EFFECTS OF FERTIGATION MANAGEMENT ON EMISSION UNIFORMITY AND CLOGGING OF ON-LINE EMITTERS

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ABSTRACT

A field experiment was conducted to study the effect of fertigation components on emission uniformity and emitter clogging. The effects of two types of emitters with two discharges (2 and 4 l/h normal emitters, 2 and 4 Lh^{-1} Pressure compensated (Pc) emitters) and six fertilization treatments (No fertilization as control, humic acid, ammonium nitrate, ammonium sulfate, mix two of humic acid and ammonium nitrate and mix two of humic acid and ammonium sulfate) were undertaken in this experiment. For all fertilization treatments, the emission uniformity (EU %) significantly decreased while emitters clogging ratio (CR %) increased with increasing number of fertigations which where periodically applied throughout the 180 days season. The 4 Lh^{-1} discharge emitters resulted in less clogging than the 2 Lh^{-1} emitters. Clogging problems obtained with the Pc emitters was less than those of normal emitters. The applied fertilization treatments increased the clogging ratio at the end of the season compared with no fertilizer treatments (F_0) under both types of emitters at both discharge rates of 2 and 4 Lh^{-1}.

Finally, the maximum clogging ratios i.e. 29.42% and 28.72% at the end of 180days season were recorded for the plots received ammonium sulphate (S) and humic acid+ ammonium sulphate (H+S) fertigation respectively, up on using normal type emitters of 2 Lh^{-1} discharge.

Keywords: *Drip irrigation; fertigation; clogging ratio; Emission Uniformity.*

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INTRODUCTION

Drip irrigation systems have many potential advantages when compared with other irrigation methods, some of them are related to low rates of water application high efficiency and more water saving. One of the most important disadvantages of drip irrigation is emitter clogging which is directly related to water quality (physical, chemical or biological contaminants). In this regard, it is essential to evaluate water supply quality for design and maintenance of micro irrigation.

Zhu *et al.*, (2005) reported that emitter clogging was one of the key factors that determine whether drip irrigation systems can succeed.

Distribution uniformity of irrigation water is critical for uniform fertilizer application. **Adin (1987)** found that the emitter clogging may be due to physical, chemical and biological factors**. De Troch (1988)** showed that two or more of these clogging reasons may occur at the same time. Emitter clogging may be due their extreme small passages of water and low flow rate **(Dasberg and Bresler1986). Hebbar *et al.* (2004)** found that normal fertilizers generally tend to clog the emitter**.**

Ravina *et al.* (1997) stated that, more clogging emitters were found at the end of the drip laterals than at the beginning probably due pressure head loss**.**

Bozkurt and Zekiei (2006) showed that different fertilizer treatments have significant effect on emitter clogging. Fertilizers containing both Ca^{2+} and So_4^{-2}caused higher clogging compared with the other elements.

Chang (2008) reported that as water flow in irrigation system slows down and/or the chemical background of the water changes, chemical precipitates and/or microbial flocks and slimes begin to form and grow, thus emitter clogging occurs.

The main objective of this work was to investigate the effect of fertigation components and emitter type on emitter clogging and Emission Uniformity.

MATERIALS AND METHODS

A field experiment was carried out at the farm of Soils and Water Research Department, Nuclear Research Center, Atomic Energy Authority, Inshas, Egypt. Soil physical and chemical analysis indicated that soil texture of the experimental area was sand with pH of 7.97, organic matter of 0.3 gkg^{-1}, CaCO3 of 10 gkg^{-1}, and C: N ratio of 34.3. Properties of irrigation water could be summarized in table (1).

Table 1. Some properties of the irrigation water.

pH	EC dS/m	SAR	Soluble ions $mmol_c\,L^{-1}$						
			Cations				Anions		
			Mg^{2+}	Ca^{2+}	K^+	Na^+	HCO_3^-	SO_4^{2-}	CL^-
7.53	0.38	2.8	0.51	1.32	0.22	2.13	0.33	1.54	2.31

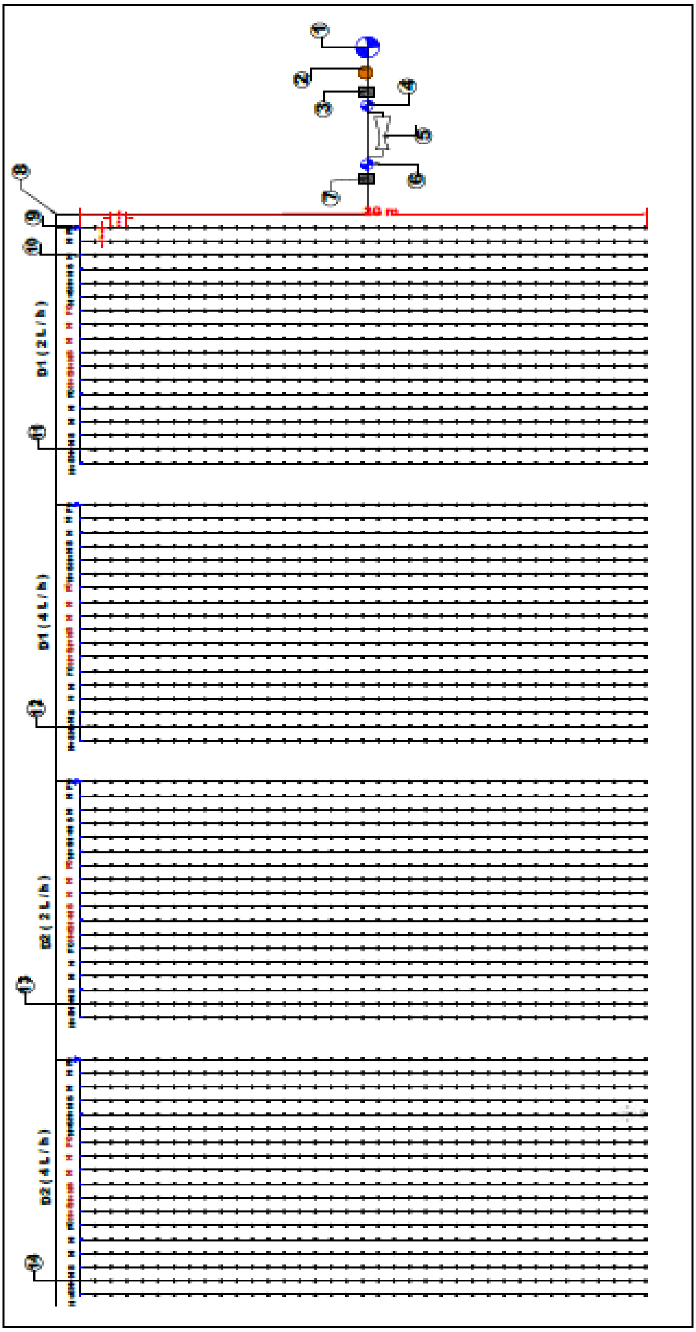
The experiment Layout:

The experiment layout consisted of electrical centrifugal pumping unit of 18 m^3/h discharge under 2 bar operating pressure, lifting the water from an open channel and deliver it to a 50 mm diameter PE main pipe through a control head involving media and screen filters, 3/4 inch venturi fertilizer injector, valves and pressure gauges. Four drip irrigation plots with 16 mm diameter PE laterals will serve as four different irrigation (emitters) treatments. Each plot included 18 laterals of 20m length and 0.5 m spacing between laterals. Each lateral have on- line emitters at 0.5m apart along the lateral line. Inside each plot the 18 laterals were used to apply the arrangement of 6 fertilizer treatments with three replicates, with the same arrangements as shown in (figure 1).

The fertilizer rates of nitrogen and humic acid were100 and 0.5$kgfed^{-1}$, respectively as recommended by Ministry of Agriculture and Land Reclamation. No crops were grown in the field during the study but the fertilizer and water requirements for garlic crop were applied throughout the estimated growing season.

The amounts of fertilizers were divided into 3 doses and each dose was injected in 2 hours during 50% of the irrigation time throughout the growing season the three doses were applied at three equal intervals. The injection rate was 180 l/h in irrigation flow rate of 323.098 l/h .So, the nitrogen fertilizer concentration in the irrigation water alone and mixed with humic acid were 220.458 and 110.229

mg L^{-1} respectively.



1-water inlet valve 2inch 2-water counter 3- Pressure gauge
4- Valve 3/4inch (fertilizer inlet) 5- Venture 3/4inch 6- Valve 3/4inch (fertilizer outlet) 7- Pressure gauge 8- main line 50 mm 9- valve 16 mm
10- lateral line 16 mm 11- D_1 (2 l/h) 12-D_1 (4 l/h) 13- D_2 (2 l/h) 14- D_2 (4 l/h)

Fig.1: The experimental layout

Main treatments: The main treatments included four irrigation treatments i.e. two types of emitters with two discharge rates as follows:

(1) Normal emitters (D_1)

- 2 Lh^{-1} discharge (D_1q_1)
- 4 Lh^{-1} discharge (D_1q_2)

(2) Pressure compensated emitters

- 2 Lh^{-1} discharge (D_2q_1)
- 4 Lh^{-1} discharge (D_2q_2)

Sub- treatments:

There were six treatments of fertilizer: 1) non fertilizer as control (F_0); 2) humic acid (H); 3) ammonium nitrate (N); 4) ammonium sulphate (S); 5) %50 humic acid + %50 ammonium nitrate (HN) and 6) %50 humic acid + %50 ammonium sulphate (HS).

Emission Uniformity (EU)

To estimate the emitter flow rate, catch cans and a stopwatch were used. EU was determined as a function of the relation between average flow emitted by the 25% of the emitters with lowest flow (q_{lq}) and the mean flow emitted by all the control emitters (q_a). The emission uniformity coefficient (Eu) was computed using **Capra and Tamburino (1995)** equation:

$$Eu = \frac{q_{lq}}{q_a} \times 100$$

Emitters clogging

Emitters from each lateral had been chosen to be evaluated by calculating their clogging ratio at the beginning and at the end of the growing season. Clogging ratio was calculated according to **El-Berry *et al.* (2003)** using the following equations**:**

$$E = \frac{q_u}{q_n} \times 100$$

$$CR = (1 - E) \times 100$$

where:

E = the emitter discharge efficiency, (%)

q_u = average emitter discharge, at the end of the growing season (Lh^{-1})
q_n = average emitter discharge, at the beginning of the growing season (Lh^{-1})
CR = the emitter clogging ratio, (%)

Statistical Analysis: All data collected were statistically analyzed as a plot design with nine replications using analysis of variance to evaluate main and interaction effects as described by **(Snedcor and Cochran (1982).** Means among treatments were compared using Least Significant Difference (LSD) at P 0.05 probability.

RESULTS AND DISCUSSION

1-Emission uniformity (EU %)

1-1Effect of emitter type on EU

Fig (2) reveals that the emission uniformity (EU %) determined at the beginning of the experiments were 90.94%, 95.16%, 97.91% and 98.05% for no fertilizer treatment (F_0) at (D_1q_1), (D_1q_2), (D_2q_1), and (D_2q_2) respectively. At the end of the season the above EU percentages were 84.62, 90.14, 92.90and 94.6٧ respectively. So, the EU for pressure compensated emitters was slightly reduced, while in normal emitters EU decreased significantly by the end of the season. Larger discharge emitters (4 Lh^{-1}) show better EU than low discharge emitters (2 Lh^{-1}).

1-2 Effect of fertigation components on EU

The obtained data, for one growing season, indicated that the effect of fertilizers treatments on EU, can be summarized in average of all types of emitters as: 92.55%, 89.96%, 91.23%, 89.000%, 90.29%, 89.54% for the fertilizer treatments of: F_0, H, N, S, H+N, and H+S, respectively. It could be concluded that using humic fertilizer either separately or mixed with ammonium nitrate or sulfate reduced EU by about 3.55% compared with the no fertilizers treatment.

1-3 The interaction effect of fertigation components and emitter type on emission uniformity EU

The interaction effect of emitter type and fertigation components on EU, shows that , at the end of season, (after 180 days) the maximum values of average EU were 95.99% and 95.53%under D_2q_2 with the treatments of (F_0) no fertilizer and (N) ammonium nitrate ,respectively ,while the minimum values of average EU were 84.58, 84.92 % and 85.31% as observed under normal emitters low discharge drippers (D_1q_1) with ammonium sulfate, (S), humic + ammonium sulfate (H+S) and humic (H) fertilizer treatments, respectively.

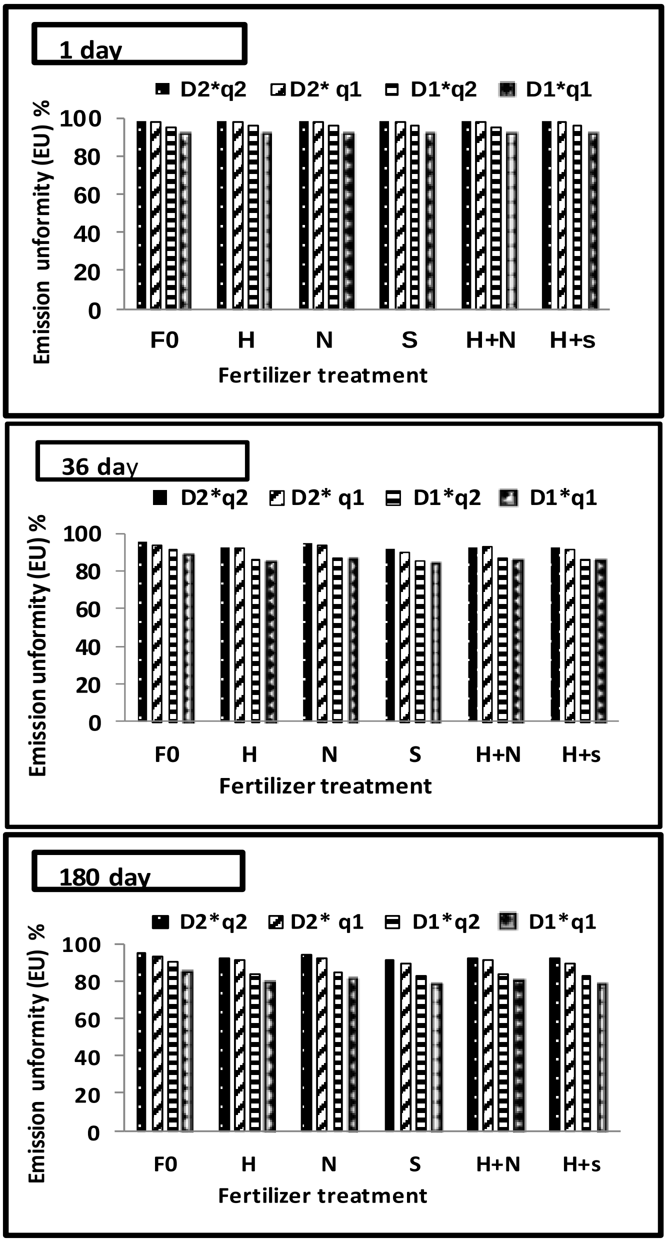


Fig (2): Emission Uniformity (EU) % for normal and pressure compensated (pc) drippers of 2l Lh^{-1} and Lh^{-1} discharge with different fertilizer treatments.

2- Clogging ratio of Emitters (CR %)

2-1 Effect of emitter type on (CR%)

Data of clogging ratio of emitters are given in Figs. (3, 4, 5 and 6) as affected by emitter type and discharge**.** The obtained data show that the normal emitters (D_1) with 2 Lh^{-1} discharge (q_1) increased significantly the clogging percent under all fertilizer treatments compared with the larger discharge (4 Lh^{-1}) for the same emitter type (D_1q_2). The Pressure Compensated Emitters (D_2) of both 2 Lh^{-1} and 4 Lh^{-1} discharge resulted in less clogging ratio than normal emitters. In general, differences in clogging percent among the emitters used were significant at 5% level.

2-2 **Effect of fertigation components on (CR%)**

Data of clogging ratio of emitters as given in Figs. (3, 4, 5 and 6) show that, the highest and lowest at clogging ratios were 21.91% and 7.93% recorded with the treatments of (S) and (F_0) under the irrigation treatments D_1q_1 and D_2q_2, respectively.

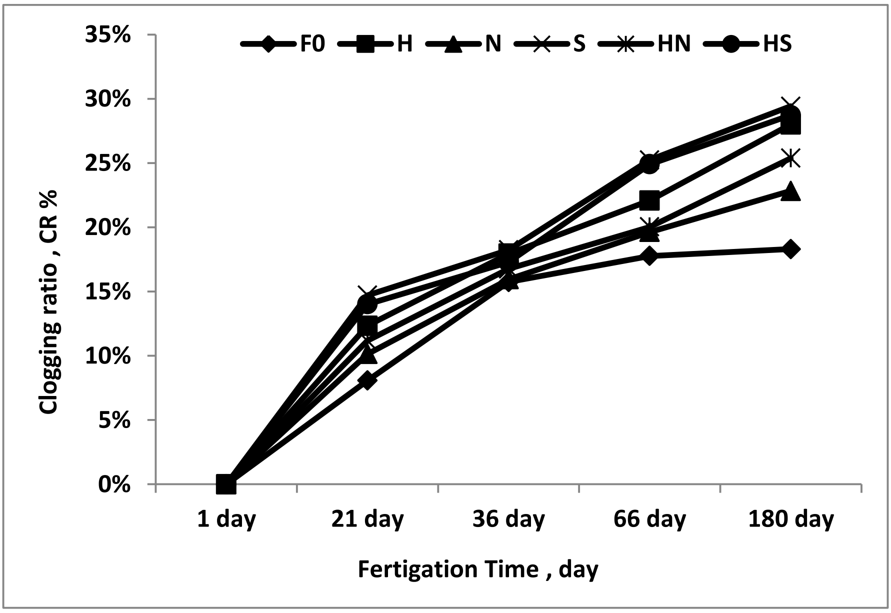


Fig. (3): Effect of fertilizers components on clogging ratio (CR %) of 2 Lh^{-1} normal emitters during 6 months fertigation.

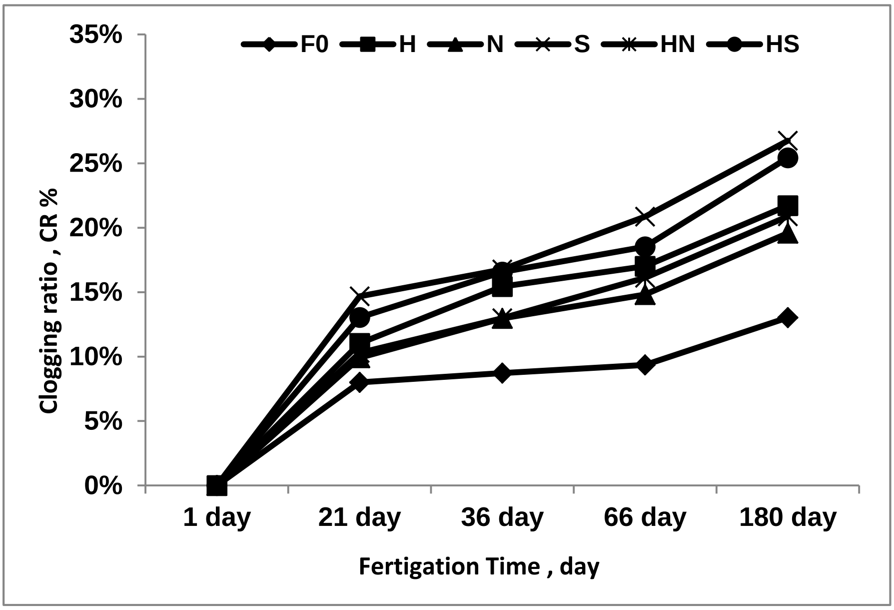


Fig. (4): Effect of fertilizers components on clogging ratio (CR %) of 4 Lh^{-1} normal emitters during 6 months fertigation.

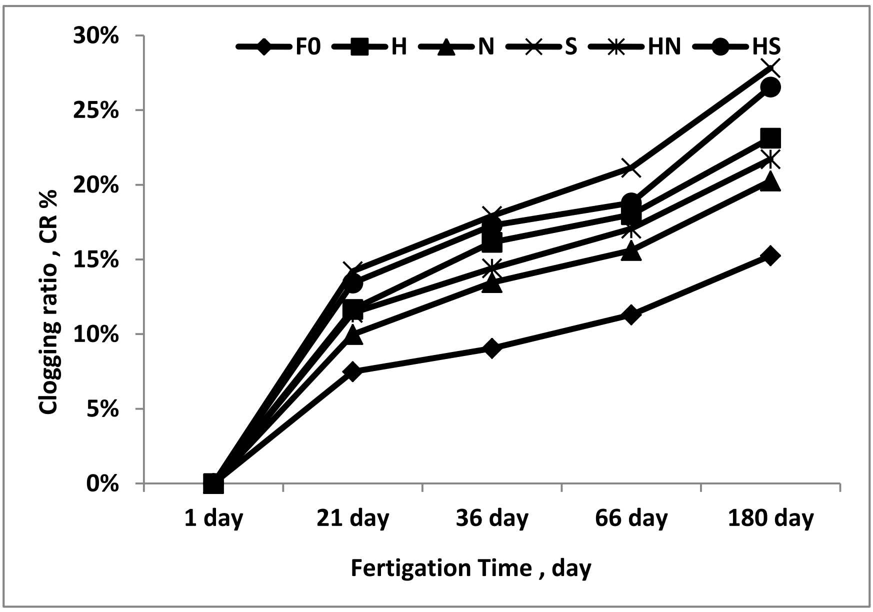


Fig. (5): Effect of fertilizers components on clogging ratio (CR %) of 2 Lh^{-1} pc emitters during 6 months fertigation.

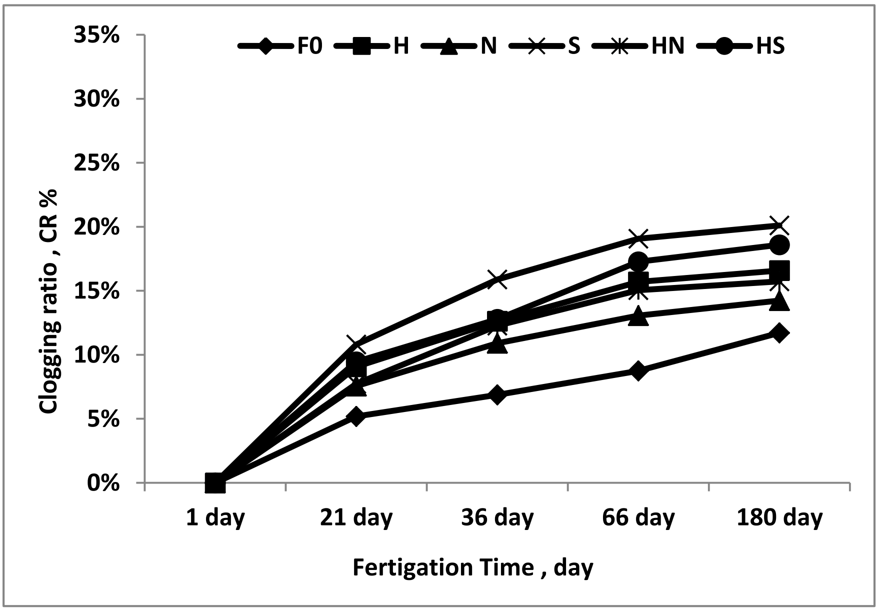


Fig. (6): Effect of fertilizers components on clogging ratio (CR %) of 4 Lh^{-1} pc emitters during 6 months fertigation.

Furthermore, emitters clogging significantly increased due to application of humic acid and different nitrogen fertilizer sources applied with irrigation water, It could be seen that the highest values of average clogging ratios were 14.98, 20.10, 17.14, 21.91, 18.34 and 21.24 % with F_0, H, N, S, H+N and H+S, respectively, at 2 L h^{-1} emitter discharge for normal emitter type, while, the least values of the average clogging ratios were 7.93, 13.49, 11.44, 16.46, 12.70 and 14.52 % with F_0, H, N, S, H+N and H+S, respectively, at 4 Lh^{-1} emitter discharge for pressure compensated emitter type.

The increase in emitters clogging percent may be attributed to the precipitating effect of SO_4^{2-} in the applied ammonium sulfate fertilizer on both Ca^{2+} and Mg^{2+} found in irrigation water within the emitters narrow opening after water evaporation. Also Iron reaction with humic organic complexing agents are also important in emitters clogging with drip irrigation system, the complexes formed between iron and tannins or humates are more stable at high pH than at lower pH levels, because acids decrease pH and increasing availability of micro elements Fe,Mn,Zn, Cu. The results obtained agree well with those of **PIPARS (2009)**.

2-3 Effect of time on (CR%)

Following up the changes of emitters clogging with time intervals up to 180days as illustrated in Figs. (3, 4, 5and 6) indicates significant increase with time. In this respect, emitters clogging tended to increase with time up to 180 days with all treatments. The clogging ratios with time intervals could be ranked as following: 180 days > 66 days > 36 days > 21 days > 1 days.

3- Effect of interaction between emitters' types and fertigation components on (CR%)

The least emitters clogging percent was detected with 21 days and the highest one with 180 days as revealed by the treatment D_1q_1. The maximum average clogging value (25.45%) occurred at the end of the season with the normal dripper of 2 Lh^{-1} discharge (D_1q_1) and the minimum average value (8.30%) was found with 4 Lh^{-1} pc emitters (D_2q_2), respectively.

Difference in clogging percent between any two factor i.e. Normal and Pressure Compensated (pc) drippers of 2 Lh^{-1} and 4 Lh^{-1} discharge with different fertilizer treatments were significant at the 5% level. The effect of fertilizer components of the applied fertilization treatments increased the clogging ratio by different degrees especially at the end of the season with the low discharge normal emitters (D_1q_1) compared with no fertilizer (F_0) and PC emitters.

CONCLUSION

In this study, emission uniformity (EU%) was significantly decreased due to the different nitrogen fertilizers with irrigation water during periods of days beginning from first day up to 180days. The maximum values of average EU % were 95.99, and 95.53 respectively at $D_2q_2 \times F_0$, and $D_2q_2 \times N$ .The minimum values of average EU % were 84.58, 84.92 and 85.31 respectively at $D_1q_1 \times S$, $D_1q_1 \times H+S$ and $D_1q_1 \times H$, respectively.

Based on the results, emitters clogging percent was lowest (8.30%) with 21 days and the highest (25.45%) was obtained at 180 days under treatment of $D_1 \times q_1$.The main effects of treatments used on clogging percent could be arranged in the following ascending order: $D_2q_2 < D_2q_1 < D_1q_2 < D_1q_1$.

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الملخص العربى

تأثير إدارة الرى التسميدى على أنتظامية التوزيع والأنسداد للنقاطات الخارجية

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أقيمت التجربة الحقلية بقسم بحوث الأراضى والمياه- هيئة الطاقة الذرية بهدف دراسة تأثيرنوع وتصرف النقاط الخارجى للرى بالتنقيط وكذلك نوعية المركبات السمادية من الأسمدة النيتروجينية المعدنية والعضوية على انتظامية توزيع المياه ونسبة انسداد النقاطات تحت نظام الرى بالتنقيط فى الارض الرملية ولتحقيق هذا الهدف تم دراسة نوعان من النقاطات وهما النقاط العادى (D_1) والنقاط منظم الضغط (D_2) مع نوعان من التصرف وهم ٢لتر/ساعةَ (q_1) و ٤لتر/ساعه (q_2) مع معاملات مختلفة من الأسمدة النتروجينية هما (سماد سلفات الامونيوم (S) و سماد نترات الامونيوم (N)) وأسمدة عضوية (حمض الهيوميك (H)) منفرده اومختلطة مع سلفات الامونيوم او نترات الامونيوم بنسبة ١:١ + معاملة كنترول بدون تسميد. وتم اضافة الاسمده مع مياه الرى من خلال الحاقن (الفنشورى) حسب المعدل الموصى به لنبات الثوم.

تم قياس نسبة انسداد النقاطات تحت الدراسة بعد كل تسميد عند بداية ١ يوم و ٢١ و٣٦ و66 يوم وفى نهاية موسم نمونبات الثوم ١٨٠ يوم .حيث اشارت النتائج انه تبعاً لنسبة الإنسداد ونسبة الانتظامية كان النقاط العادى ذوتصرف ٢لتر/ساعةَ أعلى فى نسبة الانسداد حيث وصلت الى % ٢٨.٧٢ و٢٩.٤٢% على التوالى تحت التسميد بسلفات الامونيوم والهيومك و سلفات الامونيوم وكانت هذه العناصرأيضا اقل نسبة فى الانتظامية مع النقاط العادى تصرف ٢ لتر/ ساعه حيث سجلت ٧٨.٠٤ % و٧٧.٤٠% على التوالى ، مقارنة بالنقاط منظم الضغط ذات التصرف٢ و٤لتر/ساعه حيث كان النقاط المنظم للضغط ذو تصرف ٤لتر/ساعة أعلى فى متوسط نسبة الانتظامية حيث كانت ٩٥.٩٩ % و اقل متوسط نسبة أنسداد ٧.٩٣ % وذلك تحت المعاملة بدون تسميد .وتشير النتائج أيضا أنه كانت اكبر فترة ظهر فيها تباين تأثير نوع النقاطات وتصرفاتها او نوع المركب السمادى سواء على انتظامية التوزيع او نسبة انسداد النقاطات هى ١٨٠ يوم فى نهاية الموسم.

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تشير البيانات أيضا أن نسبة الإنسداد و نسبة الانتظامية تأثرت بأنواع ومعدلات التسميد المختلفة حيث كانت أقل نسبة فى إنسداد النقاطات وأعلى فى نسبة الانتظامية هى المعاملة بنترات الامونيوم على الاطلاق حيث سجلت نسبة انسداد ١٤.٢٣ % تحت النقاط المنظم للضغط تصرف ٤ لتر / ساعة فى نهاية الموسم وكانت أعلى نسبة انسداد هى المعامله سلفات الامونيوم و سلفات الامونيوم مخلوط مع الهيومك والهيوميك تحت استخدام النقاط العادى مع التصرف ٢لتر/ساعةَ وأقل نسبة انتظامية هى النقاط العادى تصرف ٢ لتر / ساعة سجلت ٧٧.٠٤٣ % مع المعامله سلفات الامونيوم .