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RESEARCH ARTICLE

Study the relationship between using of the modified ridger and efficiency of surface irrigation system in Ras-Sudr area

Meselhy, A. A. * , M. E. El-Hagarey

Researcher in Soil Conservation and water resources Department, Desert Research Center.

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****Corresponding Author***

elhagarey@gmail.com
M. E. El-Hagarey

Abstract

The planting furrows and the surface irrigation system are considered the most prevalent in Egypt, especially in areas which face problems in the crops productivity due to the high salinity in soil or irrigation water where, these systems reduce the impact of salinity on plant growth. The ridger is the main machine used to build the furrows and prevalent in Egypt as a result of cheapness and ease of manufacture. So this research was conducted to achieve two main goals. The first objective was to develop a traditional ridger to be used as a machine for planting the furrows by adding a planting unit proved behind the ridger and thus can be exploited widespread of traditional ridger at the most of farmers in Egypt for mechanization the planting process of different crops on the furrows for the purpose of saving time, effort and money. The second objective was to increase the efficiency of furrow surface irrigation system by adding unit to compact and change the shape of irrigation channel bottom into different forms to find the best form suitable with the compaction process to reduce the irrigation water losses into the bottom of irrigation channels and increase the moisture content inside the furrows, and thus increase the efficiency of furrow surface irrigation system. To achieve these goals has been manufacturing developed unit can be attached to traditional ridger for planting on the furrows as well as containing unit to form and compacted the bottom irrigation channel. A field experiment was conducted at Ras-Sudr Research Station in South Sinai Governorate to evaluate the performance of the developed ridger and its impact on the efficiency of furrow surface irrigation system in order to achieve a higher water use efficiency and higher crop productivity. The evaluation process was achieved by carrying out three levels of irrigation rate treatment (70 %, 85 % and 100%), two levels of compacted the bottom of irrigation channel treatment (compacted and uncompacted) and three levels of forming the bottom of irrigation channel treatment (V-shape, trapezoidal shape and W-shape). The effect of these treatments were conducted on some soil physical properties, the ridger performance (pulling force, fuel consumption, actual field capacity and field efficiency), Effect of three shapes and compacted bottom of furrow irrigation was clear at advanced and recession curves, water movement was increment under compacted treatment and under V, Trapezoid and W shape receptively. And advances and recessions curves refer to last water behaviors, soil moisture content, soil salinity, water use efficiency and yield of Millet crop (fresh forage). The results showed that the treatment of W-shape with compacted of irrigation channel bottom achieved the best values of soil bulk density, soil penetration resistance and average infiltration rate caused the highest values of soil moisture content and lowest value of soil salinity which ultimately resulted the increasing in Millet yield and water use efficiency at all irrigation rates. Therefore, using traditional ridger with developed unit is recommended to be used for compaction, forming the bottom of irrigation channel (W-shape) and planting the furrows under the salinity conditions.

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Introduction

Surface irrigation is the most widely used irrigation method in Egypt. Surface irrigated lands face a number of difficult problems. The low efficiency of surface irrigation is one of the major problems, which causes tremendous losses of fresh water resources used for irrigation. **Khalid and Smith (1978)** reported approximately 40 percent decrease in the rate of infiltration from compacted furrows in sandy soil. A compaction roller will firm and smooth the furrow wall and bottom. Compaction reduces the infiltration rate, and water advances more rapidly across the field because of the smooth furrow surface. Water intake thus is more nearly uniform along the entire length of the furrow. Less total water is required and water is applied more uniformly. With appropriate compaction of irrigation furrows, crop production should be enhanced with less water and with reduced water degradation. **Borrelli et al. (1982)** reported that water advanced approximately 40 percent faster in compacted furrows. The combined effect of reducing the infiltration rate and increasing the rate of water flow in the furrow is to provide a nearly equal opportunity time along the length of the furrow. This means that the uniformity of irrigation and the irrigation efficiency would be increased. Based on results reported by **Borrelli (1982),** the efficiency of surface irrigation with compacted furrows may be nearly equal to the efficiency of sprinkler irrigation. **EWUP (1984)** reported that a relative safe estimation is that 40 percent or more of the water diverted for irrigation was wasted at farm level through either deep percolation or surface run-off. **Allen and Schneider (1992)** found that irrigation intake rate decreased by about 18 % by the effect of traffic compaction on the cultivated lands. **Hanson (1993)** mentioned that efficient furrow irrigation requires reducing deep percolation and surface runoff losses. Water that percolates below the root zone (deep percolation) is lost to crop production, although deep percolation may be necessary to control salinity. Deep percolation can be reduced by improving the evenness of the applied water and preventing over irrigation. **Charles (1995)** reported that furrow spacing is easy to adjust when furrows are used to irrigate permanent such as threes or vines, and the number of furrows / row can be varied. The same effect can be acieration every other furrow on row crops when it is desired to infiltrate a small depth of water during irrigation process. **Raine and Bakker (1996)** found that in traditional surface (e.g. bay, border check) irrigation systems, the whole surface of the soil is flooded and water flow through the soil is principally one dimensional. In these systems, water applied in excess of the soil-water holding capacity drains out of the bottom of the root zone and assists in the leaching of salts out of the root zone. However, two (e.g. furrow) dimensional water flow occurs within the soil where only part of the soil surface is wetted (e.g. furrow, LEPA, micro-irrigation applied to the surface). Similarly, three dimensional water and salt movement occurs where the water is placed at some point below the surface (e.g. sub-surface drip irrigation) within the root zone. Hence, under these conditions excess water application does not necessarily translate into deep drainage and leaching of salt below the root zone. **Omara (1997)** mentioned that, surface irrigation is accomplished by one of several application methods, including borders, furrows, chicks and basins. In each case water moves over the land surface in open channel flow. The water may be directed in small channels called furrow or corrugations or it may be move as a shallow overland flow over a carefully smoothed soil surface as in border irrigation. Moreover, he reported that, surface irrigation method operated under the force of gravity and requires less energy and less capital investment compared to other methods of irrigation. Many types of surface schemes have been developed to suite different agricultural systems and communities. In surface irrigation, water applied to different crops using furrow, border and basin irrigation methods. **Stettler et al. (1997)** mentioned that soil is a basic irrigation resource, beside determines how irrigation water should be managed. The amount of water the soil can hold for plant use is determined by its physical and chemical properties. This amount determines the length of time that a plant can be sustained adequately between irrigation or rainfall events, the frequency of irrigation, and the amount and rate to be applied. Along with plant ET, it also determines the irrigation system capacity system needed. **Omara (1997)** found that the irrigation application efficiency and irrigation distribution efficiency increased to 72.5 percent and 92 percent respectively by using gated pipe system through furrow irrigation. **Benham and Eisenhauer (2000)** reported that regardless of whether you dike or block the ends of your furrows, or if you irrigate using every or every-other furrow, soil texture, slope and surface conditions (whether the furrow is smooth or rough, wet or dry) all influence how quickly water advances down the furrow. The speed of advance is directly related to how uniformly irrigation water is distributed within the soil profile. The soil infiltration rate is also affected by soil surface conditions. **Schwankl et al. (2000)** indicated that variability of furrow physical characteristics, in decreasing order of their relative impact on furrow irrigation performance, were furrow inflow rate, infiltration, geometry, and roughness. For a field with highly variable soil roughness and infiltration characteristics, spatially varying infiltration may have a greater impact than variable furrow inflow on irrigation performance. **Osman (2002)** found that using gated pipe mean while water saving was (29.64%, 29.9%, 14.5% and 19.7%) in cotton, wheat, corn and rice respectively compared with traditional (flooding) system. **Hassan (2004)** reported that using gated pipe system increased wheat yield by 6.5% when compared with the traditional method. Due to good condition of plant growth, regulating and controlling of water application to affect the soil water balance. **Amer (2007)** reported that, in surface irrigation water flow by gravity from one end of the field towards the downstream end. The time until the water leading front reaches the either end of the field is called the advance phase. During flow process, water infiltrates into the soil (root zone) basically in one dimension. Radial flow, at least initially, occurs in furrow irrigation. Once the water reaches the downstream end it either runs off the field (free draining) or embanked depending on the downstream boundary conditions. The flow process included infiltration run off or embanked and continues until the end of irrigation. The time after the leading front reaches the other end of the field and until the irrigation is called storage phase. In this phase the water depth above the surface and consequently the flow rate gradually decreases and is called depletion phase to zero.

Therefore, this work will concentrate on the optimum level of compacting bottom of irrigation channel for sandy loam soil and the optimum shape of the irrigation channel bottom under different irrigation rates and salinity condition.

MATERIALS AND METHODS

This study was carried out at Ras-Sudr Experimental Station, South Sinai on sandy loam calcareous soil which suffers from the problem of soil and irrigation water salinity where, Salts in the soil-water solution decrease the amount of water available for plant uptake. Maintaining a higher soil-water content with more frequent irrigations relieves the effect of salt on plant moisture stress. A sandy loam is soil containing a high percentage of sand, but having enough silt and clay to make it somewhat coherent. The individual sand grains can be readily seen and felt. Squeezed when dry, a sandy loam forms a cast that falls apart readily. If squeezed when moist, a cast can be formed that bears careful handling without breaking. The field experiment was carried out in the summer season 2013 with an experimental area of about 2.5 feddans which irrigated by gated pipe irrigation system. Before the soil preparation directly, the average moisture content of soil surface layer (0-30cm) was determined and found to be 18% (d.b.). Soil texture and some chemical properties of the soil and well irrigation water as shown in Table (1).

A. Development of traditional ridger:

Traditional ridger consists of three shanks, each shank connected with a chisel blade and two moldboard to form the furrows. This ridger has been developed by adding two developed units: unit for planting on the furrows and unit to form and compacted the bottom of irrigation channel as shown in Figures (1 & 2). All treatments of study were carried out at operation depth 20 cm and forward speed 3.5 km/h.

B. Experimental procedure.

The following are the experimental details:

1. Experimental design.

The experimental area is of about 2.5 fed. This experiment was established as split-split plots in three replicates, divided into three main plots involved three levels of irrigation rates (70, 85, and 100% from total water applied). Each main plot includes two sub-plots, which involved two level of compacted bottom of irrigation channel (compacted and uncompacted). Each sub-plot includes three sub-sub plots, which involved three levels of the shape of the irrigation channel bottom (V-shape, trapezoidal-shape and W-shape), resulted in a total of 54 plots, each of 200 m^2**, furrow irrigation length 50 meter and furrow width 50 cm.**

2. Irrigation system:

The irrigation system consists of the following components:

a- Control head:

Control head consists of centrifugal pump 5/5 inches (6 m lift and 140 m^3/h discharge), driven by diesel engine (50 Hp), pressure gauges, control valves, inflow gauge, water source was an open.

b- Line of gated irrigation pipes:

P.V.C pipeline, 6 bar, 110 mm nominal outside diameter, thickness of pipe is 4.7mm, 24 m long, 50cm spacing between holes, level of pipes is near to zero.

3. Millet seeds and planting method.

The Millet was planted in May, with a rate of 25 kg/fed.

4. Harvesting.

The Millet crop was harvested as the fresh forage through three cuts and the three randomized samples were taken by hand from each plot using a wooden square frame ($1m^2$) as a simpler to determine the Millet yield (fresh forage) per feddan.

C. Measurements.

1. Soil bulk density.

Soil bulk density was measured using a core samples (Three replicates for each sample) and calculated according to **Black et al (1965)** method.

2. Soil penetration resistance.

Soil penetration resistance was measured by a Japanese cone index penetrometer **(SR-2, DIK-500)**

3. Theoretical and actual field capacity and field efficiency.

Theoretical and actual field capacity and field efficiency were calculated by using equations mentioned by **kepner et al, (1978)**.

4. Advanced and recession phases of water movements.

The water advance and recession times were recorded for each 12.5 m length during the irrigation time. The total flow time T including the times of the water advance.

5. Soil moisture content and soil salinity.

Moisture measurement (TDR 300 soil moisture meter) Soil salinity (Direct soil EC probe)

6. Pulling force.

Pulling force for ridger was measured by hydraulic dynamometer which, coupled between the two tractors with the attaching ridger to estimate its draught force. A considerable number of readings were taken at a time interval 10 seconds to obtain an accurate average of draught force.

7. Fuel consumption rate.

Fuel consumption per unit time was determined by measuring the volume of fuel consumed during operation time. It was measured using the fuel meter equipment as shown in Figure (4) the length of line which marked by the marker tool on the paper sheet represents the fuel consumption. The fuel meter was calibrated prior and the volume of fuel was determined accurately.

8. Average infiltration rate:

Infiltration characteristics of the studied soil was determined in the field by using a local made double ring (cylinder infiltrometer). The two cylinders were 30 cm deep and formed of steel sheet of 5mm thickness which allow the cylinders to enter the soil with little disturbance. The inner cylinder, from which the infiltration measurements were taken, was 30 cm in diameter. The outer cylinder, which used to form the buffer pond was 60 cm in diameter. The double ring hammered into the soil to a depth of 15 cm. Care was taken to keep the installation depth of the cylinder the same in all experiments. Average infiltration rates calculated by **Kostiakov equation (1932):**

$$I = 60\,c\,T^{m-1} \quad \ldots\ldots\ldots\ldots (1)$$

Where:

I	:	Average infiltration rate,	(cm / h),
C , m	:	Constants depend on soil properties and initial condition, and	
T	:	The time after infiltration started.	(min).

9. <u>Crop water requirement was calculated using the Reference Evapotranspiration (ET_o) and the Crop coefficients (K_C) by the following equation:-</u>

$ETc = ET_o * K_C$ …………………………..… (2)

<u>Where;</u>

ET_c	**:**	Crop Evapotranspiration,	(mm/day),
ET_o	**:**	Reference Evapotranspiration,	(mm/day), and
Kc	**:**	Crop coefficients.	

Represent the Reference Evapotranspiration ($ET_{ref.}$) according to (Center Laboratory for Agricultural Climate, CLAC.), the average crop coefficients (Kc) for Millet according to **Andreas P. (2002).**

Table (2): Growth stages**,** Reference evapotranspiration, and crop coefficient of Millet.

Growth stage	**from**	**to**	**ET_o mm/day**	**K_c**
Initial	15 April	6 may	4	0.51
Dev.	7 May	6 June	6	0.81
Mid-season	7 June	7 July	6	1.1
Season end	8 July	8 Aug.	7	0.83
Total	112 days			

Net irrigation requirement (IR_n) is derived from the field balance equation:

$$IR_n = \left[\left(\frac{Et_c \times A}{10^7 \times E_a}\right) \times (1 + LR)\right] - P_{eff} \quad \text{……………(3)}$$

$LR = EC_w / [5 (EC_e) - EC_w]$…(Rhoades and Merrill 1976) ..… **(4)**

<u>Where:</u>

IR_n	**:**	Net irrigation requirement,	(mm/day),
ET_c	**:**	Crop evapotranspiration,	(mm/day),
A	**:**	Irrigated area	(m^2),
E_a	**:**	Application efficiency	(%),
P_{eff}	**:**	Effective dependable rainfall,	(mm),
LR	**:**	Leaching requirement,	(mm),
EC_w	**:**	Electric conductivity of irrigation water,	(ds/m), and
EC_e	**:**	Electric conductivity of soil paste,	(ds/m).

Gross irrigation requirements account for losses of water incurred during conveyance and application to the field.

$IR_g = IR_n/E_a$ …………………….………………… **(5)**

<u>Where;</u>

IR_g	**:**	Gross irrigation requirements,	(mm/day),
IR_n	**:**	Net irrigation requirement,	(mm/day), and
E_a	**:**	Overall irrigation efficiency,	(%).

(Pressure piped network surface methods = (65 – 75%) **(Phocaides, 2000)**

10. <u>Field water-use efficiency:</u>

Field water-use efficiency was determined as defined by **Jensen (1983)** as follows:

$E_t = Y / WR$ ……………………….……… **(6)**

Where:

E_t	:Field water-use efficiency,	(kg/m^3),
Y	:Total crop yield,	(kg/fed), and
WR	:Total amount of irrigation water used per unit area,	(m^3/fed).

RESULTS AND DISCUSSION

Table (1): Soil texture and some chemical properties of the soil and well irrigation water.

Particle size distribution %				Texture class	$CaCO_3$ %	O.M %	pH		E.C	
Coarse sand	Fine sand	Silt	Clay				Soil	Water	Soil	Water
12.3	58.7	19.7	9.3	Sandy loam	46.1	0.43	7.76	7.89	10.5	4.8

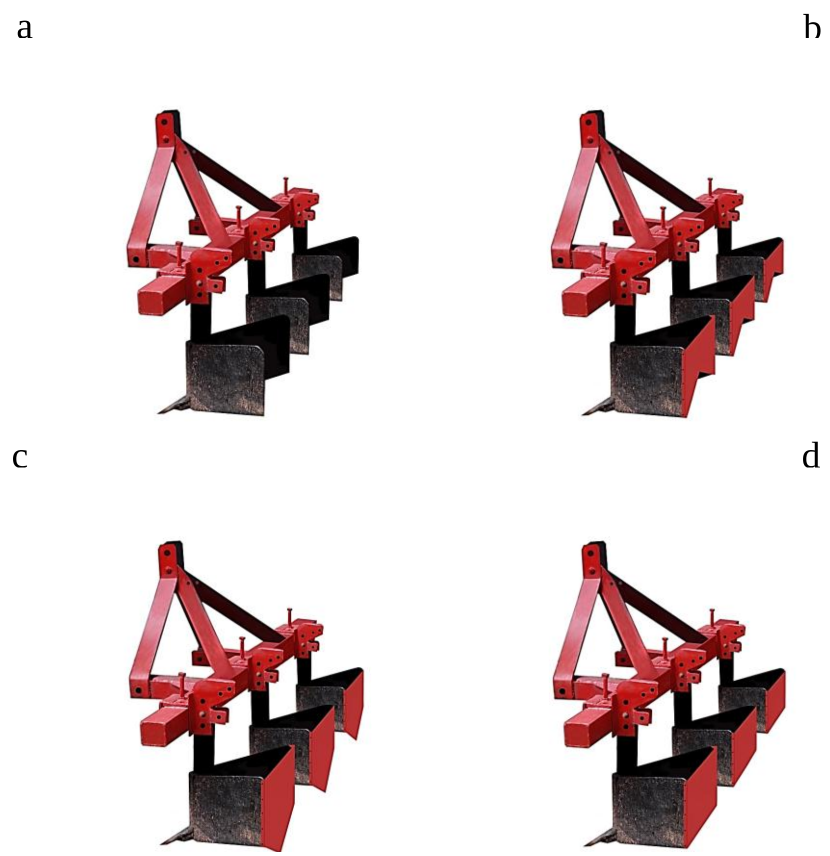
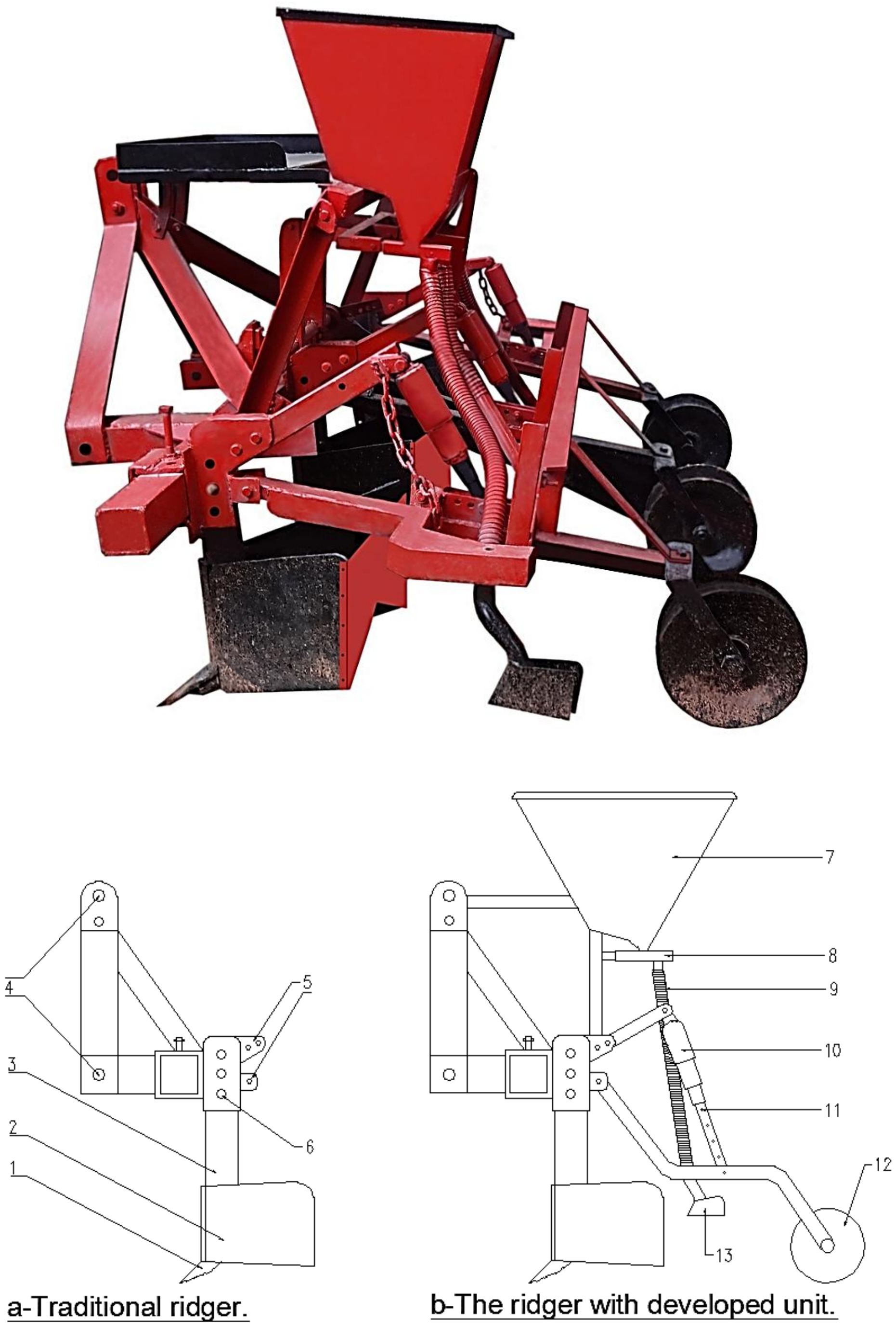


Fig. (1): a. The traditional ridger without development.
b. The ridger with rear slab to form the irrigation channel bottom (W-shape) without compaction.
c. The ridger with rear slab to form the irrigation channel bottom (V-shape) without compaction.
d. The ridger with rear slab to form the irrigation channel bottom (trapezoidal-shape) without compaction.



1- The blade.
2- The moldboard.
3- The shank.
4- Upper and lower hitch points.
5- The points for fixing the development unit.
6- The points for changing the operating depth.
7- Hopper of seeds.
8- Feeding unit.
9- Feeding tube.
10- Pressure arm.
11- The points for changing pressure values.
12- The pressure wheel.
13- Opener.

Fig. (2): Traditional ridger with developed unit.

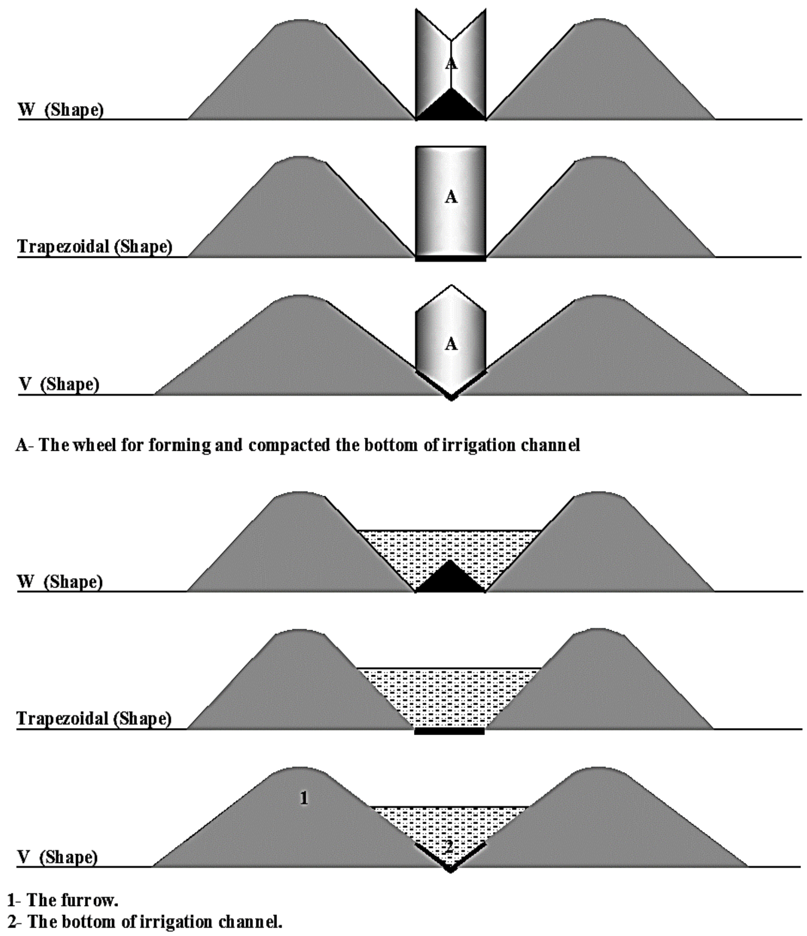


Fig. (3): The shape of wheel using for forming and compacted bottom of the irrigation channel.

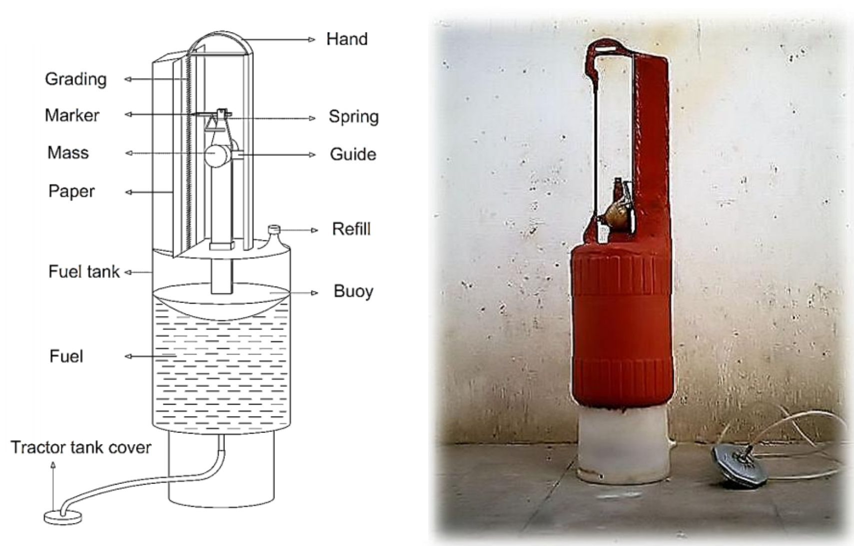


Fig. (4): Fuel meter for measuring fuel consumption.

Table (3): Total water applied with leaching Requirement (LR).

Crops	Irrigation system	Total water applied (m^3/fed.)		
		100% from total water applied	85% from total water applied	70% from total water applied
Millet	Modern Surface Irrigation	4232	3597	2962

Effect of different study treatments on actual field capacity, field efficiency, fuel consumption and pulling force:

From the results in Table (4), it is clear that the actual field capacity and field efficiency achieved the highest value at V-shape of irrigation channel bottom compared with trapezoidal shape and W-shape where, the average increasing percentage for actual field capacity and field efficiency at V-shape were (3% and 7%) and (2% and 7%) compared with (trapezoidal shape and W-shape) respectively. On the other hand, the actual field capacity and field efficiency increased at uncompacted case compared with compacted case where, the average increasing percentage for actual field capacity and field efficiency at uncompacted case were (4% and 3%) compared with compacted case respectively. The results showed that the least values of fuel consumption and pulling force obtained with V-shape compared with trapezoidal shape and W-shape where, the average decreasing percentage for fuel consumption and pulling force were (7% and 15%) and (18% and 29%) compared with (trapezoidal shape and W-shape) respectively. The fuel consumption and pulling force decreased at uncompacted case compared with compacted case where, the average decreasing percentage for fuel consumption and pulling force at uncompacted case were (7% and 12%) compared with compacted case respectively.

Table (4): **Effect of different study treatments on actual field capacity, field efficiency, fuel consumption and pulling force**.

Compacted case of irrigation channel bottom	The shape of Irrigation channel bottom	Actual field capacity (fed/h)	Field efficiency (%)	Fuel consumption (L/h)	Pulling force (kN)
Compacted	V-Shape	1.33^{BC}	75^{A}	7.6^{B}	5.1^{C}
	Trapezoidal-Shape	1.3^{C}	73^{A}	8.1^{AB}	5.9^{B}
	W-Shape	1.25^{D}	70^{A}	8.7^{A}	6.8^{A}
Uncompacted	V-Shape	1.38^{A}	77^{A}	6.8^{C}	4.1^{D}
	Trapezoidal-Shape	1.34^{B}	75^{A}	7.4^{BC}	5.3^{C}
	W-Shape	1.3^{C}	73^{A}	8.2^{AB}	6.2^{B}
L.S.D at significant level 0.05		0.02536	4.97288	0.61712	0.45031

1- Effect of different study treatments on soil bulk density, soil penetration resistance and average infiltration rate:

Soil bulk density, soil penetration resistance and average infiltration rate measured in four zones of soil (A, B, C and D) as shown in figure (5). The data in Table (5) showed that in general soil bulk density and soil penetration resistance at (A) zone achieved the highest values of W-shape compared with trapezoidal shape and V-shape. The average increasing percentage were (2% and 5%) and (7% and 17%) for soil bulk density and soil penetration resistance at W-shape compared with (trapezoidal shape and V-shape) respectively. The results clear that soil bulk density and soil penetration resistance increased with compacted case compared with uncompacted case and the average increasing percentage were (49% and 230%) respectively. The average infiltration rate taking the opposite behavior compared with soil bulk density and soil penetration resistance where the average decreasing percentage were (3% and 13%) for the average infiltration rate at W-shape compared with (trapezoidal shape and V-shape) respectively. The results clear that the average infiltration rate decreased with compacted case compared with uncompacted case and the average decreasing percentage was (86%).

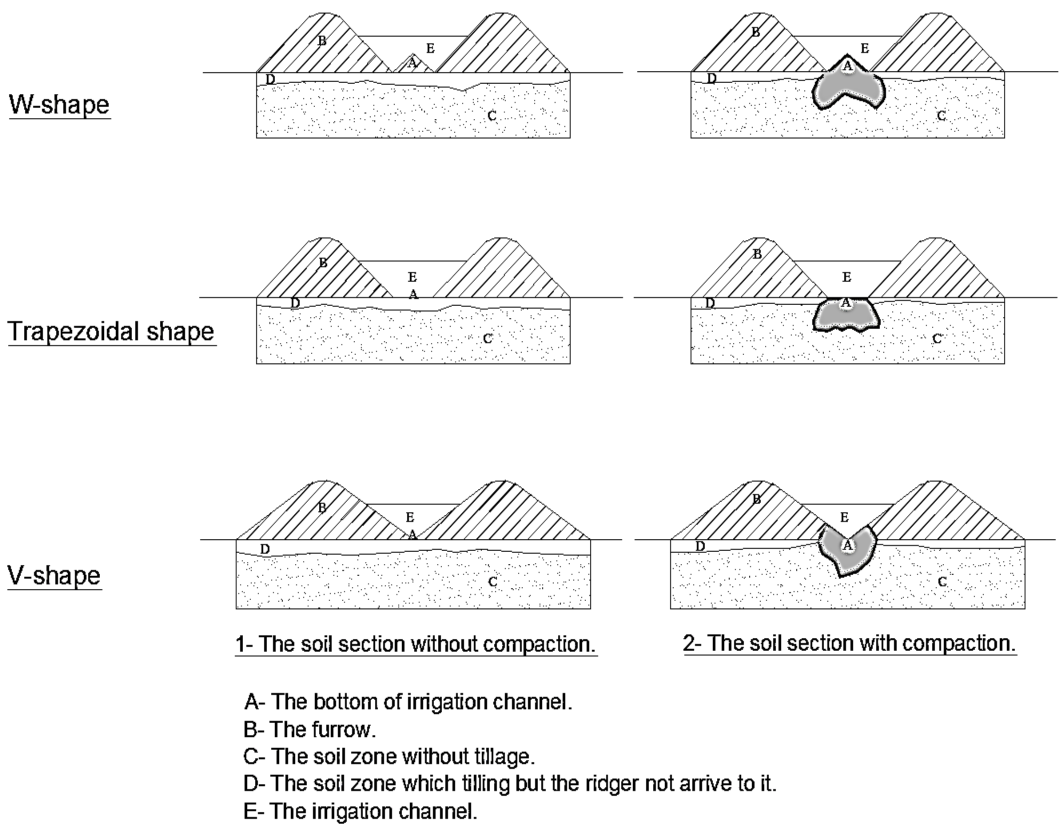
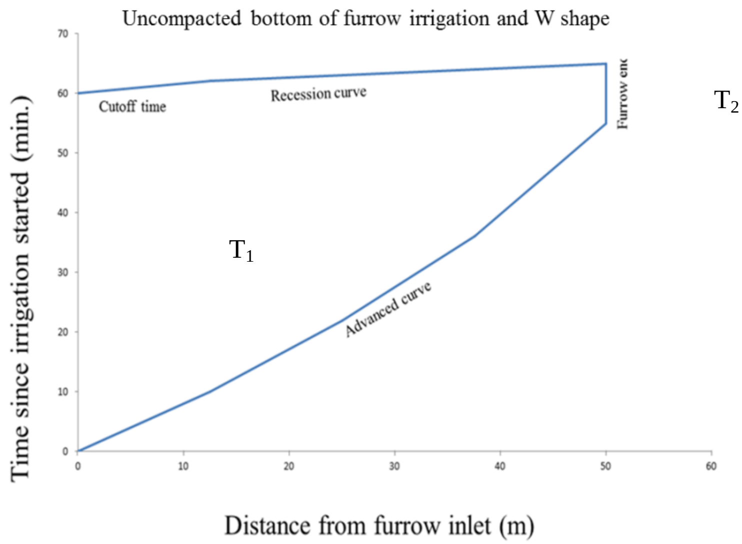


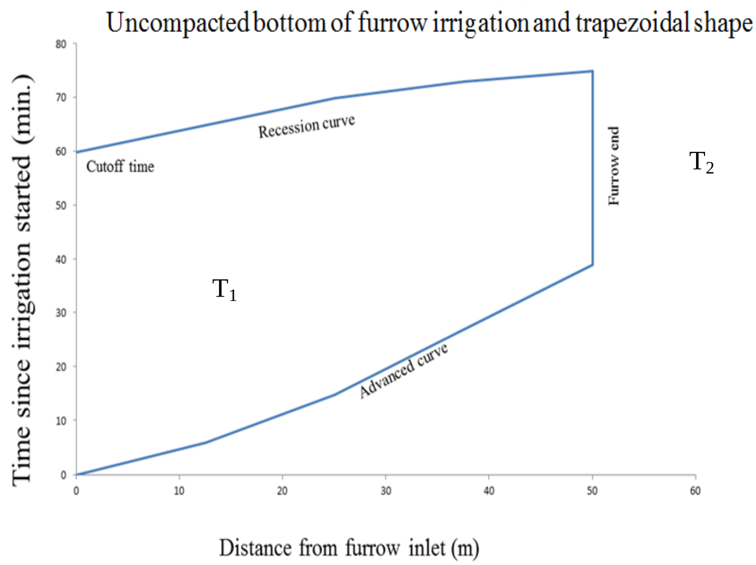
Fig. (5): The soil section with and without compaction.

Table (5): **Effect of different study treatments on soil bulk density, soil penetration resistance and average infiltration rate.**

Treatments: The shape of Irrigation channel bottom	Treatments: Compacted case of irrigation channel bottom	Soil zones	Soil bulk density (g/cm^3)	Soil penetration resistant (kPa)
V-Shape	Compacted	A	1.81^{B}	3340^{C}
		B	1.14^{KL}	532^{M}
		C	1.22^{EF}	1051^{I}
		D	1.62^{CD}	2620^{E}
	Uncompacted	A	1.21^{FGH}	994^{J}
		B	1.12^{L}	497^{N}
		C	1.19^{GHIJ}	636^{K}
		D	1.6^{D}	2565^{F}
Trapezoidal-Shape	Compacted	A	1.85^{A}	3560^{B}
		B	1.16^{IJKL}	570^{L}
		C	1.25^{EF}	1100^{H}
		D	1.64^{CD}	2680^{D}
	Uncompacted	A	1.23^{FG}	1097^{H}
		B	1.15^{JKL}	553^{LM}
		C	1.2^{GHI}	973^{J}
		D	1.63^{CD}	2623^{E}
W-Shape	Compacted	A	1.88^{A}	3930^{A}
		B	1.19^{GHIJ}	642^{K}
		C	1.28^{E}	1150^{G}
		D	1.65^{C}	2710^{D}
	Uncompacted	A	1.28^{E}	1161^{G}
		B	1.17^{HIJK}	619^{K}
		C	1.22^{FG}	987^{J}
		D	1.64^{CD}	2700^{D}
L.S.D at significant level 0.05			**0.03175969**	**25.1441333**

2- Effect of different study treatments on water advanced and recession phases.





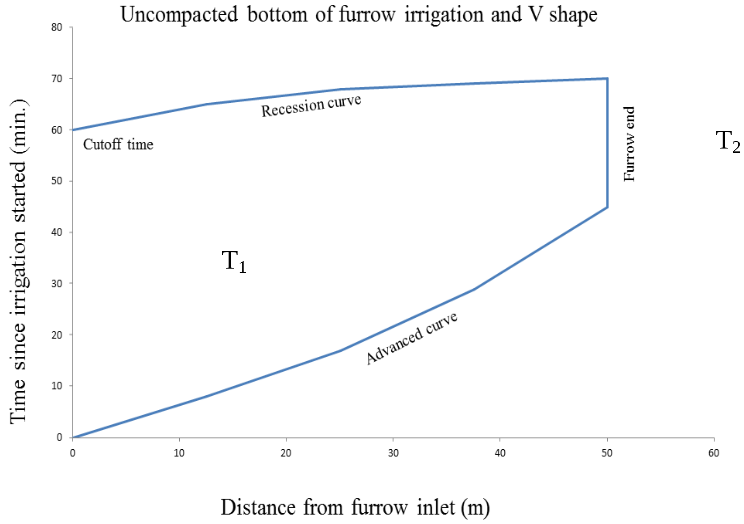
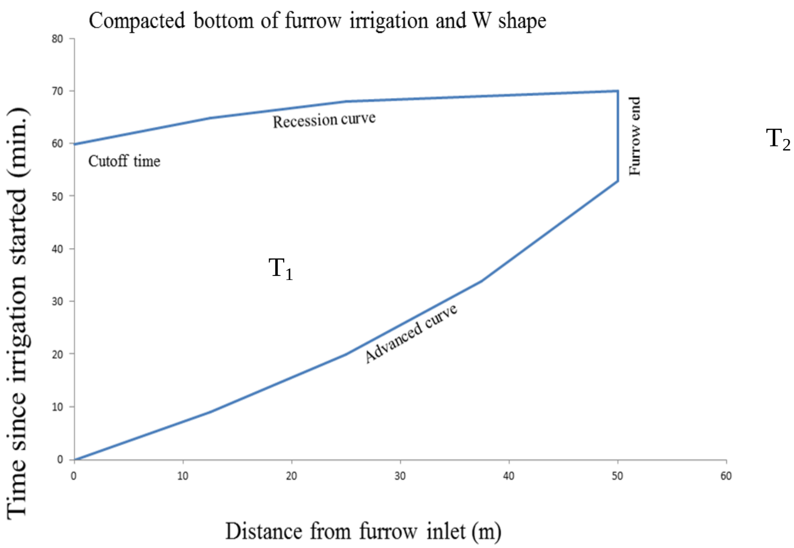
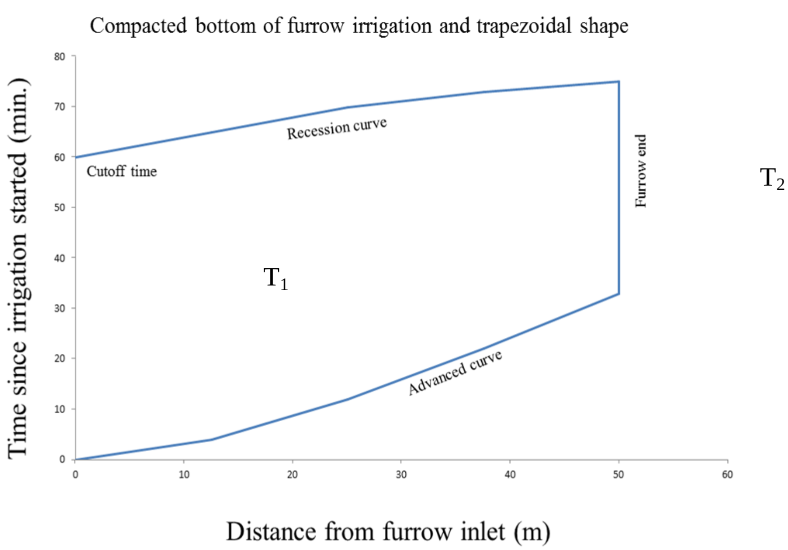


Fig. (6): Recession and advances curves of uncompacted furrow for irrigation event.





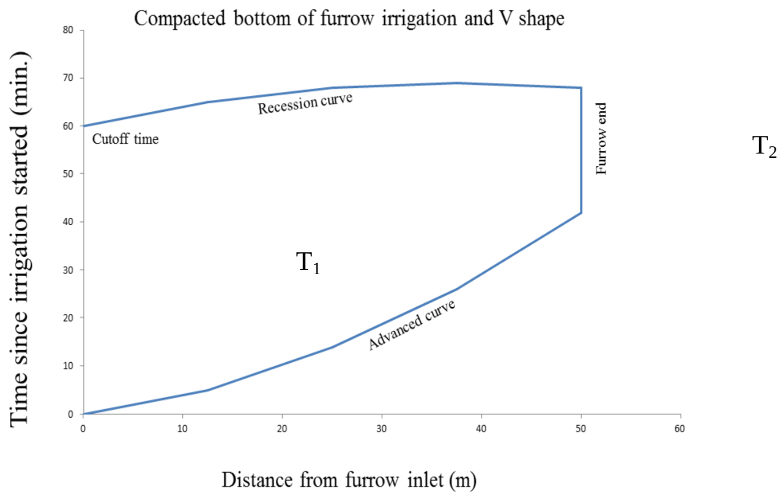


Fig. (7): Recession and advances curves of compacted furrow for irrigation event.

Regarding the three used forms of furrow irrigation bottom (W, Trapezoid and V shape), the water advanced velocity is increasing by flow area reducing and non-barriers so, the highest velocity of water movements of furrow irrigation was V shape, then the Trapezoidal shape by less water movements velocity due to the widening of flow area of furrow irrigation, and finally the slowest water movement was the W shape according to middle top which increase the contact surface area of friction, and reducing the water advanced velocity, so in W shape water take a lot of time to reach the furrow end, resulted the deep-percolation whenever it be closer to furrow inlet according to **(Lee 1982).** But in V shape the water velocity was the highest and recession of water happened at short time according the short of water advanced so, it need some soil management careful to prevent the run off, and this by forming a good and strong end boundary, Figs. (6 and 7).

It's crystal clear, the difference between uncompacted bottoms and compacted bottoms of furrow irrigation, water advanced velocity at compacted bottoms of furrow irrigation is higher the it in the uncompacted bottoms of furrow irrigation, due to the friction losses for compacted bottoms is less than uncompacted bottoms because of soil was been compacted and have a smooth surface with less friction so help water to advances strongly, and the conversely case with uncompacted bottoms which have rough surface of uncompacted soil, and cause resistance to water advanced according to friction losses and water deep-percolation through the small cracks of surface layers of soil. Figs. (6 and7)

As shown in Fig (6) and Fig (7), when

$T_1 > T_2$ that's mean deep-percolation must be happen,

$T_1 < T_2$ that's mean run-off must be happen,

$T_1 \approx T_2$ that's mean the ideal water advanced and recession was closer.

3- Effect of different study treatments on Millet yield (fresh forage), water use efficiency, soil moisture content and soil salinity.

Table (6), clear that the W-shape for irrigation channel bottom achieved the highest Millet yield compared with trapezoidal shape and V-shape where the average increasing percentage were (9% and 17%) respectively. The compacted case displayed increasing in the Millet yield compared with uncompacted case where, the average increasing percentage was (17%). The results showed that the Millet yield increased with increasing irrigation rate and the average increasing percentage for irrigation rates (85% and 100%) compared with 70% were (40% and 56%) respectively. The W-shape for irrigation channel bottom achieved the highest water use efficiency compared with trapezoidal shape and V-shape where the average increasing percentage were (8% and 18%) respectively. The compacted case displayed increasing in the water use efficiency compared with uncompacted case where, the average increasing percentage was (16%). The results showed that the water use efficiency achieved the highest value at 85% irrigation rate compared with (100% and 70%) and the average increasing percentage for irrigation rates (85% and 100%) compared with 70% were (14% and 9%) respectively. The W-shape for irrigation channel bottom achieved the highest soil moisture content compared with trapezoidal shape and V-shape where the average increasing percentage was (3% and 9%) respectively. The compacted case displayed increasing in the soil moisture content compared with uncompacted case where, the average increasing percentage was (13%). The results showed that the soil moisture content increased with increasing irrigation rate and the average increasing percentage for irrigation rates (85% and 100%) compared with 70% were (16% and 27%) respectively. The W-shape for irrigation channel bottom achieved the lowest soil salinity compared with trapezoidal shape and V-shape where the average decreasing percentage was (6% and 20%) respectively. The compacted case displayed decreasing in the soil salinity compared with uncompacted case where, the average decreasing percentage was (26%). The results showed that the soil salinity decreased with increasing irrigation rate and the average decreasing percentage for irrigation rates (85% and 100%) compared with 70% were (27% and 47%) respectively.

Table (6): Effect of different study treatments on Millet yield (fresh forage), water use efficiency, soil moisture content and soil salinity.

Irrigation rate	Compacted case of irrigation channel bottom	The shape of Irrigation channel bottom	Millet yield (fresh forage) first cut (ton/fed)	Millet yield (fresh forage) second cut (ton/fed)	Millet yield (fresh forage) third cut (ton/fed)	(first+second+third) cuts (ton/fed)	Water use effeciency (kg/m^3)	Soil moisture content (%)	Soil salinity (ds/m)
70%	Compacted	V-Shape	9.38	8.13	6.10	23.61^{J}	7.9^{FGH}	20.58^{HI}	6.4^{AB}
		Trapezoidal-Shape	10.44	8.51	6.37	25.32^{I}	8.5^{DEF}	21.82^{GH}	5.9^{BC}
		W-Shape	11.20	9.30	7.10	27.6^{H}	9.3^{BC}	23^{FG}	4.6^{D}
	Uncompacted	V-Shape	7.38	6.40	4.30	18.08^{L}	6.1^{J}	18.42^{J}	7.2^{A}
		Trapezoidal-Shape	8.00	7.20	5.50	20.7^{K}	6.9^{I}	18.72^{J}	6.9^{A}
		W-Shape	9.10	7.80	6.50	23.4^{J}	7.9^{FGH}	19.9^{I}	6.5^{AB}
85%	Compacted	V-Shape	13.50	10.00	8.70	32.2^{F}	8.9^{BCDE}	23.8^{EF}	4.4^{D}
		Trapezoidal-Shape	14.70	10.70	9.34	34.74^{DE}	9.6^{B}	24.5^{DEF}	4^{DEF}
		W-Shape	15.40	11.50	10.04	36.94^{C}	10.3^{A}	25.7^{CD}	3.2^{G}
	Uncompacted	V-Shape	11.40	8.61	7.40	27.41^{H}	7.6^{GH}	21.8^{GH}	6^{BC}
		Trapezoidal-Shape	12.50	9.10	7.90	29.5^{G}	8.2^{EFG}	22.1^{G}	5.5^{C}
		W-Shape	12.90	9.80	9.00	31.7^{F}	8.8^{CDE}	23.9^{EF}	4.2^{DE}
100%	Compacted	V-Shape	14.60	11.90	9.11	35.61^{CD}	8.4^{DEF}	26.71^{C}	3^{G}
		Trapezoidal-Shape	15.80	12.40	10.10	38.3^{B}	9.1^{BCD}	27.8^{B}	2.7^{GH}
		W-Shape	16.60	13.33	10.45	40.4^{A}	9.5^{B}	28.92^{A}	2^{I}
	Uncompacted	V-Shape	12.70	10.34	8.10	31.14^{F}	7.3^{HI}	23.5^{F}	4.5^{D}
		Trapezoidal-Shape	13.80	11.00	8.80	33.6^{E}	7.9^{FGH}	23.9^{EF}	4.1^{DEF}
		W-Shape	14.00	12.70	9.60	36.3^{C}	8.6^{DEF}	25.1^{DE}	3.5^{EFG}
L.S.D at significant level 0.05			-	-	-	**1.18832**	**0.5195**	**1.0581**	**0.6136**

CONCLUSION

The obtained results can be summarized as follows:

1. The highest values of actual field capacity and field efficiency were (1.38 fed/h and 77%) achieved at uncompacted and V-shape of irrigation channel bottom, while the lowest values were (1.25 fed/h and 70%) obtained at compacted and W-shape of irrigation channel bottom.
2. The highest values of fuel consumption and pulling force were (8.7 L/h and 6.8 kN) achieved at compacted and W-shape of irrigation channel bottom, while the lowest values were (6.8 L/h and 4.1 kN) obtained at uncompacted and V-shape of irrigation channel bottom.
3. At the soil zone (A) the highest values of soil bulk density and soil penetration resistance were (1.88 g/cm^3 and 3930 kPa) achieved at compacted and W-shape of irrigation channel bottom, while the lowest values were (1.81 g/cm^3 and 3340 kPa) obtained at uncompacted and V-shape of irrigation channel bottom.
4. At the soil zone (A) the highest value of average infiltration rate was (10.5 cm/h) achieved at uncompacted and V-shape of irrigation channel bottom, while the lowest value was (1.32 cm/h) obtained at compacted and W-shape of irrigation channel bottom.
5. At uncompacted bottoms of furrow irrigation the highest velocity of water movements of furrow irrigation was V shape, then the Trapezoidal and finally the slowest water movement was the W shape, while water advanced velocity at compacted bottoms of furrow irrigation is higher the it in the uncompacted bottoms of furrow irrigation.
6. The highest values of Millet yield and soil moisture content were (40.4 ton/fed and 28.92 %) achieved at compacted, W-shape of irrigation channel bottom and 100% irrigation rate, while the lowest values were (18.08 ton/fed and 18.42 %) obtained at uncompacted, V-shape of irrigation channel bottom and 70% irrigation rate.
7. Effect of three shapes and compacted bottom of furrow irrigation was clear at advanced and recession curves, water movement was increment under compacted treatment and under V, Trapezoid and W shape receptively. And advances and recessions curves refer to last water behaviors.
8. The highest value of water use efficiency was (10.3 kg/m^3) achieved at compacted, W-shape of irrigation channel bottom and 85% irrigation rate, while the lowest value was (6.1 kg/m^3) obtained at uncompacted, V-shape of irrigation channel bottom and 70% irrigation rate.
9. The highest value of soil salinity was (7.2 ds/m) achieved at uncompacted, V-shape of irrigation channel bottom and 70% irrigation rate, while the lowest value was (2 ds/m) obtained at compacted, W-shape of irrigation channel bottom and 100% irrigation rate.

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