Effect of pipes installation by modified machine for subsurface drip irrigation system on maize crop yield costs

Hani A. Mansour[1*], Hu Jiandong[2], Sabreen K. Pibars[1],
Bao Hong Feng[2], Liang Changmei[2]

(1. *Water Relations and Field Irrigation Department, Agriculture and Biological Research Division, National Research Centre, El-Dokki, Giza, 12622, Cairo, Egypt*;
2. *Xilingol Vocational College, Xilinhot City, 026000. Inner Mongolia, China*).

Abstract: The machine of pipes installation of subsurface drip irrigation systems was tested and studied at the Abu-Ghalib farms production (private farm), El-Giza Governorate, Egypt, in growing summer season 2017. The goal of this research was to study the technical and economical evaluation of the installation subsurface pipes for drip irrigation system by Manual method (M) as control, Semi-Mechanical method (SM), and Quad-Raw Machine method (QRM) using different lateral spacing. The QRM method of installation is powered by tractor, the SM method consists of three steps: firstly, the drill plow is drilled under the soil using the tractor, then the pipes are extended in the holes by the labors, and the M method of installation is by labors only for all steps for installation subsurface drip irrigation at different lateral spacing (0.6, 1.0, and 1.4 m) on cost analysis for maize crop production. Production costs of corn crop in US Dollar ($), results showed that net profits were higher by using sub-surface drip system with SM method exceeded 10% for the drip surface irrigation system M method. Value of the net income of the economic unit of irrigation water used ($ m^{-3}) was the highest with using drip sub-surface irrigation SM method and QRM method compared to the surface drip system by 50% and 51% under both. Value of the net income from the physical unit of irrigation water used (kg m^{-3}) were increased by 6.6% and 5.2% with subsurface drip irrigation SM method, QRM method relative to surface drip irrigation system QRM. Authors recommend using sub-surface drip irrigation designs (SM method and QRM method) using different lateral spacing machine installation because it had improved the maize yield and stover production, net profit, and the physical income.

Keywords: subsurface, drip, irrigation, semi mechanical, QRM, machine, installation, lateral

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1 Introduction

One of the main advantages of the quaternary drip irrigation system is that its cost for investment is high when working with the subsurface drip system compared with other irrigation systems. The calculations depend on the field area, topography, location of the main source of water and irrigation system automation. The researchers estimate the cost of investment for the irrigation system by taking the net cost with the tax reduction allowed into consideration based on two tax categories and the current value of the reductions applied over several years according to the regulations of the state of Nebrasska, USA, with a total average cost of $ 2000 and $ 3,200 per hectare, including installation costs estimated at $ 800 per hectare.

The costs analysis of drip irrigation systems for maize crop production in Illinois USA, In order to achieve the maximum economic feasibility of the drip irrigation system has been investigated by Mansour (2015), and

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***Corresponding author: Mansour, H. A.,** Associate professor, Water Relations and Field Irrigation Department, Agriculture and Biological Research Division, National Research Centre, El-Dokki, Giza, 12622, Cairo, Egypt. Tel: 01068989517. Email: mansourhani2011@gmail.com, ha.mansour@nrc.sci.eg.

secondly update and develop previous estimates of capital investments, fixed costs and operating cost for drip closed circuits of drip irrigation systems for the 2010/2011 summer season production. He found that the analysis indicated that modified circuits Drip Irrigation Closed (DIC), Closed with Two Manifolds (CM2) and Closed with One Manifold (CM1), meanwhile the shorter Lateral Line Length (LLL), Lateral Line Length 40 m (LLL1) and Lateral Line Length 60 m (LLL2), where it achieved the highest value of net profits for revenues, as well as the net income from irrigation water economically, and the net income of irrigation water. Several cost studies of tomato drip irrigation systems have been installed in Florida, and only one of them has made it clear that potato yields and profits (Goyal and Mansour, 2015). Mansour and Aljughaiman (2015) evaluated the economic feasibility of in-bed surface drip irrigation on corn production at Kingdom of Saudi Arabia and compared its cost with subsurface drip irrigation system.

Drip irrigation has introduced many and many distinct agricultural irrigation technologies that have contributed to a great economic development (Mansour and El Melhem 2015). Many researchers have studied the effects of irrigation system and irrigation management at different levels and fertilizers and various plants on net profit. Estimation of net income in some of the previous studies, due to the loss in one or more fixed costs such as the cost of capital and the rent value of land where irrigation water is provided free of charge to the owners of farms (Mansour et al. 2015).

Mansour (2006) found that the higher and lower net profits of 3335 and 1414 pounds were obtained from the cultivation and production of the grapes under drip and irrigation systems in the pipes classified on the Nile (Mansour et al. 2016). In another experiment, Irrigation, added water levels, irrigation management and varieties of wild beans where the highest and lowest net income was 760.7 and 270.5 dollars per hectare respectively.

Pibars and Mansour (2019 and 2016) reported that the higher and lower value of the net profits of 4521 and 709 dollars per hectare were obtained from the garlic crop based on irrigation and phosphorus levels and the use of used fertilizer injectors in another experiment where the net income obtained from The water unit ranged between 1.22 and 14.14 kg of grain yield for dry beans per m^3 of irrigation water (Mansour et al., 2014) and Dhuyvetter et al (1995). The highest and lowest value of irrigation water ranged from 6 to 13.0 and 2.5 to 3.5 pounds per m^3 Of the water used in the irrigation process, and it has been shown that the cost of drip irrigation has been significantly affected by the feed varieties And the levels of phosphorus added in the West Kansas area of the United States of America. El Amami et al. (2001) reported that good irrigation management and irrigation scheduling are good champions of the highly positive economic impacts on the farm and help to avoid major constraints such as water stress the irrigation system has weakened.

Explain both Mansour et al. (2015a) and Pibars et al. (2015) that the energy and availability of the most important determinants of the cost of irrigation system in the farm and in return, the profits generated on investment are significant and be produced by the purpose to be achieved and the tools that have been used to achieve the goal and topography of the farm and the quality of crops and land in the farm and also the area to be cultivated and irrigated using Irrigation system and other agricultural equipment.

The objectives of the current study are to determine the effect of using QRM, SM and M methods for installation the lateral lines of subsurface drip irrigation system at different lateral spacing on grain yield, stover yield, Grain Water Use Efficiency (WUEg), Stover Water Use Efficiency (WUEs) and cost analysis components for maize crop production.

2 Materials and methods

A field experiment was conducted through the summer successful season of 2017 at Abu-Ghalib Farms Production (Private Farm), El-Giza Governorate, Egypt, in sandy loam soil as shown in Table 1 to study the technical and economical evaluation of the installation subsurface pipes for drip irrigation system by M method as control, SM, and QRM methods using different lateral spacing (0.6, 1.0, and 1.4 m).

Table 1 Soil mechanical analysis and some physical properties of location*

Depth (cm)	Particle size distribution (%)				Texture class	θ_S % on weight basis			Sat. HC (mm hr^{-1})	BD (g cm^{-3})
	C. Sand	F. Sand	Silt	Clay		F.C.	W.P.	AW		
0-10	8.9	68.2	10.4	12.5	Sandy loam	19.8	12.6	5.2	25.64	1.55
10-20	8.8	68.3	10.5	12.4	Sandy loam	19.8	12.6	5.2	25.44	1.55
20-30	8.6	68.2	10.6	12.6	Sandy loam	19.8	12.6	5.2	25.33	1.56
30-40	8.7	68.3	10.6	12.4	Sandy loam	19.8	12.6	5.2	25.22	1.57

Note: F.C.: Field capacity, W.P.: Wilting point, AW: Available water, Sat.HC: Saturated hydraulic conductivity (mm hr^{-1}), and BD: Bulck density(g cm^{-3});

* Particle size distribution has been observed according (Gee and Bauder, 1986) and moisture retention has been observed according (Klute, 1986).

2.1 Irrigation systems components

Surface and sub-surface drip irrigation systems networks include the following components as shown in Figures 1 and 2:

(1) Control head: It is located at the water source supply. It consists of centrifugal pump 4`` /4``, driven by diesel engine (pump QRM charge of 100 m^3 h^{-1} and 50 m lift), sand media filter 48`` (two tanks), screen filter 2`` (120 mesh) back flow prevention device, pressure regulator, pressure gauges, flow-meter, control valves and chemical injection.

(2) Main line: PVC pipes of 125 mm in diameter (OD) to convey the water from the source to the main control points in the field.

(3) Sub-main lines: PVC pipes of 75 mm diameter (OD) were connected to with the main line through a control unit consists of a 2`` ball valve and pressure gauges.

(4) Manifold lines: PVC pipes of 40 mm in diameter (OD) were connected to the sub main line through control valves 1.5``.

(5) Emitters: These emitters Built in (GR) dripper from Polyethylene (PE) tubes 16 mm in diameter (OD) and 50 m in long (emitter QRM charge of 4 lph at 1.0 bar operating pressure, 0.3 m spacing between emitters, and (0.6, 1.0, and 1.4 m) spacing between lateral lines. Sub-surface drip depths 0.15 and 0.3 m.

Figures 3, 4 and 5 showed the QRM method, while Figure 6 showed the comparison between the three methods of installation sub-surface drip irrigation system.

QRM method of installation is powered by tractor, the semi-automatic method consists of three steps: firstly, the drill plow is drilled under the soil using the tractor, then the pipes are extended in the holes by the labors, and the M method of installation is by labors only for all steps for installation subsurface drip irrigation at different lateral spacing (0.6, 1.0, and 1.4 m) on cost analysis for maize crop production.

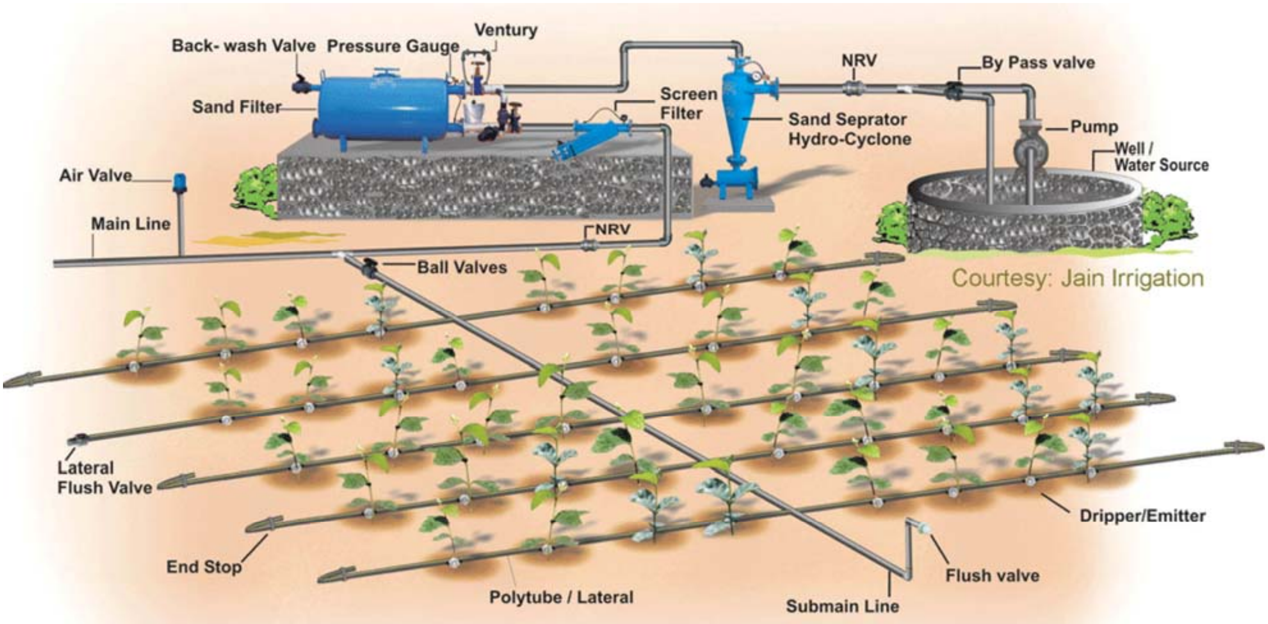

Figure 1 Drip irrigation system components

Figure 2 Drip system establishment and installation automated controller surface and subsurface drip irrigation systems in new field

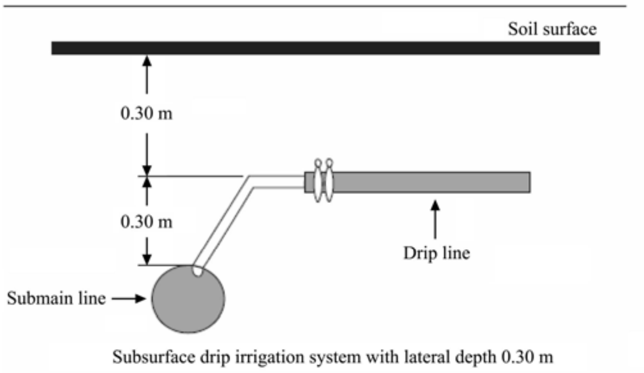

Figure 3 Drip line location with soil sub-surface by 30 cm

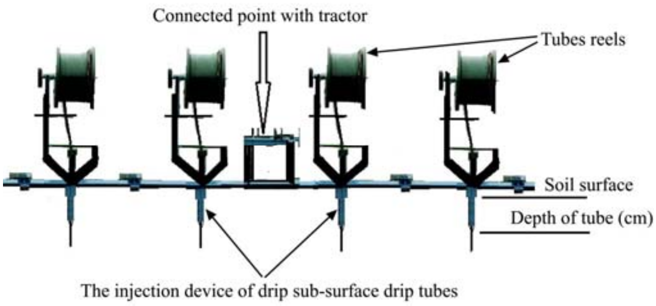

Figure 4 Quad-raw machine

Figure 5 Installing the drip lateral lines using QRM

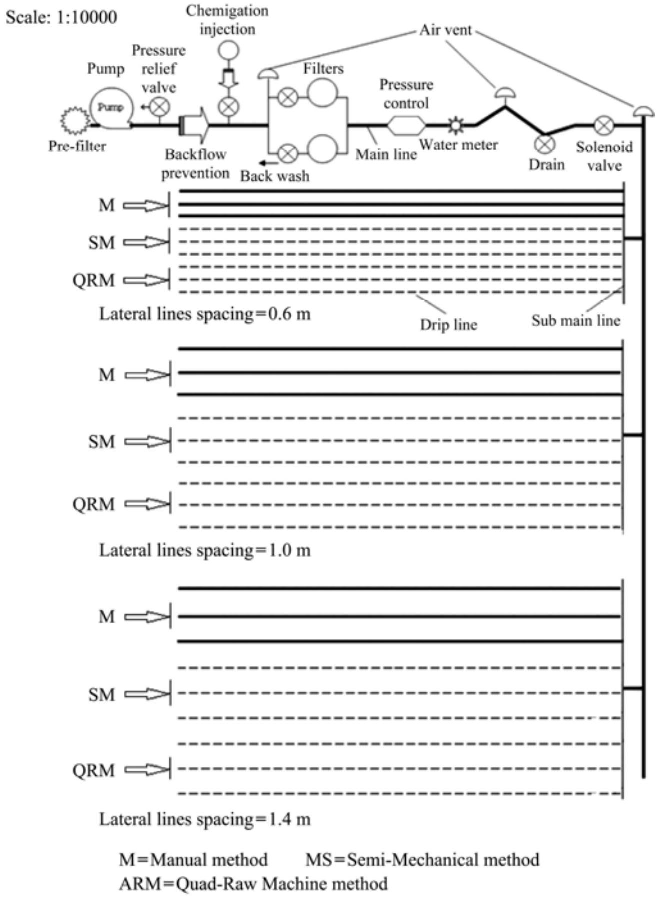

Figure 6 Experiment's layout of installation of the subsurface drip irrigation systems by using manual, semi-mechanical and quad raw machine methods and different lateral lines spacing

2.2 Technical specifications of QRM

(1) The QRM injection device of the drip pipe consists of moving parts through which the depth of the installation can be adjusted. The most important is the soil slitting weapon, which is free of movement, the cone of the entry and exit of the drip pipe and the part responsible for the connection to the kidney structure of the machine.

(2) The structure of the machine is connected to the tractor and this part contains the point of clamping jars and places of installation of the injection device and the places of installation of rollers. The kidney structure is controlled so that the injection devices have free movement so that we can adjust the distance between the lines according to the type of crop.

(3) Place the suspension of the pipe rollers where the pipe rollers are suspended.

2.3 Calculations of economic feasibility costs

2.3.1 Total production costs

Total production costs in US Dollar ($) of corn yield included irrigation, fertigation, weed control, and pest control costs.

A- Irrigation cost

B- Capital costs for automated controller of Surface Drip Irrigation (SDI) and Sub-surface drip irrigation systems (SSDI) under studied were computed according to the market price of 2004 for equipment and installation.

The annual cost (fixed and operating) of different irrigation systems for grape farms were computed according to Mansour (2015).

2.3.2 Fixed costs

The annual fixed costs invested in the irrigation systems were calculated in ($) using the following formula:

$$F.C = D + I + T \quad (1)$$

where, F.C. = Annual fixed cost, \$ year^{-1}; D = Depreciation rate, \$ year^{-1}; I = Interest, \$ year^{-1}, and T = Taxes and overhead ratio, \$ year^{-1}.

Depreciation cost differs from one system to another, according to the life span of the different components of each system. Depreciation can be calculated from the following equation:

$$D = (I.C. - Sv)/E \quad (2)$$

where, I.C. = Initial cost of irrigation system, $; Sv = Salvage value after depreciation, $, and E = Expectancy life, year.

The current interest was calculated as follows:

$$I = (I.C. + Sv)\ I.R./2 \quad (3)$$

where, I.R. = Interest rate per year, %.

Taxes and overhead ratios were taken as (1.5%-2.0%) from the initial costs.

2.3.3 Operating costs

Operating costs were calculated from the following formula:

$$O.C. = L.C + E.C + (R\&M) \quad (4)$$

where, O.C. = Annual operating costs, \$ year^{-1}; L.C = Labor costs, \$ year^{-1}; E.C = Energy costs, \$ year^{-1}, and R&M = Repair and maintenance costs, \$ year^{-1}.

Labor to operate the system and to check the system components depends on irrigation operating time. This time would change from system to another according to irrigation water application rate. Labor cost was estimated as follows:

$$L.C = T\ N\ P \quad (5)$$

where, L.C = Annual Labor cost, \$ year^{-1}; T = Annual irrigation time, h year^{-1}; N = Number of labors per ha, and P = Labor cost, \$ h^{-1}.

Energy costs were calculated by using the following formula:

$$E.C = Bp\ T\ Pr \quad (6)$$

where, E.C = Energy costs, \$ year^{-1}; Bp = Brake power, kW; T = Annual operating time, h, and Pr = Cost of electrical power, \$ kW^{-1} h^{-1}.

Repair and maintenance costs were taken as 2%, 3%, and 0.5% of the initial costs for bubbler, drip, and gated pipe irrigation system, respectively.

Total annual irrigation costs = fixed costs + operating costs.

2.3.4 Fertilization costs

Fertilization process of grapevines was carried out by fertigation system under drip and low-head bubbler and modified surface irrigation by using gated pipes irrigation for ammonium sulfate and potassium sulfate and using the traditional method (top dressing) for superphosphate. Fertilization cost was calculated as follows:

$$Fr = (Wf\ Pr) + Ac \quad (7)$$

where, Fr = Fertilization cost, \$ ha^{-1}; Wf = Amount of fertilizers, \$ ha^{-1}; Pr = Fertilizers price, \$ kg^{-1}, and Ac = Application cost of fertilizers, \$ ha^{-1}.

2.3.5 Pest control cost

Pest control carried out by using the sprayer and pest control cost was calculated as follows:

$$Pc = (Wp\ P) + Ac \quad (8)$$

where, Pc = Pest control cost, \$ ha^{-1}; Wp = Amount of pesticides, kg ha^{-1}; P = Pesticides price, \$ kg^{-1}, and Ac = Application cost of pesticides, \$ ha^{-1}.

2.3.6 Weed control cost

Weed control carried out manually by using labors and weed control cost was calculated as follows:

$$Wc = N\ L\ T \quad (9)$$

where, Wc = Weed control cost, \$ ha^{-1}; N = Number of labors per ha; L = Labor cost, \$ h^{-1}, and T = Time used, h ha^{-1}.

2.3.7 Net profit

The economical profit of grape crop under different irrigation systems was calculated by using the following formula (Mansour, 2015).

$$P = (Yt\ d) - Ct \quad (10)$$

where, P = Net profit, $ ha^{-1}; Yt = Total yield, ton ha^{-1}; D = Yield price, $ ton^{-1}, and Ct = Total production costs, $ ha^{-1}.

2.3.8 Cost of production unit

It was calculated as follows:

$$\text{Cost of production unit (\$ kg}^{-1}) = \frac{\text{Total cost (\$ ha}^{-1})}{\text{Total yield (kg ha}^{-1})} \tag{11}$$

2.4 Statistical analysis

The data were subjected to analysis of variance (ANOVA) using Costat software. The experiments design was split plot with three replicates, The main plots involved the drip irrigation subsurface installing method treatment levels (M method, SM method and QRM method) and the sub plots involved the lateral lines spacing treatment levels (0.6, 1.0 and 1.4 m), according to Van Ginkel and Kroonenberg (2014).

3 Results and discussion

3.1 The operation process are as follows

(1) Lubricated well modified machine, especially pulleys whether inside the injection device or rollers.

(2) The injection device is placed at the appropriate depth of the crop and also the distance between the lines on the kidney structure by pinning the end of the drip pipe at the beginning of the lines.

(3) The machine is connected with the tractor.

(4) The pipe ends shall be fixed at the beginning of the lines by passing from the cone to the injection device and fixed with strong iron or wooden wedges at the beginning of the sub-lines (points of contact with the sub-lines or distributers) or their ends.

(5) At the beginning of operation, the depth of the irrigation pipe installation device is adjusted by the tractor driver, and installation is done at slow speeds.

(6) To avoid any cutting with hoses, it should be noted that all pulleys are in rotation with the tractor.

(7) We find that the pipes have been installed and were destroyed by the machine in the first four lines.

(8) Repeat the previous work for the whole set of four lines and so on until the completion of the whole field.

3.2 This QRM mechanism is characterized by the following

(1) The structure of this modified machine should be regular as the pipes should be at a constant depth under the surface of the soil.

(2) Provide the effort (where you do not need the workers during the operation).

(3) Do not need many costs (renting the tractor to be attached).

(4) The pipes can be installed at different depths and different planting distances suitable for the crop.

(5) Save time where you need a short time to complete this process.

(6) Ease of work, whether for small or large land holdings.

(7) Encourage the use of sub-surface drip irrigation system, which in turn helps to provide water.

(8) The use of sub-surface drip irrigation preserves the tubes and increases their lifetime for longer.

Three-dimensional geometry of QRM install device in Figure 7 as follows.

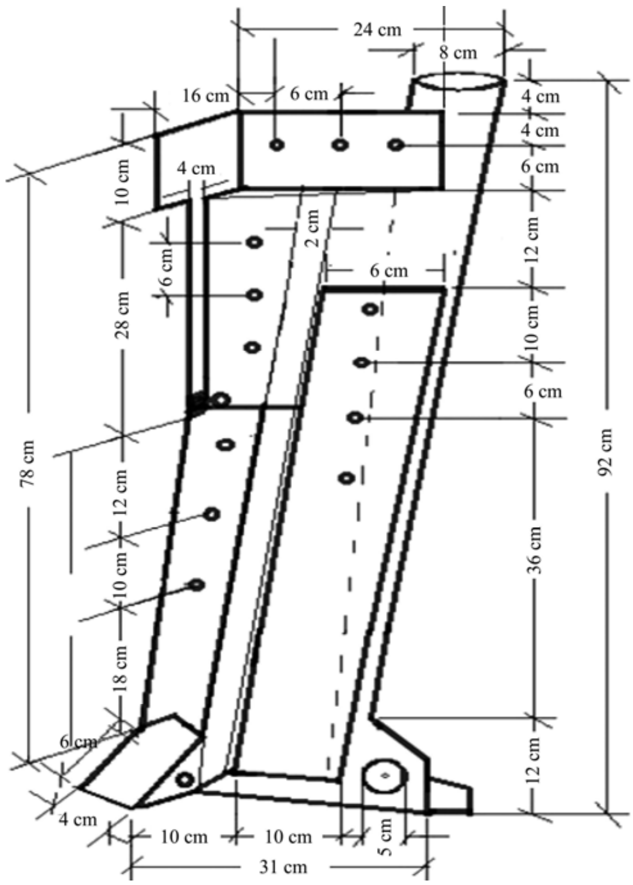

Figure 7 Three dimensions design of QRM device for install sub-surface drip irrigation (scale 1:10)

Table 2 showed the capital cost in US Dollar ($) of the technical and economical evaluation of the installation subsurface pipes for drip irrigation system by M as control, SM, and QRM using different lateral spacing. Total capital costs recorded the lowest value with QRM (70.2 \$ ha^{-1}).

Table 2 Capital costs of drip irrigation subsurface by M, SM and QRM method at 1.0 m spacing (According to the market price of 2018)

Drip irrigation system cost	\$ ha^{-1} with drip lines spacing = 1.0 m		
	M	SM	QRM
Pump unit			
Pump and variable speed drive	179	179	179
Primary filter	366	366	366
Irrigation controller	99	99	99
Fertigation pump	138	138	138
Shed and slab	196	196	196
Suction line (to pump) & connections	185	185	185
Cables and electrical circuits	116	116	116
Subtotal (pump unit)	1278	1278	1278
In field	0	0	0
Submains, pipes and connectors	1316	1316	1316
Valves (control, air release, flushing)	742	742	742
Secondary filtration (at each block)	74	74	74
Meters (for each valve to monitoring volume)	174	174	174
Drip line with emitters	3104	3104	3104
Subtotal (field)	5410	5410	5410
Installation costs	0	0	0
Tape laying (approx \$350 per ha)	344	344	344
Trenching	393	393	393
Labors fees (240 hours)	670	670	670
Power connection (rough estimate)	175	175	175
Subtotal (installation costs)	1581	1581	1581
Subsurface machine lateral costs	-	0	0
Deep rippling (16 hours)	-	193	240
Seed establishment costs	-	290	425
Subtotal (installation costs)	-	388	570
Total capital costs	8269.0	8656.8	8839.1

Followed by M, total capital costs recorded (8656.8 \$ ha^{-1}), and the highest values recorded (8839.1 \$ ha^{-1}) with SM. The highest installation costs were due to Manual (M) and Semi Mechanical (SM) but the lowest one due to using installation modified machine Quad-Raw Machine Method (QRM) for installing subsurface drip irrigation system. It was obvious that the capital costs increased with increasing the depth of lateral line lengths (LLS). This might be due to the extra work of quad row installation machine of lateral lines tubes used.

The total cost of all agricultural operations is a major input to farm capital, either capital cost and annual cost (fixed costs and operating costs) for different drip irrigation systems of Quad-Raw Machine Method (QRM): M, SM and full mechanical method by QRM and LLS: (0.6, 1.0; 1.4 m) on the analysis of costs for corn crop production (the total cost, the total revenue and both of physical and money incomes per unit which used from the irrigation water) were given in Tables 2; 3 and 4. In Table 2, relative to the total costs, the fixed ones accounted to (34.6%, 33.3% and 31.9%), (40.1%, 38.8% and 37.4%) and (39.7%, 35.7% and 37.0%) under M, SM, QRM, 0.6, 1.0 and 1.4 m, respectively. On the other hand, the operation costs reached: (23.0%, 23.4% and 23.9%), (10.3%, 10.5% and 10.7%) and (10.6%, 11.3% and 11.1%), total ones in same the ranked mentioned before. Table 3 shown the grain yield, the stover yield, net profit and both of physical and the money incomes from the unit of irrigation water used. The obtained values of these parameters were: (12880, 12231 and 12028 kg ha^{-1}), (12619, 12011 and 11867 kg ha^{-1}), (12024, 11030 and 10426 kg ha^{-1}), (8384, 8250 and 8132 kg ha^{-1}), (8322, 8195 and 8092 kg ha^{-1}) and (8271, 8102 and 8079 kg ha^{-1}), (0.13, 0.12 and 0.12 kg m^{-3}), (0.13, 0.12 and 0.12 kg m^{-3}), (0.13, 0.11 and 0.10 kg m^{-3}), (2.2, 2.1 and 2.0 \$US m^{-3}), (2.2, 2.1 and 2.1 \$US m^{-3}) and (2.1, 2.0 and 1.9 \$US m^{-3}) in the same sequence under (M, SM and QRM) and (6.0, 1.0 and 1.4 m), respectively. These data agreed with ASAE (1975), Doorenbos and Pruitt (1977), Zartman et al. (1992), Neibling and Brooks (1995), DeTar et al. (1996), Fabeiro et al. (2001), Mansour and Aljughaiman (2015), Mansour et al. (2015a, 2015b), Mansour et al. (2016a) and Samir et al. (2019).

Table 4 shown that the influence of both Drip Irrigation Circuits, (DIC) and Lateral Line Length, (LLL) used of the total costs (\$/fed/season); the total revenue (\$/fed/season); the physical income (kg/m^3) and the money incomes (\$/m^3). Concerning the effect of (DIC) on the parameters under studying, the (DIC) which used could put in the following arrangements: (M > SM > QRM), (M > SM > QRM), (M > SM > QRM), (M > SM > QRM), the same order. Whereas, the difference was significant in the total cost and income between the M and SM types on the one hand and the QRM method on the other hand at 5%. The differences were significant in the total profit from irrigation units and used by the QRM method at 5% The effects of LLS on the traits studied were all possible, with the following ascending order possible 0.6<1.0<1.4 except the physical income, whereas the order took the trend: 0.6<1.0<1.4. The differences in the data on hand between LLS were highly significant at 5% level except among 1.0 and 1.4 m, in case of physical incomes.

The influence of interactions among QRM x LLS were obtained in the Table 4, maximum and minimum values of total costs; total revenue; the physical incomes and money incomes by the irrigation water unit which used were obtained in the next interactions: (M X 0.6; QRM X 1.0), (M X 0.6; QRM X 1.4), (M X 0.6; QRM X 1.4) and (M X 0.6; QRM X 1.4), respectively. These data agreed with Zartman et al. (1992), Neibling and Brooks (1995), Mansour and Aljughaiman (2015), Mansour et al. (2015a, 2015b), and Mansour et al. (2016a, 2019).

Table 3 Fixed and operating costs of drip irrigation subsurface installed by manual method (M), semi-mechanical method (SM) and quad-raw machine method (QRM) at different lateral lines spacing.

Cost items	M			SM			QRM		
	0.6	1	1.4	0.6	1	1.4	0.6	1	1.4
Fixed costs ($ ha^{-1} season^{-1})									
1- Depreciation	133.1	126.1	118	132.5	125.4	118.4	130.8	123.7	116.7
2- Interest	75.9	72	67.2	75.7	71.6	67.5	74.7	46.4	66.6
3- Taxes and insurance	28.6	26.9	25.2	28.3	26.9	25.2	27.9	26.6	24.9
Sub-total	237.7	225	210.4	236.3	223.9	211.1	233.4	196.7	208.2
Operating costs ($ ha^{-1} season^{-1})									
1- Electricity for pump motor		25.5			26.9			28.6	
2- Maintenance and Repairing		33.6			33.6			33.6	
Sub-total		158			60.5			62.2	
Total annual irrigation cost ($ ha^{-1} season^{-1})	395.8	383	368.5	296.9	284.4	271.6	295.6	258.9	270.4
Total agricultural costs		292.2			292.2			292.2	
Total costs ($ ha^{-1} season^{-1})	688	675.2	660.7	589.1	576.6	563.9	587.8	551.1	562.6

Note: M: manual method, SM: quad-raw machine method, and QRM: quad-raw machine method.

Table 4 Impact of drip irrigation subsurface installed by manual method (M), semi-mechanical method (SM) and quad-raw machine method (QRM) at different lateral lines spacing on maize grain and stover yield costs

Cost item		M			SM			QRM		
Lateral lines spacing (m)		0.6	1.0	1.4	0.6	1.0	1.4	0.6	1	1.4
Yield	Grain (kg ha^{-1})	12024	11030	10426	12880	12231	12028	12619	12011	11867
	Stover (kg ha^{-1})	8271	8102	8079	8384	8250	8132	8322	8195	8092
Price ($ ha^{-1})	Grain	1699.9	1559.5	1474.4	1821.5	1729.6	1700.9	1784.9	1698.9	1678.1
	Stover	367.9	360.9	360	372.8	366.9	361.9	369.8	364.9	360
Total revenue ($ ha^{-1} season^{-1})		2068.8	2068.8	1920.4	1833.4	2194.3	2096.4	2062.8	2154.8	2062.8
Physical net income (kg m^{-3})		37.38	37.38	35.244	34.176	39.16	37.736	37.202	38.626	37.202
Net profit ($ ha^{-1} season^{-1})		**1181**	**1481**	**1369.3**	**1270.8**	**1506.4**	**1421.2**	**1402.1**	**1565.7**	**1486.2**
Net income ($ m^{-3})		128.6	128.6	108.8	9.9	128.6	118.7	118.7	128.6	118.7

Note: Water requirements of QRM, M and SM = 9663.13 m^3 ha^{-1} season^{-1} & ha = 10000 m^2, M: manual method, SM: quad-raw machine method, and QRM: quad-raw machine method.

The results obtained can be explained by the direct effects of the modified QRM system on the studied characteristics. Their effects were studied on the most important hydraulic characteristics of the drip irrigation system on the flow. Examples of the QRM system shipments which also emit the costs of charging, operating pressure, friction losses and speeds the positive effects of the QRM system have led to regularity of water and fertilizer along the sub-drip lines. This has greatly improved the characteristics of the irrigation network, resulting in an increase in the yield of the corn crop Resulting in an increase in income and net annual profits from the use of the irrigation water unit that was used. At the same time, the effect of both DIC and LLL on the studied characteristics was positive through the study of fixed costs and operating costs and their analyzes. These data agreed with Abd-Elmabod et al. (2019), Zartman et al. (1992), Neibling and Brooks (1995), Simonne et al. (2002), Tayel et al. (2012), Pibars and Mansour (2015), Tayel et al. (2015, 2018, 2019), Pibars and Mansour (2016; 2019), Mansour et al. (2016b; 2019), Ibrahim et al. (2018).

4 Conclusion

It could be concluded that: grain and stover yield (kg ha^{-1}), LIS and QRM used could be ranked in the following ascending and descending orders: M>SM> QRM and 0.6<1.0<1.4 m, respectively for studied parameters. The effect of interaction LIS X QRM on yield parameters mentioned above was significant at the 5% level with few exceptions. The highest values of grain and stover yield (kg ha^{-1}) were (12880 and 8384 kg ha^{-1}) and the lowest ones were (10426 kg ha^{-1} and 8079 kg ha^{-1}) could be seen in the interactions: QRM with 1.4 m line width and M with 0.6 m line width, respectively.

The net profits in US Dollar ($), were higher by using quad-raw machine (QRM) exceeded 10% for the semi-mechanical method (SM). Value of the net income of the economic unit of irrigation water used ($ m^{-3}) was the highest with manual method (M) and SM method compared to QRM method by 50% and 51% under both. Value of the net income from the physical unit of irrigation water used (kg m^{-3}) were increased by 6.6% and 5.2% with manual method (M) and semi-mechanical (SM) method relative to the quad raw machine (QRM).

From the above mentioned, we recommend to

- Using the quad raw machine for installation the sub-surface drip irrigation designs at different lateral lines, because this installation machine had improved the maize yield and Stover production, net profit, the physical income and water price.

- Utilizing this machine and its operation time is exploited because what is done in 3-4 working days with workers and simple machines can be allowed in a few hours using this machine.

- Exploiting the workers' effort in other works that require the presence of workers and cannot be dispensed with in the farm.

- Exploiting the large costs of workers' wages and providing them for other important purposes such as reclamation of new lands.

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