

PERFORMANCE FIELD EVALUATION OF DRIP IRRIGATION SYSTEMS UNDER CONDITIONS OF THE DESERT REGION IN WESTERN IRAQ

SH.M.Al-Mehmdy¹

M.A.Abood²

B.A.A.H.Alkhateeb¹

Assis. Prof

Assis. Prof.

Assis.Prof

¹ Department of Soil Sci. and Water Resources, College of Agri. Univ. of Anbar / Iraq.

² Department of Soil Sci. and Water Resources, College of Agri. Univ. of Diyala / Iraq.

ABSTRACT

A field experiment was carried out at Al-Saqlawiya township Al-Anbar governorate at north in latitude 33°24'57" and east longitude 43°41'23", during period from 15/10/2018 to 15/1/2019 in order to evaluate the performance of 5 units of surface drip irrigation system, components and periods of use, by the steps recommended by the American Agriculture Engineers Association, at 50 kPa operational pressure. Results showed that there was a disparity in values of emitters actual discharge, uniformity coefficient, emission uniformity and variation percent of discharge. Although the similarity of most measurement conditions such as land area, design, management and the operational pressure except of the periods of using these systems which ranged 2-5 years. The decrease percent of actual discharge values 8.06%, 8.74%, and 19.04% when comparing the actual discharge for the system 1 with the values of systems 2,3 and 4, respectively. While the increase percent of the actual discharge value reached 29.74% when comparing of system 1 with system 5. Uniformity coefficient of system decreased were 5.32%, 19.95%, 3.81% and 7.21%, respectively, and 10.73%,37.25%,7.51% and 14.36% for the decrease percent of emission uniformity comparing the system 1 with the systems 2, 3, 4 and 5, respectively, as for the increase percent for the variation emitters discharge, it were 7.70%, 118.73%, 7.70%, respectively. Non- compliance of users of these systems with regular maintenance of the end of agriculture seasons, poor storage conditions, not maintained at high temperature or cold conditions and increase use periods, all had caused the expansion of emitters' holes, which affected negatively in some values of the followed evaluation standard.

Key Words: Evaluation, uniformity coefficient, emission uniformity discharge variation

تقييم نظم الري بالتنقيط حقلياً تحت ظروف المنطقة الصحراوية غرب العراق

بسام الدين الخطيب هشام الخطيب¹
أستاذ مساعد

محمد علي عبود²
أستاذ مساعد

شكر محمود حسن المحمدي¹
أستاذ مساعد

¹ قسم علوم التربة والموارد المائية – كلية الزراعة – جامعة الأنبار – العراق

² قسم علوم التربة والموارد المائية – كلية الزراعة – جامعة ديالى – العراق

المستخلص

نفذت تجربة حقلياً في ناحية الصقلاوية – محافظة الأنبار – العراق وعلى دائرة عرض 33° 24'57" شمالاً وخط طول 43°41'23 شرقاً للمدة من 15/10/2018 لغاية 15/1/2019 لتقييم خصائص أداء نظم الري بالتنقيط السطحي ومكوناتها ومدد استعمالها ، إذ تم اجراء التقييم الحقلي لخمس منظومات ري بالتنقيط ، من خلال الخطوات الموصى بها من قبل جمعية المهندسين الزراعيين الامريكية ، عند ضغط تشغيلي قدره 50 كيلو باسكال ، بينت النتائج وجود تفاوت في قيم كل من التصريف الفعلي للمنقطات وقيم معامل التناسق وتناسق الانبعاث ونسب التغيرات في التصريف ، بالرغم من تشابه غالبية ظروف القياس من مساحة الارض والتصميم والادارة والضغط التشغيلي ، عدا الاختلاف في مدة استعمال هذه الانظمة التي تراوحت بين سنتان وخمس سنوات، اذ بلغت نسب الانخفاض في قيم التصريف الفعلي 8.06% ، 8.74% و 19.04% عند مقارنة قيمة التصريف الفعلي للنظام رقم 1 مع قيم الانظمة 2 ، 3 ، 4 ، حسب التتابع. فيما بلغت نسبة الارتفاع في قيمة التصريف الفعلي 29.74% ، عند مقارنة قيمة النظام رقم 1 مع النظام رقم 5 .وبلغت نسب الانخفاض في قيم معامل التناسق 5.32% ، 19.95% ، 3.81% و 7.21% ، حسب التتابع فيما كانت نسب الانخفاض لتناسق الانبعاث 10.73% ، 37.25% ، 7.51% و 14.36% عند مقارنة القيمة للنظام رقم 1 مع القيم للأنظمة 2 ، 3 ، 4 و 5 ، حسب التتابع ، اما نسبة الارتفاع لقيم التغيرات في تصريف المنقطات فقد بلغت 7.70% ، 118.73% ، 7.70% و 20.23% ، حسب التتابع. وان عدم التزام مستعملي هذه الانظمة بالصيانة الدورية في نهاية موسم الزراعة وكذلك ظروف الخزن السيئة وعدم المحافظة عليها في درجات الحرارة المرتفعة وظروف البرودة وزيادة مدد الاستعمال جميعها قد سببت انسداد او توسع فتحات المنقطات مما اثر ذلك سلباً في بعض معايير التقييم المتبعة.

الكلمات المفتاحية: تقييم، معامل التناسق ، تناسق الانبعاث ، تغيرات التصريف

INTRODUCTION

The problems of limited available water for agricultural purposes in Iraq and particularly in Al-Saqlawiya, Al-Anbar, are considered of the main issues that challenge the water resources planners and the researchers. The demand for water for agricultural purposes has increased significantly last years, especially that the agricultural sector has become one of the biggest sectors consuming water. Studies have shown that the water allocated for irrigation purposes is not exploited properly due to the increase of water losses percent as well as the poor usage for these resources. The attention of using the modern systems has increased in order to rationalize the water use and to reduce the demand. Subsequently, the use of drip irrigation systems has increased in the agricultural fields and greenhouses of most of Al-Saqlawiya areas, which led to import big amount of the components of drip irrigation systems different companies with non-standard specifications. The use of these components available in markets which often come without data or specification from their companies, in addition to the lack of sufficient expertise by their manufacture resulting in significant reduction in their design standards, and an increase in the costs of their maintenance and management. (5) have found that there was a variation in the actual emitters discharge at their design discharge with a differences in water distribution rates along the emitters deployed on the distribution line. (16,17,18) showed that the emitters and emitters tubes are often made from polyethylene, and when they are put on ground they are affected by the climate conditions such as temperature and cool, where this effects on the hydraulic properties of the emitters. (4) indicated in a study, that the energy loss may sometimes reach 30% from the total loss as a result of protrusion in the emitter that may encounter the route of water flowing. Whereas (11), and (15) showed that emitters sensitivity for clogging is one of (20) classified the variation value of discharge to preferable when its equal to 10% acceptable when its 10 to 20% and not acceptable if it exceeds 20%. (3) obtained the best values for

the most important considerations when choosing the emitters with different characteristic, and they described the emitters according to their ability for clogging, so when their holes diameters is bigger than 0.7 mm they are very clogging – sensitivity, when the diameter is ranged between 0.7 to 1.5 mm they are sensitive, while they are not sensitive relatively when the diameter of their holes is bigger than 1.5 mm. (14) indicated that the poor design for system and the not responsible maintenance and management result in irregular emitters discharge, and that's a result of many factors such as the hydraulic difference. The same researchers above showed that the hydraulic differences along the emitters line are affected by the slope, length and diameter of the tube as well as the relationship between the applied operational pressure and emitters discharge. Also they indicated that the uniformity coefficient depends on the variable properties of system that are shown at the evaluation. (1) have obtained the actual discharge 4.00, 4.43 and 4.81 L h⁻¹ when using operational pressure from 50, 70 and 100 kPa by using emitters whose design discharge 4 L h⁻¹. The actual discharge percent increased 10.75% and 20.25% for 70 and 100 kPa depended values above by the effect of operational pressure 50 kPa with the 70 and 100 kPa, respectively, (3) indicated that the 50 kPa operational pressure is the best to operate the irrigation system, where an actual discharge of 3.94 L h⁻¹ was obtained and it's the nearest to the design discharge 4 L h⁻¹. (8) noted that the regularity of irrigation water to the plant by drip irrigation system has a big significance for design and operating the system. (10) found that the most factor effective in the regularity of irrigation water exiting the emitters is the variation in pressure regulators used in the system and the sensitivity of these emitters to change in pressure and temperature.

uniformity coefficient, emission uniformity and percent of discharge variation, when they were about 96.77, 96.69 and 9.64%, respectively, at 50 kPa operational pressure and emitters whose 4 L

h^{-1} discharge. Whereas (19) classified the value of uniformity coefficient as follow: $UC > 90\%$ is "excellent", $80\% < UC < 90\%$ "good" , $70\% < UC < 80\%$ "satisfactory" , $60\% < UC < 70\%$ is "poor" and $UC < 60\%$ is " not acceptable". (12) have defined the emission uniformity as in another alternative criterion, were it represents the ratio between the rate of the minimum quarter of emitters discharge over the rate of the overall discharge of emitters. (2) concluded that not conducting the regular maintenance for some apparatus led to clog some nozzles, which affected negatively in values of uniformity coefficient and low water depth as well as the nozzles discharge for some apparatus used in the study, and not joining the nozzles in their proper places had a negative effect on the regularity of water distribution and the performance of these system, and therefore this study aims to:

- 1- Evaluating performance and regularity of added water for drip irrigation systems in

a set of agricultural fields in Al-Saqlawiya sector.

- 2- Evaluating the properties for the emitters commonly(Actual discharge, Uniformity coefficient, Emission uniformity and Variation percent of emitters discharge) used and then judging their quality and matching for the requirements of the drip irrigation system design.

MATERIALS AND METHODS

The questionnaire was evaluated, data and information were collected about the use of drip irrigation system under field operating conditions in agricultural fields in Al-saqlawiya sector (5 fields),. Where in the beginning scan was conducted to determine the cites and places of the fields that use these systems. The study included determining the places of designing and installing drip irrigation systems, and this was done in fall season 2018/2019. Table 1 shows periods of using irrigation systems used in the study.

Table1. Periods of drip irrigation systems

System No.	Periods of using drip irrigation system	Company name
System 1	2 years Consecutive with a change for some simple parts	Eurodrip,Greece
System 2,3	3 years Consecutive with a change for some simple parts	Eurodrip,Greece
System 4	4 years Consecutive with a change for some simple parts	Eurodrip,Greece
System 5	5 years Consecutive with a change for some simple parts	Eurodrip,Greece

Fields experiments were conducted in Al-Saqlawiya region - Al-Anbar governorate at north in latitude $33^{\circ} 24' 57''$ and east longitude $43^{\circ} 41' 23''$, from 15/10/2018 to 15/1/2019 to evaluate performance properties of drip irrigation system and its components under the study conditions. A soil samples were from 0-0.15, 0.15-0.3 m and 0.30-0.45 m and analyzed in laboratory for determine some physical and chemical characteristic. Table 2 shows some physical and chemical characteristic of field soil according to (7, 15). Five drip irrigation systems were evaluated in this study ($600 m^2$ area for each) each one has included :the main unit which consist of a steel tank with $2 m^3$ capacity, pumping crew composed of a gasoline pump with 5.5 Hp and gives $30 m^3 h^{-1}$ discharge, a disk filter, pressure gage meter, switches to on and off the water and a set of tubes for water

distribution, length of lateral tubes with 16 mm diameter were used that interposed with emitters type GR whose $4 L h^{-1}$ design discharge and 0.40 m the distance between them on one lateral line. The drip irrigation systems were installing in their allocated areas in order to the field preparation and evaluation for potato crop cultivating.

Field evaluation for drip irrigation system

In order to conduct the field evaluation for each drip irrigation system in each farm the steps recommended by the American Agricultural Engineer Association were followed, therefore the performance of each system in the field was evaluated by measuring the water distribution regularity of the irrigated area, where operational pressure 50 kPa was used. Distribution uniformity of the units was

determined according to the equation mentioned in (8):

$$q = \frac{v}{t} \text{ --- (1)}$$

Where:

q=emitters discharge (L h⁻¹).

t= operating time (hr).

v = Water volume received in the cans (L).

Table2. Some physical and chemical characteristics of field soil

property	Soil depth (m)			Measuring unit
	0 – 0.15	0.15 – 0.30	0.30 – 0.45	
Bulk density	1.32	1.34	1.35	Mg m ⁻³
Soil separates	Sand	244	266	g kg ⁻¹
	Silt	639	590	
	clay	117	144	
Texture		Silty loam		
EC _{1:1}	6.38	5.83	6.27	dS m ⁻¹
pH _{1:1}	8.02	8.14	8.21	-----
Gypsum	56	38	80	g kg ⁻¹
Lime	255	250	250	
CEC	24.23	-	-	Cmole kg ⁻¹
SAR	11.88	11.42	11.81	-----
ESP	13.99	-	-	%

Table 3 shows the water volume compiled in collection cans according to the drip irrigation systems that are being studied, at 4 minute time and 50 kPa operational pressure. The emission uniformity was calculated by the equation mentioned in (12):

$$EU = \frac{qn}{qa} \times 100 \text{ --- (2)}$$

Where:

EU= Emission uniformity (%).

qn= Average of minimum quarter of emitters discharge (L h⁻¹).

qa= Average of overall discharge of the emitters (L h⁻¹).

Uniformity coefficient (UC) was calculated according to Christiansen's formula (7):

$$UC = \left[1 - \frac{\sum_{i=1}^{i=n} |X_i - \bar{X}|}{n \times \bar{X}} \right] \times 100 \text{ --- (3)}$$

Where:

Σ= Summation

X_i = Water volume compiled in each cans (ml).

X̄ = Average of water depths compiled in the cans (ml).

n= Number of water collection cans.

Therefore the distribution uniformity can be calculated according to the following equation:

$$DU = \left[1 - \frac{sd}{qa} \right] \times 100 \text{ --- (4)}$$

Where:

DU= Distribution uniformity of water distribution (%).

Sd= Absolute deflection average of discharge over the overall discharge (L h⁻¹).

qa = Average of overall discharge of the emitters (L h⁻¹).

Table3. Water volume collected in the cans for drip irrigation systems for 4 minutes time and 50 kPa operational pressure

Emitters No.	water volume collected (ml)				
	Drip irrigation system number				
	1	2	3	4	5
1	290	280	210	240	195
2	300	270	250	250	385
3	280	290	205	240	210
4	250	240	250	240	305
5	280	260	200	245	340
6	285	250	200	230	350
7	280	265	215	250	360
8	265	275	125	250	380
9	280	255	266	245	385
10	260	240	210	220	430
11	265	230	250	240	340
12	280	250	315	240	400
13	260	260	270	240	385
14	300	250	290	230	345
15	260	270	255	220	350
16	260	220	073	240	335
17	265	230	320	220	320
18	265	210	260	210	420
19	265	250	270	235	400
20	260	240	060	230	410
21	260	260	270	220	420
22	265	255	130	215	265
23	250	265	230	220	280
24	248	275	220	200	390
25	300	300	225	210	420
26	265	290	300	205	400
27	280	280	238	210	300
28	280	275	190	200	340
29	260	285	230	200	380
30	265	265	220	210	380
31	260	220	150	170	365
32	350	210	160	180	390
33	250	230	093	190	305
34	250	195	250	200	280
35	248	200	190	195	335
36	248	190	260	190	325
37	250	190	150	180	320
38	240	200	075	170	310
39	220	180	250	160	300
40	220	230	240	150	280

Note:

- 1- Water volume are converted from milliliter to liter and time from minute to hour.
- 2- Finding discharge in (L h⁻¹).
- 3- Discharge are in descending order.

Example:

$$q = \frac{290/1000 \times 60}{4} = 4.35 \text{ (L h}^{-1}\text{)}.$$

RESULTS AND DISCUSSION

Actual discharge

Fig.1 shows the values of actual discharge for five surface drip irrigation systems used in the study, values of actual discharge were 3.997, 3.675, 3.248 and 5.186 L h⁻¹ for the systems 1, 2, 3, 4 and 5, respectively. It was noticed that there was a disparity in values of actual discharge, where 3.997 L h⁻¹ actual discharge of system 1 was the nearest value to the design discharge 4 L h⁻¹, while the values of the systems 2, 3 and 4 have reduced to eventually be 3.236 L h⁻¹ for the system 4. Maximum

discharge value 5.186 L h⁻¹ was obtained with 5. The reason of the disparity of actual discharge values for the systems used in this study may be attributed to the different use periods for most of these apparatus (Table1), despite the similarity in designing criteria of the five drip system. Also the disparity in values may be attributed to the effect of climate conditions such as temperature, cool and clog sensitivity of tubes and emitters as a result of the poor maintenance and management by users of these systems, and This agrees with what mentioned by (14,16,17,18).

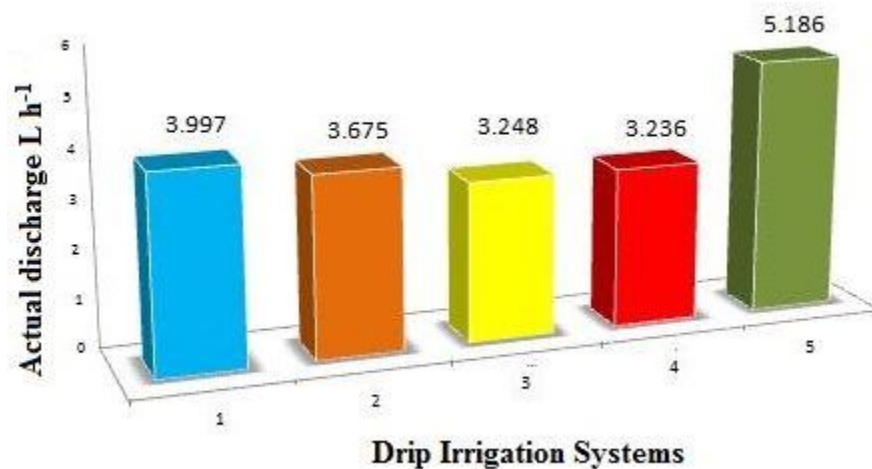


Fig.1. Actual discharge values for the surface drip irrigation systems at 50 kPa operational pressure

Uniformity coefficient

Fig 2 shows the value of uniformity coefficient for the five drip irrigation systems used in the study. It's noticed that the values of uniformity coefficient were 93.98%, 88.98%, 75.23%, 90.40% and 87.20% for the systems 1, 2, 3, 4 and 5 respectively. From Fig. 2, its noticed that there are differences in values of uniformity coefficient, where the first three systems (1, 2, 3) have reached gradually, then the value of system 4 increased to 90.40%. The decreased percent decreasing was 5.32%, 19.95%, 3.81% and 7.21% for system 2, 3, 4 and 5, respectively in compared with system 1. This increase in reduction percent of uniformity coefficient value

was expected especially for the system 2 and 3 compared with system 1, This may be due to the operating period for these systems which range between 2 to 3 years (Table2), This agrees with results of (3), As for system 4, it wasn't expected comparing with its use periods despite of most of the systems conditions are similar such as lateral tubes, emitters and the land area on which the systems were designed except of the use period for this system is different (Table2) (2).While the result obtained from system 5 is identical to the value of actual discharge rate(Fig.1), and this agrees with what mentioned by (10) that the most effective factor in the regularity of irrigation water exiting the emitters

is the variation in pressure regulators used in the system and the sensitivity of these emitters for

the variation in pressure and temperature.

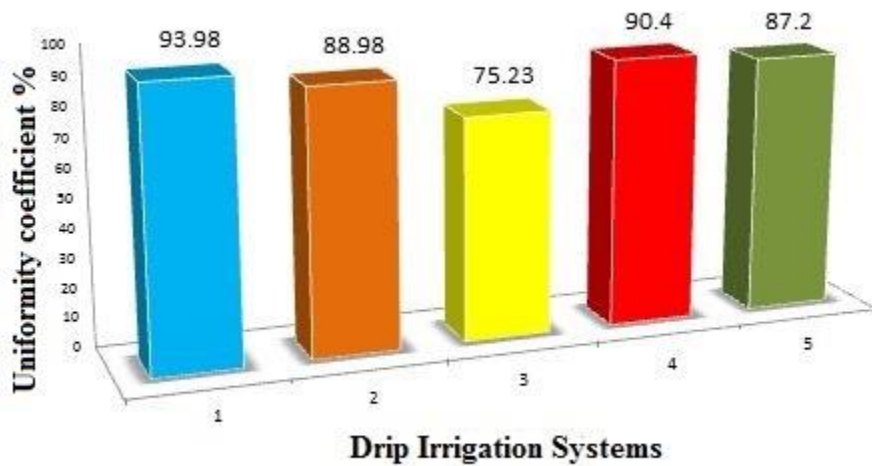


Fig.2. Uniformity coefficient values for the surface drip irrigation systems at 50 kPa operational pressure

Emission uniformity

Fig. 3 shows the values of emission uniformity for the five surface drip irrigation systems used in the study. It's noticed that the values are 90.96%, 81.20%, 57.08%, 84.13% and 77.90% for the systems 1, 2, 3, 4 and 5, respectively.

The maximum value is 90.96% for the system 1 then decreased to 57.08% for system 3. It's shown from fig.3 that the values of emission uniformity for systems 1, 2 and 3 have reduced then for system 4.

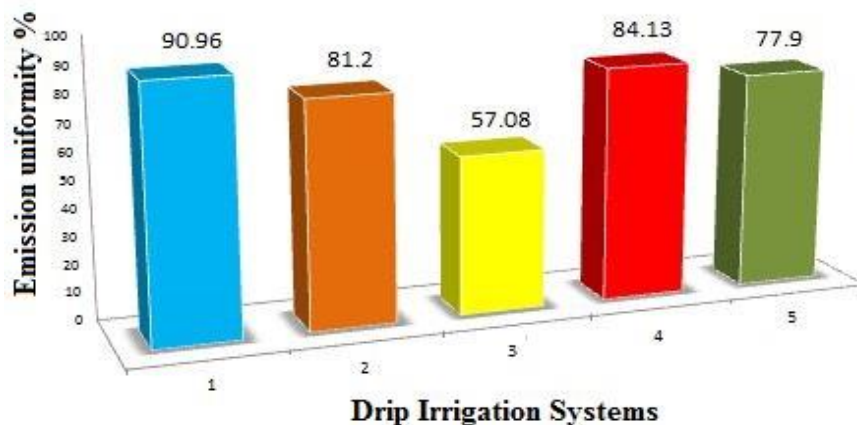


Fig. 3. Emission uniformity values for the surface drip irrigation systems at 50 kPa operational pressure

The decrease percent of emission uniformity are 10.73%, 37.25%, 7.51% and 14.36% when comparing emission uniformity for system for system 1 with the systems 2, 3 and 4, respectively. The values of emission uniformity for the surface drip irrigation systems and their decrease in percentage are identical to that of

uniformity coefficient, and this is consistent with what mentioned by (12) Emission uniformity is an another alternative criterion for uniformity coefficient of water distribution of emitters because it represents the ratio between the rate of minimum quarter of emitters discharge and overall discharge.

Variation percent of emitters discharge

Fig. 4 shows percent variation emitters discharge for the surface drip irrigation systems used in the study. variation percent of discharge were 37.14%, 40.00%, 81.25%, 40.00% and 54.65%, for system 1, 2, 3, 4 and 5 respectively, the minimum value for system 1 is 37.14% and 81.25% for system 3 is the maximum 1. Also noticed that the variation percent of emitters

discharge have increased gradually for the systems 1,2and 3 then decreased to 40.00% for the system 4 and again increased to 54.65% for the system 5. The increase percent's of variation of emitters discharge reached as follows: 7.70%, 118.77%, 7.70% and 20.73% when comparing the discharge variation for system 1 with the systems 2, 3, 4 and 5 respectively. It's shown from Fig.4.

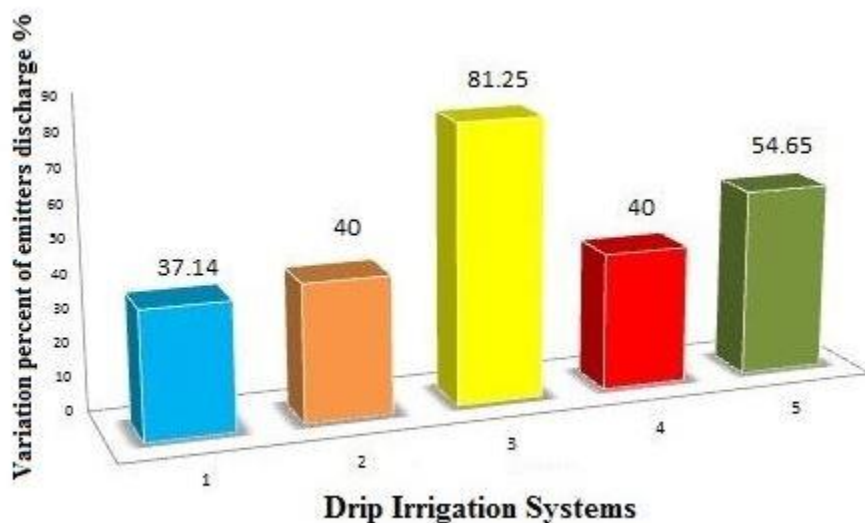


Fig. 4. Variation of emitters discharge values for surface drip irrigation systems at 50 kPa operational pressure

That most of the values of variation percent are not acceptable in the field and performance evaluation for the drip irrigation systems except of system 1 which is nearest one to be acceptable, and this agrees with the classification of (20) that the variation percentage of discharge are preferable at 10% or less, acceptable at 10% to 20% and not acceptable at 20% or more, and this agrees with (14) that the poor design, management and

maintenance for the system result in an irregularity the emitters discharge of the field.

Conclusions

- From the results of this study, we concluded that the regular maintenance for the drip irrigation systems is essential especially at the end of the season for each crop in order to remove the precipitations and to fix the broken parts

- there save them in an appropriate conditions such as temperature and cool.
- Conducting the regular evaluation for these systems according to the recommended criteria in order to know the good and appropriate qualities under the conditions of the study area.
 - In form all users (of these systems) of the need to rationalize water consumption, achieve a high irrigation efficiency and distribution as well as a rise water unit value in order to increase the production and improve its quality.

REFERENCES

1. AL-Mehmdy, SH.M.H and S.E.H. Al-dulaimy, 2018. Performance evaluation of drip irrigation system according to the suggested standards. Iraqi. J. of Agric.Sci.49(6):1099-1109.
2. AL-Mehmdy, SH.M.H. 2015. Field study to evaluate the performance center pivot sprinkler irrigation systems under desert condition west of Iraq. Iraqi. J. of Agric. Sci. 46(5):847-853.
3. AL-Mehmdy, SH.M.H. 2011. Effect of Emitters, Discharge and Irrigation Water Salinity on some physical properties of soil, Salt Distribution, Growth and Potato Yield. PhD Dissertation Dept. of Soil Sci. and Water Resources., Coll. Agric., Univ. Anbar, Anbar, Iraq.
4. Al-Amoud, A1995. Significant of energy losses due to emitter connection trickle irrigation lines .J. Agric. Eng. Res. 60 , 1-5.
5. Al-Amoud, A.I. and H.M. Al-Ghabari, 1994. Evaluation of hydraulic characteristic of some locally available emitters. J. king Saud university. 6(1):15-26.
6. Black , G.R. 1965. Bulk density . In C.A., Black et al. (eds.). Methods of soil analysis . Part 1. Agron. Mono. No. 9 (1) : 374-390. Amer. Soc. Agron. Madison. Wisconsin , USA.
7. Christiansen , J. E. 1942. Irrigation by Sprinkling University of California Agriculture Experiment Station Bulletin 670. Davis CA. PP:124.
8. Hachem, A.Y. and H.I.Yassen.1992.Engineering of Field Irrigation Systems. Dar Alkutub for printing and publishing. Mosul – Iraq.pp:1-483.
9. Howell, T.A., D.S. Stevenson, F.K. Aljiburg, H.M. Gitlin, I.P. Wu,A.W.Warriek, and P.A.C. Raats. 1980. Design and Operation of Trickle (drip) Systems, In: M.5.Jensen (ed.) Design and Operation of Form Irrigation Systems, ASAE Monograph No.3, ASAE, St. Joseph, M.I.
10. Mized, N and E.G. Kruse. 1989. Emitter discharge evaluation of subsurface trickle irrigation systems. Transactions of the ASAE, 32(4): 1223-1228
11. Nakayama , F. S. and D. A. Bucks. 1981. Emitter clogging effects on trickle irrigation uniformity. Trans of the ASAE 24(1):77-80.
12. Ortega, J. F.; J. M. Tarjuelo; and J. A.de Juan. 2002.Evaluation of irrigation Performance in localized irrigation system of Semiarid regions (Castilla–La Mancha, Spain): Agricultural Engineering International: CIGR J. Sci. Res. and Develop., 4 : 1-17.
13. Page , A.L. ; Miller , R.H. ; and Kenny , D.R. 1982. Methods of soil analysis part (2) . 2nd ed. American Society of Agronomy crop Sci. Soc. of Agronomy 9. USA.
14. Pereira, L.S., T. Oweis and A. Zairi. 2002.Irrigation management under water scarcity . Agricultural water management. 57(3):175-206.
15. Schneider, A.D. 2000. Efficiency and uniformity of the LEPA and spray sprinkler methods: a Review. Transaction of the ASAE 43(4): 937-944.

16. Solomon, H.S.. 1985. Global uniformity of the LEPA and spray sprinkler methods: A Review
17. Solomon, K. 1979. Manufacturing variation of trickle emitters. Trans. ASAE. 22(5):1034- 1043.
18. Solomon, K; and J. Keller. 1978. Trickle irrigation uniformity and efficiency. J. Irri. and Drain. Div., ASCE. 104 (IR3) : 293-306.
19. Tüzel, İ.H. (1993). Evaluation of Irrigation Uniformity in Trickle Irrigation Systems. J. Ege University, Agric. Faculty; 30 (1-2): 119-126 (in Turkish).
20. Wu, I.P., H.M.Gitlin. 1979. The Manufacture's Coefficient of Variation of Emitters Flow for Drip Irrigation. University of Hawaii at Manoa and U.S.D.A .,pp: 1-3.