J. Agric. Sci. Mansoura Univ., 30 (5): 2609 - 2626, 2005

EMITTER DISCHARGE AS AFFECTED BY HYDRAULIC CHARACTERISTICS, MANUFACTURING VARIATIONS, AND WATER TEMPERATURE

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ABSTRACT

The current study was carried out at Nubaria Research Station. Seven emission devices were extensively used in a trickle irrigation system. They were hydraulically characterized under laboratory conditions. The types of the tested emitters were: A. labyrinth- long path; B. Orifice; C. orifice-vortex; D and E spiral- long path; F. self-flushing, compensating-long path; and G. self-flushing, compensating-orifice.

Tests were conducted under different operating pressures ranging from 50 to 350 kPa for types A, B, C, D and E. This range was extended to 500 kPa for the compensating emitter types F and G.

The coefficients of manufacture variation, C.V., as related to operating pressure were calculated for each type. Then emitters were classified based on ASAE and ISO- standards. Results indicated that emitter E had the highest values of C.V. followed by emitters B, D and F whereas emitters A, C and G had lower values of this factor. Also, the data showed that the C.V. values varied with pressure.

The flow rate equation was used to evaluate the emitter flow sensitivity to change of pressure. The lower the value of the discharge exponent, x, the more pressure-compensating the device is. Emitters A, B and C were categorized as turbulent flow, non-pressure compensating, whereas both emitters D and E were classified as partially turbulent flow, non- pressure compensating types. On the other hand, emitter F was categorized as compensating type while, emitter G was fully compensating one.

Laboratory experiments were conducted to evaluate the effect of water temperature ranging from 5 to 40 °C on discharge rates of the tested emitters. Results illustrated that emitter type D was the most affected by water temperature variations followed by emitter E, A and B. Emitter C was inversely affected by water temperature. Discharges of emitters F and G were not affected by water temperature variations.

INTRODUCTION

Trickle irrigation is the frequent or slow application of filtered water either directly onto the land surface or into the root zone of the crop. Trickle irrigation system is characterized by its high application efficiency than the other irrigation systems such as furrow and sprinkler. Bernstein and Francois (1973) pointed out that trickle irrigation is a new water application method through which water is distributed on the irrigation surface under pressure to grid outlets discharging water at nearly zero pressure. Trickle irrigation is a system for supplying filtered water and sometimes fertilizer into the soil (Merriam and Killer 1978). Gilbert, et al. (1981) pointed out that trickle irrigation is a system for water applied by means of mains, manifolds and plastic laterals, usually laid on the ground surface. Equally spaced along the laterals are drippers or (trickles). Drippers are point sources of water operating at low inlet pressure heads (roughly 10 meters) and small discharge. Keller and Bliesner (1990) cited from Ibrahim (2000) mentioned that, trickle irrigation system discharges water close to each plant, travel over the soil surface through the air is of limited importance for distributing the water. The application uniformity basically depends on the uniformity of discharge from the emission devices (emitters). Keller and Kanneli (1975) summarized the advantages of trickle irrigation as following:

1. It saves and improves the utilization of water.
2. It slows down weed growth and the non-beneficial consumptive use of water by weed.
3. It increases the yield and improves its quality.
4. Fertilizers and other chemical can be applied through the system.
5. It reduces the development of many insects, diseases and fungal problems.
6. It decreases expensive manual energy requirements.
7. It improves agricultural production.

Holzapfel et al, (1990) pointed out that the initial cost of a drip irrigation system, which is mainly due to the pipe network, tees, and emitters, is the major disadvantage of this type of irrigation technique. Numan and Jordon (1989) stated that the main factors affecting the uniformity of a trickle irrigation system are:

1. Manufacturing variations in emitters and pressure regulators used in the system.
2. Pressure variations caused by elevation changes and friction head losses throughout the pipe network.
3. The sensitivity of emitters to pressure and temperature variations.
4. The degree and extent of emitter clogging.

El-Adl and Amin (1996) indicated that the lowest value of x, emitter discharge exponent, was obtained with emitter Kc4 but the highest value of x was obtained with emitter Natafim. The value of F, friction factor, decreased by increasing the operating pressure for all types of emitters. The energy drop in the lateral increased by increasing the number of emitters on the lateral. The variation for all slopes (1.0 %, 2.0% and 3.0% up and down slopes) is less than 20%.

Keller and Karmeli (1974) have suggested two parameters to define the uniformity of application of a trickle irrigation system. Their emission uniformity, EU, involves the relationship between minimum and average emitter discharge rates within the system. Roland (1977) mentioned that irrigation systems are designed to give a reasonably uniform water distribution. The surface distribution uniformity of irrigation water is expressed by the Christiansen Uniformity Coefficient, CU. Pipe laterals are designed so that the variation in outflow between individual outlets should not be excessive. The allowable variation is usually expressed in terms of the difference in outlet between the first and the last outlets. Bralts and Kesner (1983) proposed a method of field uniformity estimation upon the statistical uniformity coefficient. The statistical uniformity method uses the coefficient of variation as determined from randomly sampled emitter flow rates. Wu (1992) said that there are several uniformity parameters which can be used as design criteria. The following is a review of several different uniformity definitions. Emitter flow variation was defined as:

$$q_{var} = \frac{q_{max} - q_{min}}{q_{max}} \qquad 1$$

Where q_{var} is the emitter flow variation, q_{max} and q_{min} are maximum and minimum emitter flow rate respectively along a lateral line or in a sub-main unit.

$$UCC = 1 - \frac{\Delta\bar{q}}{\bar{q}} \qquad 2$$

The uniformity coefficient of emitter flow is determined using the uniformity coefficient equation developed by Christiansen, equation 2. The UCC is the Christiansen uniformity coefficient, q is the mean emitter flow and Δq is the mean deviation of emitter flow. The statistical uniformity is expressed as:

$$UCS = 1 - \frac{S_q}{q} \quad \ldots\ldots. \qquad 3$$

Where UCS is the statistical uniformity coefficient, S_q is the standard deviation of emitter flow and q is the emitter flow.

Keller and Karmeli (1975) pointed out that the flow characteristics of emitters can be characterized by

$$q = KH^x \qquad \ldots 4$$

Where:

q = Emitter discharge,
k = Constant of proportionality which characterizes each emitter,
H = Working pressure head at the emitter,
x = Emitter discharge exponent that is characterized by the flow regime.

To determine K and x, the discharges (q_1, q_2) at two different operating pressure heads (H_1,H_2) have to be known.

Giay and Zeienka (1985) mentioned that According to the new ISO- Test method the relation between the emission rate and the inlet pressure is given by equation 5.

$$q = k\,P^{m} \qquad 5$$

Where:

q = emission rate (1 / hr)
k = constant
P = inlet pressure (k Pa)
m = emitter exponent, which can be calculated using equation 6.

$$m = \frac{\sum_{i=1}^{1}(\log p_i) * (\log q_{mi}) - \frac{1}{n}(\sum_{i=1}^{n}\log p_i) * (\sum_{i=1}^{n}\log q_{mi})}{\sum_{i=1}^{n}(\log p_i) - \frac{1}{n}(\sum_{i=1}^{n}\log p_i)^2} \quad \ldots. \qquad 6$$

Where:

n = Number of pressure values.

For regulated emitters, the value of the emitter exponent m shall not exceed 0.2. For non-regulated emitters, m values is higher than 0.2.

James (1988) showed that smaller values of C.V. mean better emitters. Author mentioned that the manufacturing coefficient of variation is estimated from flow rate measurements for several identical emission devices and is computed with the following equation.

$$C.V. = \frac{(q_1^2 + q_2^2 + q_3^2 + L + q_n^2 - nq_n^2)^{1/2}}{q(n-1)^{1/2}} \quad \ldots\ldots 7$$

Where:

C.V. = Manufacturing coefficient of variation.

q_i ,q_z...... q_n = Discharge of emission devices .

q = Average discharge of emission devices.

n = Number of emission devices under experiment.

ASAE (1985) recommendations for classifying the C.V. are listed in table 1.

Table 1: Recommended classification of C.V. by ASAE (1985)

Emitter type	C.V. range	Classification
Point source	<0.05 0.05 to 0.10 0.10 to 0.15 >0.15	Good Average Marginal Unacceptable
Line source	<0.10 0.10 to 0.20 >0.20	Good Average Marginal to unacceptable

According to the new ISO-test method (1983), (Giay and Zeienka, 1985), emitters can be classified based on their uniformity of emission rate into the uniformity categories of Table 2.

Table 2: Uniformity values recommended by ISO

Category	q_m/q_n	C.V.
A	5%	5%
B	10%	10%

A = First class emitter, B = Second class emitter

q_m / q_n describes the variation of the average measured value of emitter discharge (q_m) from the nominal flow rate (q_n) claimed by the manufacture .It is called manufacturing drift or deviation of q_m from q_n and can be calculated from this equation.

Absoulte deviation of **q_m from q_n = 100 * $|q_n - q_m| / q_n$** **8**

Parchomchuk (1976) reported that in theory, discharge rate through an orifice is independent of water temperature, but in practice, flows are slightly viscosity dependent on orifice length. He also added that discharge rates of vortex emitter decreased with increasing water temperature.

Ibrahim (2000) studied the effect of water temperature on some different types of emitters. He found that the variance of emitter types and / or irrigation water temperatures' levels and/ or the interaction between them is highly significant at 1 % level. Nevertheless, emitter types dominated the significant effect over the temperature levels, namely, significance of temperature treatments was only achieved at 5 %. He added that the changes in emitters discharge due to the variation in irrigation water temperatures may be explained by the changes of water viscosity. It is thus obvious due to the fact that water viscosity decreases as water temperature increases. Consequently, the emitter discharge increased. Therefore, the objectives of this work were to study the following:

1. The hydraulic characteristics of some of the most commonly used emitters.
2. The effect of manufacturing variations on emitter discharge rate.
3. The temperature effect on emitter discharge rate.

MATERIALS AND METHODS

1. Materials:

Emitters Testing Unit:

This unit consisted of a water tank, two centrifugal pumps, a screen filter, pressure gauges, polyethylene lines, emitters, control valves, thermometers, and peckers. Schematic diagram of this unit is shown in Fig. 1.

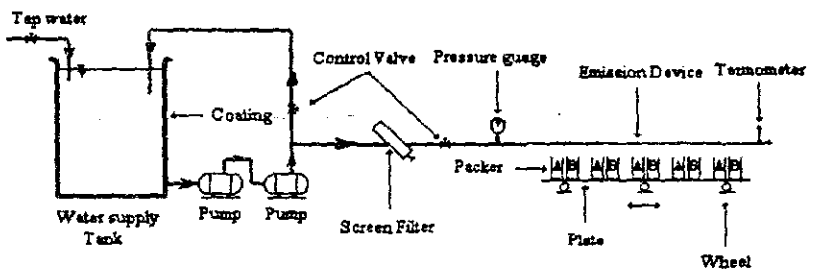


Figure 1: Schematic diagram of emitter testing unit

Water tank:

Cylindrical shape tank, 30-cm diameter and height of 35 cm, was used.

Pumps:

Two centrifugal pumps, driven by electric motors, were connected in series to increase the pressure to be suitable for conducting laboratory experiments.

160-mesh screen filter:

This screen was fitted just after the pumps.

Pressure gauges:

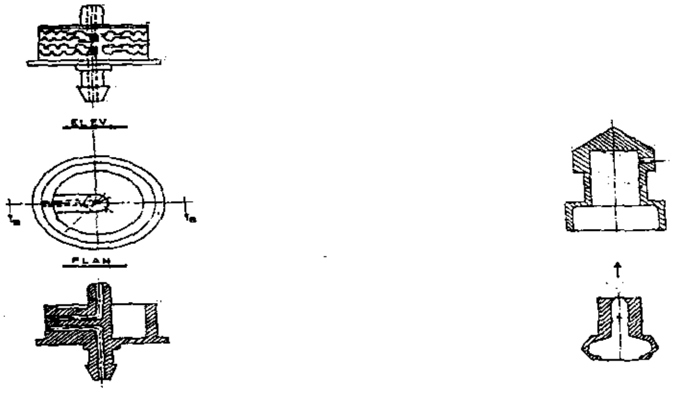
Two pressure gauges were used. One of them was used for measuring pressures less than 350 kPa with accuracy of 10 kPa, however, the second was used for measuring higher pressures up to 500 kPa. The pressure gauges were fitted at the line inlet of the tested emitters.

P.E tubing:

16-mm polyethylene emitter lines were used. The lines of emitters were carried on a horizontal stand.

Emitters:

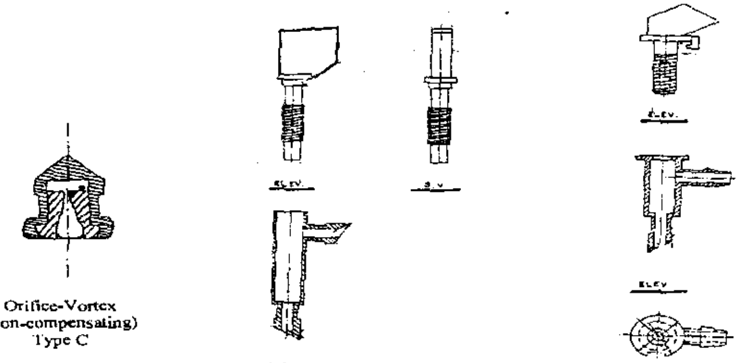
Seven commercially available emission devices (A, B, C, D, E, F and G) representing the general classes of emission devices used in trickle irrigation were chosen to be tested. All these types were on-line emitters as shown in Figures 2, 3, 4. The specifications of the emission devices tested in this research are listed in Table 3.



Labyrinth long path (non-compensating)
Type A

Orifice (non-compensating)
Type B

Figure 2: Emission devices A and B



Orifice-Vortex
(non-compensating)
Type C

Spiral long path (non-compensating)
Type D

Spiral long path (non-compensating)
Type E

Figure 3: Emission devices A, B and C

Control valves:

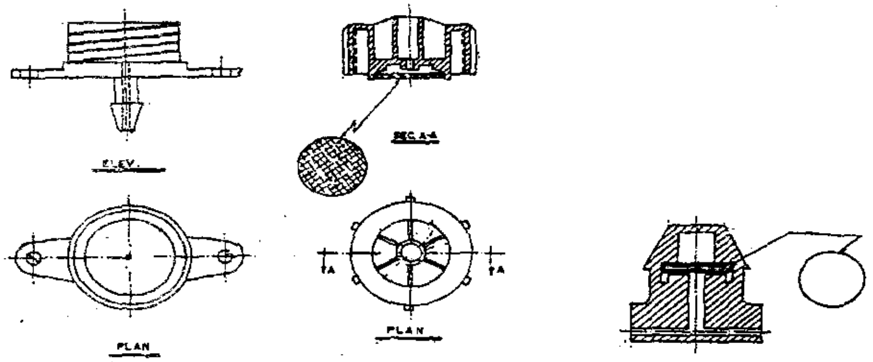
Two control valves were used, one was located before the pressure gauge and the other was fitted on the over flow line.

Thermometers:

One thermometer was installed for measuring temperature of the water in the tank. Another was fitted at the end of emitter line.

Peckers:

Each one was one-liter capacity. They were carried on a car for moving left and right.



Long path-Self flushing
(compensating)
Type F

Orifice - Self flushing
(fully compensating)
Type G

Figure 4: **Emission devices F and G**

Electronic Balance:

This balance was use for weighting water samples collected during testing emission devices.

Sieves Set:

It consisted of concentric sieves of various sizes of pores to fit properly into a rotary-sieve machine. It was used for sieving samples of soil particles.

2. Methods:

Uniformity of Emitters Flow Rate:

All emitters and drip tapes were randomly selected. Tap filtered water was used as a water supply. Fifty new emitters from each type were tested. Each five emitters were on one PE line. The length of the P.E line was about 170 cm, which was meant to be short enough that the pressure differences along the section were negligible. The spacing between emitters on line was 30 cm. Also, minor friction losses across emitters were neglected.

At the beginning of each experiment, water discharged at certain pressure was collected in peckers A_s (A_1, A_2, A_3, A_4 and A_5) for a period of five minutes. Then, the car was moved to the left side in the position in which water discharged from emitters must be collected in peckers Bs (B1, B2, B3, B4 and B5). After each run, the water collected in every pecker B was weighed by using the electronic balance. The net weight was converted to volume. The measurements were repeated three times for each emitter line. Water temperature was controlled at 20 to 22 °C. The emission devices were measured at the following pressure:

a. 50,100,150,200, 250 kPa for types A, B, C, D and E.
b. 50,100,150,200, 250, 300 and 350 kPa for type F.
c. 60,100,150, 200,250, 300 and 350 kPa for type G

Determination of Coefficient of Manufacturing Variation:

Coefficient of manufacturing variation C.V. was used for determining how much the variation in emitter flow rate was.

For all tested types, C.V. values were calculated according to the equation 9:

$$C.V=s/q \qquad 9$$

Where

C.V = Coefficient of manufacturing variation, dimensionless;

s = Standard deviation of the flow rates from a sample of emitters all tested at a given pressure, 1/hr,

q = Mean of the flow rates of the tested samples, 1/hr.

C.V. values were determined at different pressures based on the operating pressure range for each emitter type. Then emitters were classified according to ASAE and ISO- standards.

Determination of Discharge Equation Factors:

Emission devices generally operate according to equation 10 (Keller and Karmeli, 1975):

$$q=kH^{x} \qquad 10$$

Where:

q = emitter flow rate, 1/hr;

k = flow coefficient;

H = operating pressure head, m; and

x = emitter discharge exponent.

The flow exponent value x may range from zero to one, depending upon the emission device and the nature of the flow, whereas the coefficient of flow k characterizes the physical dimensions of the water passage for the emitter.

This test was conducted according to ASAE and ISO standards to evaluate seven different types of emitters by determining the emitter discharge exponent x and the emitter flow coefficient k in equation 10.

Effect of Water Temperature on Emitter Discharge Rates:

Temperature effects on discharge rate were measured for type A, B, C, D, E, F and G. The five emitters used in discharge-pressure test were examined under the nominal operating pressure (100 kPa) for type A, B, C, D and E (non-compensating emitters) and under a mid-point pressure (200 kPa) for types F and G (compensating emitters).

Temperature ranged from 5 to 40 °C with intervals of 5 °C for all types. Using 20 °C as the standard operating temperature, Parchomchuk (1976), percentage variation from the discharge rate at this temperature was calculated.

RESULTS AND DISCUSSION

1. Uniformity of Emitters Flow Rate:

The deviations of the mean discharge for the selected seven types of emitters tested at nominal pressure of 100 KPa for non-compensating emitters A, B, C, D and E and at a mid- range pressure of 200 KPa for compensating types F and G are shown in table 3.

Also from table 4, it can be observed that in some types such as A, C and G, values of q, n: qn for sample size =50 emitters (ASAE-standards) were a little different from that of sample with 25 emitters (ISO-standards). For some other types as D and F, this difference was relatively greater but each type was with the same category under born sizes of sample.

Table 3: Uniformity of the emitters tested.

Emitter type	P_n kPa	q_n, 1/hr	ASAE standards			ISO- standards		
			q_m, 1/hr	$(q_m:q_n)$, %	Category	q_m, 1/hr	$(q_m: q_n)$, %	Category
A	100	4.00	4.259	6.48	2nd class	4.266	6.65	2nd class
B	100	4.00	3.311	17.23	——	3.421	14.48	——
C	100	2.00	2.153	7.65	2nd class	2.152	7.60	2nd class
D	100	4.00	5.259	32.38		5.558	38.95	——
E	100	4.00	4.373	9.33	2nd class	4.303	7.58	2nd class
F	200	4.00	5.643	41.08	——	5.957	48.93	——
G	200	3.75	4.140	10.40		4.163	11.01	

P_n = Nominal pressure. Q_{ni} = Mean flow rate, q_n = Nominal flow rate.

Determination of Coefficient of Manufacturing Variation C.V.

The coefficient of manufacturing variation C.V for the seven different types of emitters tested under different operation pressures are listed in table 4. Pressures ranged from 50 to 250 kPa, in steps of 50 kPa, for types A, B, C, D and E respectively, and in the same mode, but pressures were up to 350 kPa for emitter type F. Type G had pressure values like type F but first value of pressure was 60 kPa. Equation 9 was used to calculate C.V. values at each tested pressure for every emitter type.

For type A, C.V. values, based on ISO standards, varied from 2.35 % at 50 kPa to 0.59% at 150 kPa again increased to 1.21 % at 250 kPa. Thus, it was categorized as "1st class" emitter. Also, from the same table, based on ASAE standard, C.V. values varied from 0.53 % at 150 kPa up to 2.25 % at 50 kPa. The emitter was classified as a good emitter.

Values of C.V., for type B based on ISO-standards, varied inversely with pressure. The table also shows that under ISO-standards C.V at 50 kPa was 29.20 % and decreased to become 26.48 % at 200 kPa. However, C.V values -from this table, based on ASAE-were 27.42 % at 200 kPa and 28.46 % at 50 kPa. This type was graded, under all test pressures, as non- "1st class or 2nd class" and unacceptable according to ISO and ASAE standards, respectively

From the same Table 4, it is shown that C.V values of vortex emitter (type C) were varied, based on ISO-standards, from 3.23 % and 3.71 % at 50 and 100 kPa to be 1.44 % and 1.85 % at pressures 150, 200 Kpa, respectively. Then, it increased to 3.15 % at 250 kPa. On the other hand, under ASAE standards, C.V. values at 50 and 100 kPa were 3.09% and 3.11% then decreased to become 1.35%, 1.95% at 150 and 200 kPa, respectively. Finally, C.V. reached 2.77 % at 250 kPa. The emitter was considered as "1st class" for all test pressures based on ISO-standards and as a good one according to ASAE standards.

Table 4: Coefficient of manufacturing variation for the tested emitters based on ISO and ASAE standards.

Pressure kPa	Emitter type	ISO-Standard		ASAE-Standard	
		C.V%	Category	C.V %	Category
50	A	2.35	1s class	2.25	Good
	B	29.20	--	28.46	Unacceptable
	C	3.23	1st class	3.09	Good
	D	27.20	--	24.93	Unacceptable
	E	44.90	--	44.51	Unacceptable
	F	9.47	2nd class	10.24	Marginal
60	G	1.52	1st class	1.53	Good
100	A	2.12	1st class	1.72	Good
	B	28.81	--	28.72	Unacceptable
	C	3.71	1st class	3.11	Good
	D	23.66	--	22.44	Unacceptable
	E	42.67	--	45.91	Unacceptable
	F	7.92	2nd class	8.50	Average
	G	3.53	1st class	4.47	Good
150	A	0.59	1s class	0.53	Good
	B	28.48	--	28.25	Unacceptable
	C	1.44	1st class	1.35	Good
	D	19.70	--	19.90	Unacceptable
	E	44.34	--	44.40	Unacceptable
	F	7.09	2nd class	9.52	Average
	G	3.37	1st class	4.15	Good
200	A	1.04	1st class	1.26	Good
	B	26.48	--	27.42	Unacceptable
	C	1.85	1st class	1.95	Good
	D	20.46	--	19.63	Unacceptable
	E	44.40	--	45.71	Unacceptable
	F	6.50	2nd class	9.30	Average
	G	3.66	1st class	3.81	Good
250	A	1.21	1st class	1.02	Good
	B	26.64	--	27.70	Unacceptable
	C	3.15	1st class	2.77	Good
	D	21.20	--	20.32	Unacceptable
	E	40.45	--	43.86	Unacceptable
	F	6.60	2nd class	8.71	Average
	G	2.64	I* class	3.10	Good
300	F	7.22	2nd class	8.25	Average
	G	4.03	1st class	3.62	Good
350	F	6.68	2nd class	7.33	Average
	G	2.75	1st class	2.78	Good

It is observed from table 4 that C.V. values were relatively high for emitter D under all test pressures. At 50 kPa "ISO-standards" C.V was 27.2% and then by increasing pressure to 150 kPa, C.V. values gradually decreased to 23.66% at 100 kPa and 19.7% at 150 kPa. Then, increasing pressure increased the C.V. value to become 20.46 % and 21.20 % at 200 and 250 kPa, respectively. So, category of this emitter according to ISO was neither "1st class nor 2nd class" and was unacceptable based on classification of

ASAE. Data of this table show that maximum variation between C.V. values of ISO and that of ASAE was about 2.27 % at 50 kPa whereas the least difference was 0.2% at 150 kPa.

Calculations of C.V. for type E are shown in Table 4, for ISO standards. Their values under all test pressures were very high. Maximum value of C.V. was 44.9 % at 50 kPa, while the lowest value was 40.45 % at the end point of test pressures. C.V. values ranged from 45.91 % at 100 kPa to 43.86 at 250 kPa (Table 4, ASAE standards). Greatest variation between C.V. values of ISO and ASAE were 3.41 % at 250 kPa followed by 3.24 % at 100 kPa. From previous data in this table, emitter E was rated as non-1st or 2nd class and rated as an unacceptable emitter based on ISO and ASAE standards, respectively.

C.V. values of type F. varied with pressure according too to the following trend (Table 4). The highest value was 10.24 % at 50 kPa, then it decreased to 8.50 at 100 kPa and when pressures of test increased to 150 and 200 kPa, the C.V. values increased to 9.52 % and 9.30 %, respectively. By increasing pressure to 250 and 300 kPa, C.V became 8.71 % and 8.25%, respectively. Finally, C.V. value changed to be 7.3 % due to increasing the pressure to 350 kPa. In general, emitter E under these conditions was graded as marginal at a pressure of 50 kPa and was classified as an average emitter in all other pressures. From Table 4, (ISO standards). C.V. shows another trend. At 50 kPa C.V was 9.47 %, then increasing pressure resulted in a gradual decrease in the value of C.V to be 6.60 % at 250 kPa. From 250 kPa to 300 kPa, value of C.V changed to 7.22 %, then it continued decreasing to be 6.68 % at the highest pressure. However, based on these results, emitter F was rated as 2nd class emitter under all test pressures.

Data of Table 4, ISO-standards, show that lowest value of C.V. for type G was 1.52 % at 60 kPa. From 100 to 200 kPa C.V. values were 3.53 %, 3.37 %, and 3.66 % respectively. Increasing pressure to 250 kPa resulted in decreasing it to a value of 2.64%. Maximum value was 4.03 % at 300 kPa and by increasing pressure up to 350 kPa, C.V became 2.75 %. Thus emitter G was rated as a 1st class emitter. From the same table, under the ASAE standards, C.V. at 60 and 350 kPa was approximately equal to the values calculated at same pressures under ISO standards. Highest value of C.V. was 4.47 %, which was attained at 100 kPa. According to these data, type G was rated as a good emitter.

Determination of Discharge Equation Factors:

The average discharge values of the emitters under ASAE and ISO standards for different pressures were presented in Table 5. Equation 6, least-squares method, was used to find the emission device exponent x and the constant k values. Then, these values were fitted to the theoretical curve (eq.10) to get the flow-pressure curves for the ASAE and ISO standards on the right and left sides of the figure, respectively (Figures 5, 6).

Table 6 indicates characteristics of hydraulic performance for all tested emitters based on ASAE and ISO standards, respectively. Types A, B, C, D and E were classified as non-compensating emitters according to ASAE, whereas, type F was categorized as partially compensating type. The exponent value, x, of type G through the regulating pressure range from 60 to 350 kPa was approximately equal to zero so that it was fully compensating emitter. According to ISO-standards, in which x value for compensating emitters must not exceed 0.2, all types were categorized as non-regulating types except for type G which was used as regulating emitter (x = 0.011). Thus type F was non-compensating based on ISO- standards and was partially compensating according to ASAE standards.

The discharge- pressure curves for the tested emitters based on ASAE and ISO-standards are shown in Figure 5, 6. For type A, the curve under ASAE was approximately similar to the curve of ISO standards (Fig.5). Similar results were obtained for types C followed by type B and F. Also, it was shown that there was greater difference between the curve under ASAE and under ISO, for types D, compared with the previous curves especially in the pressure range from 100 to 250 kPa. Similar to type E, type G was self - flushing emitter so that the discharge-pressure curve consisted of three phases (Fig.6). In this mode flow rate at the beginning and the end of irrigation event is higher than at normal operating pressure.

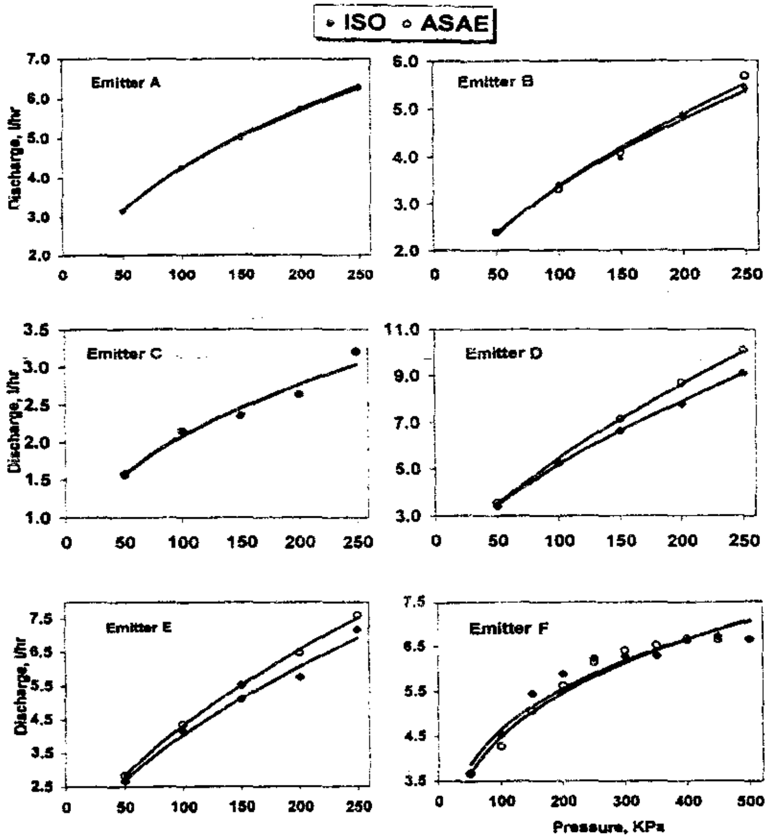


Figure 5: Flow-pressure curves for the ASAE and ISO standards for emitters A-F

Table 5: **Pressure vs. flow rate for the tested emitters based on ASAE and ISO**

Emitter type	Pressure kPa	Average flow rate (q_m) Basd on ASAE	Average flow rate (q_m) Basd on ISO
A	50	3.160	3.140
	100	4.258	4.270
	150	4.998	5.070
	200	5.726	5.750
	250	6.262	6.310
B	50	2.388	2.363
	100	3.300	3.410
	150	4.074	3.964
	200	4.850	4.799
	250	5.672	5.413
C	50	1.554	1.580
	100	2.150	2.146
	150	2.350	2.355
	200	2.634	2.634
	250	3.190	3.210
D	50	3.540	3.391
	100	5.244	5.256
	150	7.150	6.640
	200	8.680	7.809
	250	10.086	9.098
E	50	2.832	2.663
	100	4.360	4.165
	150	5.520	5.101
	200	6.476	5.761
	250	7.608	7.169
F	50	3.660	3.963
	100	4.280	4.541
	150	5.084	5.460
	200	5.634	5.894
	250	6.150	6.239
	300	6.414	6.285
	350	6.538	6.296
	400	6.688	6.638
	450	6.656	6.735
	500	6.676	6.689
G	10	2.100	2.049
	20	4.090	4.003
	30	5.520	5.451
	40	6.790	6.701
	50	5.500	5.060
	60	3.818	3.830
	100	4.148	4.220
	150	4.126	4.150
	200	4.130	4.170
	250	4.168	4.140
	300	4.096	3.980
	350	4.132	4.133
	400	4.010	4.020
	450	4.036	4.010
	500	4.014	3.985

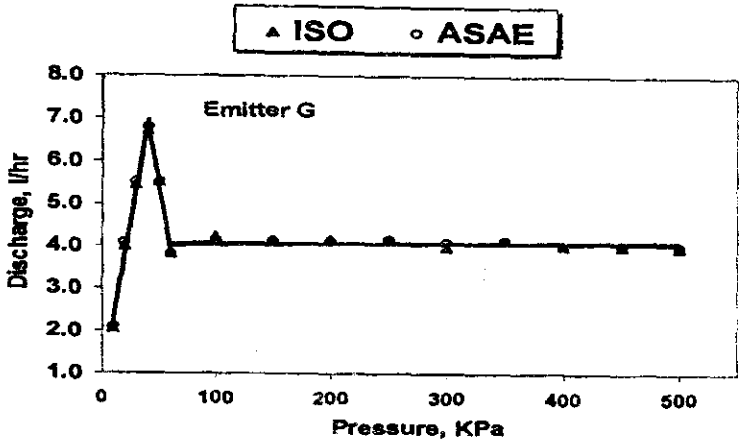


Figure 6: Flow-pressure curves for the ASAE and ISO standards for emitter type G

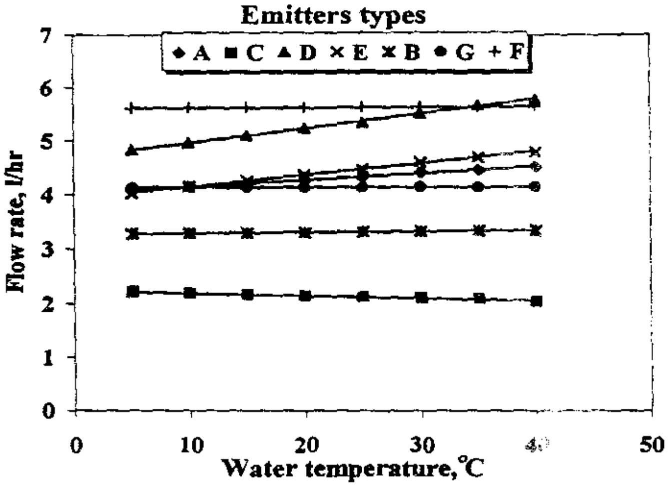
Table 6: Characteristics of hydraulic performance for emitters tested

Emitter type	Test pressure range, kPa	ASAE		ISO		Flow Type
		k	x	k	x	
A	50 – 250	4.2428	0.425	4.2522	0.4338	Turbulent
B	50 – 250	3.3749	0.5309	3.3535	0.5077	Turbulent
C	50 – 250	2.0722	0.4133	2.0855	0.4065	Turbulent
D	50 – 250	5.4648	0.6579	5.1914	0.6067	Partially turbulent
E	50 – 250	4.3216	0.6060	4.0384	0. 5881	Partially turbulent
F	50 – 500	4.6490	0.2611	4.4949	0.2843	Compensating
G	10-40	15.246	0.8493	15. 186	0.8586	Unstable Fully
	40-60	1.939	-1.4024	1.999	-1.3596	
	60 - 500	4.0292	0.011	4.0555	0.002	Compensating

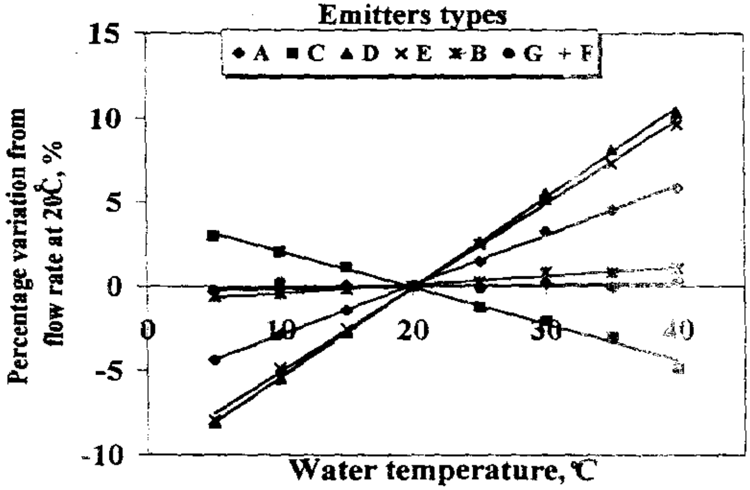
Effect of Water Temperature on Emitter Discharge Rates:

Influence of water temperature on discharge rate of the emitters tested is shown in Fig.7. It was indicated that the discharge rate of labyrinth long path, type A, increased with increasing water temperature. In the temperature range 5 - 40 °C the discharge rate varied from - 0.437 to +5.82 percent relative to the discharge rate at 20 °C. Flow through the orifice emitter, B, increased about 1.636 percent in the temperature range 5 to 40 °C. The discharge rate of type C decreased 7.82 % between 5 and 40 °C. The decrease in discharge rate is probably caused by increased vortex action as viscosity decreases. For spiral long path emitters (D and E) the discharge rate varied from -8.13 to +10.30 percent and from -7.94 to +9.59 percent, respectively, in the same range of temperature, relative to the discharge rate at 20 °C. For both types F and G, water temperature did not affect on flow rates. These results were in quite agreement with that of Parchomchuk (1975) and Decroix and Malaval (1985).

From Fig.3, it is shown that type D was the most affected by temperature followed by types E, A and B, respectively. Emitter C was inversely affected by temperature variations whereas there was no effect on types F and G. The discharge rates of the tested emitters relative to its discharges at 20 °C are shown in Fig. 3.



Influence of water temperature on discharge rate for the tested emitters.



Discharge rate of tested emitters relative to their discharges at 20 °C.

Figure 7: Emitter discharge as affected by water temperature.

Summary and Conclusions

The efficiency of trickle irrigation system depends directly on the uniformity with which water is discharged from emitters throughout the system. Laboratory tests were conducted on seven types of emitters (A, B, C, D, E, F and G) extensively used in trickle irrigation systems to study the importance of the following parameters in affecting the uniformity of water application under drip irrigation system:

1. Coefficient of manufacturing variation C.V.
2. Discharge equation factors x, k.
3. Susceptibility to temperature of water.

Tests were performed on fifty unused emitters, randomly selected from each type, to evaluate the uniformity degree of emitter discharge. Experiments were carried out under different operating pressures ranging from 50 kPa to 350 kPa for types A, B, C, D and E. This range was extended to 500 kPa for compensating emitter types F and G.

The C.V is affected by pressure. Therefore, when selecting an emitter it is recommended to know the C.V value over the range of pressures expected within the field installation. Moreover, the manufacturer should provide the value of the discharge exponent for the emitter.

To find discharge equation factors x and k, two methods were used five samples (which discharge in the previous test corresponding approximately to the average measured discharge) and, four samples were chosen (from the first twenty-five emitters of the fifty tested ones) to be tested at pressure values. thus, emitters were classified based on ASAE standards and ISO-standards, receptivity. Discharge-pressure curves, based on ASAE and ISO-standards showed that for types A and C both curves are similar to each other, followed by emitters B and F. For types D and E, there was greater difference between two curves of each type compared with other emitters.

The effect of water temperature on emitter discharge was only measured on the five samples- used for the discharge-pressure test- under the nominal pressure for types A, B, C, D and E and under a mid-range pressure for emitters F and G. Results indicated that type F and G were non-affected by temperature variations whereas long path emitter D was the most emitter affected by temperature changes. Orifice emitter was slightly sensitive to temperature. On the other hand, vortex type C inversely was influenced by temperature variations.

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تقييم الخصائص الهندسية المؤثرة على كفاءة الرى بالتنقيط فى أنظمة الرى بالتنقيط

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تعتمد كفاءه الرى بالتنقيط على مدى تجانس توزيع الماء المتدفق من المنقطات خلال النظام. و قد انتشرت فى الآونة الأخيرة أصناف عديدة من المنقطات و التي تؤثر بشكل مباشر فى تصرف الماء من خلال شبكة الرى بالتنقيط، و قد أجريت هذه الدراسة المعملية فى محطة البحوث الزراعية بالنوبارية على سبعة أنواع مختلفة من المنقطات شائعة الاستعمال فى السوق المحلى و هى

الصنف A : طويل ومتعرج المسار (محلى) الصنف B : فونية (محلى)
الصنف C : فونية دوامى المسار (مستورد) الصنف D :حلزونى طويل المسار (محلى)
الصنف E :حلزونى طويل المسار (محلى)
الصنف F : منظم للضغط طويل المسار ذاتى الغسيل (مستورد)
الصنف G : منظم للضغط- فونية- ذاتى الغسيل (مستورد)

يستهدف هذا البحث دراسة العوامل الهندسية الآتية المؤثرة على كفاءة استخدام المنقطات فى شبكة الرى بالتنقيط لما لها من أهمية في التأثير على تجانس إضافة الماء تحت نظام الري بالتنقيط:

١- معامل الاختلاف في التصنيع
٢- عاملي معادلة التصرف (الأس x ، الثابت k).
٣- تأثير درجة حرارة الماء على تصرف المنقطات.

- من النتائج السابقة يمكن استنتاج الآتى:

١- المنقطات (G, F) كانت أكثر ملائمة للاستخدام فى أنظمة الرى آلتي بها تذبذب فى ضغط التشغيل والمنقطات (E . D . C, B, A) يمكن استخدامها فى أنظمة الرى آلتي ليس بها تذبذب فى ضغط للتشغيل.
٢- أظهرت النتائج أن معامل الإختلاف فى التصنيع كانت ذات قيم أعلى فى المنقطات (F D, B, E) أما المنقطات (A, C, G) فكان معامل الإختلاف فى التصنيع لها أقل.
٣- كان لدرجة الحرارة تأثير مباشر على عملية التصرف فى المنقطات (B . C . . A, E, D) اما المنقطات (G, F) فكانت لا تتأثر بدرجة الحرارة المياه خلال عملية تصرف المنقطات.