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Effect of Inter Spaces and Emitter Types on the Hydraulic Performance of Drip Irrigation System

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Abstract

This study was conducted at the Demonstration Farm of the Faculty of Agriculture, University of Khartoum – Shambat, during May 2011 to February 2012, to investigate the effect of inter-space and emitter type on hydraulic performance of drip irrigation system. The farm lies at 32° E and 15.36° N and 380 m above mean Sea level. Two types of emitters were used, online pressure compensation (Eo) and inline labyrinth (Ei) with two different inter spaces (0.5 and 0.3 m). Factorial design was used to analyze the variation in Discharge (q), Reduction of discharge(R)%, Coefficient Uniformity (CU)%, Emission Uniformity (EU%) and Clogging percentage (P_{clog}). Analysis of variation showed that there were significant differences ($P \leq 0.05$) among the measured parameters. Whereas highest values of discharge(q), Coefficient Uniformity (CU)% and Emission Uniformity (EU)% were recorded by Eo. While the highest values of Clogging percentage (P_{clog}) and Reduction of discharge (R) were recorded by Ei . The 0.5m emitter inter space showed higher values of Discharge (q), Uniformity of Coefficient(CU)% and Emission Uniformity (EU)% than 0.3m inter space, and at the same time it is showed the lowest values of Reduction of discharge (R)% and Clogging percentage (P_{clog}). This study concluded that emitter types and inter spaces are important factor in drip irrigation system design. Therefore, should be considered when planning for efficient drip irrigation system.

Keywords: Drip irrigation system; Uniformity parameters; Emitter types; Inter-Spaces.

1. Introduction

The growing scarcity and misuse of available water resources particularly in arid and semi-arid regions constitute challenges to water demands for various utilities, and major threats are facing sustainable agricultural development which use about 80-85% of water consumption.

Adequate water demand management necessitates the establishment of structure of incentives regulations and restrictions that will help guide influence and coordinate how water is used efficiently. Hence, innovations in irrigation water saving technologies are highly needed. For obtaining high effectiveness of irrigation water application, drip irrigation is the most appropriate modern technology of irrigation, Sharma, (2013). It is considered as a method which takes water from source to plant without water losses. Thus, it is saving for about 70% of used water without affecting significantly the crop yield, (Pandey, 2005). Also Dutta, (2008) stated that water will be saved with

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saving in the quantity and quality of the crop, when using drip irrigation technology. Drip irrigation is some time call trickle irrigation, a name suggested by the American Society of Agricultural Engineers (ASAE, 1983) or localized irrigation, a name recommended by Food and Agriculture Organization (FAO, 1980). Drip (or trickle) irrigation refers to the frequent application of small quantities of water at low flow rates and pressures. The advantage of using drip-irrigation system is to significantly reduce evaporation losses and increase water use efficiency by creating a low, wet area in the root zone. Due to water shortages in many parts of the world today, drip irrigation is becoming quite popular (Sahin *et al.*, 2005; Powell and Wright, 1998;).The high efficiency of drip irrigation results from two primary factors: The first is that the water soaks into the soil before it can evaporate or run off. Secondly water is only applied where it is needed, (at the plant's roots) rather than sprayed everywhere.

The emitter or dripper is the core of this technology, which is made of plastic materials, Sne, (2005). An emitter (dripper) is used to transfer water from a pipe or tube to the area required to be irrigated . Clogging of emitters is considered as one of thoughtful problems facing drip irrigation systems users (Wei *et al.*, 2008). Emitter clogging can seriously interfere with uniform application of irrigation water and system-applied fertilizers which leads to reduced crop yield and quality. Clogging can result from biological growths, physical particles, or chemical precipitates in the drip system. Therefore, this study aim to evaluate the drip emitters clogging according to, the emitter types and emitters inter spaces.

2. Material and Methods

The experiment was conducted at the demonstration farm of the Faculty of Agriculture, University of Khartoum –Shambat. The farm lies on the Eastern Bank of the River Nile at 32°E, 15.36° N and 380 m above mean Sea level . The climate of the area is tropical, which is characterized by low relative humidity, with average daily maximum and minimum temperatures of about 36°C and 21° C, respectively.

The system unit components were pump, control unit (two polyethylene plastic valves, a pressure gauge disc filter and one valve was fixed at each entry of lateral to control discharge and pressure), main line (Polyvinyl Chloride (PVC) of 50 mm diameter), sub main line (Polyvinyl Chloride (PVC) of 25mm diameter), lateral lines (black Linear Low Density Polyethylene (LLDPE) of 16mm inside diameter, they were divided into two equal groups one has inter emitters spaces of 0.5m and the other has 0.3m inter spaces) and Emitters (online pressure-compensation, (Eo) and inline-labyrinth, (Ei)), plate (1) .

Plate (1) The system components

Materials of pressure gauge (2bar) of analogue types, meter tape, catch cans, measuring cylinder and stop watch were used.

A volumetric calibration of the emitters was made by using cans and a graduated measuring cylinder. Under each emitter there was catch cans located to collect the volume of discharge in specific time. The collected water was measured using measuring cylinder to determine the volume. The measured volume was used to calculate Discharge (q), Reduction of Discharge (Rreduction), Coefficient Uniformity

(CU%), Emission Uniformity (EU%), Clogging percentage (Pclog %), according to the equations as follows:

$$Q = \frac{V}{T} \quad (1)$$

Where
Q = discharge (l/h)
V= volume of water collected by catch cans (l)
T= operating time (h), (Keller and Karameli 1975)

$$R\ \% = \frac{(V1 - V2)}{V1\ \times 100} \quad (2)$$

Where
R % = Reduction of Discharge
V1 = Volume of the first emitter in the lateral
V2 = Volume of the last emitter in the lateral, (Bralts and Kesner, 1983)

$$Cu\% = 100\left(1 - \frac{\Delta q}{q}\right) \quad (3)$$

Where:
Cu = Christiansen's uniformity coefficient in percentage
Δq = Mean deviation of individual emitters flow from the mean (l/h)
q = Mean flow rate from emitters, (Christiansen, 1942)

$$Eu = 100\left[1 - \frac{1.27}{\sqrt{Nes}}CV\right]\frac{qmin}{qave} \quad (4)$$

Where:
Eu = the design emission uniformity in percent
Nes = number of point source emitters per emission point
CV= manufactures coefficient of variation (0.05)
qmin= minimum emitters flow along the lateral line
qave = average discharge rate of all emitters (l/h), (Keller and Biller, 1990)

$$Pc\ \log = \frac{N_{\text{clog}}}{N} \times 100 \quad (5)$$

Where:
P clog = clogging percentage
N clog= number of complete clogged emitters
N = number of total emitter, (Bralts and Wu, 1979).

The experiment was organized in factorial plot design, whereas, emitter types were assigned in main plot and emitter inter spaces were plotted in sub plot. The analysis was done using SAS program under windows.

3. Results

Table (1) showed the effect of emitter types and inter spaces on emitter discharge .The results revealed that online pressure compensation (Eo) has significant difference at $P \leq .05$ compared with inline – labyrinth(Ei) in emitter discharge. On the other hand, no significant differences were recorded between emitter inter spaces. Moreover, the emitter types showed negative effect on reduction of discharge, while 0.3m inter spaces recorded higher significant differences ($P \leq .05$) than that of 0.5 m, (Table 2).

Table (1) The effect of emitter types and inter spaces on Discharge l/h

Emitter type	**Emitter interspaces**		**Mean**
	0.5m	Space 0.3m	
(Eo) online pressure compensation	4.01	4.07	4.04 [a]
(Ei) inline – labyrinth	2.40	2.42	2.41 [b]
Mean	3.20 [a]	3.24 [a]	
LSD	0.034		0.035

Means with the same letter in in the same column are not significant difference at $P \leq 0.05$

Table (2) the effect of emitter types and inter spaces on Reduction of Discharge **%**

Emitter type	**Emitter interspaces**		**Mean**
	0.5m	0.3m	
(Eo) online pressure compensation	24.10	31.53	27.82 a
(Ei) inline – labyrinth	17.07	39.90	28.48 a
Mean	20.58 b	35.72 a	
LSD	4.61		4.60

Means with the same letters in the same column are not significant difference at $P \leq 0.05$

Table (3) showed the results of coefficient of uniformity (CU%), which indicated high significant differences ($P\leq 0.5$) amongst treatments. However, Eo (online pressure compensation emitter) and 0.5m inter spaces revealed highest values of CU% compared with Ei (inline- labyrinth) and 0.3m inter spaces, respectively.

Table (3) the effect of emitter types and inter spaces on Christiansen coefficient of uniformity (CU%)

Emitter type	**Emitter interspaces**		**Mean**
	0.5m	0.3m	
(Eo) online pressure compensation	90.80	91.43	91.12 [a]
(Ei) inline – labyrinth	91.65	88.60	90.08 [b]
Mean	91.18[a]	90.02 [b]	
LSD	0.330		0.331

Means with the same letters in the same column are not significant difference at $P \leq 0.05$

As shown in table (4) the emitter types recorded non-significant differences at $P\leq 0.05$ in emission uniformity. The same result was observed with emitter inter spaces. Table (5) showed no significant differences ($P\leq 0.05$) in clogging percentage (Pclog) within emitter types and emitter inter spaces, respectively. Nevertheless, Ei (inline – labyrinth) with 0.3m inter spaces recorded highest values, while Eo (online pressure compensation) with 0.3m recorded the lowest ones.

Table (4) the effect of emitter types and inter spaces on Emission uniformity %

Emitter type	**Emitter interspaces**		**Mean**
	0.5m	0.3m	
(Eo) online pressure compensation	87.11	82.21	84.66 [a]
(Ei) inline – labyrinth	81.28	84	83.03 [a]
Mean	84.20 [a]	83.50 [a]	
LSD	4.14		4.15

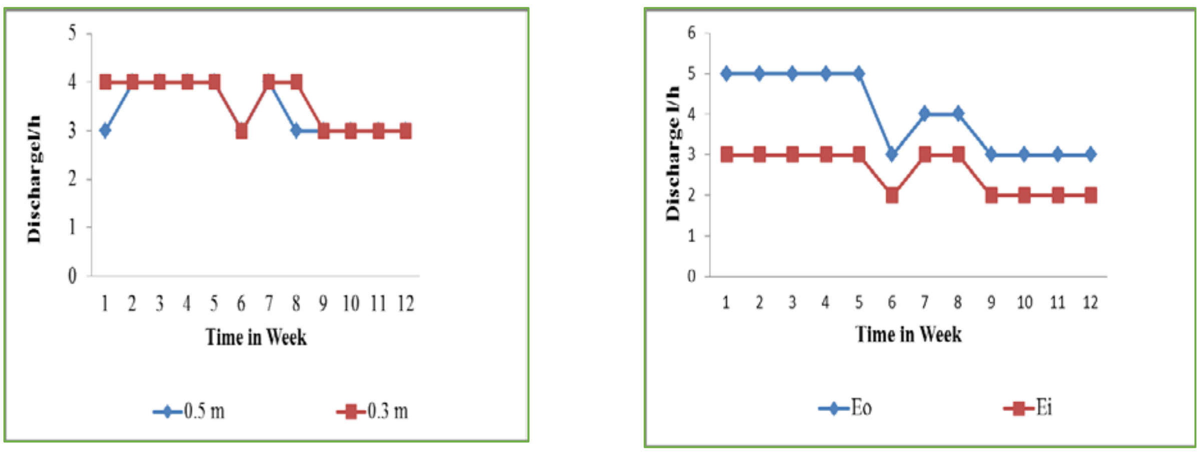
Means with the same letters in the same column are not significant difference at $P \leq 0.05$

Table 5 the effect of emitter types and inter spaces on Clogging %

Emitter type	**Emitter interspaces**		**Mean**
	0.5m	0.3m	
(Eo) online pressure compensation	15.00	13.33	14.17 [a]
(Ei) inline – labyrinth	15.17	17.17	16.17 [a]
Mean	15.09 [a]	15.25 [a]	
LSD	5.31		5.30

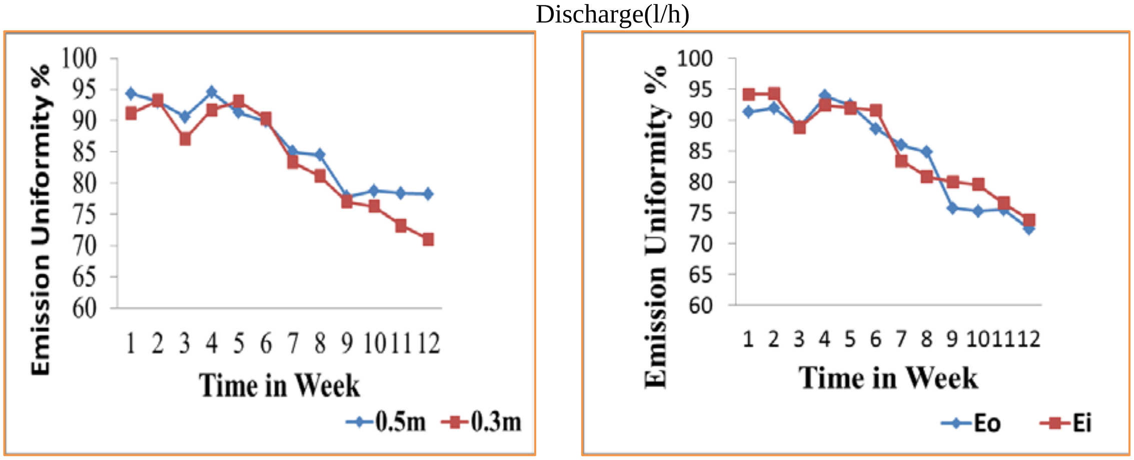
Means with the same letters in the same column are not significant difference at $P \leq 0.05$

Figures (1a), (2a), (3a) and (4a) showed that the inter spaces have the same effect on discharge of emitters , coefficient of uniformity (CU%), and emission of uniformity (EU%). On the other hand the above mentioned parameters decreased with time with both inter spaces. The clogging percentage (Pclog) increased with time with both inter spaces, as well as 0.5 m inter space showed higher values than 0.3m. While Figs. (1b), (2b), (3b) and (4b) revealed the same effect of emitter types on discharge of emitter, coefficient of uniformity (CU%), and emission of uniformity (EU%). The clogging percentage (Pclog) increased with increasing of operation time with both types.



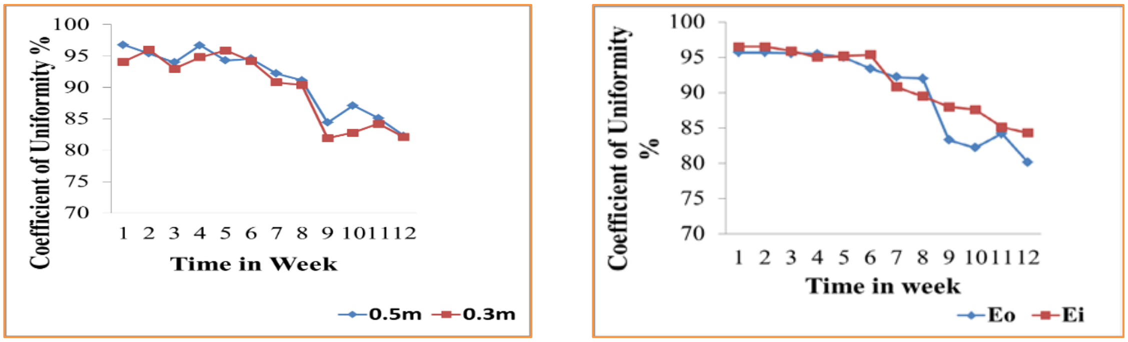
a b

Figure 1 (a and b)the effect of emitter inter spaces (0.5m and 0.3m) and emitter types (Eo and Ei) on the Discharge(l/h)



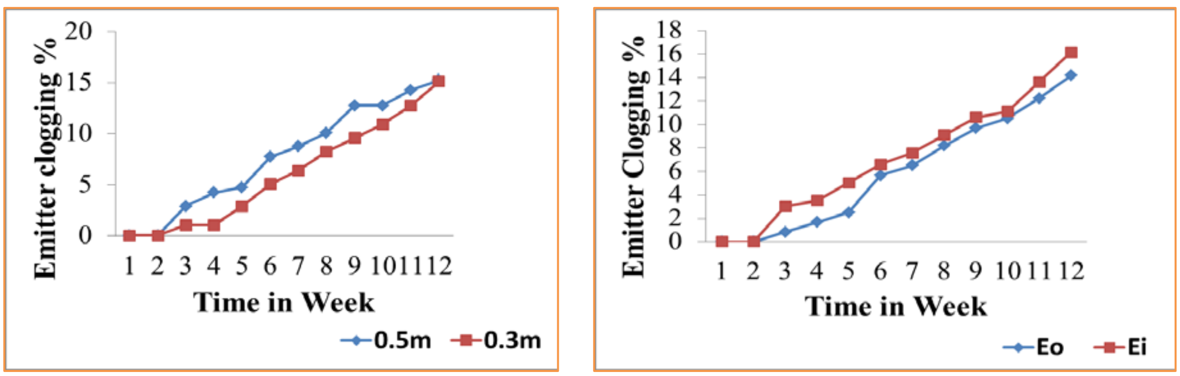
a b

Figure 2 (a and b) the effect of emitter inter spaces (0.5m and 0.3m) and emitter types (Eo and Ei) on the Emission Uniformity %



a b

Figure 3 (a and b)the effect of emitter inter spaces (0.5m and 0.3m) and emitter types (Eo and Ei) on the Coefficient of Uniformity %



a b

Figure 4 (a and b)the effect of emitter inter spaces (0.5m and 0.3m) and emitter types (Eo and Ei) on the emitters clogging %

4. Discussion

As shown in Table (1) the obtained results of the discharge may be due to that Eo has ability to resist any type of pressure failure, therefore, it keeps the discharge approximately a constant, in addition the inline – labyrinth is more sensitive for partial or complete clogging. The emitter clogging is affected by operating pressure and both have effect on emitter discharge. Therefore, is well documented that the emitter type Eo is saving the pressure constant when compared with other types of emitters. This finding agreed with that of Yavu et al., (2010), who stated that emitter clogging is formed in a short time when system operating under an inadequate pressure. On the other hand, Table (2) illustrated the results of reduction of discharge , and due to occurrence of partial clogging and pressure variation the emitter discharge reduced with time, as stated by Nakayama and Bucks, (1978).

The coefficient of uniformity (CU%) is affected by emitter types and interspaces, as shown in Table (3).This result may be attributed to that Eo is compensating the losses in pressure approximately secured uniformity in emitters discharges. These results were similar to those obtained by Ravina et al., (1997). The obtained results of emission uniformity (EU%) as explained in Table (4), were found in the line of Nakayama and Bucks, (1978), and agreed with that of Sharma (2013), who stated that emission uniformity of the water application varies with pressure, emitter variation, and number of emitters.

In Table (5) the effect of treatment on emitters clogging was presented, and explain that the highest values of Pclog % were recorded by Ei (inline – labyrinth) with 0.3m. This result agreed with the that of Hills et al., (1982).

The effect of interspaces and emitter types on the discharge, CU%, EU%, and clogging percentage illustrated in Figs (1a, 2a, 3a, 4a, 1b, 2b, 3b and 4b). The obtained results may be due to that increasing of inter space enable precipitation to take place with time. This result supported by Tyson and Harrison (1995). Moreover, may be due to precipitation of clogging materials particles on emitter with time and causes the partial clogging and at last complete clogging, as stated by Ravina et al., (1992).

5. Conclusion

In this study the performance of drip irrigation system is highly affected by emitter types and emitter inter spaces. Moreover the pressure-compensation emitter (Eo) has high resistance for clogging problem. Therefore, precise selection of emitter types should be done before system installation. Moreover, pressure compensation emitters are suitable to used when clogging problem is common.

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