Effect of some drip irrigation system design parameters on the emission uniformity

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Abstract

A field experiment was conducted in Dhi-Qar governorate in Al-Salem area, carried out in the autumn season 2018, a drip irrigation system was used, lateral field tubes content of the main line made of PVC with a diameter of 53.3 mm and 50 mm and 16 mm sub main pipe for. The pipe network components were installed from the main conveyor pipe with a length of 100 m, connected to three sub-tubes (25 m length for each). The end of each tube was placed by a piezometer, a transparent tube form with 1.50 m a height, to regulate and standardize the operational pressure and drain pan in the pipeline network, sub-tube was divided into 36 field tubes, (10, 15 and 20) m tube length according to treatment, (2, 4, 6 and 8) liters an hour^{-1} emitter, interchangeably for each field pipe with a distance of 1.50 m, three spaces between emitters (20, 30 and 40) cm were used, 108 the total number of units. Factorial experiment designing with Randomized Complete Block Design (RCBD) were used. The results showed that a significant effect ($P \leq 0.05$) for The results showed a significant effect of emitters discharge, The emitters discharge exceeded 8 liters per hour^{-1} with the highest values (97.66%), with an increase of 1.14%, 2.66%, and 3.78% compared to the discharge of 2, 4 and 6 liters per hour^{-1}, the effect of the distance between the emitters gave the distance 40 cm the highest values (97.20%), increased by 2.79 and 1.05% compared to the distance 20 and 30 cm, 10 m field length gave the highest values (96.82%), while the lengths of pipes 15 and 20 m recorded rates of 95.97 and 95.06%.

Keywords: drip, irrigation system, design parameters, the emission uniformity.

<u>Part of first researcher thesis</u>

Introduction

The emission uniformity defined as the ratio between the lowest discharge quadrant rate to the general discharge rate of emitters (Ortega et al., 2002), it wass another criterion for homogeneity of distribution of emitters, calculated from the equation by determining the percentage of homogeneity of distribution by field test, which is adopted by the American Organization for Conservation and Soil Conservation, by the relationship between lowest quadrant and total discharge rate of emitters, the formula is:

$$Eu=\frac{q_{25\%}}{\underline{q}} \qquad (1) \ldots\ldots\ldots\ldots 100\times$$

Eu: Emission Uniformity (%).

$\underline{q}_{25}$: The discharge rate for the least quarter of total number of emitters (liters/ hour^{-1}).

q : Total discharge (liter/ hour^{-1}).

Wu et al. (2006) and Barragau et al. (2006) were developed previous formula, to find the absolute value of the homogeneity of the distribution as a percentage:

(2).............. $Eu = 1 - \sqrt{\left[1 - \frac{qmin}{q}\right]^2 + \left[\frac{1.27\ Cv}{\sqrt{N}}\right]^2}$.

Eu: Emission Uniformity (%).

q_{min} = less discharge of emitters(liters/ hour^{-1}).

Excellent; the value is equal to or more than (90%).

Good; the value (70-80%) .

Poor; less than (70%).

Keller and Karmeli (1976) concluded an analytical equation, correlate the design discharge rate and less discharge from the emitter, as well as the effect of the coefficient of industrial variation and emitters number, to express the coefficient of homogeneity of distribution, the formula is:

(3).................... $Eu = 100\left[1 - 1.27\left(\frac{CV}{N}\right)\right] \times \left[\frac{qn}{qa}\right]$

Eu: Emission Uniformity (%).

CV= Industrial variation coefficient

N = Emitters number assigned/ plant.

Irregular drainage of drip irrigation systems, the result of a many factors, such as the pump operating pressure, discharge available, pressure differentials due to the loss of friction in conveyor pipes, distributed water, diameters and lengths, different field topography, emitters type that calibrate the water amount added near the plant, industrial variation and its blockage (Al-Obeidi, 2001). Pragna et al. (2017) and Pawar et al. (2017) were found increased emission uniformity with increased emitters discharge. El-Obeid (2006) observed a reduction in emission uniformity by increasing of field pipe length from 95.07% to 90.92%, then 86.52% by increasing the pipe length from 40 to 60 and then 80m. Senyigit and Ilkhan (2017) and Ndewi et al. (2018) show that increasing distance between emitters due to emission uniformity increases, the distance between the emitters 50cm was the better compared to other distances (20, 25, 33, 37) cm.

The study aims to determine the effect of discharge emitters, the distance between the emitters and the field pipe length on emission uniformity.

Materials and Methods

A field experiment was conducted in Dhi-Qar governorate, Al-Gharaf district in Al-Salem area farms. The experiment was carried out in the 2018 planting season on clay-texture soil. PVC main line were used 53.3 mm diameter, 50 mm sub main pipe and 16 mm field pipes (lateral), to ensure the required design discharge to the field. The network components were installed from the main conveyor pipe with a length of 100 m, connected to three sub-tubes, 25 m for each tube. The end of each tube was placed by a piezometer, a transparent tube with a height of 1.50 m, to regulating and standardizing operational pressure and discharge throughout the network, sub-tube was divided into 36 field tubes, (10, 15 and 20) m tube length according to treatment, (2, 4, 6 and 8) liters an hour^{-1} emitter, interchangeably for each field pipe with a distance of 1.50 m, three spaces between emitters (20, 30 and 40) cm were used, 108 the total number of units. Factorial experiment designing with Randomized Complete Block Design (RCBD) were used. Pressure and drainage were controlled by valves at the beginning and end of conveyor tubes, sub-pipes and field, the discharge of emitters in the first, second, third and last quarter of each field tube was measured individually by volumetric method, The discharge was calculated according to formula number 4 mentioned by (Al-Hadithi et al., 2010) as follows:

$$q = \frac{V}{t} \dots\dots\dots\dots\dots\dots (4)$$

q: emitter discharge (L/ hour^{-1}).

V: volume of water received in the can (L).

t: Operating time (hours).

The emission uniformity was calculated from formula (1).

Results and discussions

The results of the statistical analysis in Table 1. show that a highly significant effect (P≤0.01) of the emitter discharge treatments on the emission uniformity values. When comparing with emitter discharge treatments (Table 2), there were significant differences (P≤0.05) between all treatments in this study, the highest values appeared in 8 liters/ hour^{-1} (97.66%), 6 liters/ hour^{-1} which recorded 96.61%, 4 liters/ hour^{-1} gave 95.43% and 2 liters/ hour -1 which recorded the lowest value (94.10%). The increase rates for the 4, 6 and 8 liters/ hour^{-1} treatments were 1.14, 2.66 and 3.78%, respectively. Increased emission uniformity with increased discharge is due to increased operational pressure with increased discharge of emitters, thus increasing the total discharge in the field tube, which leads to a power lack on the downhill field length of the tube, this reduces the percentage of variance in the emitters discharge, especially in the last quarter (Al-Asadi, 2008), the result coincided with Sharma (2013) when he found increased emission uniformity by increasing emitters discharge from 2 to 8 liters/ hour^{-1}.

Table 1. variance analysis of F tabular value of emission uniformity.

Source	d.f	%Eu
Q	3	740.05**
S	2	795.20**
L	2	326.71**
Q.S	6	23.28**
Q.L	6	1.11^{NS}
S.L	4	7.14**
Q.S.L	12	1.58^{NS}

Q: emitters discharge (liters/ hour^{-1}). S: distance between emitters (cm). L: field tube length (m).

A high significant (P≤0.01) was observed in distance factor between the emitters on emission uniformity values (Table 1). Table 2. shows that the differences were significant (P≤0.01) among all treatments, the distance between the emitters 40 cm gave the highest values (97.20%), followed by 30 cm recorded 96.17%, then 20 cm gave the lowest values (94.48%), the declines for the treatments of 20 and 30 cm were 2.79% and 1.05%, respectively. The increase in emission uniformity values is due to the increase in the rate of emitters discharge by distance increasing among emitters in field pipes, the emitters in the field pipe will be affected by almost equal operating pressure, this is reflected in the increased uniformity of the rates of expenditures for emitters (Camp et al., 2013). the reduce of distance among the emitters, the opposite occurs, the emitters number were increase on the field pipe, this increases the total discharge rate and increases the discharge loss, There was a difference in pressure on the field pipe installed on the field tubes, this reduces the rate of emitters discharge due to pressure declines on the field pipe (Boman and Skukla, 2004). This is consistent with Ortega et al., 2002, who defined emission uniformity as the ratio between the lowest quartile discharge rate to the general discharge rate of the emitters.

Table 2. Effect of experiment parameters on emission uniformity (Eu%).

L	**10**			**20**			**30**			**Q*S**		
S **Q**	**20**	**30**	**40**	**20**	**30**	**40**	**20**	**30**	**40**	**20**	**30**	**40**
2	93.3	95.2	96.3	92.2	94.5	95.7	91.3	93.5	94.5	92.3	94.4	95.5
4	94.7	96.8	97.6	93.2	95.5	97.5	92.3	94.5	96.3	93.4	95.6	97.2
6	96.4	97.6	98.2	95.4	96.7	97.4	94.6	95.7	97.0	95.5	96.6	97.6
8	97.8	98.5	98.9	96.5	97.9	98.6	95.4	97.2	97.8	96.6	97.9	98.4
RLSD	N.S									0.365		
Q **L**	**2**	**4**	**6**	**8**	**S**				**2**	**4**	**6**	**8**
					20	**30**	**40**					
10	94.9	96.3	97.4	98.4	95.5	97.0	97.8	**Q**	94.1	95.4	96.6	97.6
15	94.1	95.4	96.5	97.6	97.3	96.2	94.3	**S**	20	30	40	0.211
20	93.1	94.4	95.8	96.8	93.4	95.2	93.4		94.4	96.1	94.4	0.183
Q: emitters discharge (liters/ $hour^{-1}$). S: distance between emitters (cm). L: field tube length (m).								**L**	10	20	30	0.183
									96.8	95.9	95.0	RLSD

Table 1, shows a highly significant effect (P≤0.01) of the field tube length factor on the emission uniformity values, there were significant differences (P≤0.05) among all treatments (Table 2), 10 m field length was the highest (96.82%) followed by the 15 m which recorded 95.97% and the 20 m field length with the lowest values (95.06%), the increase rates for treatments 10 and 15 m compared to treatment 20 m decreases with the increase of the field pipe length, reaching 1.85 and 0.95% for treatments 10 and 15 m, respectively. The decrease in emission uniformity by increasing the length of the pipe is due to the fact that the pressure energy (E_i), the flow velocity highest value at the beginning of the field pipe, the pressure (E_i+$_l$) is at its lowest value at the end of the field pipe, the flow speed is then reduced to a minimum, especially when the length of the field pipe is increased due to high friction energy losses (H△), this leads to a decrease in the emitters discharge to the conservation energy law (formula 5) according to Baiamonte (2015), and consequently lower emission uniformity values.

$$E_i = E_{i+l} + \triangle H \ldots\ldots\ldots\ldots\ldots\ldots(5)$$

This was confirmed by Tagar et al., (2010) and Asenso et al., (2014), and they found lower emission uniformity values as the field tube length increased.

The statistical analysis of the F test of Table 1. shows that there is a highly significant ($P \leq 0.01$) effect of the interference between the emitter discharge treatments with the distance among the emitters in the values of the uniformity factor, the emitters discharge on the varies factor values according to the variation of the distance among the emitters (Table 2), 40 cm gave significant differences ($P \leq 0.05$) with the highest values of 95.54, 97.21, 97.60 and 98.45%, 30 cm that gave the values 94.45, 95.63, 96.69 and 97.91% and 20 cm which recorded the lowest values 92.32, 93.44, 95.54 and 96.61% and for all emitter discharge treatments 2, 4, 6, 8 liters hour^{-1}, respectively. The reason for the low emission uniformity values at close distances and low charges is due to the variance of the emitters on the field pipe, especially in the middle and the end, due to reduced pressure and consequently reduced emitters discharge (Tagar et al., 2010), as well as increase the coefficient of difference by increasing the distance among the emitters, reduced discharge and thus reduced emission uniformity values. In spaced distances and high discharges, decreases on the field pipe, due to increased emitter discharge rate due to increased operating pressure, The rate of emitters discharge on the field pipe is incrementally related to the operating pressure, the higher the pressure inside the field pipe, the lower the length of the pipe, or increase the distance between the emitters, the emitters discharge rate increases, thus increasing the values of emission uniformity, this is consistent with the findings of Berlamont and Beken (1973).

Tables 1. and 2. show that the effect of field-tube length on emission uniformity values varies according to the distance among the emitters, significant differences ($P \leq 0.01$) in emission uniformity values are shown to increase with the decrease of the field tube length, This increase varies by the distance among the emitters, the significant increase in emission uniformity values by decreasing the field length from 10, 15 to 20 m varies depending on the distance among the emitters, at the distance between the dots 20 cm appeared the highest significant differences, these differences decrease by increasing the distance among the emitters to 30 and 40 cm, the highest values were recorded with significant superiority when treating 10 m field length of 95.59, 97.06 and 97.80%, compared with the field length treatmrnts of 15 m which gave 94.37, 96.21 and 97.33% and the field length of 20 m which recorded the lowest values of 93.46, 95.24 and 96.46% and for all distance coefficients among emitters 20, 30 and 40 cm, respectively. The low emission uniformity values at close distances on pipes were due to the increase in the coefficient of variation, since the emission uniformity is affected by the difference of the coefficient of variation (CV) of the emitters, all discharge variance rates affecting emission uniformity values within the range qa (1- 1.27CV), this is consistent with Mofoke et al. (2004) found increased emission uniformity by decreasing the values of the coefficient of industrial variation, when the value of the industrial coefficient of difference was 0.12, the value of emission uniformity was 90.6%, while it increased to 96.6% with the decrease in the value of the industrial coefficient of difference to 0.042.

The effect of the di-interaction between the emitters discharge treatments and the field tube length, and the tri-interaction among emitters discharge treatments, the distance among emitters and the field tube length had no significant effect on the Eu values (Table 1).

In this study, the emission uniformity value (Eu%) of the irrigation system of the factors and their interactions was more than 90%, as a general rate for all treatments 95.94% within the excellent classification mentioned by the Al-Mujahid (2006) (Table 3).

Table 3. Some General Standards of Emission Uniformity Coefficient (% Eu) (Al-Mujahid, 2006).

Emission Uniformity value (%)	The evaluation
Greater than 90	excellent
80-90	good
70-80	Acceptable
60-70	poor
Less than 60	Unacceptable

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