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Determine the Appropriate Length of Micro-Irrigation Systems Utilizing a Mathematical Model

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ABSTRACT

The present research was carried out to determine the best lateral length of micro-irrigation systems using a mathematical model of Microsoft Matlab version 10.0. The program models were designed to find a discharge variation (10, 15 and 20 %) and uniformity of emission (*UE*) of more than 80 %. After that, the experimental field included three emitter devices for validating the mathematical program. The examined test emitter devices were on-line (Em_{on}), built-in (Em_{in}) and micro-tube (Em_{mt}, 3.82 mm internal diameter with 25 cm length), three different length lengths (20, 40 and 60 m), at five operating head pressures (40, 60, 80, 100 and 120 kPa). The comparison between mathematical models showed a very agreement with the experimental validation. The experimentally obtained results have a strong relationship with the determination coefficient (R^2) ≥ 0.9512 between the calculated and predicted *UE* for Em_{on} and Em_{in}. This relationship was decreased with R^2 about 0.8082 for Em_{mt} at different treatments.

***Keywords**:* Micro-irrigation, Lateral, Uniformity Emission, Model.

INTRODUCTION

The pressurized irrigation system is one of the most essential modern including the two systems, sprinklers and micro-irrigation. Micro-irrigation methods such as trickle, sprays, micro-tube and bubblers slow water and provide it directly to the plant. An ideal micro-irrigation system is characterized by watering uniformly and delivering an equal flow rate from emitters as necessary by the plant per one irrigation time (Ngigi, 2008). It plays a prominent role in improving irrigation efficiency and water application uniformity. In addition, to reducing water changes compared to other systems (Lamm *et al*., 2007 and ASABE, 2008).

Modern micro-irrigation systems are considered the best method from an agriculture and engineering point of view and are appropriate for many crops. In modern micro-irrigation, however the emission of uniformity depends on field calculates as mean emitter device discharge and minimum emitter device discharge and there is no system to expect it before the installation of the system (Smith, 2003 and Sharaf, 2004). Mahrous *et al.* (2008) stated that the predicted values of the emission of uniformity in triangular, trapezoidal, and rectangular irrigation subunit systems of different area were in very good agreement with field calculated. Using computer program EGY-DRIP to determine the best length of lateral for on-line and built-in devices. The length was determined by the base on 10 % difference in the devices' flow rate and 50 % head loss friction for the laterals. There was a good agreement between the calculated and the predicted length by using model EGY-DRIP. The average variation between the calculated and the predicted length of lateral was 58 cm for on-line emitter and 50 cm for the built-in-line emitters (Imam and Pibars, 2019).

The success of micro-irrigation is possible if the method is appropriately managed and designed. The initial step in the plan micro-irrigation method is to conclude the best lengths of lateral allow consent distribution water along the lateral. The classification of drippers and the losses of friction along the length for a newly produced micro-irrigation lateral are the main data for the best lengths of lateral (Yurdem *et al.*, 2011). The frictional head losses for micro-irrigation laterals using the Darcy Weisbach equation (Watters and Keller, 1987; Alazba and El-Nesr, 2011 and Nina *et al.*, 2012). Studies were carried out recently to develop some experiential computer program for predicting friction losses (Yildirim, 2010).

The classifications of uniformity resulting from micro-irrigation ranged from excellent to unacceptable were accepted by (ASAE, 1999) for emitters. Uniformity above 90 %, from 80 to 90 %, from 70 to 80 %, 60 to 70 % and below 60 % are referred to as excellent, good, fair, poor and unacceptable emission of uniformity, respectively. Too, flow variation manufacturing V_m is one of the significant causes affecting the general uniformity of the micro-irrigation method. Classification V_m was changed from excellent to unacceptable according to ASABE EP (2008).

While there is already available computer simulation for designing micro-irrigation methods, there is no available program to describe the best practical properties of newly designed devices and value the appropriate lateral length. This research is addressing the most appropriate lateral length for micro-irrigation systems using modern technology. Therefore, computer models were applied in this study to predict the emitter operating head, discharge uniformity under different emitters and validating between calculated uniformity emission (*UE*) and predicted values.

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MATERIALS AND METHODS

Computer Model

A mathematical model of some numerical equations of the micro-irrigation system was used for the study. Microsoft Matlab version 10.0 was set up for analyzing different calculations of uniformity emission, number of emitter devices, flow rate and best length. The friction losses and the best lateral length were calculated and evaluated based on obtained data in the laboratory by using the model.

Several properties of emitter were determined as the following: in pressure H_e (m), discharges emitter Q (ℓh^{-1}) and the manufacturing variation (V_m). The latter could be described based on the following table by ASABE (2008) and recommended by many academics (Keller and Bliesner, 1990; Keller and Karmeli, 1975; Wu and Gitlin, 1974):

$$Q = k\, H_e^{\,x} \quad \textbf{(1)}$$

$$V_m = \frac{S_q}{\overline{Q}} \quad \textbf{(2)}$$

Where, ***x*** **is a dimensionless emitter device flow rate exponent that is classified by the flow regime,** ***k*** **is a constant of proportionality that classification each emitter,** S_q **is a deviation of standard discharge and** $\overline{Q}$ **is the flow rate of the mean emitter.**

The calculation of the friction between emitters was also done without testing friction in the experimental field by using the model of mathematical. So, the Darcy Weisbach equation was used to calculate the friction for smooth pipes and small diameters (Giles *et al.*, 1995) as:

$$\Delta H_f = f_c \cdot \frac{L}{D_i} \cdot \frac{V^2}{2g} \quad \textbf{(3)}$$

Where, ΔH_f **is friction head loss (m),** L **is length of the pipe (m),** D_i **is pipe internal diameter (m),** V **is mean flow velocity (m s**$^{-1}$**),** g **is gravity acceleration (m s**$^{-2}$**), and** f_c **is coefficient of friction.**

The number of Reynolds ($Re \leq 2000$ is laminar flow and $Re \geq 400$ is turbulent flow) was also calculated by the following equation:

$$\mathrm{Re} = \frac{\rho V D_i}{\mu} \quad \textbf{(4)}$$

$$v = \frac{\mu}{\rho} \quad \textbf{(5)}$$

$$\mathrm{Re} = \frac{V\, D_i}{v} \quad \textbf{(6)}$$

Where, V **is the mean of flow velocity (m s**$^{-1}$**),** D_i **is the pipe's internal diameter (m),** μ **is dynamic viscosity of water, (kg m**$^{-1}$**sec**$^{-1}$**) and v the viscosity of water kinematics m**^{2} **s**$^{-1}$ **at 20°C),**

It could be used to classification the flow regime and the flow rate Q (m^3 s^{-1}) evaluate the mean flow velocity of the emitter V (m s^{-1}) as the continuity equation:

$$Q = AV \quad \textbf{(7)}$$

$$V = Q/A \ \textbf{with} \ A = \frac{\pi D_i^{\,2}}{4} \quad \textbf{(8)}$$

$$V = \frac{4\,Q}{\pi\, D_i^{\,2}} \quad \textbf{(9)}$$

Accordingly, in the first case of emitters (*Em*), the loss of friction ΔH_f (m) was measured in the distance between the two emitters S (m); where L = S (notice that the first emitter at full distance from lateral inlet end).

$$\textbf{For flow of laminar} \ \Delta H_f = \frac{1.16\, S\, Q}{D_i^{\,4}} \quad \textbf{(10)}$$

$$\textbf{For flow of turbulent} \ \Delta H_f = \frac{0.471\, S\, Q^{1.75}}{D_i^{\,4.75}} \quad \textbf{(11)}$$

The total losses of head ΔH_{fn} of emitter location on the lateral length were calculated using the following steps:

$$\Delta H_{f1} = \Delta H_1$$
$$\Delta H_{f2} = \Delta H_1 + \Delta H_2$$
$$\Delta H_{f3} = \Delta H_1 + \Delta H_2 + \Delta H_3$$
$$\downarrow$$
$$\Delta H_{f\,n} = \sum_{n=1}^{N} \Delta H_n \quad \textbf{(12)}$$

Also, the length of lateral flow rate at the first device (Q_T) was equal the flow rate of all emitter as follows:

$$Q_T = Q_1 + Q_2 + Q_3 + \ldots\ldots\ldots\ldots\ Q_{n-1} + Q_n \quad \textbf{(13)}$$

Assuming that for equal emitter flow rate

$$Q_1 = Q_2 = Q_3 = \ldots\ldots\ldots\ldots\ldots = Q_{n-1} = Q_n$$

Therefore, the length of lateral flow rate will decrease then after every device through its flow rate value (Q_i) as shown in figure (1).

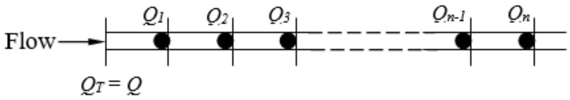

Figure 1. The flow rate in the lateral length sections.

$$Q_1 = NQ$$
$$Q_2 = NQ - Q = Q\,(N-1)$$
$$Q_3 = NQ - 2Q = Q\,(N-2)$$
$$\downarrow$$
$$Q_n = NQ - (n-1)\,Q = Q\,(N - n + 1) \quad \textbf{(14)}$$

From equation 10, 11, 13 and 14 the friction between devices could be measured by the formula 15 for flow of laminar and 16 for flow of turbulent:

For flow of laminar:

$$\Delta H_{f\,n} = S\left[1.16\,Q\,D_i^{-4}\sum_{i=1}^{N}(N-n+1) + \delta_S\right] \quad \textbf{(15)}$$

For flow of turbulent:

$$\Delta H_{f\,n} = S\left[0.471\,Q^{1.75}\,D_i^{-4.75}\sum_{i=1}^{N}(N-n+1)^{1.75} + \delta_s\right] \quad \textbf{(16)}$$

Where, Q **is the emitter flow rate (ℓ h**$^{-1}$**),** D **is lateral of inside diameter (mm),** δ_s **is slope percentage (decimal),** N **is number of emitter total and** n **is number of emitters.**

In the second case with on-line emitter (Em_{on}), the head losses between two devices were calculated by formula 17 given by (Demir *et al.*, 2007):

$$\Delta H_{fn} = 8859.2\, Q_i^{1.789}\, D_i^{-3.904}\, S^{0.635}\, a_e^{1.153} \quad \textbf{(17)}$$

Where, ΔH_{fn} **is total losses of head (m),** Q_i **is the discharge in lateral (m**^{3} **s**$^{-1}$**),** D_i **is the lateral line of inside diameter (m),** a_e **is barb protrusion area (m**^{2}**) and** S **is the interval emitter spacing (m).**

In the third case for built-in emitter (Em_{in}), the head losses between two devices were calculated by formula 18 given by Yurdem *et al.* (2011):

$$\Delta H_{fn} = 5.89 \, x \, 10^{-5} \, Q_i^{1.725} \, D_i^{-2.203} \, S^{0.742} \, d_i^{-3.074} \, L_e^{0.066} \quad (18)$$

Where, L_e is the length of emitter (m) and d_i is the internal diameter of emitter (m).

As stated above, the model developed program needs the choice of device types as both on-line, built-in and micro-tube as shown in figure (2).

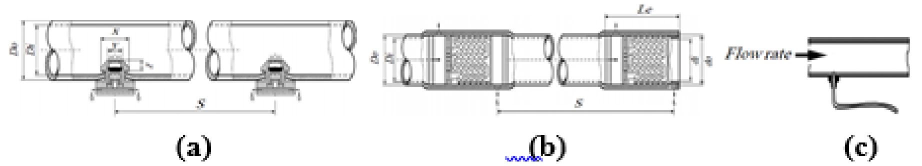

Figure 2. A schematic types of the used devices for (a) on-line, (b) built-in and (c) micro-tube emitter.

Therefore, the head effective (H_e) at the device was measured as:

$$H_e = H_I - \Delta H_{fn} \quad \textbf{(19)}$$

Some criteria were used to estimate the best lateral length to get distribution uniformity till the end of the program running.

The uniformity of emission (*UE*) was an important parameter for expressing the performance of the lateral lines. *UE* was determined by Li *et al.* (2012).

$$UE = \frac{\overline{Q}_{25}}{Q_{avr}} 100 \quad \textbf{(20)}$$

Where, ***UE*** **is the uniformity of emission (%),** $\overline{Q}_{25}$ **is the average of the lowest quarter of the emitter discharge (ℓh^{-1}) and Q_{avr} is the average of all emitter discharge (ℓh^{-1}).**

The best lateral length was then valued based on the uniformity (*UE*) ≥ 80 %.

The parameter calculated from the hydraulic field experiment was the discharge variation (Q_{var}) according to Jiang and Kang (2010) using the following equation:

$$Q_{var} = \frac{Q_{max} - Q_{min}}{Q_{max}} = 1 - \left(\frac{Q_{min}}{Q_{max}} \right) \quad \textbf{(21)}$$

Where, q_{max} and q_{min} are the maximum and minimum emitter flow rates (ℓh^{-1}).

The print data of the model (flow rate, uniformity emission predicted, number of devices and length of lateral) and computed with those found from the real measured values. Flow-chart of the calculations was used in the mathematical model as shown in figures (3 and 4).

The computer software model was evaluated by computing the mean relative deviation (*MRD*, %) and relative error (*RE*, %) between the calculated and the predicted uniformity emission (*UE*) at different lateral lengths for three emitters by using mathematical formulas 22 and 23 (Chen and Morey, 1989; ElGamal *et al*., 2015 and Khedr, 2020):

$$MRD = \left[\frac{1}{N} \sum_{j=1}^{N} \left(\frac{UE_{calcu,j} - UE_{predic,j}}{UE_{calcu,j}} \right)^2 \right]^{0.5} \times 100 \quad \textbf{(22)}$$

$$RE = \frac{\left| UE_{calcu} - UE_{predic} \right|}{UE_{calcu}} \times 100 \quad \textbf{(23)}$$

Where UE_{calcu} and UE_{predic} are the calculated and predicted values of uniformity emission (*UE*), respectively, and *N* is the number of estimates in each test.

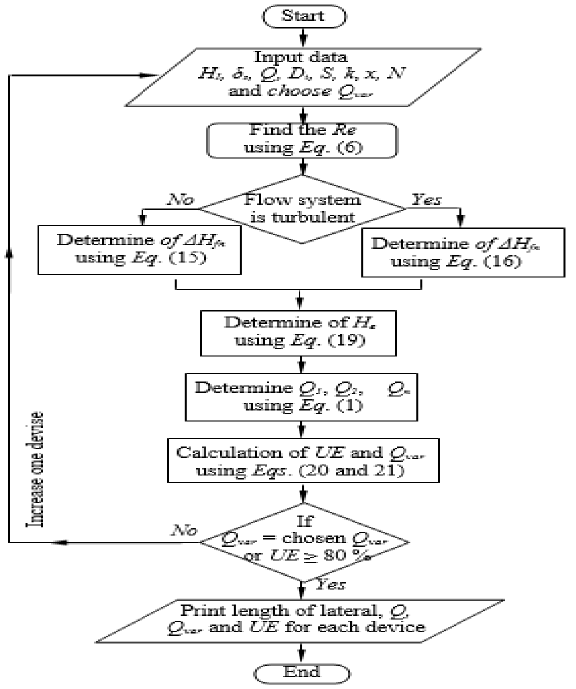

Figure 3. Software model flow-chart for the best length of micro-irrigation laterals using micro-tube determination.

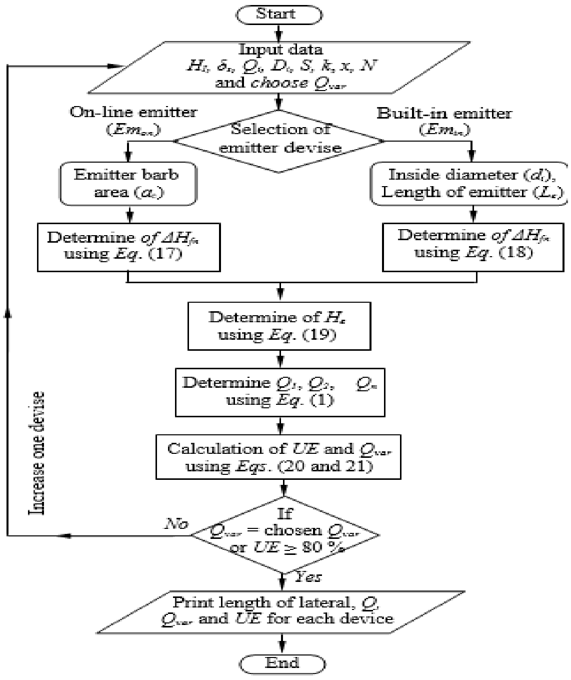

Figure 4. Software model flow-chart for the best length of micro-irrigation laterals using different devices determination.

Field Assessment

An experiment in the laboratory was conducted to determine some hydraulic characteristics of tested different emitters. These parameters were water discharge uniformity, flow rate exponent constants *x* and flow variation manufacturing V_m. The devices were divided into manufactured on-line (Em_{on}), built-in (Em_{in}) and micro-tube (Em_{mt}, 4.0 mm *OD* with 25 cm of length) under lateral space of 1.0 m and distance between emitters 0.3 m were examined under five operating pressures as presented in figure (5).

Model validation was conducted by comparing the calculated and predicted emission of uniformity at five operating pressures (40, 60, 80, 100 and 120 kPa) and three lateral lengths (20, 40 and 60 m) of three emitters. The emitter flow rate was calculated by dividing the volume of water in catch cans 200 x 150 mm, collecting the water and putted along the length of lateral below the emitter devices on a quantified time under different pressures. Devices were tested on each device lateral at four locations.

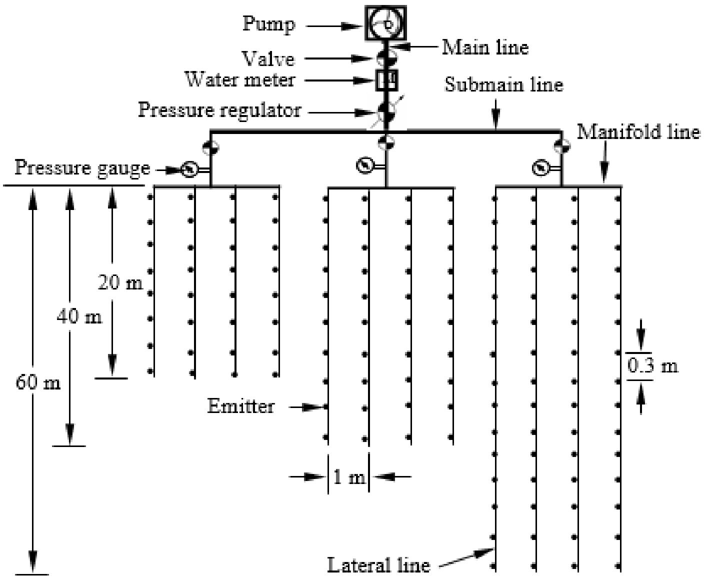

Figure 5. A schematic plan of the tested emitter devices with different lengths of lateral.

RESULTS AND DISCUSSION

Emitters Classification

The pressure-discharge correlation shows a vital part of emitter type classification in micro-irrigation methods and it is considered one of the factors in choosing the suitable device and design method. The calculated and nominal discharge, emitter device constants (*x* and *k*), flow variation manufacturing (V_m), flow regime, and classification of the emitters at 100 kPa were presented in Table (1). The data indicated low differences between calculated and nominal flow rates for built-in (Em_{in}) device. While, the nominal discharge of the device micro-tube (Em_{mt}) was unknown. Usually, the obtained results of the flow rates of examined devices were greatly affected by head pressure.

Table 1. Mean of discharge ($\ell\ h^{-1}$), emitter constants (*x*, *k*), flow regime and variation manufacturing (V_m) for devices at 100 kPa.

Emitter device	Flow rate "$\ell\ h^{-1}$"		Device constants		Flow system	Flow variation " V_m "	
	Nominal	Calculated	"*x*"	"*k*"		Value	Classification
On-line (Em_{on})	4.0	5.54	0.31	1.34	Partially pressure compensating	0.02	Excellent
Built-in (Em_{in})	4.0	4.04	0.31	0.93	Partially pressure compensating	0.01	Excellent
Micro-tube (Em_{mt})	-	20.44	0.58	1.54	Partially turbulent	0.17	Unacceptable

The variance percentage of the calculated flow rate was 38.50 % for Em_{on} and higher than nominal, while the variance percentage of 1.0 % was obtained with Em_{in}. The exponent of emitters' *x* indicated that its characterization is partially turbulent and partially pressure compensating. The calculations too showed that the Em_{on} and Em_{in} emitter devices were excellent as classified devices built on variation manufacturing V_m values; while Em_{mt} was classified as an unacceptable device.

Calculated model

The mathematical model in the present study was used to calculate uniformity of emission (*UE*), lateral discharge, friction, number of devices, ideal lateral at pressures, and different variations of discharge. The mathematical programs were examined to evaluate this parameter for three emitter devices and presented in Table (2). Found the results, the length of lateral proportionally was related with pressures for three devices. All emitters flow rate has a proportional correlation with different pressures. While *UE* values were increased by decreasing discharge variations q_{var}, Em_{on} and Em_{in} emitter devices are still categorized as excellent devices at levels of pressure. But *UE* value of the micro-tube device (Em_{mt}) was proportion inversely with flow rate, its classification was increased from good to excellent when the variations of discharge q_{var} decreased from 20 to 10 % at different pressures.

Table 2. Prediction of maximum length of laterals, flow rates and uniformity at different pressures and discharge variations (q_{var}) of tested emitters.

Emitter device	P (kPa)	Maximum lateral length								
		q_{var}								
		10%			15%			20%		
		L_L(m)	Q (ℓh^{-1})	UE (%)	L_L (m)	Q (ℓh^{-1})	UE (%)	L_L (m)	Q (ℓh^{-1})	UE (%)
Em_{on}	40	33.1	810.7	94.30	55.7	903.0	93.31	68.6	1000.0	92.12
	50	39.8	890.4	96.44	61.7	940.0	94.42	72.5	1091.0	93.46
	60	50.0	970.0	96.58	66.0	977.0	94.38	83.1	1182.0	93.67
	80	63.0	1042.4	96.71	66.3	1002.2	94.34	85.2	1245.0	93.89
	100	89.3	1179.7	96.68	97.1	1223.8	94.68	112.0	1583.6	94.02
	120	106.7	1518.4	96.54	112.2	1704.4	94.02	134.7	1914.4	93.38
Em_{in}	40	43.0	448.8	96.54	50.1	681.4	94.77	61.2	832.3	92.22
	50	52.6	544.0	98.28	57.9	829.8	96.07	76.2	1016.8	94.32
	60	59.7	639.2	98.26	68.4	978.1	96.16	89.0	1201.2	94.48
	80	74.7	870.7	98.23	87.5	1397.5	96.26	102.2	1608.2	94.64
	100	96.3	1199.6	98.60	110.6	1752.7	96.73	126.5	1983.8	94.95
	120	116.1	1310.5	98.53	132.2	2095.1	96.66	149.3	2347.0	95.25
Em_{mt}	40	17.0	992.0	90.90	19.0	1054.0	86.18	20.0	1116.0	84.27
	50	18.0	1141.0	89.65	21.0	1129.0	85.94	25.0	1203.0	83.21
	60	22.0	1290.0	88.52	24.0	1204.0	85.98	34.0	1290.0	83.46
	80	30.0	1232.0	88.40	35.0	1320.0	86.03	44.0	1408.0	83.72
	100	41.0	1462.5	87.05	48.0	1560.0	85.43	53.0	1657.5	82.96
	120	54.0	1530.0	86.69	61.0	1632.0	85.25	66.00	1734.0	81.19

Model data verification

The uniformity of emission (*UE*) was calculated under three lengths of lateral (20, 40 and 60 m) at five levels of pressure (40, 60, 80, 100 and 120 kPa) for three emitter devices. Influence of pressure and length of different emitter devices laterals on uniformity emission was illustrated in figure (6). Normally, the *UE* of micro-tube devices Em_{mt} was increased with decreasing operating pressure at three lengths of lateral. While, for Em_{on} and Em_{in} devices the *UE* were increased by increasing under four levels of pressure up to high value with 100 kPa and were reduced at all study of lengths. Three examined devices, the reduction in *UE* with increasing the length of laterals may be accredited to the friction (Imam and Pibars, 2019).

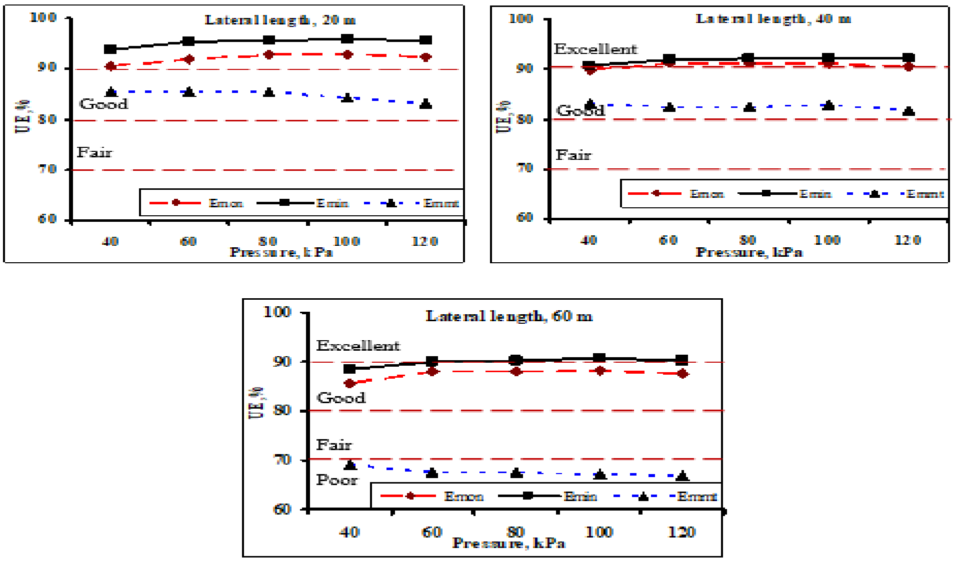

Figure 6. Influence of pressure and lateral lengths on uniformity emission of different devices.

The maximum value of *UE* was found at a pressure of 100 kPa and 20 m length of lateral for five tested pressures. The maximum values of *UE* were 92.80 and 95.74 % for the Em_{on} and Em_{in} devices, respectively. The classifications of uniformity values were achieved excellently at lateral lengths of 20, 40 m for Em_{on}, Em_{in} emitter devices and 60 m length of lateral for Em_{on} and Em_{in} devices were good as it was above 80 % (ASABE, 2008). However, 40 kPa of pressure and 20 m lateral for Em_{mt} as a micro-tube was high *UE* value of 85.44%. Micro-tube emitter Em_{mt} the lateral decrease from 60 to 20 m changed the *UE* classification from poor to good (ASABE, 2008).

Finally, uniformity was decreased with increasing length until a certain length of lateral then uniformity was remarkably decreased according to Guirguis *et al.* (2009). On the other hand, uniformity tended to increase with decreasing emitter exponent, and uniformity was remarkably increased from 84.28 to 95.74 %, 82.81 to 92.34 % and from 67.19 to 90.61 % at 100 kPa with different tested emitters, respectively for lateral lengths 20, 40 and 60 m.

Modeling data validation

The results of the evaluated computer model were the best values of micro-irrigation system design parameters. After that, the experimental field included three emitter devices that calculate *UE* are used for validating the mathematical model. The predicted and the calculated values were important to figure out how far the replicated results were from the calculated ones to assess the skill of the mathematical model in studying newly designed emitters. Determination coefficient (R^2) was applicability approximately constant value ranged between 0.95 and 0.97, between predicted and calculated *UE* for different lengths of Em_{on} and Em_{in} emitter as shown in figure (7) and Table (3). While, there is an inverse correlation between the R^2 and length for Em_{mt}. The obtained results of R^2 value, it was decreased from 0.944 to 0.80 with Em_{mt}, respectively at change lengths from 20 to 60 m. These results showed that differences between R^2 of devices might be attributed to his values variation manufacturing (V_m). The classifications V_m of Em_{on} and Em_{in} were excellent as classified, meanwhile V_m value of Em_{mt} was unacceptable as classified as listed in the Table (1). The mathematical program and the validation experiment data were compared showing that there was a strong correlation between the calculated and predicted *UE* at different lengths of lateral and three devices with the study.

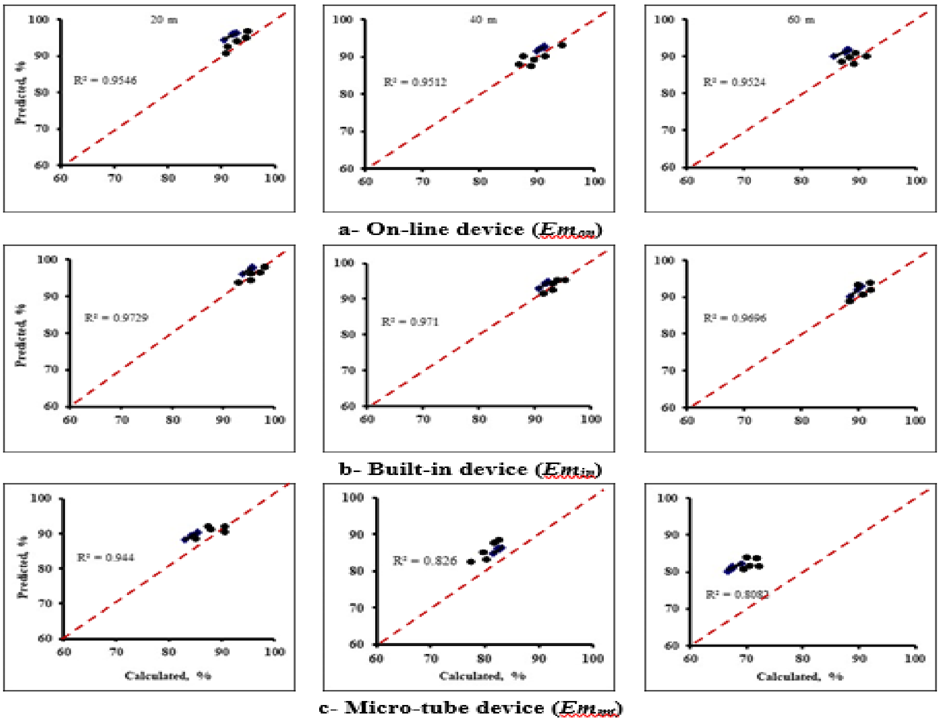

Figure 7. The correlation between predicted and calculated uniformity under different lateral lengths of three devices.

Table 3. The determination coefficient (R^2) at lateral lengths and different emitters.

Different emitter	Determination coefficient (R^2) Lateral length, m		
	20	40	60
Em_{on}	0.9546	0.9512	0.9524
Em_{in}	0.9729	0.9710	0.9696
Em_{mt}	0.9440	0.8260	0.8082

Results showed a very good agreement (ranging from 1 to 5 % differences) between the experimental and the predicted (see Table 4). As listed in Table 4, the computer model predicted the uniformity emission with high accuracy for all tested emitters except micro-tube (Em_{mt}) emitter at lateral length (L_{60}) where the value > 5. To access the appropriate micro-irrigation length of lateral in a short time with high accuracy the current mathematical program used in this work is recommended for the specialists in the field of irrigation systems.

Table 4. Mean relative deviation (*MRD*, %) and relative error (*RE*, %) between the calculated and predicted uniformity emission (*UE*) at different lateral length for three emitters.

Pressure (kPa)	The relative error (*RE*, %) of different emitter								
	Em_{on}			Em_{in}			Em_{mt}		
	L_{20}	L_{40}	L_{60}	L_{20}	L_{40}	L_{60}	L_{20}	L_{40}	L_{60}
40	3.21	2.41	4.99	2.45	2.59	1.80	3.43	3.95	18.84
60	3.16	2.17	3.74	2.14	2.55	2.41	3.22	4.55	19.98
80	2.63	2.04	4.18	2.14	2.65	2.78	2.98	4.35	20.97
100	2.53	2.37	4.16	2.43	2.84	2.53	3.85	3.82	20.31
120	2.89	2.39	4.20	2.39	2.96	2.99	3.71	3.78	20.18
MRD,%	2.90	2.28	4.27	2.32	2.72	2.53	3.45	4.10	20.07

CONCLUSION

The present research work aimed to create a mathematical model for hydraulic experiment validation of emitters and different lateral lengths (20, 40, and 60 m) under pressures (40, 60, 80, 100 and 120 kPa). The key results could be summarized as follows: -

- Water uniformity *UE* was inversely proportional with length, the greatest results were found at 100 kPa for Em_{on} and Em_{in} devices and 40 kPa for Em_{mt} micro-tube.
- Relationship between predicted and calculated uniformity under different laterals and pressures of the different devices, declared a strong correlation with determinate coefficient (R^2) of more than 0.95 for Em_{on} and Em_{in} emitters.
- Determination coefficient (R^2) has an inversed relationship with Em_{mt} micro-tube, R^2 value was decreased from 0.94 to 0.80 at length changes from 20 to 60 m with Em_{mt}, respectively.
- The calculated uniformity of the emission values obtained from the field experiment was similar to the computed predicted values.

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تحديد الطول المناسب لأنظمة الرى الدقيق باستخدام نموذج رياضى

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الملخص

نظرا لمحدودية مصادر المياه فى مصر، فكانت الحاجة الماسة إلى استخدام نظم الري الحديثة في زراعة المناطق الجافة وشبة الجافة. لذلك تهدف هذه الدراسة إلي استخدام نموذج كمبيوتر ذو دقة عالية في التصميم لتحدد أفضل طول مناسب للخطوط الفرعية لنظم الري الميكرو لتحسين ورفع كفاءة توزيع المياه، والتنبؤ بالتصرف والضاغط عند كل منقط تحت ظروف التشغيل المختلفة ومقانة بن النتائج المحسوبة والنتائج المتنبأ بها من نموذج حاسوب. وفى هذا النموذج تم إستخدم نظام محكاه لحساب انتظامية انبعاث المياه وتحديد أفضل طول مناسب عند معامل اختلاف التصرف أو انتظامية توزيع المياه ($UE \geq 80$ %). وتم التحقق من صحة النموذج الرياضي من خلال تجربة هيدروليكية لثلاث أنواع من المنقطات، منقطات مركبة على الخط الفرعى (Em_{on})، ومنقطات مصنعة كوحدة واحدة مع الخط الفرعى (Em_{in}) والأنابيب الدقيقة المركبة على الخط الفرعى بطول ٢٥ سم (Em_{mt}) وثلاث أطوال للخط الفرعى ٢٠، ٤٠ و ٦٠م تحت تأثيرخمس ضغوط تشغيل من ٤٠، ٦٠، ٨٠، ١٠٠ و ١٢٠ ك بسكال. أظهرت النتائج أن معامل الارتباط (R^2) أعلى من ٠,٩٥١٢ لكل من المنقط (Em_{on}, Em_{in})، لكن هذه العلاقة انخفض R^2 لتصل ٠,٨٠٨٢ للأنابيب الدقيقة (Em_{mt}) بين القيم المتنبأ بها والقيمة المقاسة لانتظامية انبعاث المياه. ويوصى البجث بأن النموذج الرياضى قادر على التنبؤ بصورة جيد جدًا وذو دقة عالية وبطريقة سريعة لتحدد أفضل طول مناسب للخط الفرعى لأنظمة الري الميكرو، كما أن هناك ارتباط قوى بين القيم المقاسة والقيمة المتنبأ بها.

الكلمات الدالة: الرى الدقيق، الخط الفرعى، انتظامية الانبعاث، النموذج.