Examining of Water Distribution Uniformity in Drip Irrigation Systems: A Review of Various Recent Studies Worldwide

Bilal Acar, Sena Afacan, Nasuh Açık

Dept. of Farm Buildings and Irrigation, Faculty of Agriculture, University of Selçuk, Konya, Türkiye
E-mail: biacar@selcuk.edu.tr, senafacan30@gmail.com, nasuhacik@hotmail.com

Abstract: *This study was aimed to evaluate water application uniformity of emitters for drip irrigation systems. The data was obtained from our previous studies or some researches in the world relevant to watering performance of drippers. In results, reasons of poor watering performance of drip irrigation systems were inadequate design and mainly incorrect management of systems. Following recommendations were proposed for better distribution of water for crops / plants; 1- correct design and management of the systems, 2- applications of physical, chemical, and biological for preventing dripper clogging, 3- timely control of system components particularly emitters, and 4- participation of farmers courses about agricultural water management.*

KEYWORDS: *WATER DELIVERY, EMITTER, MANAGEMENT OF IRRIGATION SYSTEMS.*

1. Introduction

There are various artificially water application methodologies for crops. The way that is introducing of water to crops is called as irrigation method. It is effective strategy for improving crop production in areas with insufficient rainfall. The main target in irrigation process is to apply water to plants with minimal losses.

The possibly drip irrigation is the most innovative irrigation method for application of water for crops with high uniformly. It allows more water savings and can be strongly recommended in regions with low amount water resources which is not suited for surface irrigation systems utilization [1,2]. By comparison to the rain-fed or surface irrigation systems, drip irrigation may improve crop production as 20%-80%, and water saving as 30%-70% [3].

There is no doubt that better watering productivity results more areas bringing into irrigation as a consequently increment in net returns of landowners. The main issue for water managers is to apply water by emitters onto crops or within crop rooting systems with high uniformity [4]. The water distribution uniformity is affected many factors such as operating pressure, emitter spacing, land topography, diameters of water delivery pipes, variations in emitter flow rate and emitter manufacturing, emitter clogging, and aging of partial or complete system components [5,6].

The differences between dripper flow rates should be lower than 10% for achievement of acceptable water distribution uniformity [7,8]. Emitter is backbone of drip irrigation system, and soil characteristic, crop water consumption, dripper discharge, and irrigation water quality is very important role to play in emitter selection [9].

The major aim of the current study is therefore to analysis some criteria's for interpreting water application uniformity of drippers.

2. Materials and Methods

In current study, following parameters were used for determination of water application uniformity;

A- Emitter Flow Rate Variation (Q_{var})

$$Q_{var} = \left(1 - \frac{q_{min}}{q_{max}}\right) \times 100$$

Where; q_{min}- Lowest flow rate (L/h), q_{max}- Highest flow rate (L/h).

Q_{var} is greater than 20% is not acceptable [10].

B- Uniformity Coefficient (UC)

UC can be expressed as [11];

$$UC = \left[(1 - (\frac{\Delta q}{qavr})\right] \times 100$$

Where; UC- Uniformity Coefficient, %

Δq – Mean of absolute deviation from mean flow rate, L/h

Q_{avr}–Mean flow rate, L/h

The relationship between UC and watering class was presented at Table 1 [12].

Table 1. *Relationships between UC and Water Application Uniformity*

UC, %	Water Distribution Class
> 90	Perfect
80 – 90	Good
70– 80	Moderate
60 – 70	Poor
< 60	Unacceptable

C- Emission Uniformity (EU)

$$EU = \frac{q_{25\%min}}{q_{avr}}$$

Where; EU-Emission Uniformity (%), $q_{25\%min}$- Mean of the lowest quarter of emitter flow rates (L/h), q_{avr}- Mean flow rate of emitters (L/h).

The relationship between EU and watering class was presented at Table 2 [10].

Table 2. *Relationships between EU and Water Application Uniformity*

EU, %	Water Distribution Class
>94-100	Perfect
81– 87	Good
68– 75	Acceptable
56 – 62	Poor
< 50	Unacceptable

3. Results and Discussions

There was found direct relationships between working pressure and dripper flow rates with use of emitters having no pressure compensating. In that regard, determination of correct operating pressure is one of the important design parameters in micro irrigation system design. In one study [10], Q_{var} values were found acceptable, Q_{var} is lower than 20% for operating pressure between 0.4 and 1.2 kg/cm^2 under in-line dripper uses (Table 3). The lowest Q_{var} value as 10.6 % was obtained from 1.2 kg/cm^2 operating pressure. In other word, emitter watering performance was stated as **Acceptable** under working pressure of 1.2 kg/cm^2.

Table 3. *Q_{var} and EU values for different operating pressures* [10]

	Operating Pressure (kg/cm^2)							
	0.3	0.4	0.6	0.7	0.9	1.0	1.1	1.2
$Q_{var\,(\%)}$	33.3	15.2	12.7	22.6	13.6	15.8	11.4	10.6
EU (%)								

Emitter flow rate was researched at Konya province of Türkiye. In that study, average dripper discharge was 2.57 L/h that is lower than recommended value of 3.8 L/h by Producer Company. The reason was stated as much seepage losses from pipe lines. Therefore, it was strongly suggested that drip irrigation whole components should be controlled regularly for achieving satisfactory water applications to the crops [13].

The well-known indicator for assessment of dripper water application efficiency is UC. The UC value for calculated as 94.6% in study performed at drip irrigation system using at Public Park situated at Konya province, Türkiye. The watering performance of such drippers was classified as **Perfect** [13]. In that study, although there was no found many differences among emitter flow rates, all discharges of drippers were lower than the value suggested by pipe production company. Therefore, irrigation system should be scheduled by using actual flow rate of 2.57 L/h.

In other study [14], the UC value was reported as 95%. In accordance of that value, the emitter watering performance was stated as **Perfect** [12].

The UC and EU values varied from 84% to 68% (**Good** and **Poor** watering Uniformity, and from 71% to 44% (**Poor** and **Unacceptable** watering uniformity) at drip irrigation systems using corn fields situated at Konya-Çumra province, Türkiye [15].

The EU values varied from as about 80% to 95% depending on the applied working pressure on system [10]. There was found almost no difference between 1.0 kg/cm^2 (94.5%) and 1.2 kg/cm^2 (94.8%) operating pressures. The maximal EU value was obtained as 94.8% from 1.2 kg/cm^2 working pressure (Fig 1). The watering class was **Excellent** in accordance of this result. In that case, working pressure of both the 1.0 and 1.2 kg/cm^2 could be advisable for satisfactory water application across to the fields.

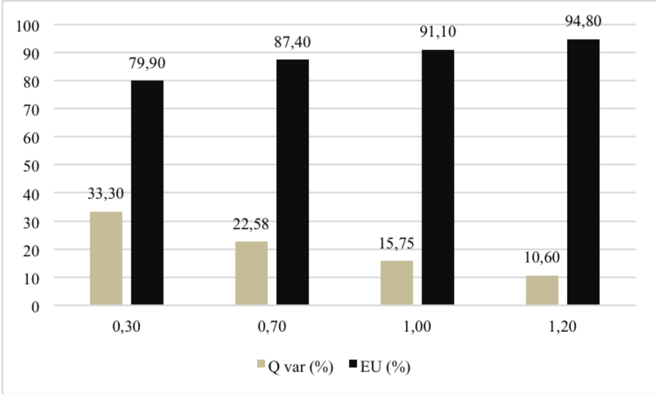

Fig 1. Q_{var} and EU accordance of different operating pressures [10].

The study performed at Ghana [16] about determination of water application efficiency of drip irrigation systems for loamy-Sand or Sand condition using one-year old drip lines with 30 cm emitter spacing showed that UC as 78% (**Fair** water application), and EU as 90% (**Very Good** water application). It was stated that the emitter watering performance could be improved by regular cleaning filters, controlling pressure reduction, cleaning the gates of filters, and flushing of drip-lines at minimum two or three times a year.

The most important factor lowering water distribution uniformity is emitter clogging. In that case, emitter clogging can be prevented by some ways. The innovative emitter clogging prevention methodologies were given in a study [17].

Table 4. *Innovative emitter clogging treatment methodologies* [17]

Prevention methods	Explanations
Physical	Use of filters and flushing emitters or drip-lines
	Magnetization of irrigation water
	Application of MERUS ring: Separating the big particles by using MERUS ring and making them easy for flushing out those small particles.
	Pulsating and dynamic pressure application
	Treatment of water with ultrasound
Chemical	Application of small amount of fertilizer in necessary time
	Application of N-holamine nano particles (NPs)
	Electro-chemical application
Biological	Treatment via various antagonist bacteria strains such as *Basillus* spp., *Burkholdria* ssp., and *Basillus amyloliquefaciens.*

4. Conclusion

In outcomes of the present study, sustainable use of water resources is necessarily prerequisites particularly water shortage ecologies such Konya Closed Basin of Türkiye. One of the most important significant interests is application of water saving irrigation systems like drip irrigation with great care. In that context, irrigation water should be applied as uniform as possible on around the rooting systems for maximal crop production. Some factors such as poor design of systems, and differences in land slopes can affect watering uniformity. Beside those, emitter clogging resulting from water quality, or damages or aging of lateral tubes is the reason of poor water application performance. In general, there are three main improvement methodologies for solving emitter-clogging problems: physical, chemical, and biological methodologies. They should be applied in accordance of sources of emitter clogging. The drip irrigation is an advance technology, needs specialist background, so farmers should be informed about drip irrigation system management with some practical activities.

Conflict of interests

The authors declare there is no conflict.

5. References

1. M. Irfan, M. Arshad, A. Shakoor, L. Anjum, 2014. Impact of irrigation management practices and water quality on maize production and water use efficiency. J. Anim. Plant Sci., 24,5: 1518-1524 (2014)
2. B. Acar, Efficacy of drip irrigation system for some vegetables: assessments of yield and water productivity. International Journal of Agriculture and Economic Development, 8,2: 1-7 (2020)
3. P. Shamshery, R.Q. Wang, D.V. Tran, A.G. Winter, Modeling the future of irrigation: A parametric description of pressure compensating drip irrigation emitter performance. PLoONE, 12, 4: 1-24 (2017)
4. M.Y. Tayel, H.A. Mansour, S.Kh. Pibars, The hydraulic evaluation of drip irrigation system by hydrocalc model under different dripper types and low quality water. Plant Archives, 19,2: 554-561 (2019)
5. M.S. Ardey, Effects of Pressure Head on Water Distribution Uniformity of Pressure Compensating (PC) Emitters Fitted in a Polyvinyl Chloride (PVC) Pipe. This Thesis is submitted to the University of Ghana, Legon in Partial Fulfilment of the Requirement for the Award of Bachelor of Science Degree in Agricultural Engineering, Department of Agricultural Engineering Sciences, College of Basic and Applied Sciences, University of Ghana, Legon, 45 ps (2021).
6. O.D. Raphael, M.F. Amodu, D.A. Okunade, O.O. Elemile, A.A. Gbadamosi, Field evaluation of gravity-fed surface drip irrigation systems in a sloped greenhouse. International Journal of Civil Engineering and Technology, (IJCIET), 9,10: 536-548 (2018)
7. O.E. Omofunmi, O.A. Ilesanmi, T. Orisabinone, Performance evaluation of hydraulic parameters of a developed drip irrigation system. Malysian Journal of Civil Engineering, 31,2: 9-16 (2019)
8. A. Trivedi, A.K. Gautam, Temporal effects on the performance of emitters. Bulletin of Environment, Pharmacology and Life Sciences, 8,2: 37-42 (2019)
9. W.M.A. Khalifa, A computer model for trickle irrigation system design. Int Trans J Eng Manag Sci Tech., 11,7: 1-17 (2020)
10. P. Mistry, M. Akil, T.M.V. Suryanarayana, F.P. Parekh, Evaluation of drip irrigation system for different operating pressure. IJAERD, National Conference on Application of Nanotechnology, February, 63-69, (2017).
11. A. Capra, V. Tanburina, Evalution and control of distribution uniformity in farm irrigation systems. Proceedings of 46 th International Executive Council Meeting, ICID, CIID special Technical session, Roma, Italy (1995).
12. Anonymous, Field Evaluation of Micro Irrigation Systems. ASABE Standards, 46th Ed. EP 458, St. Joseph, Mich.: ASAE (1999).
13. H. Dinç, Konya-Şefikcan Parkında Kullanılan Basınçlı Sulama Sistemlerinin Su Yönetimi Açısından Değerlendirilmesi. MSc Thesis, The Graduate School of Natural And Applied Science of Selçuk University, 42 s (2023).
14. P.K. Jamrey, G.K. Nigam, Performance evaluation of drip irrigation systems. The Pharma Innovation Journal, 7,1: 346-348 (2018).
15. A.R. Inciman, B. Acar, Watering uniformity of drip irrigation systems using in irrigation of maize for Konya-Çumra province, Turkey. Seria Agronomie, 63,1: 41-44 (2020).
16. H.S. Darimani, N. Kpoda, S.M. Suleman, A. Luut, Field performance evaluation of a small-scale drip irrigation system installed in the upper west region of Ghana. Computational Water, Energy, and Environmental Engineering, 10: 82-94.
17. V.R. Ramachandrula., R.R. Kasa, Prevention and treatment of drip emitter clogging: a review of various innovative methods. Water Practica & Technolgy, 17,10: doi: 10.2166/wpt.2022.115.