

EFFECT OF OPERATING PRESSURE ON TREATED SEWAGE WASTE WATER DISTRIBUTION UNIFORMITY FOR EMITTERS UNDER LANDSCAPE

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ABSTRACT

The aim of this research was to investigate the performance of two types of emitters, (Non-Pc,GR and Pc,GR lateral line) to determine optimum operating conditions that achieve high water distribution uniformity. The coefficient of variation (Cv), The coefficient of uniformity (CU), the distribution uniformity (DU), application efficiency of low quarter (AELQ) and Field emission uniformity (Euf) were evaluated under different levels of operating pressure. It was concluded that discharge and wetting diameter were increased by increasing operating pressure for both types of emitters. Results revealed that the high of water distribution uniformity was achieved at operating pressure of 100 kPa for both types of emitters. Additionally the values of distribution uniformity for PC, GR lateral line are higher than the values of Non-PC, GR lateral line at the same conditions of operating pressures.

Based on the obtained results it can be concluded that, the high performance of both types of emitters can be achieved at operating pressure of 100 kPa.

Keywords: *Pressure, Emitters, Distribution, Uniformity*

1.Introduction

The water is precious and limited resource that is essential for agricultural production, which must be conserved and used judiciously. Sprinkler, trickle and subsurface irrigation methods are relatively modern techniques which have many advantages. Drip irrigation is a relatively new method in Egypt especially in the newly reclaimed areas due to its high control of water distribution and suitability to most of soil and crop types.

Drip irrigation is one of the microirrigation systems which have many advantages. Water and energy savings are the most important advantage which is smaller than other irrigation systems. Capital cost and maintenance requirements are low. Microirrigation achieves higher irrigation efficiency and higher yields than other irrigation systems.

Hydraulic performance evaluation which is used to determine and verify the characteristics of the bubbler systems can be determined on the basis of parameters, such as coefficient of manufacturing variation (Cv), Coefficient of uniformity (Cu) and (k, x) parameters. The key to efficient irrigation is the coefficient of uniformity. Irrigation system performance can be expressed in terms of the determined coefficient of manufacturing variation and Coefficient of uniformity. The more uniformly water is applied, potentially the more efficient irrigation system.

Lamm et al., (2007) mentioned that the manufacturer's coefficient of variation for five models tested ranged from 8 to 21 %, which is relatively high for microirrigation emitters. **ASAE Standards (2001)** recommends values less than 11% and suggests that values greater than 15 % are unacceptable.

Habib and Awady (1992) stated that the discharge uniformity from drip irrigation system is controlled by varying the tube diameter and/ or length and/ or using valve for each drip along lateral line.

Nakayama and bucks (1986) studied the relationship between emitter flow variation and uniformity coefficient and reported that a uniformity coefficient of about (98%) equal an emitter flow variation of (10%) and a uniformity coefficient of about (95%) equals an emitter flow variation of (20%).

Benami and Ofen (1984) stated that for practical purpose it is recommended that allowable variation in pressure head be limited to (15%) for lateral line design in drip irrigation system.

An ideal irrigation system should minimize the losses, and apply the water uniformly (**D.Z. Haman et al, 2003**). The discharge and diameter of throw increases with increase in pressure for all types of micro-sprinklers (**S. L. Muley, 2004, A. A. Kale, 2006**). **Ismail (1985)** showed that when the operating pressure increased from 220 to 275 kPa, the application efficiency of low quarter (*AELQ*) values ranged between from 75.70 % to 52.70 % under low-pressure center pivot sprinkler irrigation system. **Ascough and Kiker (2002)** studied that the application uniformity of different irrigation systems in the sugar industry in five sugar-growing regions in South Africa. The average low-quarter distribution uniformity (*DU*) of center pivot, dragline, micro-irrigation, floppy and semi-permanent sprinkler systems was 81.40 %, 60.90 %, 72.70 %, 67.40 % and 56.90 %, respectively.

To design an efficient drip system, it is necessary to determine the optimum operating conditions that achieve high CU, DU, AELQ and excellent distribution efficiency, therefore the main objective of this study was to compare irrigation performance of pressure-regulated drip lines (PC, GR), and Non-pressure-regulated drip lines (Non-PC, GR) that achieves optimum water distribution uniformity and study the effect of operating pressure on water distribution uniformity for two types of emitters.

MATERIALS AND METHODS

The experimental work was carried out at landscape area located in Hyde Park in the Fifth Settlement of New Cairo, during the season 2022 year. The experimental unit is consists of water source, pump, control valve, pressure gauge, flow meter, pressure regulator. Tow devices of emitters, pressure-regulated drip lines (PC, GR), and Non-pressure-regulated drip lines (Non-PC, GR) were installed as a permanent system.

Two Emitters lateral lines (pressure-regulated drip lines (PC, GR, Rivulis) and non-pressure-regulated drip lines (Non-PC, GR, Eurodrip) were installed and tested at different operating pressure (50, 100,

150, and 200 kPa). Emitters with a flow rate of 4 liters/hour were used for drip irrigation system. These emitters were 50 cm emitter distance and 50 cm between laterals. Drip line saddles were used to connect the lateral lines to the drip hoses. The Emitters lateral lines were evaluated at different levels of operating pressure.

The tools used to improve water quality; water quality is a critical factor in determining the efficiency of various irrigation systems. Contaminated water or water containing solid particles can lead to pipe blockages and poor water distribution, affecting irrigation performance. Therefore, studying the impact of water quality on the performance of irrigation systems is essential to ensure their sustainability and achieve optimal agricultural results.

Disc filter; A130-micron disc filter was used to remove impurities from the water. The disc filter consists of stacked rings that trap particles and prevent clogging. This filter type is more efficient and durable than mesh filters, as it can be cleaned without sustaining damage as shown in figure 1.



Figure 1: Configurations of disc filter

Geotextiles, these synthetic materials, with a permeability of 200 g/m², were used to filter out larger particles from water. Geotextiles were also utilized to enhance the stability of the irrigation system by preventing soil erosion and sediment accumulation in the pipes.

Plastic catch cans 120 mm diameter; 40 mm height were located under emitters to collect the water. The catch cans were distributed according to (**ASAE Standard, 2001**). The emitters was evaluated at different levels of operating pressure (50, 100, 150 and 200 kPa) under Egyptian conditions.

Flow rate of emitter was measured and collecting known volume of water in a container over a specified period (2 min). The flow rate was calculated using the following formula (**Melvyn, 1983**):-

$$Q = \frac{V}{t}$$

Where, Q is the flow rate of emitter in l h^{-1} , V is the collecting water volume in m^3 and t is time of collecting water in h.

The coefficients of manufacturer's variation describe the quality of the processes which used to manufacture those emission devices.

$$Cv = \frac{S}{qm}$$

Where: Cv : The coefficient of variation of emitter flow, S : standard deviation of the emitter flow and qm : average flow rate through emitter (l/h)

The distribution uniformity DU was calculated by the following formula (**Heermann et al., 1990**):-

$$DU = 100 \frac{Z_{lq}}{Z_{av}}$$

Where, DU is the distribution uniformity in %, Z_{lq} is the average catch can depth in the low quarter of the field in mm and Z_{av} is the average catch can depth in the entire field in mm.

Uniformity tests were conducted by placing several identical collectors in an equally spaced grid in the field. The amount of water caught in each can was measured and recorded and the coefficient of uniformity was calculated by the following equation, **Christiansen (1942)**:-

$$CU = 100 \left(1 - \frac{\sum |X_i - \bar{X}|}{n \bar{X}} \right)$$

Where, CU is the Christiansen's coefficient of uniformity in %, X_i is the individual collector amount in mm, $\bar{X}$: mean of collectors amount in mm, Σ is the summation of n values, $| |$ is the absolute value and n is the number of measuring collectors.

Application efficiency of low quarter (AEQ , %) was calculated by the following formula (**Merriam and Keller, 1978**):-

$$AEQ = 100 \frac{Z_{r.lq}}{D}$$

Where, $Z_{r.lq}$ is the average low quarter depth of collected water in mm and D is the average depth of water applied in mm.

To define the uniformity of water application by drip irrigation method, **Keller and Karmeli (1974)** suggested parameter, namely field emission uniformity (EUf). It is defined by the equation

$$EUf = \left(\frac{qn}{qa} \right) \times 100$$

Where: EUf = Field emission uniformity, qn = The average of lowest 1/4th of the emitter flow rate (l/h) and qa = The average of all emitters flow rate (l/h).

RESULTS AND DISCUSSION

Effect of operating pressure on discharge and wetted diameter for emitters

The effect of operating pressure on the performance of two types of GR lateral line included Non-PC, GR lateral line and PC, GR lateral line have been investigated presented in table 1.

Emitter discharge proportionally increased with increasing the operating pressure for all treatments. Due to increasing the operating pressure from 50 to 200 kPa, the discharge was increased from 3.50 to 4.33 l/h and from 2.35 to 4.04 l/h for Non-PC, GR lateral line and PC, GR lateral line, respectively.

The discharge of water depends on the head pressure; Table (1) shows the discharge of water for drip irrigation systems under different pressures. The relationship between discharge and operating pressure was natural (the discharge of the irrigation systems increased by increasing the pressure). Relating to drip irrigation system, increasing the pressure from 50 to 200 kPa, the emitter discharge will be increased by 23.7% and 71.9% for Non-PC and PC, GR lateral line, respectively.

The results indicated that the highest values of discharge were 4.33 and 4.04 l/h were achieved at operating pressure of 200 kPa for Non-PC and PC, GR lateral line, respectively.

Table (1) shows the effect of operating pressure on wetted diameter. In general, the wetted diameter was affected by operating pressure for Non-PC and PC, GR lateral line. The results demonstrated that the wetted diameter was higher than that of other treatment. When the operating pressure increased from 50 to 200 kPa the wetted diameter increased from 35 to 65 cm and from 30 to 50 cm for using Non-PC and PC, GR lateral line, respectively. Also, the maximum wetted diameter obtained with operating pressure 200 kPa for both GR lateral lines. Similar trends were observed with all tested operating pressures under study.

The Discharge and wetted diameter for Non-PC, GR lateral line was higher than PC, GR lateral line increased with increasing operating pressure. Based on the obtained results, it can be concluded that the high discharge and wetted diameter could be achieved by high operating pressure for the Non-PC and PC, GR lateral line.

Table (1): Effect of operating pressure on discharge and wetting diameter for Non-PC, GR and PC, GR lateral line

Emitter type	Operating pressure (kPa)	Discharge (Q) (Lit / Hr)	Wetting diameter (cm)
Non-PC, GR lateral line	50	3.50	35
	100	3.95	45
	150	4.15	55
	200	4.33	65
PC, GR lateral line	50	2.35	30
	100	3.61	45
	150	3.82	48
	200	4.04	50

Water distribution uniformity

The uniformity of application is considered as a primary concern in the drip irrigation design procedure. The coefficient of variation, distribution uniformity, the coefficient of uniformity, application efficiency of low quarter and field emission uniformity were determined at different levels of operating pressure. Table 2 show the relationship between operating pressure and coefficient of variation, distribution uniformity, coefficient of uniformity, application efficiency of low quarter and field emission uniformity for two types of emitters.

Cv values of the emitters were ranged between 0.038 to 0.054 and 0.035 to 0.050 for tow both emitters as shown in Table (2) at 50 to 200 kPa effective pressure respectively which considered excellent according to the classification of manufacturing variation coefficient for point source which recommended by **ASAE Standards, (2001)**.

The DU increased with increased operating pressure, but at the operating pressure 100 kPa obtained the higher DU than others treatments it was 95.79% and 96.30% for Non-PC and PC, GR lateral line, respectively which considered (Excellent).

When the operating pressure increased from 50 to 200 kPa the DU value increased from 93.18% to 95.53% and from 93.46% to 95.89% for Non-PC and PC, GR lateral line, respectively but classified (Excellent). The results indicated that the highest values of DU were achieved at operating pressure of 100 kPa; it is classified (Excellent) according to **(Keller and Bliesner, 1990)**.

Coefficient of uniformity (CU) was described as a numerical expression representing the index of water distribution uniformity on the soil surface. The coefficient of uniformity was determined with different operating pressures of 50, 100, 150 and 200 kPa.

Table (2) showed that the relationship between coefficient of uniformity and operating pressure it can be seen that increasing of operating pressure from 50 to 200 kPa leads to increase CU from 95.47% to

96.72% and from 95.54% to 95.99% for Non-PC and PC, GR lateral line, respectively but classified (Excellent).

The results indicate that the highest value of coefficient of uniformity was obtained at operating pressure 100 kPa with both emitters for all tested ranges of operating pressure. This result is in agreement with recommended pressure provided by manufacturer of drippers. In addition, it is clear that the coefficient of uniformity (CU) was affected by operating pressure.

The results indicated that the highest values of CU were achieved at operating pressure of 100 kPa with Non-PC and PC, GR lateral line it is classified (Excellent) which is in agreement with the results reported by (**Christiansen, 1942**).

In general, AELQ increased with increasing the operating pressure from 50 to 200 kPa.

When operating pressure increased from 50 to 200 kPa, the AELQ values increased from 83.86% to 85.97% and from 84.11% to 86.30% for Non-PC and PC, GR lateral line, respectively.

In addition, the increase of operating pressure leads the AELQ to be increased. It is clear from the obtained results that the highest values of AELQ were achieved at operating pressure of 100 kPa it was 86.21% and 86.67% for Non-PC and PC, GR lateral line, respectively which considered (Good). These results related to AELQ are in agreement with those related to DU and CU. This means that the high water application uniformity could be achieved at operating pressure of 100 kPa.

The results indicated that the highest values of AELQ were achieved at operating pressure of 100 kPa treated water it is classified (Good) according to (**Keller and Bliesner, 1990**).

the Field emission uniformity values for drip irrigation systems 92.00% with operating pressure 200 kPa and 92.06% with operating pressure 100 kPa for Non-PC and PC, GR lateral line, respectively which considered Excellent these values are in agreement with the range recommended by **Merriam and Keller (1978)** (more than 90%).

Based on obtained results, it is clear that there is a parallel trend of DU, CU and AELQ under all tested levels of operating pressure. The highest values of DU, CU, AELQ and Euf were achieved with operating pressure 100 kPa. This means that the more improved water application uniformity could be achieved under previously mentioned operating pressure.

Table 2: Relationship between operating pressure and coefficient of variation, distribution uniformity, coefficient of uniformity, application efficiency of low quarter and field emission uniformity for two types of emitters.

Emitter type	Operating pressure (kPa)	CV	Du %	Cu %	AELQ %	Euf %
Non-PC, GR lateral line	50	0.054	93.18%	95.47%	83.86	86.93%
	100	0.038	95.79%	96.64%	86.21	90.65%
	150	0.047	95.44%	96.35%	85.89	88.00%
	200	0.040	95.53%	96.72%	85.97	92.00%
PC, GR lateral line	50	0.050	93.46%	95.54%	84.11	88.35%
	100	0.035	96.30%	96.97%	86.67	92.06%
	150	0.039	95.89%	96.63%	86.30	90.37%
	200	0.047	93.60%	95.99%	84.24	88.73%

Red: Excellent Green: Good Yellow: medium White: Poor

CONCLUSION

It has been concluded that the performance of two types of emitters, Non-PC and PC, GR lateral line was affected by operating pressures. The results led to the following concluded points.

- 1- Discharge and Wetting diameter were increased by increasing operating pressure for both types of emitters.
- 2- The high of water distribution uniformity was achieved at operating pressure of 100 kPa for both types of emitters.
- 3- The values of distribution uniformity for PC, GR lateral line are higher than the values of Non-PC, GR lateral line at the same conditions of operating pressures.

Based on the obtained results we concluded that, the high performance of both types of emitters can be achieved at operating pressure of 100 kPa.

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