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Hydraulic Performance of Three Types of Imported Emitters Used in Drip Irrigation Systems in Sudan

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Abstract

Drip or Trickle irrigation system is designed to apply precise amount of water near the plant with a certain degree of uniformity. This study was conducted at the Experimental Farm of the Faculty of Agricultural Sciences, University of Gezira, during March, 2018. The study was aimed to design and evaluate the hydraulic performance of drip emitters including: average discharge (Q_{avg}), discharge variation ($Q_{var\ \%}$), coefficient uniformity (CU %), coefficient of manufacture variation (CV %), distribution uniformity (DU %), statistical uniformity (Us %), clogging (%) wetted diameter (cm) and wetted depth (cm). Three emitters type were used under drip irrigation system namely regular gauges (RG), high compensating pressure (HCP) and low compensating pressure (LCP). The treatments were laid out in a randomized complete block design (RCBD) with three replications. Results showed that there were significant differences ($P \leq 0.05$) in all tested parameters except clogging, wetted diameter and wetted depth. Discharge variation ($Q_{var\ \%}$) values were 12.71, 15.57 and 19.17 for RG, LCP and HCP, respectively it consider quite good and found to be within the acceptable range. Results of coefficient of manufacture variation (CV %) were 10.9, 27.8 and 52.7 for RG, LCP and HCP, respectively it consider within the unacceptable range except RG type it's excellent. Statistical uniformity (Us %) values were 89.1, 72.2 and 45.7 for RG, LCP and HCP, respectively it consider good, acceptable and unacceptable, respectively. Results of coefficient of coefficient uniformity (CU %) were 91.3, 77.7 and 56.7 for RG, LCP and HCP, respectively it consider excellent, fair and unacceptable, respectively. Distribution uniformity (DU %) were 90.2, 67.9 and 36.5 for RG, LCP and HCP, respectively it consider excellent, poor and poor, respectively. Thus the study recommended regular gauges (RG) type emitters under the heavy clay soil conditions of the Gezira State, Sudan.

Keywords: Drip irrigation, uniformity, clogging.

Introduction

Drip irrigation is considered as the most efficient irrigation system, but there is proof from literature that this system can also be in-efficient, as a result of water quality, mismanagement and maintenance problems (Koegelenberg et al., 2003). Drip irrigation system is designed to apply precise amount of water near the plant with a certain degree of uniformity. The uniformity describes how evenly an irrigation system distributes water over a field. It is regarded as one of the important features for selection, design, and management of the irrigation system (Mirjat, et al., 2010). Emitter plays a crucial role in system performance and the hydraulic performance significantly affected by the optimum selection of emitters, lateral diameter and length, ideal manufacturer's coefficient of variation (CV%), and pressure variations (Bush, 2016). In drip irrigation system, water is delivered precisely through the emitters. The capacity of the emitters available in the market varies from 2 to 16 lph. These are categorized as pressure and non-pressure compensating (Sharma, 2013). There are several basic types of water delivery devices unique to micro-irrigation. They are designed to discharge water at low flow rates through small openings. The application rate of water is very small and slow, thus the name trickle or drip. The discharge rate per emitter is usually given in US gallons per hour or litres per hour (ranging from 0.5 to 25 gph or from 1.0 to 4.0 lph). Operating pressure ranges between two and 60 psi depending on the type of emitter. Emitters can also be pressure-compensating, which means discharge rates remain relatively constant over a range of pressures (Saskatchewan trickle irrigation manual, 2011). Distribution uniformity (DU) is an indicator of the magnitude of the system's distribution problems (Awe et. al.; 2017). Al-Ghobari, (2007) in Saudi Arabia found that the irrigation performances are mostly lower than the accepted values for most evaluated systems and varied in their uniformities of the applied water. The causes of non-uniformity and low efficiency could be related to some factors such as, pressure variation in the system, in correct system design and emitter discharge variation. Husham and Al-shammari, (2014) evaluate some drip irrigation systems in Iraq by using dot T-Tape, GR and Turbo under the influence of operating pressure 20, 30, 40, 50 and 60 kPa. The results showed an increase in the rate of discharge emitters with operational pressure moral and all types of emitters. Mohamed Nour, et al., (2017) tested three types of emitters have the trade names of Turbo, Octa and Burrell. Results indicated that the Turbo and the Octa types of emitters are better than the Burrell type of emitter under the three operating pressures. The main objective of this work to study the hydraulic performance of three types of emitters in drip irrigation system under clay soil condition, Sudan.

Materials and Methods

Experiments were carried out during the winter seasons of 2014/15 (first season) and 2015/16 (second season) at the experimental farm, University of Gezira. It lies north of Wad Medani town, Lat. 14° 06` N, Long. 33° 38` E and altitude of 405 masl. The soil is Vertisol, with a high CEC, a pH of 7.5 and alkaline with low permeability (Alhilo, 1996). The experiment was laid out in a RCBD with four replicates. The main objective of this work to study the performance of three types of emitters (regular gage (RG), high pressure compensated (HPC) and low pressure compensated (LCP)) under Gezira clay soil condition. The performance parameters evaluated include: average discharge (Q_{avg}), discharge variation ($Q_{var\%}$), coefficient of manufacture variation (CV%), statistical uniformity (Us %), coefficient uniformity (CU %), distribution uniformity (DU %), clogging (%), wetted diameter (cm) and wetted depth (cm) as described below:

Discharge measurement

Average discharge rate was measured using graduated measuring cylinder, catch cans and stopwatch. The model was lifted to work for 15 minutes, and then the collected water in catch cans measured. The test was repeated three times to get the average volume in liter. The average volume divided by time, to obtain the discharge (q) l/hr (Eq. 1).

$$\mathbf{q = V/t} \quad \text{...} \quad (1)$$

Where:

q = Discharge (L/h)

V = Volume collected (ml)

t = Time taken (hours)

Discharge variation (Q_{var})

Flow variation is also a design parameter to evaluate a trickle lateral design. The defining equation for flow variation is

$$\mathbf{q_{var} = (q_{max} - q_{min})/q_{max}} \quad \text{.........................} \quad (2)$$

Where:

q_{var} = Flow variation

q_{max} =maximum emitter discharge rate in system (l/h)

q_{min} =the lowest emitter discharge rate in system (l/h)

General criteria for Q_{var} values are 10% or less (desirable) and 10 to 20% acceptable and greater than 25%, not acceptable (Guguloth, 2016).

Coefficient of manufacture variation (C_V %)

The CV can be calculated, using the following formula (Burt and Styles, 2007).

$$\mathbf{CV\% = Sq/q_{avg}} \quad \text{...........................} \quad (3)$$

Keller and Bliesner (1990) represented localized irrigation sub-units classification according to coefficient of variations as presented in Table (1).

Table 1. Classification of coefficient of variation

Coefficient of variation, C_v	Classification
> 0.4	Unacceptable
0.4 – 0.3	Low
0.3 – 0.2	Acceptable
0.2 – 0.1	Very good
< 0.1	Excellent

Uniformity coefficient (CU %)

One of the widely used CU is Christiansen uniformity coefficient. Uniformity coefficients of emitters were tested using the Christiansen's formula (1942). It gives the information that how efficiently water is distributed in the field.

$$\mathbf{CU = 100 - (80*Sd/V_{avg})} \quad \text{..................} \quad (4)$$

Where:

CU = Uniformity coefficient (%),

Sd = Standard deviation of observations,

V_{avg} = Average volume collected.

The coefficient of uniformities and classifications is presented by (ASABE standards EP458, 1999) in Table 2.

Table 2. Classification/standards of uniformity coefficient

Uniformity coefficient, Cu (%)	Classification
Above 90%	Excellent
90 – 80%	Good
80 – 70%	Fair
70 – 60%	Poor
Below 60%	Unacceptable

Emitter flow uniformity or (DU)

Distribution uniformity (DU) was computed according to Keller and Karmeli (1974):

$$\mathbf{DU\ (\%) = (q_{avg25\%}/\ \bar{q})*100} \quad \text{................} \quad (5)$$

Where:

q_{avg25}% = mean of the lowest 0.25 of emitter discharge.

$\bar{q}$ = average emitter flow rate (L/h).

According to Merriam and Keller (1978), the classifications of distribution uniformities are expressed in Table 3.

Table 3. Classifications of emission uniformity

Eu (%)	Classification Merriam and Keller (1978)
<70%	Poor
70 – 80%	Acceptable
80 – 86%	Good
86 – 90 %	Good
90 – 94%	Excellent
>94%	Excellent

Statistical uniformity (Us %)

Statistical uniformity between the emitters is determined by Eq. (6) (Bralts and Kesner 1983).

Us= 100 (1 – Sq/q¯) …………………….(6)
Where:
Us= statistical uniformity (%)
Vq = overall change in emitters discharge
Sq = standard deviation of emitters discharge (l/h)

Statistical uniformity is evaluated according to ASAE (2003) based on the classification criterion presented in Table 4.

Table 4. System classification according to statistical uniformity values

Us (%)	Classification
<60	Un acceptable
60 – 70	Poor
70 – 80	Acceptable
80 – 90	Good
>90	Excellent

Clogging (%)

Percentage of completely clogged emitters (Pclog) was calculated as:

Pclog =100 *(Nclog/ N) ………………. (7)

Where:

Nclog, N = number of completely clogged emitters and the total number of emitters in experimental manifold, respectively

Wetted diameter (cm)

The wetted diameter in the soil surface for each emitter's type was measured, using a ruler.

Wetted depth (cm)

Pits were dug for measuring the wetted depth of the soil profile. Nine random pits were dug for each emitter's type.

Statistical analysis

Analysis of variance appropriate for complete randomized block factorial design was applied by using Statistics 8.

Results and Discussion I

Discharge (l/h)

Discharge (l/h) of the three emitter's type is shown in Table (1). There were highly significant differences (P≤0.01) in discharge (l/h) among emitters type. Comparing the measured results in the network at three emitters type the difference in the discharge between the emitters along and between the laterals is showed in Fig. 1. It shows the effect of emitter's type on emitter discharge along the lateral length. From this Figure it is seen that RG and HCP emitter discharge had a same trend. The discharge rates from the emitters ranged between 2.44 and 11.56 L/h. The largest discharge value was obtained by LCP emitter, followed by HCP the least by RG. Mofoke *et al.* (2004) stated that the general variability in discharge could be attributed to major and minor losses occurring at the delivery pipe joints and fittings right from the supply tank to the emitters.

Discharge variation (Q_{var})

Average discharge variation (Q_{var}) was significantly (P≤0.01) influenced by the emitter's type (Table 1). RG emitter's had significantly lower Q_{var} than LCP and HCP. The general criteria Q_{var} values are ≤10%, desirable; 10-20%, acceptable; and > 20% is not acceptable. Manisha and Tripathi (2015) stated that the discharge flow rate of emitter is increased when the increase of the pressure and the coefficient of variation is increased when the pressure is decreased means the pressure directly affected the discharge rate of emitter.

Coefficient of variation (CV %)

The coefficient of variation was significantly (P ≤0.05) affected by the emitters type Table

(2). For RG type the coefficient of variation was found to be less than 20 % (Excellent) whereas the coefficient of variation of LCP and HCP type were found to be more than 20 % (unacceptable). On the other hand, HCP emitters recorded highest values of coefficient of variation (CV %), while RG emitter and LCP revealed the lowest one (Table 2). The average values of CV% for RG emitters were generally low and according to American Society of Agricultural Engineering recommended classification of coefficient of global variation in discharge; these values are below the 10% threshold as 'good'. These results were in line with those obtained by Halil *et. al*., (2004) who found that non-compensating emitters widely used in the region had very high manufacturer's variations that are classified as unacceptable. Also, Muharrem *et. al*., (2010) determined that emitter coefficient of variation varied in the ranges of 0.43 and 0.63, 0.43 and 0.69, 0.48 and 0.58, 0.56 and 0.73 for unused emitters, for one year, for two years and for three years used emitters.

Statistical uniformity (Us %)

The statistical uniformity was significantly (P≤0.05) affected by the emitters type Table (2). It shows the statistical uniformity for RG and LCP types of emitters fell within the acceptable range but the statistical uniformity for HCP type fell within the unacceptable range as specified by Michael (1978). Zamaniyan (2014) reported that performance of micro irrigation systems in Iran is low and poor, the average distribution uniformity, statistical uniformity, and coefficient of variation values in different sites were 52.8, 61.3, and 38.2%, respectively. Most frequent problems detected in irrigation units were: inadequate working pressure and emitters clogging.

Uniformity coefficient (CU %)

Uniformity coefficient was significantly (P≤0.05) affected by emitters type (Table 3). The highest uniformity coefficient value of 91.3 % (Excellent) was observed at RG emitters and the lowest uniformity coefficient value of 56.7 (Unacceptable) was observed in HCP. Tagar *et. al.,* (2010) found that the pressure compensated emitters perform better and manage the pressure losses at different locations along the laterals length, hence could be preferred over micro tube emitters. Also, Alamin (2017) reported that the types of emitters and operating pressures have a clear effect on the performance of drip irrigation system. Shareef *et. al.,* (2016) found that the emitter type and water quality are the main factors affecting the hydraulic performance of drip irrigation systems.

Distribution uniformity (DU %)

Distribution uniformity was significantly (P≤0.05) affected by emitters type (Table 3). The highest distribution uniformity value of 90.2 % (Excellent) was observed at RG emitters and the lowest distribution uniformity value of 36.5 (Poor) was observed in HCP. According to the classification of irrigation system performance by ASAE, a CU rating of 90 - 95% is considered excellent and the system would only require regular maintenance, while a distribution uniformity of 85% or greater is considered excellent. In this study, the average values of both CU and DU at RG emitters were high, indicating that the system performance was excellent. The reduced uniformity coefficient in HCP is due to high variation in flow rates. The results also agreed with the results obtained by Bush (2016) who revealed that uniformity of water application in drip irrigation system was significantly affected by emitter type. Charles (2004) reported that approximately 45% of the non-uniformity was due to pressure differences, 52% was due to "other causes", 1% due to unequal drainage, and 2% due to unequal application rates. The data show that with good design and management, it is possible to have high system DU values for at least a 20-year system life.

Clogging (%)

Table (4) and Fig. (2) shows the clogging (%) for the three types of emitters under test. The analysis of data showed that there were no significant differences between emitters type on clogging (%).

Wetted depth (cm) and wetted diameter (cm)

Table (4) and Fig. (2) show the wetted depth of the soil profile for the three types of emitters under test. The analysis of data showed that there were no significant differences between emitters type.

Conclusions

The values of hydraulic performance of drip irrigation system under three type of emitters, including: discharge variation, coefficient of manufacture variation, statistical uniformity, coefficient uniformity, distribution uniformity, and were quite good and found to be within the acceptable range for RG type followed by LCP and HCP.

Recommendations

From the results obtained and conclusions drawn from this study the following recommendations can be made: RG is the best one of emitter's type because it has the highest hydraulic performance as compared other emitters in condition in Gezira state Sudan.

References

Al-Ghobari. H. M. 2007. Field evaluation of drip irrigation systems in Saudi Arabia WIT Transactions on Ecology and the Environment, Vol 103, © 2007 WIT Press Water Resources Management IV-583- 592.

Awe, G.O., T.P. Abegunrin, J.O. Ojediran, and O.O. Oyetoro. 2017. Performance evaluation and characterization of wetted soil parameters of improvised med emitters installed in a drip irrigation tomato field. International Journal of Environment, Agriculture and Biotechnology (IJEAB). Vol-2, Issue -1. pp 319-328.

Charles M. B. 2004. Irrigation and Drainage Systems 18: 275–297, 2004. Kluwer Academic Publishers. Printed in the Netherlands. Rapid field evaluation of drip and micro spray distribution uniformity.

Elamin, A.W.M., A. M. Abd Eldaiam, N.A. Abdalla, and M.E. Hussain. 2017. "Hydraulic performance of drip irrigation system under different emitter types, and operating pressures using treated wastewater at Khartoum state", International Journal of Development and Sustainability, Vol. 6 No. 9, pp. 1086-1095.

Guguloth. P 2016. Hydraulic performance evaluation of drip irrigation system for cabbage (Brassica oleracea L). M.Sc Thesis. Professor Jaya Shankar Telangana State Agricultural University.

Halil K.; E dogan; S. Demir. and S Yaslin .2004. Determination of Hydraulic Performance of Trickle Irrigation Emitters used in Irrigation Systems in the Harran Plain. IOSR Journal of Agriculture and Veterinary Science (IOSR-JAVS). ISSN: 2319-2380, ISBN: 2319-2372. Volume 2, Issue 1, pp. 15-20. www.iosrjournals.org.

Keller J and D. Karmeli 1975. Trickle Irrigation Design. Rain Bird Sprinkler.

Manufacturing Corporation Glendora, California, U.S.A, pp.1–5, 17–18: 46–49

Keller. J and D. Karmeli 1974). Trickle irrigation design parameters. Transaction of the ASAE. 7.678-684.

Koegelenberg, F.H., F.B. Reinders, A.S. van Niekerk, R. van Niekerk and W.J. Uys. 2003. Performance of surface drip irrigation systems under field conditions. ARC-institute for agricultural engineering.Water Research Commission, 2003. WRC Report No.1036/1/02. ISBN No. 1-86845-973-X.

Manisha, J. S. and M.P. Tripathi. 2015. Studies on hydraulic performance of drip irrigation system under different operating pressure. International Journal of Applied Engineering and Technology ISSN: 2277-212X (Online). An Open Access, Online International Journal Available at http://www.cibtech.org/jet.htm 2015 Vol. 5 (2). pp. 58-63.

Merriam. J. L and J. Keller 1978. Farm irrigation system evaluation: A guide for management. Logan: Agricultural and irrigation engineering department, Utah State University. pp. 120 – 130.

Mirjat M. S.; M. U. Mirjat and F. A. Chandio. 2010. Water distribution pattern, discharge uniformity and application efficiency of locally made emitters used in a trickle subunit. Pakistan Journal of Agricultural. Agriculture Engineering. Veterinary. Sciences, 26 (1): 1-15.

MohamedNour, M. M; A. E. Mohamed, A. M. Abdellah and H. I. Elnazeer. 2017. Assessment of Field Performance of Three Types of Non-Pressure Compensating Drip Irrigation Emitters. Journal of Multidisciplinary Engineering Science and Technology (JMEST) ISSN: 2458-9403 Vol. 4 Issue 3.

Muharrem, Y. Y., K. Demırel, O. Erken, E. Bahar and M. Devecıler. 2010. Emitter clogging and effects on drip irrigation systems performances. African Journal of Agricultural Research Vol. 5 (7), pp. 532-538. Available online at http://www.academicjournals.org/AJAR. ISSN 1991-637X © 2010 Academic Journals.

Sharma. P 2013. Hydraulic performance of drip emitters under field condition. (IOSR-JAVS) ISSN: 2319-2380, ISBN: 2319-2372. 2, : 15-20, www.iosrjournals.org

Tagar, A. A. M. S. Mirjat, A. Soomro and A. Sarki. 2010. Hydraulic performance of different emitters under varying lateral lengths. Pakistan Journal of Agricultural, Agricultural Engineering and Veterinary Sciences, 26 (2): 48-59. ISSN 1023-1072

Shareef, T. M. E; Amir B. Saeed, Ali W.M. Elamin and B. Zhao. 2016. Hydraulic Performance of Drip Emitters under Different Types of Emitters and Levels of water Salinity. Journal of Agri-Food and Applied Sciences Available online at jaas.blue-ap.org ©2016 JAAS Journal. Vol. 4(2), pp. 43-52.

Zamaniyan M., R. Fatahi, S. Boroomand-Nasab. 2014. Field performance evaluation of micro irrigation systems in Iran. Soil and Water Resources. 9: 135–142.

الاداء الهيدروليكى لثلاث انواع من النقاطات التجارية المستخدمة فى انظمة الرى بالتنقيط فى السودان

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المستخلص

نظام الرى بالتنقيط صمم من اجل مد النبات بكميات مياه محددة وبدرجة عالية من الانتظامية. اجريت الدراسة بالمزرعة التجريبية التابعة لكلية العلوم الزراعية ، جامعة الجزيرة فى مارس 2018م. هدفت التجربة الى تقييم الاداء الهيدروليكى لمنظومة الرى تحت ثلاث انواع من النقاطات التجارية المستخدمة فى السودان شمل التقييم كل من: متوسط التصرف (Q) و ومعدل التباين فى التصرف (% Q_{var}) و معامل التباين التصميمى (CV%) و معامل الانتظامية (% CU) ومعامل التوزيع (DU%) و الانتظامية الاحصائية (Us%) و نسبة الانسداد (Clog.%) وقطر وعمق البلل (سم). النقاطات هى: (RG) و (HCP) و (LCP) . تم وضع المعاملات فى نظام القطاعات العشوائية الكاملة بثلاث مكررات. اوضحت النتائج وجود فروق معنوية فى كل عناصر التقييم ماعدا نسبة الانسداد وقطر وعمق البلل. كانت قيم التصرف هى 2.44 و 3.18 و 11.06 لتر للساعة للنقاط (RG) و (HCP) و (LCP) على التوالى بينما كانت قيم (% Q_{var}) 12.71 و 15.57 و 19.17 للنقاط (RG) و (HCP) و (LCP) على التوالى وهذه القيم تعتبر جيدة وفى حدود المسموح به. اما قيم معامل التباين التصميمى (CV%) فهى 10.9 و 28.8 و 52.7 للنقاط (RG) و (HCP) و (LCP) على التوالى وهذه القيم تعتبر غير مقبولة ماعدا النوع (RG). الانتظامية الاحصائية (Us%) فهى 89.1 و 72.2 و 45.7 للنقاط (RG) و (HCP) و (LCP) على التوالى وهذه القيم تعتبر غير مقبولة ماعدا النوع (RG) والتى تعتبر جيدة. نتائج معامل الانتظامية (% CU) 91.3 و 77.7 و 56.7 وهذه القيم تعتبر جيدة و مقبولة وغير مقبولة للنقاط (RG) و (HCP) و (LCP) على التوالى. اما قيم معامل التوزيع (DU%) 90.2 و 67.9 و 36.5 للنقاط (RG) و (HCP) و (LCP) على التوالى وهذه القيم تعتبر غير مقبولة ماعدا النوع (RG) والتى تعتبر جيدة. لهذا توصى الدراسة باستخدام النقاط (RG) تحت ظروف الترب الطينية بولاية الجزيرة.

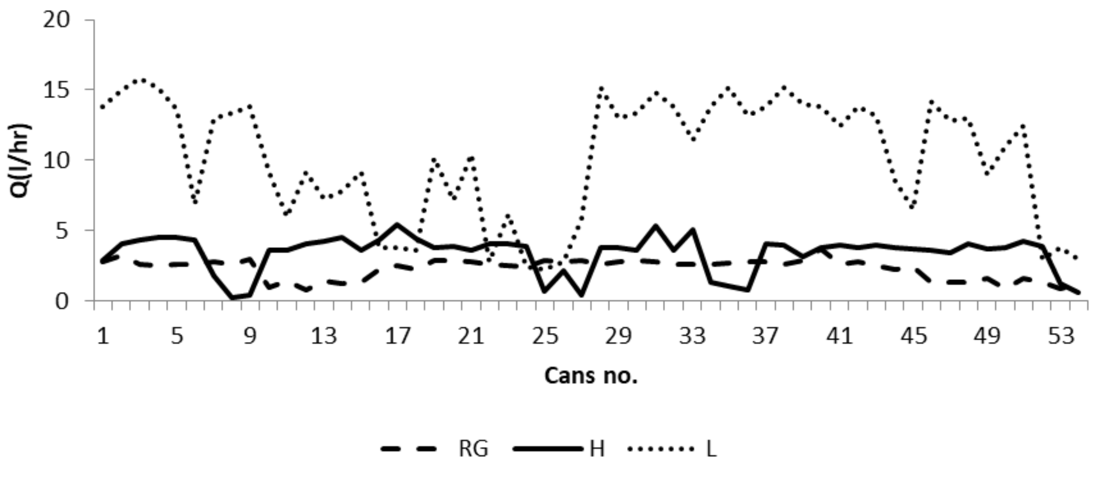

Fig. (1): Discharge (L/hr) by the three emitter's type.

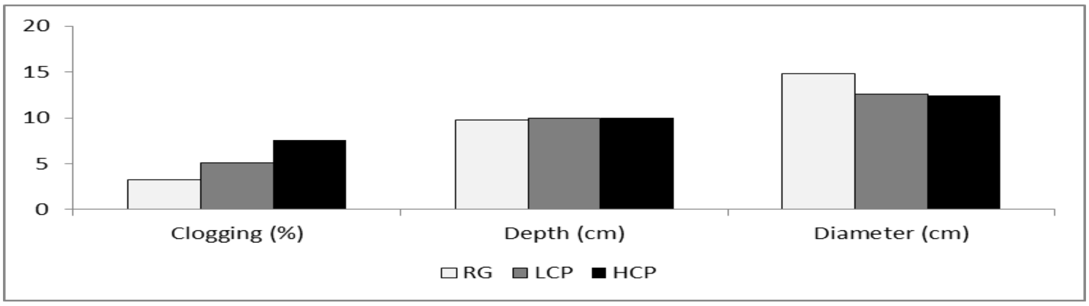

Fig. (2): Effect of emitter's type on clogging, wetted depth and wetted diameter

Table (1): Discharge (l/h) and discharge variation (Q_{var}) of emitter's type

Emitter type	Discharge (l/h)	Q_{var}
RG	02.44 b	2.71 c
LCP	11.06 a	5.57 b
HCP	03.18 b	9.17 a
CV%	30.67	1.68
SE±	0.7627	0.44
Sig. L	**	**
LSD	2.49	1.43

RG= Regular gage LCP= low pressure compensated HCP= high pressure compensated

Table (2): Coefficient of variation and statistical uniformity of emitter's type

Emitter type	CV%	Comment	Us%	Comment
RG	10.9 c	Excellent	89.1 a	Good
LCP	27.8 b	Unacceptable	72.2 b	Acceptable
HCP	52.7 a	Unacceptable	45.7 c	Unacceptable
CV%	32.06		14.22	
SE±	4.37		4.388	
Sig. L	**		**	
LSD	14.26		14.31	

Table (3): Uniformity coefficient and distribution uniformity of emitter's type

Emitter type	CU%	Comment	DU%	Comment
RG	91.3 a	Excellent	90.2 a	Excellent
LCP	77.7 b	Fair	67.9 b	Poor
HCP	56.7 c	Unacceptable	36.5 c	Poor
CV%	10.41		22.13	
SE±	3.5		6.39	
Sig. L	**		**	
LSD	11.42		20.84	

Table (4): Wetted depth and wetted diameter of emitter's type

Emitter type	Clogging (%)	Depth (cm)	Diameter (cm)
RG	3.40 a	9.8 a	14.8 a
LCP	5.87 a	10 a	12.6 a
HCP	7.93 a	10 a	12.4 a
CV%	5.70	7.47	8.54
SE±	0.19	0.33	0.38
Sig. L	N.S	N.S	N.S
LSD	0.74	1.08	1.24