 91.04 and 86.78%, respectively. Whereas, Q_2L_0 level recorded the lowest percentage in adequacy, Christiansen's coefficient, distribution uniformity and storage efficiency of 80.57, 83.09, 73.70, and 80.57%, respectively. It is noted that the interference between the tillage treatment and the discharge rate treatment with Q_1T_1 level recorded the highest percentage in adequacy, the Christiansen's coefficient, distribution uniformity and the storage efficiency of 87.57, 89.99, 84.73 and 87.57%, respectively. The lowest percentage in efficiency and storage efficiency was recorded with Q_1T_2 level of 80.25 and 80.25%, respectively. The Q_2T_2 level recorded the lowest percentage in Christiansen's coefficient and distribution uniformity of 83.43 and 77.26%, respectively.

The interference between the slope percentage of the soil surface leveling treatment, tillage equipment treatment and the discharge rate treatment with $Q_1T_1L_1$ level recorded the highest percentage in adequacy, Christiansen's coefficient, distribution uniformity, and storage efficiency of 89.61, 92.41, 88.82 and 89.61%, respectively. While $Q_2T_2L_0$ level recorded the lowest percentage in adequacy, Christiansen's coefficient, distribution uniformity, and storage efficiency of 77.64, 81.42, 71.92, and 77.64%, respectively.

It is worth mentioning, the deviation gives an idea of the water depth to be compensated to meet the shortage of the water crop's requirement (So it placed a negative sign to clarify the extent of the treatment's limitations in depth of the added water (and deviation is related by a positive correlation with mean of storage water depth of soil in the root zone, The latter also has a positive correlation with adequacy, Christiansen's coefficient, distribution uniformity and storage efficiency.

Table 4 shows that the slope percentage of the soil surface leveling treatment, with L_1 level recorded the highest mean of storage water depth in the soil of the root zone of 31.77 mm and mean of deviation and sum deviation of -5.13 and -41.07 mm, respectively. The L_0 level recorded the lowest mean of storage water depth in the soil of the root zone of 29.88 mm and mean of deviation and sum deviation of -7.02 and -56.16 mm, respectively. The tillage equipment treatment, with T_1 level recorded the highest mean of storage water depth in the soil of the root zone of 32.24 mm and mean of deviation and sum deviation of -4.66 and -37.32 mm, respectively. The T_2 level recorded the lowest mean of storage water depth in the soil of the root zone of 29.99 mm and mean of deviation and sum deviation of -6.91 and -55.31 mm, respectively. The discharge rate treatment with Q_2 level recorded the highest mean of storage water depth in the soil of the root zone of 31.26 mm and mean of deviation and sum deviation of -5.64 and - 45.13 mm, respectively. The Q_1 level recorded the lowest average depth of water stored in the soil of the root zone with a depth of 30.96 mm and an average deviation and the sum of the deviation of -5.94 and -47.49 mm, respectively.

The interference between the slope percentage of the soil surface leveling treatment and the tillage equipment treatment with T_1L_1 level recorded the highest mean of storage water depth in the soil of the root zone of 32.96 mm and mean of deviation and sum deviation -3.94 and 31.52 mm, respectively. The T_2L_0 level recorded the lowest mean of storage water depth in the soil of the root zone of 28.93 mm and mean of deviation and sum deviation -7.97 and -63.72 mm, respectively. The interference between the slope percentage of the soil surface leveling treatment and the discharge rate treatment with Q_2L_1 level recorded the highest mean of storage water depth in the soil of the root zone of 32.05 mm and mean of deviation and sum deviation -4.85 and -38.82 mm, respectively. While Q_2L0 level recorded the lowest mean of storage water depth in the soil of the root zone of 29.73 mm and mean of deviation and sum

Table 3: Adequacy, Christiansen's coefficient, distribution uniformity, and storage efficiency.

Storage efficiency (%)	Distribution Uniformity (%)	Christiansen coefficient (%)	Adequacy (%)	Treatments
80.98	76.86	85.23	80.98	L_0
86.09	84.51	89.48	86.09	L_1
85.87	80.98	85.45	85.87	L_2
87.36	82.07	88.10	87.36	T_1
81.26	79.50	85.33	81.26	T_2
83.91	83.23	88.61	83.91	Q_1
84.71	78.34	84.82	84.71	Q_2
83.54	78.08	86.76	83.54	T_1L_0
89.32	86.40	90.49	89.32	T_1L_1
89.22	81.75	87.06	89.22	T_1L_2
78.41	75.65	83.70	78.42	T_2L_0
82.85	82.63	88.46	82.85	T_2L_1
82.53	80.22	83.84	82.53	T_2L_2
81.38	80.03	87.36	81.38	Q_1L_0
85.32	86.78	91.04	85.32	Q_1L_1
85.03	82.90	87.44	85.03	Q_1L_2
80.57	73.70	83.09	80.57	Q_2L_0
86.85	82.25	87.91	86.85	Q_2L_1
86.71	79.06	83.46	86.72	Q_2L_2
87.57	84.73	89.99	87.57	Q_1T_1
80.25	81.74	87.23	80.25	Q_1T_2
87.15	79.41	86.21	87.15	Q_2T_1
82.27	77.26	83.43	82.27	Q_2T_2
83.57	80.67	88.74	83.57	$Q_1T_1L_0$
89.61	88.82	92.41	89.61	$Q_1T_1L_1$
89.52	84.71	88.83	89.52	$Q_1T_1L_2$
79.19	79.38	85.98	79.19	$Q_1T_2L_0$
81.03	84.74	89.67	81.03	$Q_1T_2L_1$
80.54	81.09	86.05	80.54	$Q_1T_2L_2$
83.50	75.48	84.77	83.50	$Q_2T_1L_0$
89.03	83.97	88.57	89.03	$Q_2T_1L_1$
88.91	78.78	85.29	88.91	$Q_2T_1L_2$
77.64	71.92	81.42	77.64	$Q_2T_2L_0$
84.66	80.52	87.25	84.66	$Q_2T_2L_1$
84.52	79.34	81.62	84.52	$Q_2T_2L_2$

deviation -17.17 and -57.36 mm, respectively. The interference between the tillage equipment treatment and the discharge rate treated with Q_1T_1 level recorded the highest mean of storage water depth in the soil of the root zone of 32.31 mm and mean of deviation and sum deviation -4.59 and -36.69 mm, respectively. While the Q_1T_2 level recorded the lowest mean of storage water depth in the soil of the root zone of 29.61 mm and mean of deviation and sum deviation of -7.29 and -58.29 mm, respectively.

The interference between the slope percentage of the soil surface leveling treatment, tillage equipment treatment and discharge rate treatment with $Q_2T_2L_0$ level the highest mean of storage water depth in the soil of the root zone of 33.07 mm and mean of deviation and sum deviation -3.83 and -30.66 mm, respectively. While the $Q_2T_2L_0$ level recorded the lowest mean of storage water depth in the soil of the root zone of 28.65 mm, and mean of deviation and sum deviation of -8.25 and -66.02 mm, it is very high, respectively.

The correlation between the depth of irrigation water with the depth of actual water consumption is a positive correlation, because the correlation between them was 0.9989, which is a positive correlation. This means the increase in the depth of irrigation water will lead to increase the depth of actual water consumption too.

The correlations between the depth of the irrigation water with adequacy, with Christiansen's coefficient and

Table 4: The mean depth of stored water at a depth of 100 mm along the border strip and its deviation of the required water depth.

Sampling depth (mm)	Depth of water required (mm)	Sum deviation	Mean deviation	Mean storage water (mm)	Treatments
100.00	36.90	-56.16	-7.02	29.88	L_0
100.00	36.90	-41.07	-5.13	31.77	L_1
100.00	36.90	-41.71	-5.21	31.69	L_2
100.00	36.90	-37.32	-4.66	32.24	T_1
100.00	36.90	-55.31	-6.91	29.99	T_2
100.00	36.90	-47.49	-5.94	30.96	Q_1
100.00	36.90	-45.13	-5.64	31.26	Q_2
100.00	36.90	-48.60	-6.07	30.83	T_1L_0
100.00	36.90	-31.52	-3.94	32.96	T_1L_1
100.00	36.90	-31.83	-3.98	32.92	T_1L_2
100.00	36.90	-63.72	-7.97	28.93	T_2L_0
100.00	36.90	-50.63	-6.33	30.57	T_2L_1
100.00	36.90	-51.58	-6.45	30.45	T_2L_2
100.00	36.90	-54.96	-6.87	30.03	Q_1L_0
100.00	36.90	-43.33	-5.42	31.48	Q_1L_1
100.00	36.90	-44.19	-5.52	31.38	Q_1L_2
100.00	36.90	-57.36	-7.17	29.73	Q_2L_0
100.00	36.90	-38.82	-4.85	32.05	Q_2L_1
100.00	36.90	-39.22	-4.90	32.00	Q_2L_2
100.00	36.90	-36.69	-4.59	32.31	Q_1T_1
100.00	36.90	-58.29	-7.29	29.61	Q_1T_2
100.00	36.90	-37.94	-4.74	32.16	Q_2T_1
100.00	36.90	-52.33	-6.54	30.36	Q_2T_2
100.00	36.90	-48.50	-6.06	30.84	$Q_1T_1L_0$
100.00	36.90	-30.66	-3.83	33.07	$Q_1T_1L_1$
100.00	36.90	-30.92	-3.87	33.03	$Q_1T_1L_2$
100.00	36.90	-61.43	-7.68	29.22	$Q_1T_2L_0$
100.00	36.90	-55.99	-7.00	29.90	$Q_1T_2L_1$
100.00	36.90	-57.46	-7.18	29.72	$Q_1T_2L_2$
100.00	36.90	-48.70	-6.09	30.81	$Q_2T_1L_0$
100.00	36.90	-32.37	-4.05	32.85	$Q_2T_1L_1$
100.00	36.90	-32.74	-4.09	32.81	$Q_2T_1L_2$
100.00	36.90	-66.02	-8.25	28.65	$Q_2T_2L_0$
100.00	36.90	-45.27	-5.66	31.24	$Q_2T_2L_1$
100.00	36.90	-45.70	-5.71	31.19	$Q_2T_2L_2$

with distribution uniformity are a negative correlation, the correlation between them was -0.8400, -0.6844 and -0.5925, respectively. This means the increase the depth of irrigation water will lead to decrease, the percentage of the adequacy, Christiansen's coefficient, and distribution uniformity.

The correlation between the depth of actual water consumption with adequacy, with Christiansen's coefficient and with distribution uniformity are a negative correlation, the correlation between them was -0.8356, -0.6990 and -0.6081, respectively. This means the increase the depth of actual water consumption will lead to decrease, the percentage of the adequacy, Christiansen's coefficient, and distribution uniformity.

The correlation between adequacy with Christiansen's coefficient, the correlation between adequacy with distribution uniformity and the correlation between Christiansen's coefficient with distribution uniformity are a positive correlation, the correlation between them was 0.4985, 0.8790 and 0.6018, ýrespectively.

The sequence of the depth of the wasted irrigation water (the depths of the water to be added to obtain a

100% distribution uniformity) was with the levels of the slope percentage of the soil surface leveling treatment as follows: $L_0>L_2>L_1$ with a depth of 127.33, 93.11 and 69.76 mm, respectively. The sequence of the depth of the wasted irrigation water was with levels of the tillage equipment treatment as follows: $T_2>T_1$ with a depth of 116.92 and 75.73, respectively. and the depth of wasted irrigation water sequence with levels of discharge rate treatment were as follows: $Q_2>Q_1$ with a depth of 113.84 and 78.24 mm, respectively.

The sequence of the depth of the wasted irrigation water with levels of interference between the slope percentage of the soil surface leveling treatment and the tillage equipment treatment was as follows: $T_2L_0>T_2L_2>T_1L_0>T_2L_1>T_1L_2>T_1L_1$ with a depth of 154.84, 110.86, 102.48, 90.32 and 76. 70 and 52.23 mm, respectively. The sequence of the depth of the wasted irrigation water with levels of interference between the slope percentage of the soil surface leveling treatment and the discharge rate treatment was as follows: $Q_2L_0>Q_2L_2>Q_1L_0>Q_2L_1>Q_1L_2>Q_1L_1$ with a depth of 154.72, 108.35, 102.94, 84.69, 79 18 and 56.21 mm, respectively. The sequence of the depth of the wasted irrigation water with levels of interference between the tillage equipments treatment and the discharge rate treatment was as follows: $Q_2T_2>Q_1T_2>Q_2T_1>Q_1T_1$ with a depth of 137.36, 98.34, 92.46 and 60.67 mm, respectively.

The sequence of The depth of the wasted irrigation water with levels of interference between the slope percentage of the soil surface leveling treatment, the tillage equipment and the discharge rate treatment was as follows:

$Q_2T_2L_0>Q_1T_2L_0>Q_2T_1L_0>Q_2T_2L_2>Q_2T_2L_1>Q_1T_2L_2>Q_2T_1L_2>Q_1T_1L_0>Q_1T_2L_1>Q_2T_1L_1>Q_1T_1L_2>Q_1T_1L_1$ with depth 192.38, 121.92, 121.63, 120.50 and 107.55 101.74, 95.71, 85.18, 74.68, 64.91, 59.82 and 40.70 mm, respectively,

The depth of wasted irrigation water is observed inversely proportional to the uniformity of the irrigation water distribution, the descending sequence of treatments as previously mentioned (wastewater irrigation depth sequence), it also represents the ascending sequence of the distribution uniformity of the same treatments,

The level of The leveling with the slope percentage of 0.15% (L_1) worked to reduce the irrigation water depth and consequently all irrigation indicators increased with this level, which led to a decrease in the actual water consumption depth with this level and the other levels of laser land leveling treatment.

The mold board plow (T_1) worked to reduce the irrigation water depth and consequently all irrigation indicators increased with this level, which led to a decrease in the actual water consumption depth. But the discharge rate of 24 L sec^{-1} (Q_2) recorded the highest adequacy and lowest Christiansen's coefficient compared to the discharge rate of 16 L sce^{-1} (Q_1).

Through this we see that not necessarily high adequacy is evidence of the high Christiansen's coefficient of and distribution uniformity, rather that adequacy increase comes from Increased depth of added irrigation water for the purpose of filling the shortage of some areas of the field with a high height (at the beginning of the slope), and since the level of Q_2 allows the depth of irrigation water to flow on the surface of the field soil relatively quickly, and this leads to adding a greater depth of irrigation water Compared to the Q_1 level to fill the lack of need for areas of high field height from the depth of irrigation water. This resulted in the wasted water depth and added water depth with Q_2 level compared to the Q_1 level, and this was reflected in the increase in the actual water consumption depth as a result of the decrease in Christiansen's coefficients and distribution uniformity.

A summary of the above explains the contribution of laser leveling to reducing the depth of added water to field soil, this is reflected in the reduction in the actual water consumption of the crop, this is done by increasing the depth of water stored in the soil of the root zone, not doing a precise leveling of It increases the depth of added irrigation water to the field soil, thus increasing the actual water consumption of the crop and this is due to the low mean depth of water stored in the soil of the root zone. The mold board reduced the depth of added irrigation water to the field soil, this is reflected in the reduction in the actual water consumption of the crop and this is done by increasing the depth of stored water in the soil of the root zone. The discharge rate of 16 L sce^{-1} reduces the depth of added water to the field soil, This is reflected in the reduction in the actual water consumption of the crop and this is done by increasing the depth of water stored in the soil of the root zone.

Conclusions

1. The most important indicators of irrigation performance is distribution uniformity when studying the depth of wasted irrigation water, and the rest of the indicators of irrigation performance are also important, but with other aspects of irrigation.
2. The relationship between the depth of wasted irrigation water and the distribution uniformity is inverse.
3. To reach a perfect distribution uniformity based on how much the plant consumes water depth (water

consumption of the plant) as a result there will be wastage in the depth of irrigation water, an increase in the depth of wasted water.

4. Storage efficiency and sufficiency in border strip irrigation are a value that is quite similar under the conditions and methods of measuring this study.

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