WATERING UNIFORMITY OF DRIP IRRIGATION SYSTEMS USING IN IRRIGATION OF MAIZE FOR KONYA-ÇUMRA PROVINCE, TURKEY

Ahmet Rasih İNCİMAN[1], Bilal ACAR[1]

e-mail: ahmet_rasih19@hotmail.com

Abstract

This study was conducted to determine water distribution uniformity of emitters at different drip irrigation systems using at maize farms in Çumra region of Konya, Turkey. Watering performance of drippers was classified by using two criteria namely Uniformity Coefficient, UC, and Emission Uniformity, EU. In results, UC varied from 68% to 84% with an average of 75% and water delivery class was 'Moderate' in accordance of such a mean value. EU varied from 44% to 71% with an average of 55%, and watering performance was 'Poor' or 'Unacceptable' in regard to average of EU value. Variations in emitter discharge rates in all examined drip irrigation systems were found higher than 10%. Drip irrigation system should be designated in accordance of hydraulic principles, installed by experienced people and timely maintenance-repair works are needed for maximizing water distribution uniformity consequently improvement grain/ silage yields as well as more economical returns.

Key words: maize, drip irrigation systems, watering efficiency of drippers

Agriculture is huge fresh water user sector worldwide. As we know that irrigation is backbone input for increasing crop yield, and productive utilization of water resources are great interests particularly in regions having water scarcity (Hanson and May, 2007; Acar *et al,* 2014; Yavuz *et al,* 2017).

In water shortage environments, pressurized irrigation techniques are very efficient in respect to well crop developments, and yield consequently better economical returns. It is possible for farmers to obtain high water, energy, and fertilizer savings in such irrigation systems under proper water management (Şimşek *et al,* 2004; Zamanian *et al,* 2014; Yavuz *et al,* 2015 a,b; Yavuz *et al,* 2016; Yavuz *et al,* 2019; Santana Junior *et al,* 2020).

Drip irrigation, one of the pressurized irrigation systems, has allowed to more uniform water application through root zone depth with greater water economy consequently optimal crop yield. Pressure variations within laterals have direct effect on water delivery efficacy of drippers (Mohanty *et al,* 2016).

In recent years, corn production has increased step by step due to resulting better income for farmers at Konya region, Turkey. It is impossible for producers to obtain economical income without irrigation in such environment even for winter cereals. In recent, drip irrigation system has used for irrigation of corn with an increasing trend. Yavuz *et al,* (2018) stated that full or irrigation at whole plant growth stages has resulted optimum yield and quality so such strategy could be highly beneficial particularly in environments having plenty water supplies.

Drip irrigation system has caused more water economy, possible to reach up to 90 or 95% water application efficiency, and manpower savings (Amoo *et al,* 2019; Patil and Patil, 2019; Selvaperumal *et al,* 2019; Trivedi and Gautam, 2019), and is also possible to use water more productive with deficit irrigation by drip irrigation system (Attila *et al,* 2019).

The main goal of irrigation activity is application of water to crops as uniform as possible. The flow variations among emitters should be little (less than 10% of acceptable range) to accomplish adequate water uniformity a cross to irrigated fields (Omofunmi *et al,* 2019; Trivedi and Gautam, 2019).

In drip irrigation system design, emitter spacing and wetting front are paramount useful information for obtaining optimal water content within root zone. The wetted volume, mainly depending on soil properties, is amount of available water for plants e.g. maximal width and depth of wetting advance were determined as 0.35 m and 0.56 m, respectively for sandy-loam soil under usages emitter with flow rate of 1.3 and 3 L/h (Mirjat *et al,* 2010).

[1] University of Selçuk, Konya, Turkey

Correct design, installation, timely maintenance-repair works such as well filtration of irrigation water and proper management of drip irrigation systems are very important role to play for obtaining satisfactory water delivery performance (Hanson and May, 2007; Mostafa and Thörmann, 2013; Cannan *et al,* 2020). Among those, clogging and huge pressure variations in pipe networks are two common problems causing fluctuations in water level (Trivedi and Gautam, 2019). Amer and Gomaa (2003), found UC values as almost 92%, 94%, and 94% for 2% upslope, zero slopes, and 2% downslope, respectively; EU values as around 79%, 84%, and 88%, respectively for similar slopes. Yavuz *et al,* (2010) found mean UC values of 98% and 80%, and EU values of 97% and 73% for none-used and aging-laterals, respectively under 100 kPa pressure head. Omofunmi *et al,* (2019) found both UC and EU as about 99%, respectively; consequently, system was perfect designated.

In research region, Konya-Çumra, none study was performed about assessment of water uniformity under drip irrigation systems using for corn irrigation. The aim of the study, therefore, was to research water application uniformities in corn farming under drip irrigation systems.

MATERIAL AND METHOD

This study was carried out at Çumra province belonging to Konya city of Turkey. The research area, situated at Middle Anatolian Region, is 1013 m above sea level and has popularity in productions of cereals, sugar beet, corn, alfalfa, dry bean, sunflower and some vegetables such as carrot, pepper, tomato, and lettuce. The region has semi-arid climate and almost 40% of precipitation has observed during crop growth period (Yavuz *et al,* 2014).

Water distribution uniformity of drip irrigation systems was evaluated by measuring volume of collected water from some emitters on selected laterals. In position of water inlet representative three laterals situated at initial, middle, and far or end on manifold were used. The emitter flow rates were between 1.9 and 2.6 L/h. About 36 plastic containers having capacity of 200 ml were placed just under selective emitters on those three lateral lines (each lateral had 12 measurement points). Then, drip irrigation systems were run about 10 or 15 minutes. After all drops ended in drip irrigation system, water volumes within plastic cups were measured by using graded cylinder and then they were converted to unit of L/h as suggested by Mostafa and Thörmann (2013).

Emitter performance was determined by using Uniformity Coefficients UC, and Emission Uniformity, EU.

UC was calculated by (Capra and Tanburina, 1995):

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

where, UC- Uniformity Coefficient, %, Δq – Mean of absolute deviation from mean emitter discharge, L/h, and qmean – Mean emitter discharge, L/h. Emitter watering performance, EWP, was classified by using *table 1* (Tüzel, 1993).

Table 1

Relationships between UC and EWP

UC (%)	Emitter watering performance, EWP
> 90	Very Well
80 – 90	Well
70– 80	Moderate
60 – 70	Poor
< % 60	Not Acceptable

EU was calculated by (Keller and Karmeli, 1974):

$$EU = \frac{q_{25}}{qmean} x100$$

where; EU - Emission uniformity, %, q25- Mean of the lowest quarter of the emitter discharge, L/ h. In regard to EU values, water distribution quality was classified by use of *table 2*.

Table 2

Relationships between EU and EWP

EU (%)	EWP (Merriam and Keller, 1978)	EWP (Anonymous, 1983)
<70	Poor	No-Acceptable
70–80	Acceptable	Poor
80–86	Well	Acceptable
86–90	Well	Well
90–94	Very Good	Well
>94	Very Good	Very Good

RESULTS AND DISCUSSIONS

Characteristics of pipes of drip irrigation systems were presented at *table 3*. In examined drip irrigation systems, main, manifold and lateral diameters varied from 110 mm to 175 mm; from 90 mm to 125 mm and from 22 mm to 25 mm, respectively. In general lateral length was measured as 250 m with emitter spacing of 25-30 cm.

The maximum UC was determined as 84% and performances of drippers was **well** in regard to such value. However, minimum UC was determined as 68% and emitter water application performance was classified as **poor**. In general, water distribution performance was **moderate** in current study.

UC values reported as about 94% by Amer and Gomaa (2003), 98% for new or 80% for using three-year lateral by Yavuz *et al,* (2010), 82-87% by Mirjat *et al,* (2010), 98% for on-line and 97%

for in-line drippers by Popale *et al*, (2011), 44%-99% by Acar and Yılmaz (2018); 62%-95% by Acar *et al*, (2009); 52-95% by Acar *et al*, (2015), 78-99% by Ünal *et al*, (2015), 95% by Arya *et al*, (2017), around 99% by Omofunmi *et al*, (2019) and almost 98% by Sadatiya *et al*, (2019). The finding of current study was as an average of 75%, and is almost agreement with Acar *et al*, (2009), Acar *et al*, (2015), and Acar and Yılmaz (2018) but lower than results of somewhere else (Amer and Gomaa, 2003; Yavuz *et al*, 2010; Mirjat *et al*, 2010; Popale *et al*, 2011, Ünal *et al*, 2015; Arya *et al*, 2017; Omofunmi *et al*, 2019; Sadatiya *et al*, 2019).

Table 3

Pipe components of drip irrigation systems

Farms	Main line (mm)	Manifold (mm)	Lateral tube (mm)	Lateral length (m)	Emitter spacing (cm)
1	125	125	22	247	30
2	175	125	25	250	25
3	175	90	25	250	25
4	175	125	25	250	25
5	175	125	25	230	25
6	110	90	25	250	25
7	110	90	25	250	25
8	125	125	22.5	250	30
9	175	125	22.5	250	30
10	175	125	25	250	25
11	175	125	22.5	250	30

EU values were maximum as 71% and minimum as 44% with mean of 55%. In result, almost all drippers had as **poor** or **no-acceptable** performance. In that regard, it is possible to say that drippers resulted none-uniform water application for maize crops.

In some previous studies about EU values; about 75% by Soccol *et al*, (2002), 84% by Amer and Gomaa (2003), 97% for brandy or 73% for used 3-year lateral by Yavuz *et al*, (2010), 75-81% by Mirjat *et al*, (2010), 97% for on-line and 99% for in-line drippers by Popale et al, (2011), 23-99% by Acar and Yılmaz (2018), 23-82% by Acar *et al*, (2015), 65-99% by Ünal *et al*, (2015), and 91% by Arya *et al*, (2017), about 99% by Omofunmi *et al*, (2019), and around 96% by Sadatiya *et al*, (2019). Our finding of mean 55% is almost conformity with Acar and Yılmaz (2018), and Acar *et al*, (2015), but not-agreement with Soccol *et al*, (2002), Amer and Gomaa (2003), Yavuz *et al*, (2010), Mirjat *et al*, (2010), Popale *et al*, (2011), Ünal *et al*, (2015), Arya *et al*, (2017), Omofunmi *et al*, (2019), and Sadatiya *et al*, (2019).

In general, reasons of low watering uniformity in present study may be resulted from using age-distribution lines, narrower emitter spacing, and use of longer laterals, partial or complete clogging in some emitters, and improper maintenance-repair works in systems.

CONCLUSIONS

In general, water distribution class was far from expectations since variations between the emitter flow rates were greater than the 10% in which is low acceptable threshold level for micro irrigation system. The reasons behind low water distribution efficiency could be as follows: poor design and installation of systems, preferences of laterals with longer lengths and narrower dripper spacing, improper selections of water delivery pipes, poor maintenance-repair works consequently great pressure variations through systems.

Proper design and installation as well as correct management of drip irrigation systems are vital important for accomplishing satisfactory water distribution uniformity. Farmers should be trained about efficient management of such system. It is obvious that drip irrigation system has led to savings in water and plant nutrients so farmlands having such systems should be widen particularly at water scant environments for sustainable utilization of current water resources.

REFERENCES

Acar B., Yavuz F.C., Topak R., Uğurlu N., 2009 - *Water quality and uniformity in trickle irrigation systems: A case study of Antalya-Turkey.* Asian Journal of Chemistry, 21(5), 3981–3987.

Acar B., Topak R., Yavuz D., Kalender M.A., 2014 - *Is drip irrigation technique sustainable solution in agriculture for semi-arid regions? A case study of Middle Anatolian Region, Turkey.* International Journal of Agriculture and Economic Development, 2 (2) : 1-8.

Acar B., Çicek Y., Topak R., 2015 - *Water distribution uniformities of drip irrigation systems in olive trees for Izmir province of Turkey.* Analele Universitatii Din Craiova, 20 (LVI), 13-20.

Acar, B. Yılmaz, A. M., 2018 - *Dripirrigation systemperformance evaluation based on previous reserach.* 8 th International Conference on Ecosystems, Tirana - 2018, 236-241.

Amer K.H., Gomaa A.H., 2003 - *Uniformity determination in drip irrigation lateral design.* Misr J. Ag. Eng., 20(3): 405-431.

Amoo M., Ademiju T., Adesigbin A., Ali G., 2019 - *Performanceevaluation of dripirrigationsystems on production of Okra (Hibuscusesculentus) in Soutwestern, Nigeria.* Journal of Engineering Researchand Reports, 5 (3): 1-10.

Anonymous., 1983 - IRYDA (Instituto de Reforma Y Desarrollo Agrario): *Normas para la redacción de proyectos de riego localizado.* Ministerio de Agricultura, Pesca y Alimentación. Madrid, Spain.

Arya C.K., Purohit R.C., Dashora L.K., Singh P.K., Kothari M., 2017 - *Performance evaluation of drip irrigation systems.* International Journal of

Current Microbiology and Applied Sciences, 6 (4), 2287-2292.

Attila S.S., El-Gindy,. A.M., Mansour H.A., Kalil S.E., Arafa Y.E. 2019 - *Performance analysis of pressurized irrigation systems using simulation model technique.* Plant Archives, 19 (1): 721-731.

Capra A., Tamburina V., 1995 - *Evalution and control of distribution uniformity in farm irrigation systems.* Procedings of 46 th International Executive Council Meeting ICID,CIID special Technical session, Roma, Italy.

Cannan B., Janani N., Thanganami S., Selvaperumal A., 2020 - *Development and evaluation of low cost drip Filter.* CJAST, 39 (8) : 87-94.

Hanson B., May D., 2007 - *The effect of drip line placement on yield and quality of drip-irrigated processing tomatoes.* Irrig Drainage Syst , 21 :109–118.

Keller J., Karmeli D., 1974 - *Trickle irrigation design parameters.* Transactions of the American Society of Agri. Engi. 17 (4): 678-784.

Merriam J. L., Keller J., 1978 - *Farm irrigation system evaluation, a guide for management.* Utah state Univ. Utah.

Mirjat M.S., Mirjat M.U., Chandio F.A., 2010 - *Water distribution pattern, discharge uniformity and appliation efficiency of locally made emitters used in trickle subunit.* Pak. J. Agril., Engg., Vet. Sci., 26 (1) : 1-15.

Mohanty B., Senepati S.C., Sahu A.P., Panigrahi B., 2016 - *Clogging ratio of emitters as affected by single and double inlet laterals and sub-main sizes.* International Journal of Humanities and Social Sciences, 5 (4): 33-40.

Mostafa H., Thörmann H., 2013 - *On-farm evaluation of low-pressure drip irrigation system for smallholders.* Soil &Water Res., 8 (2) : 87-95.

Omofunmi O.E., Ilesanmi O.A., Orisabinone T., 2019 - *Performance evaluation of hydraulic parameters of a developed drip irrigation system.* Malysian Journal of Civil Engineering, 31 (2): 9-16.

Patil M., Patil S.S. 2019 - Develoment of s system to *compare and analyze the yield of drip and without drip irrigation plots of plants.* International Conference on Sustainable Computing in Science, Technology & Management (SUSCOM-2019), February 26-28, 2019. Amity University Rajathan, Jaipur, India: 1858-1864.

Popale P.G., Bombale V.T., Magar A.P., 2011 - *Hyraulic performance of drip irrigation sysem.* Engineering and Technology in India, 2 (1&2): 24-28.

Sadatiya Y.R., Kapupara P.J., Patel R.J., Dwivedi D.K., 2019 - *Hydraulic performance evaluation of different emitters at different operating pressures.* The Pharma Innovation Journal, 8 (8): 323-327.

Santana Junior E.B., Coelho E.F., Cruz J.L., da S. Reis J.B.R., de Mello D.M., da S. Pereira B.L., 2020 - *Trickle irrigation systems affect spatial distribution of roots of banana crop.* R. Bras. Eng. Agríc. Ambiental, 24 (5): 325-331.

Selvaperumal A., Sujitha E., Muthuchamy I., 2019 - *Evaluation of uniformity coefficient and soil moisture distribution under drip irrigation system.* CJAST, 34 (5): 1-9.

Soccol O.J., Ullmann M.N., Frizzone J.A., 2002 - *Performance analysis of a trickle irrigation subunit insalled in an apple orchard.* Brazilian Archives of Biology and Technology, 45 (4): 425-430.

Şimşek M., Kacira M., Tonkaz T., 2004 - *The effects of different trickle irrigation regime on watermelon (citrullus lanatus) yield and yield components under semi-arid climatic conditions.* Aust.J.Agric.Res., 55:1149-1157.

Trivedi A., Gautam A.K., 2019 - *Temporal effects on the performance of emitters.* Bulletin of Environment, Pharmacology and Life Sciences, 8 (2): 37-42.

Tüzel I.H., 1993 - *Evaluation of uniformity in drip irrigation systems.* Ege University, Journal of Faculty of Agriculture 30 (1–2): 119–126 (In Turkish).

Ünal Y., Acar B., Direk M., 2015 - *Research on water distribution uniformity for different drip irrigation laterals.* XXXVI CIOSTA§ CIGR Section V Conference, Environmentally Friendly Agriculture and Forestry for Future Generations, 26-28 May, Saint Petersburg, Russia :865-875.

Yavuz M.Y., Demirel K., Erkan O., Bahar E., Deveciler M., 2010 - *Emitter clogging and effects on drip irrigation systems performances.* African Journal of Agricultural Research, 5 (7): 532-538.

Yavuz D., Topak R., Yavuz N., 2014 - *Determining energy consumption of sprinkler irrigation for different crops in Konya Plain*. Türk Tarım ve Doğa Bilimleri Dergisi, 1(3): 312-321.

Yavuz D., Yavuz N., Seymen M., Türkmen Ö., 2015a - *Evapotranspiration, crop coefficient and seed yield of drip irrigated pumpkin under semi-arid conditions.* Scientia Horticulturae, 197: 33-40.

Yavuz D., Seymen M., Yavuz N., Türkmen Ö., 2015b - *Effects of irrigation interval and quantity on the yield and quality of confectionary pumpkin grown under field conditions.* Agricultural Water Management, 159: 290-298

Yavuz D., Yavuz N., Süheri S., 2016 - *Energy and water use for drip-irrigated potato in the Middle Anatolian region of Turkey.* Environmental Progress & Sustainable Energy, 35: 212-220.

Yavuz N., Seymen M., Yavuz D., Acar B., Türkmen Ö., 2017 - *Deficit irrigation effect on yield performance of pumpkin in semi-arid Middle Anatolian Region of Turkey.* International Journal of Agriculture and Economic Development, 5 (2): 1-10.

Yavuz D., Acar B., Yavuz N., Çiftçi N., 2018 - *Irrigation in various growth stages effect on yield and water productivity of drip- irrigated sunflower in semi-arid Konya environment, Turkey.* International Journal of Agriculture and Economic Development, 6 (2) : 7-17.

Yavuz N., Çiftçi N., Yavuz D., 2019 - *Effects of different irrigation interval and plant-pan coefficient applications on yield and quality parameters of oil sunflower grown in semi-arid climate conditions.* Arabian Journal of Geoscienses. https//doi.org/10.1007/s12517-019-4867-1

Zamanian M., Fatahi R., Boroomand-Nasab S., 2014 - Field performance evaluation *of micro irrigation systems in Iran.* Soil§Water Res. 9 (3) : 135-142.