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CLOGGING EVALUATION OF SIX EMITTERS AS AFFECTED BY SUSPENDED SAND PARTICLES IN IRRIGATION WATER

Zaghluol, k. F.; A. M. ELNaggar and M. A. Salih
Science Department, Faculty of Agriculture, Cairo University, Egypt.

ABSTRACT

Six different types of emitters were selected for clogging susceptibility, (GR in line, Fan on line, Turbo key on line, Micro jet on line, Button on line, and Katif on line). The setup of the system consists of centrifugal pump (0.5 HP), reservoir (0.80 x0.60 x0.60m) contains water with suspended particles, tray (1m x 2m) with a height of 20 cm provided with sink pipe to collect water that comes out from emitters back to the reservoir, and piping network from the pump to the lateral lines at the upper edge of the tray. The system provided with bypass valve and pressure gauge mechanism not only to adjust the operating pressure at 1 bar but also to agitate the suspended solid in water (sand particles) during the test. Tap water source was used after adding sand particles (diameter <0.1mm) with concentration of 2 gram/liter. Emitter discharges were measured in cyclic duration (each 15 minutes). According to ASAE (1997), the coefficient of variation (Cv) of all tested emitter was good, except Em6 which was of average classification. Based on the coefficient of variation criteria the systems performance emitter discharge decrease with increasing operation time. The more sensitive emitters for clogging are Em1 and Em5 (GR in Line emitter and Button on Line emitter) respectively. While the most stand without clogging was Em6 (Katif on Line emitter). The recommended emitters are Katif on Line, and Micro jet on Line emitter. It is not recommended to use GR in Line emitter and Button on Line emitters under such conditions of suspended particles.

Keywords: Trickle irrigation, emitter, clogging, sand particles

INTRODUCTION

It is well known that emitter clogging in drip irrigation systems fall into three main categories: (1) physical, caused by suspended solids; (2) chemical, caused by precipitation reactions; and (3) biological, caused by bacterial and algae growth (Bucks *et al*., 1979). Emitter clogging is usually the result of two or more of these processes working in concert (Nakayama, 1978).

Drip irrigation generally has an important potential in terms of lower energy consumption, lower water loss and higher irrigation efficiency. The most important reason for this is that it has lower evaporation, runoff and deep percolation losses compared with other irrigation methods. In drip irrigation method, higher irrigation efficiency depends particularly on emission uniformity of the emitter discharge. Emission uniformity depends on manufacturing differences, hydraulic change in irrigation system due to land slope, head losses in pipes, sensitivity of emitters towards pressure and temperature changes and emitter clogging.

There were definable differences between emitters of various types as to their clogging susceptibility which were not directly correlated with differences in emitter flow-rate, although, for any particular type, the emitter with smaller discharge is always more sensitive to clogging. The clogging process generally started with emitters located at the far end of the lateral and partial emitter clogging was more common than complete plugging.

The emitter is considered as the most significant device in this irrigation system (Wei, 2011; Hezarjaribi, *et al,* 2008; Zhengying, et al, 2012; Bassett *et al,* 1983).

The drip irrigation emitter is a small mechanical device which is designed to dissipate pressure and constantly discharge a small uniform flow of water.

The reliability of drip irrigation is defined as the capability of achieving the required task under a specified operating pressure for a given period of time (Jeznach, J., 1998).

The performance of the emitter is determined by several factors including the type of the drip emitter and its condition. The drip emitter can also suffer from clogging due to the escape of some particles (e.g. sand, impurities) from filtering (Fan, *et al*, 2011; Wei, *et al,* 2009; Zhengying, *et al,* 2012).

Drip irrigation emitter clogging will increase the maintenance cost (Oron, *et al,* 1991); therefore, the clogging of emitters is one of the most serious problems associated with micro irrigation use. Emitter clogging can severely hamper water application uniformity (Pitts, et al 2003).

After examining three different drip emitter, Adin and sacks (1991) showed that clogging of drippers that use of waste water was occurred by solid particles but this is not the first step of clogging necessarily, and the velocity of clogging is more influenced by the size of particle not its amount.

The types of emitter clogging problems vary with the source of the irrigation water. Water sources can be grouped into two categories: surface and ground water. Each of these is likely to present specific clogging hazards (Benham and Ross, 2002).

The small orifices found in the trickle emission devices can be clogged easily by physical and chemical contaminants found in the water. Groundwater from wells is generally of good quality and should be used when possible.

Groundwater may contain sand or chemical precipitates. Surface water can be used but often contains bacteria, algae, and other aquatic life. Emitter types and time of systems working.

Muharrem *et al.* (2010) investigated emitters clogging effects on trickle irrigation system performance. To determine the clogging level of drippers, they concluded that in general, the more time droppers were used have more clog and their performance reduced. The aim of this work is to evaluate of six emitters as affected by suspended sand particles in irrigation water.

Experimental Design

This study was conducted at the Research Laboratory of Soil Science Department, (Cairo Univ. Faculty of Agric, Egypt in 2014); Using a laboratory scale drip irrigation setup with 6 lines of irrigation tubing, each of one meter. Six different types of emitters were selected for clogging susceptibility.

The setup of the system is shown in Fig (1). A 0.5 HP centrifugal pump was used. The system provided with bypass valve and pressure gauge mechanism not only to adjust the operating pressure to 1 bar but also to agitate the suspended solid in water (sand particles) during the test also. In addition to the previous, the system included a collecting sink back to the reservoir.

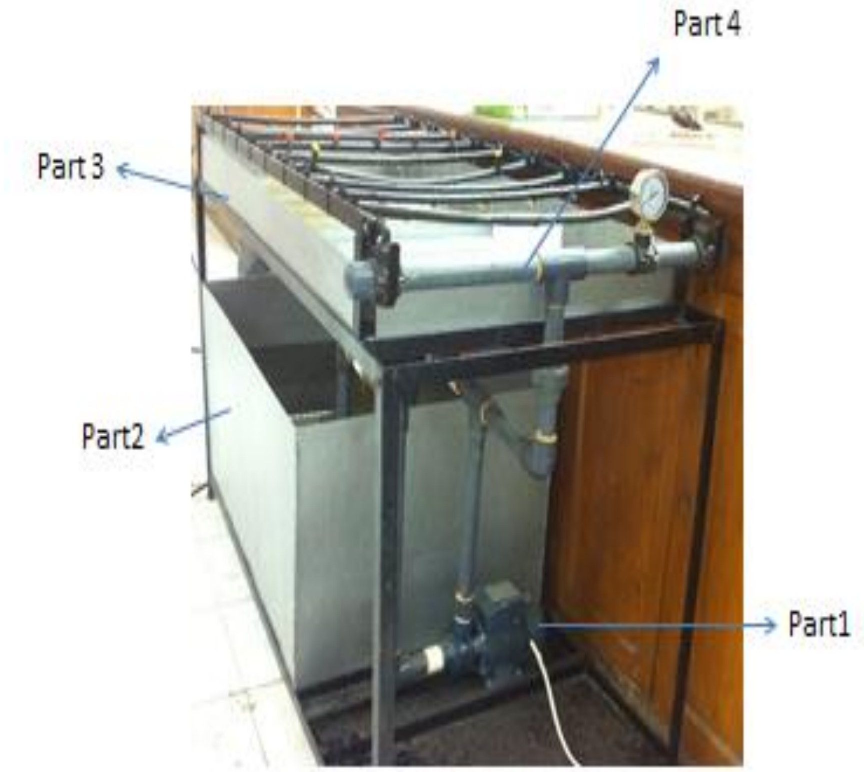

Figure (1): The setup of the laboratory irrigation system

Part1: A 0.5 HP centrifugal pump with suction (connected to the reservoir) and discharge lines with bypass valve

Part2: A reservoir (0.80 x0.60 x0.60m) contains water with suspended particles

Part 3: A tray (1m x 2m) with high 20 cm provided with sink pipe to collect water that comes out of emitters back to the reservoir

Part 4: Piping network from the pump to the lateral lines at upper edge of the tray.

Tap water source is used with concentration of 2 gram/liter of sand particles (diameter <0.1mm).Emitter discharges were measured in cyclic duration (each 15 minutes).

Six different drip emitters were tested, at an operating pressure of 1 bar, by measuring the water discharged from each emitter for a 30-second period, the collected volumes (mL) were converted to emitter discharge rate (L/h) .The collected data are averaged for each emitter type and are shown in Table (1)

EL Awady *et. al.* (2008) reported that the degree of emitter clogging was related directly to the reduction in the average flow rate for each emitter to the design flow- rate.

Therefore, flow rates of individual emitters were measured, and clogging was considered when the flow rate reduced to less than 50 percent of the design rate. The degree of emitter clogging can be calculated for any emitter duration as follows:

$$(\alpha) = (1 - (Q_{avg.} / Q_d)) * 100.$$

Where:

(α)= clogging ratio, (%)

Q_{avg}= average flow rate for each emitter (Lph), and

Q_d = design flow rate for each emitter type (Lph).

RESULTS AND DISCUSSIONS

The data of examine the 6 used emitters (Table 1 and Figure 2) shows that The highest emitter discharge is Em4 followed by Em2 and the lowest discharge was observed for Em6 also, the highest slandered deviation (STD) emitter discharge is Em6 followed by Em3 while the lowest is Em5.

Table (1): initial Average Emitter discharge (L/h) tested at 1bar

	Types of emitters	**Initial Flow L/h**
Em1	GR in Line emitter 4 L/h NPC	4.2
Em2	Fan on Line emitter 18 L/h NC	17.1
Em3	Turbo key on Line emitter 4 L/h NPC	3.6
Em4	Micro jet on Line emitter 20 L/h NPC	19.5
Em5	Button emitter on Line emitter 4L/h	3.9
Em6	Katif on Line emitter 3.8 L/h PC	3.3

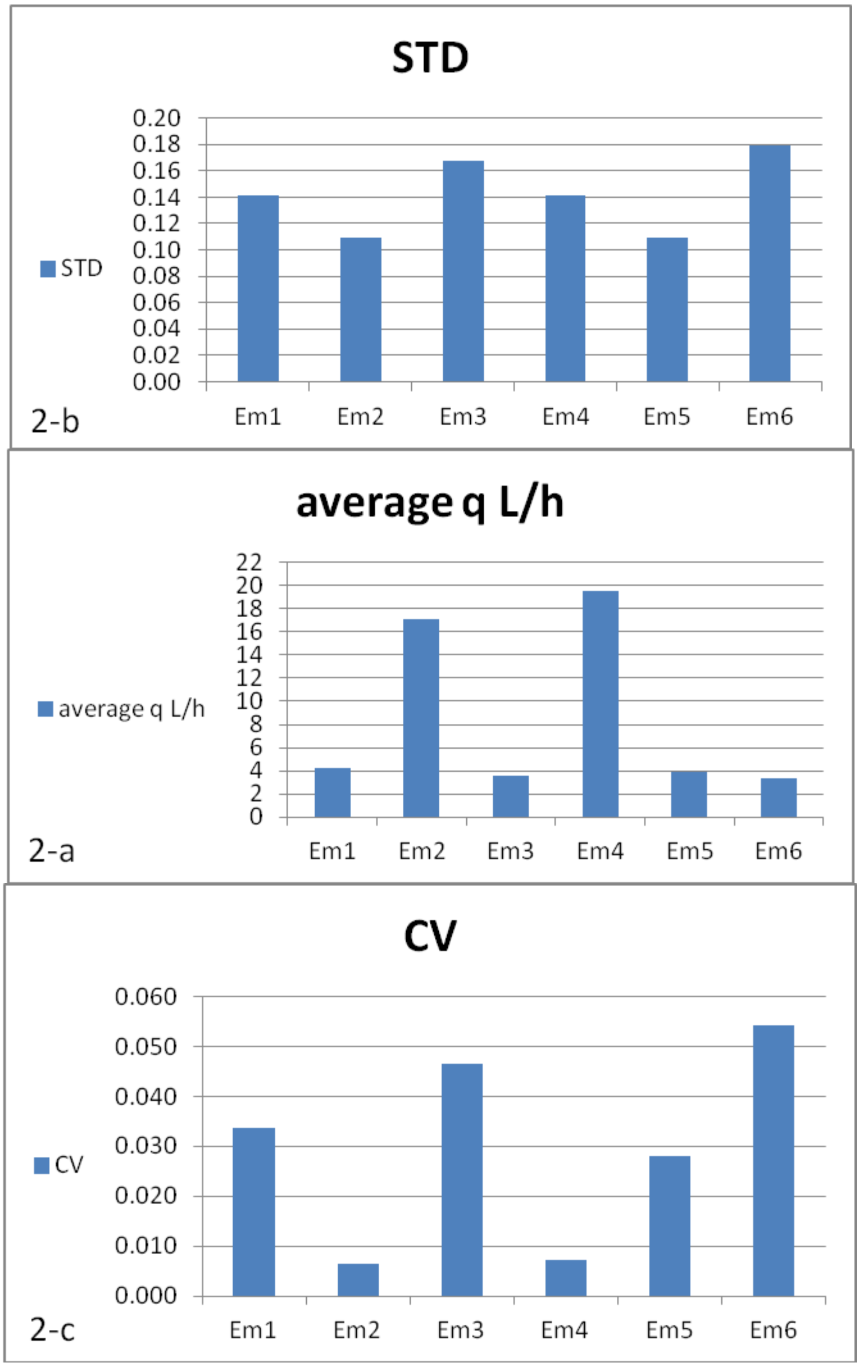

Figure (2): The average discharge, STD, and CV of the studied emitters

According to ASAE (1997), the expected manufacturer's coefficient of variation (C_v) should be available for new emitters operated at a constant temperature and near the design emitter operating pressure. A general guide for classifying values is show in Table (2).

Table 2: Recommended classification of manufacturer's coefficient of variation (C_v).

Emitter type	C_v range	classification
Point-source	<0.05	Excellent
	0.05 to 0.07	Average
	0.07 to 0.11	Marginal
	0.11 to 0.15	Poor
	>0.15	Unacceptable
Line-source	<0.10	Good
	0.10 to 0.20	average
	>0.20	Marginal to unacceptable

Regarding to Figure (2-c), the highest c_v value is for Em6 and the lowest value for Em4.

Table 3: (C_v) value for the studies emitter.

Emitter	C_v range	classification
Em1	0.030- 0.040	good
Em2	>0.01	good
Em3	0.040- 0.050	good
Em4	>0.01	good
Em5	0.020- 0.030	good
Em6	0.050- 0.060	average

All tested emitter having good classification, Except Em6 which has an average classification. The Cv is a statistical description of how uniformly each device is manufactured in relation to one another in terms of its flow rate. It is defined as the standard deviation divided by the average flow rate from a sample of emitters.

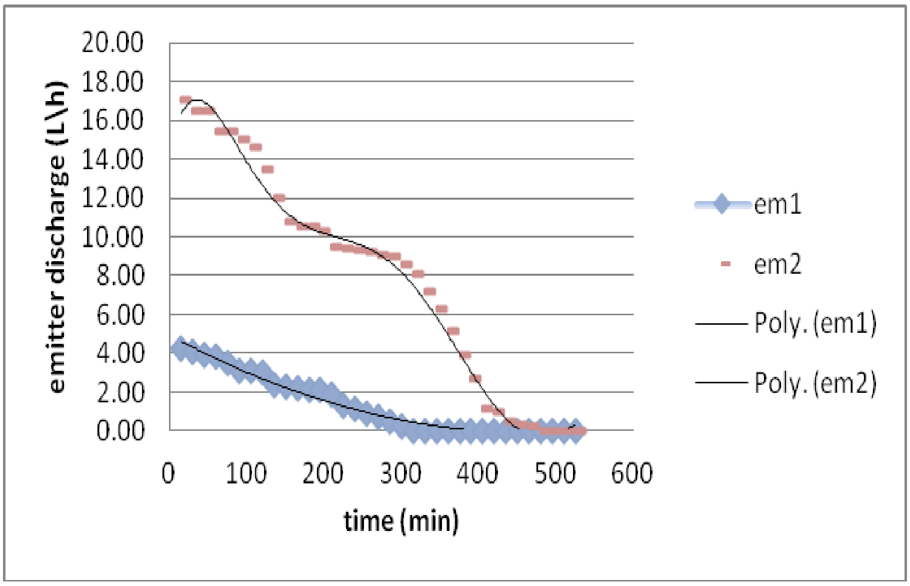

Figure (3): Operating time (min) v.s. emitter discharge (L/h) For em1 and em2

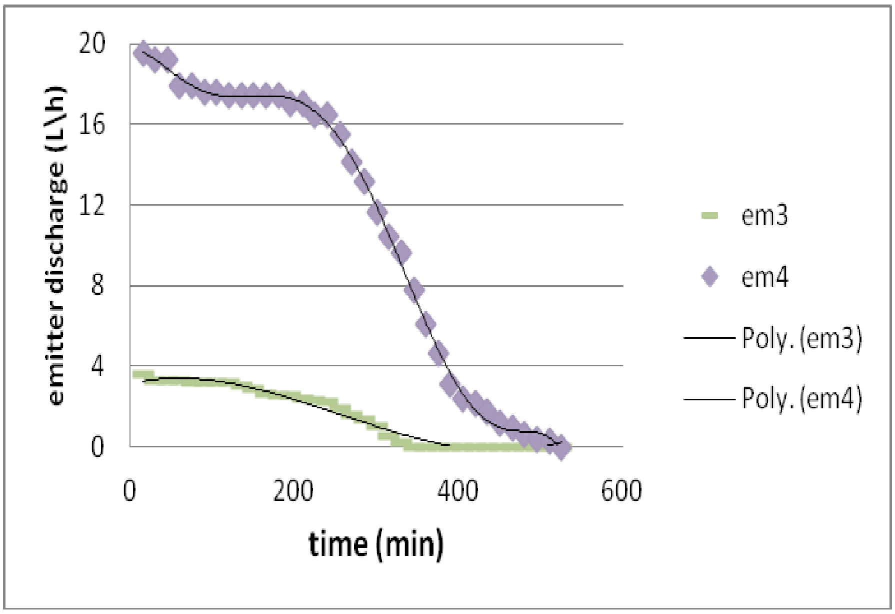

Figure (4): Operating time (min) v.s. emitter discharge (L/h) For em3 and em4

The chosen six emitters were subjected to clogging test by passing tap water containing 2 gm/L sand particle (<0.1 mm diameter) and determine the emitters discharge every 15 minutes and for a total period of 525 minutes. The collected data are presented in Table (4) and figure (5). The data revealed that emitter discharge, in general reduced as the time increased. However, the rate and type of this decrease always follow a polynomial form (Table 5).

Table 4:Emitters discharge in respect to operation time.

Time (min)	em1	em2	em3	em4	em5	em6
15	4.20	17.1	3.6	19.5	3.9	3.3
30	4.10	16.5	3.3	19.2	3.8	3.3
45	3.90	16.5	3.3	19.2	3.5	3.3
60	3.80	15.4	3.3	17.9	3.4	3.15
75	3.50	15.4	3.15	17.9	3.2	3.15
90	3.10	15	3.15	17.6	3	3.15
105	3.10	14.6	3.15	17.6	2.8	3.15
120	3.00	13.5	3.15	17.45	2.5	3.15
135	2.40	12	3	17.4	2.3	3
150	2.30	10.8	2.85	17.4	2.2	2.85
165	2.20	10.5	2.6	17.4	1.6	2.7
180	2.15	10.5	2.55	17.4	1.4	2.7
195	2.10	10.3	2.5	17	1.3	2.5
210	1.90	9.5	2.4	17	1	2.5
225	1.30	9.4	2.3	16.5	0.9	2.35
240	1.10	9.3	2.2	16.5	0.8	2
255	0.9	9.2	1.9	15.5	0.6	1.5
270	0.7	9.1	1.6	14.1	0.4	1.1
285	0.5	9	1.3	13.2	0.2	0.9
300	0.2	8.6	1	11.6	0	0.7
315	0	8.1	0.5	10.4	0	0.6
330	0	7.2	0.2	9.6	0	0.3
345	0	6.3	0	7.8	0	0.2
360	0	5.1	0	6.1	0	0
375	0	3.9	0	4.6	0	0
390	0	2.7	0	3.1	0	0
405	0	1.1	0	2.4	0	0
420	0	1	0	2.1	0	0
435	0	0.5	0	1.7	0	0
450	0	0.3	0	1.2	0	0
465	0	0.2	0	0.9	0	0
480	0	0	0	0.6	0	0
495	0	0	0	0.4	0	0
510	0	0	0	0.3	0	0
525	0	0	0	0	0	0

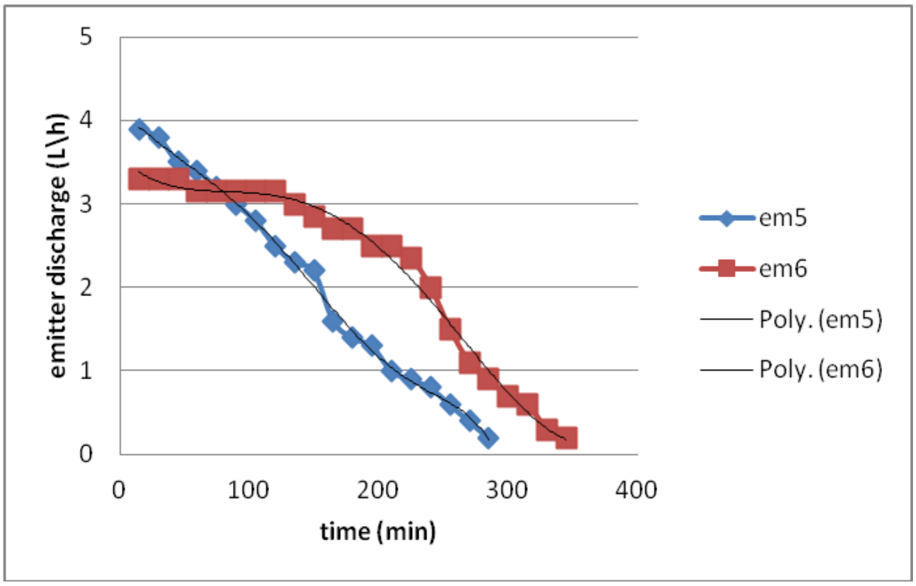

Figure (5): Operating time (min) v.s. emitter discharge (L/h) For em5 and em6

Table 5: The best fit equation.

	Emitter	Best fit form	equation	R^2
Em1	GR	polynomial	$y = 2E\text{-}09x^4 - 2E\text{-}06x^3 + 0.0006x^2 - 0.105x + 19.665$	$R^2 = 0.9796$
Em2	Fan	polynomial	$y = 2E\text{-}05x^2 - 0.0214x + 4.925$	$R^2 = 0.9788$
Em3	Turbo key	polynomial	$y = 1E\text{-}07x^3 - 9E\text{-}05x^2 + 0.0094x + 3.1233$	$R^2 = 0.9778$
Em4	Micro jet	polynomial	$y = -7E\text{-}14x^6 + 1E\text{-}10x^5 - 6E\text{-}08x^4 + 1E\text{-}05x^3 - 0.0011x^2 + 0.0096x + 19.626$	$R^2 = 0.9988$
Em5	Button	polynomial	$y = 3E\text{-}07x^3 - 0.0001x^2 - 0.0026x + 3.9223$	$R^2 = 0.9941$
Em6	Katif	polynomial	y٣ = E-07x٠.٠٠٠١ - ٣x٠.٠٠٢٦ - ٢x + 3.9223	$R^2 = 0.9941$

Moreover, the ratio of decreasing emitter discharge (α) was measured (Table 6 and figure 6) and it is found that, the highest of clogging ratio at (α) 25% is Em4 followed by Em6 while the lowest ratio is for Em1. At (α) 50% the highest clogging ratio is for Em4 followed by Em2 while the lowest ratio is for Em1. At (α) 75% the highest of clogging ratio is for Em4 followed by Em2 while the lowest ratio is for Em5, and at (α) 100% the highest of clogging ratio is for Em4 followed by Em2 while the lowest ratio is for Em5. Hence, it could be concluded that, the emitter discharge which is mainly depends on its opening diameter is also the main factor controlling its clogging and that katif emitter (6) is considered as the best in respect to clogging although of its low discharge but it was more resistant for clogging.

Table 6: Time (min) required for clogging for different emitters.

Time	**(α)= clogging ratio, (%)**					
min	**em1**	**em2**	**em3**	**em4**	**em5**	**em6**
15	0.0	0.0	0.0	0.0	0.0	0.0
30	2.4	3.5	8.3	1.5	2.6	0.0
45	7.1	3.5	8.3	1.5	10.3	0.0
60	9.5	9.9	8.3	8.2	12.8	4.5
75	16.7	9.9	12.5	8.2	17.9	4.5
90	26.2	12.3	12.5	9.7	23.1	4.5
105	26.2	14.6	12.5	9.7	28.2	4.5
120	28.6	21.1	12.5	10.5	35.9	4.5
135	42.9	29.8	16.7	10.8	41.0	9.1
150	45.2	36.8	20.8	10.8	43.6	13.6
165	47.6	38.6	27.8	10.8	59.0	18.2
180	48.8	38.6	29.2	10.8	64.1	18.2
195	50.0	39.8	30.6	12.8	66.7	24.2
210	54.8	44.4	33.3	12.8	74.4	24.2
225	69.0	45.0	36.1	15.4	76.9	28.8
240	73.8	45.6	38.9	15.4	79.5	39.4
255	78.6	46.2	47.2	20.5	84.6	54.5
270	83.3	46.8	55.6	27.7	89.7	66.7
285	88.1	47.4	63.9	32.3	94.9	72.7
300	95.2	49.7	72.2	40.5	100.0	78.8
315	100.0	52.6	86.1	46.7		81.8
330		57.9	94.4	50.8		90.9
345		63.2	100.0	60.0		93.9
360		70.2		68.7		100.0
375		77.2		76.4		
390		84.2		84.1		
405		93.6		87.7		
420		94.2		89.2		
435		97.1		91.3		
450		98.2		93.8		
465		98.8		95.4		
480		100.0		96.9		
495				97.9		
510				98.5		
525				100.0		

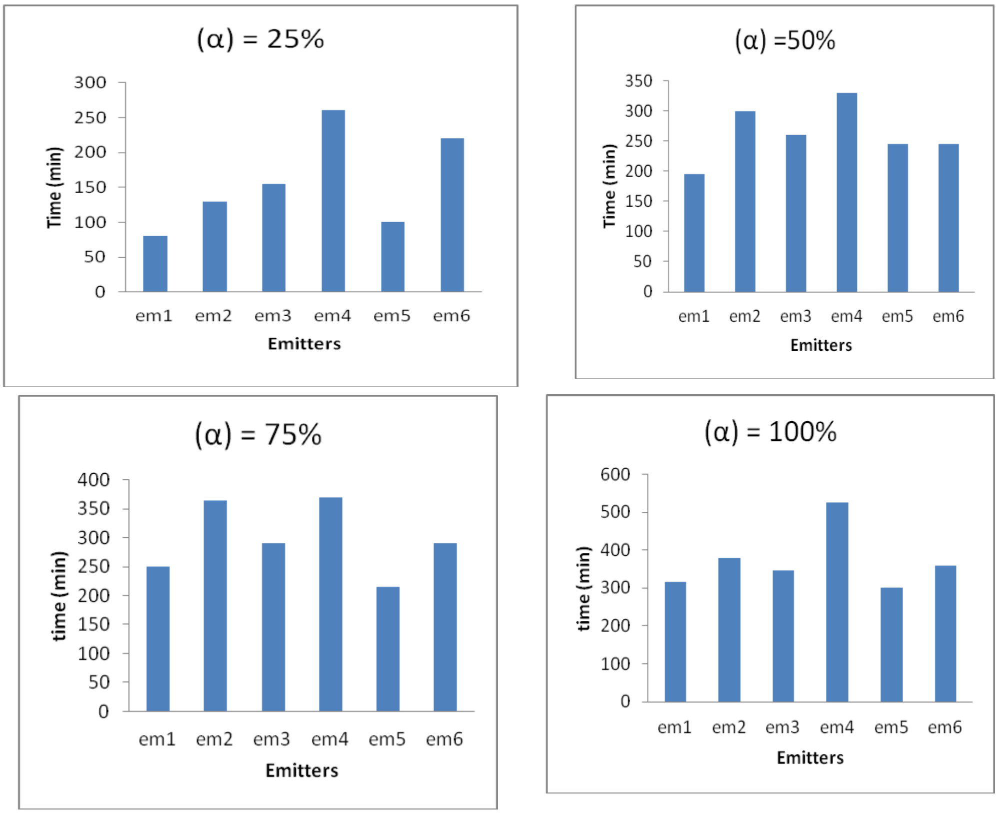

Fig.6: Time (min) required for clogging ratio of (25, 50, 75,100) % for different emitters.

CONCLUSION

A laboratory setup was used to evaluate clogging of different six emitters, using irrigation water with 2g\L sand particle. Average emitter discharges were ranged from low discharge (3.3, 3.6, 3.9, and 4.2) for Katif on Line emitter, Turbo key on Line emitter, Button on Line emitter, and GR in Line emitter respectively. While the high discharge (19.5, and 17.1) for Micro jet on Line emitter and Fan on Line emitter, respectively.

Based on the coefficient of variation criteria the systems' performance, emitter discharge decrease with increasing operation time. Arranging emitter clogging the worst "need shorter time to be clogged" are Em1 and Em5, while the best "need longer time to be clogged" are Em4 and Em6.

The relationship between operation time and clogging ratio was found as polynomial (different orders) when the operation time increase the clogging ratio increased. The more sensitive emitters for clogging are Em1 and Em5 (GR in Line emitter and Button on Line emitter), respectively. While the most stand without clogging is Em6 (Katif on Line emitter). The recommended emitters are Katif on Line emitter, Micro jet on Line emitter and it is not recommended to use GR in Line and Button on Line emitters.

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تقييم انسداد ستة نقاطات متأثرة بحبيبات الرمل العالقة في مياه الري

قدري فؤاد زغلول ، علي محمد أحمد التجار و ميسر عبدالله صالح
قسم علوم الأراضي كلية الزراعة - جامعة القاهرة.

تم اختيار ستة أنواع مختلفة من النقاطات لدراسة مدى حساسيتها للانسداد، (جي آر داخل الخط، نقاط المروحة على الخط، توربوكي على الخط، مايكروجين على الخط، نقاط زرار على الخط، نقاط كاتيف على الخط).

تم تصنيع جهاز لتقييم إنسداد النقاطات مكونة من مضخة الطرد المركزي (٠.٥ حصان)، وخزان (٠.٨ * ٠.٦ *٠.٦ متر) يحتوي على حبيبات الرمل العالقة في المياه، ويحتوي الجهاز على صينية علوية (١متر * ٢ متر) ,وارتفاعها ٢٠ سم مزودة بفتحة الصرف لتجميع المياه الخارجة من النقاطات واعادتها إلى الخزان. ويحتوي الجهاز أيضا على شبكة مواسير وخراطيم مركب عليها النقاطات. وقد تم استخدام حبيبات الرمل قطرها أقل من ٠.١ ملم وتركيزها ٢ جرام/لتر.

تم قياس تصرف النقاطات تحت ضغط (١ بار) في دورات التشغيل كل منها ١٥ دقيقة، تم حساب معامل الاختلاف (cv) ووجد ان قيمة تصنيفه جيد لكل النقاطات ما عدا النقاط رقم ٦ (كاتيف على الخط) الذي كان له تصنيف متوسط ويلاحظ ان تصرف النقاطات يقل بزيادة زمن التشغيل واكثر انواع النقاطات حساسية للانسداد هما النقاط الأول (جي آر داخل الخط) والنقاط الخامس (نقاط زرار على الخط) بينما النقاطات التي استمرت بدون الانسداد هما النقاط رقم ٦ (نقاط كاتيف على الخط) والنقاط رقم ٤ (مايكروجين على الخط).

ولا يوصى باستخدام النقاطات الجي آر و الزرار تحت مثل هذه النوعية من مياه الري.