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Research on Drip Irrigation System Performance under Greenhouse Conditions

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Abstract. This study was conducted to evaluate trickle irrigation system performance under greenhouse conditions in Antalya Province of Turkey. For this purpose, uniformity coefficient (UC) by graphical method as well as emission uniformity (EU) was researched. The UC varied from 56% (unacceptable) to 90 % (perfect) and EU varied from 41% (poor) or (unacceptable) to 92% (perfect or good). The main problems detected were poor system design and clogging within systems. This fact is produced by different reasons, standing out the low efficiency distribution networks, insufficiency in maintenance and repair works and friction losses.

Keywords: trickle irrigation, water quality, emitter discharge, uniformity coefficient.

INTRODUCTION

Selection of irrigation method, properly design of the systems, well management is necessarily prerequisites for efficient irrigation (Yıldırım and Korukçu, 1999). Drip irrigation applies water frequently at very low rates to achieve optimum moisture levels and plant growth (Nir, 1982; Karmeli and Keller, 1975; Burt and Styles, 1999; Yıldırım and Korukçu, 2000).

It is inevitable in near future because of high water savings, friendship of environment and is suitable for most crops with frequent and uniform applications of water, adaptable over a wide range of topographic and soil conditions (Çetin and Bilgel, 2002; Du *et al.* 2008).

Irrigation uniformity is the most important indicator for evaluation of the irrigation system performance (Letey et al. 2000) and is affected by the field topography, hydraulic design of drip system as well as level of partial or complete clogging (Mofoke *et al.,* 2004; Yıldırım, 2007; Yıldırım, 2010; Zhu *et al.* 2009; Al-Amound, 1995).

The evaluation of operating irrigation systems aims the understanding of the systems adequacy and determination of the necessary procedures for improving the system's performance (Soccol *et al.,* 2002).

It is recommended that evaluation should be carried out soon after the system's establishment, and periodically repeated, especially when considering systems, due to their sensitivity to operational conditions along the time (Keller and Bliesner, 1990).

Uniformity coefficient, UC, for localized irrigation systems, based on emitter flow measures is highly recommended (Keller and Karmeli, 1974; Bralts, 1986; Capra and Tamburina, 1995).

Tüzel (1993) classified the water distribution level in accordance uniformity coefficient; UC> 90%- excellent; 80 %< UC<90% - good; 70 %< UC<80% -moderate; 60 %< UC<70% - poor; UC< 60%-unacceptable.

Bağdatlı and Acar (2009) reported that UC varied from 78% to 96% in a study of vegetable irrigated trickle systems for Konya Region of Turkey**.** Bozkurt (1996) tested 11 new drip systems and found that UC values were between 85% and 90% in one lateral and greater than 95% in others.

Determination of UC by conventional methods is both complex and time consuming. The aims of this work are, therefore, to evaluate the performance of drip irrigation systems by means of the parameters analysis such as firstly UC by graphical method as well as emission uniformity, EU, and to suggest management alterations to improve their performances.

MATERIALS AND METHODS

The study was conducted in Antalya province, Mediterranean Region, of Turkey during the growing seasons of 2006 and 2007 with 54 m above sea level. The greenhouse production is very common in region due to ideal location, high winter light intensity, moderate winter temperatures, low humidity, and easy access to markets.

Some climatologically data on the experimental site are given in Table 1. According to Table 1, annual average temperature, relative humidity, and precipitation in the area are 18.1° C, 63%, and 1130 mm, respectively.

Tab. 1

Long – term (1975-2004) monthly climatologically data of the research area (Anonymous, 2007).

Climatic Data	Months												
	1	2	3	4	5	6	7	8	9	10	11	12	Annual
Temperature (°C)	9.5	9.9	12.2	15.7	20.3	25.3	28.3	27.8	24.3	19.5	14.2	10.7	-
Relative Humidity (%)	66.0	64.0	67.0	68.0	66.0	59.0	56.0	59.0	60.0	61.0	66.0	68.0	-
Sunshine (hours)	4.7	4.6	4.4	4.4	3.5	1.9	1.2	1.2	1.4	2.7	3.9	4.8	-
Wind Speed (m $s^{-1)}$	3.2	3.4	3.1	2.8	2.5	2.8	2.7	2.5	2.5	2.5	2.7	2.9	-
Rainfall (mm)	218.8	136.4	110.5	66.0	31.8	7.9	2.0	2.1	8.6	76.2	190.8	279.1	1130.2

The drip system, in-line type and placed 0.35-0.80 m apart from each other and had 2 – 4 L h^{-1} flow rate at 100 kPa pressure, consisted of polyethylene laterals of 16 – 20 mm obtained from different companies laid parallel to one or two drip lines for each crop rows depending on vegetable types.

For flow measurement, 8 laterals on one manifold were randomly identified and emitter discharge was measured at three points along each lateral, corresponding approximately to the top, mid-point and end of each lateral. An about 24 individual emitters are tested (Fig.1).

For each measurement, a small area in the bed or ridge was excavated, and a catch-can was placed under the emitters.

To assess the performance, irrigation uniformity by using graphical method (Goyal, 2007) and Emission Uniformity (EU) were analyzed for 11 different systems under greenhouse conditions.

For determination of UC, the 3 highest and the 3 lowest flow rates first summed and then these were plotted (Fig. 2.) The point where those flow rates are intersected, it is the value of UC with water distribution class. The UC values were evaluated by Tüzel (1993), Farouk (1998).

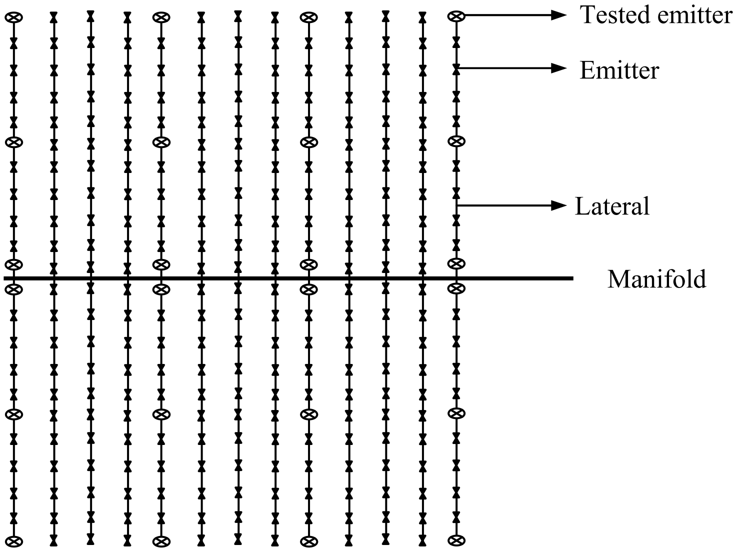

Fig. 1. Flow measurement points on laterals

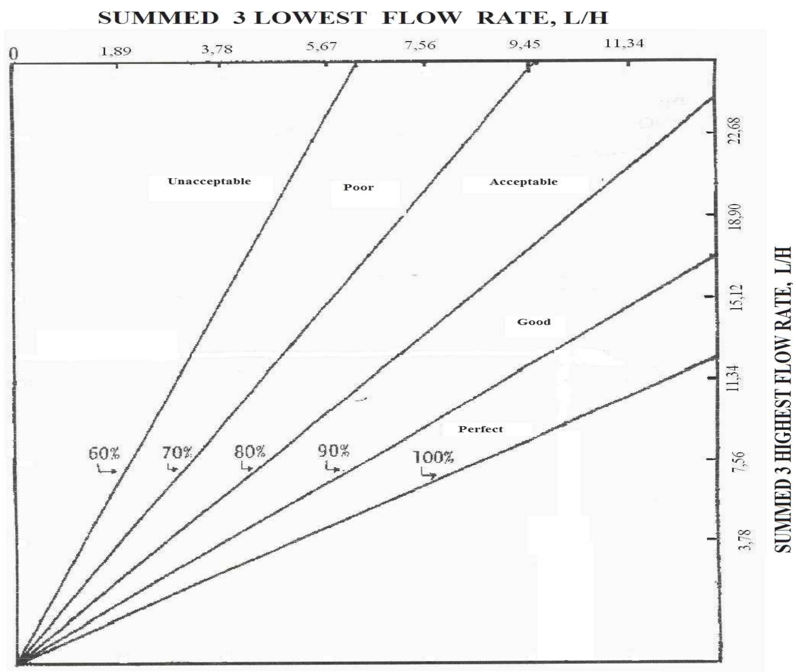

Fig. 2. The uniformity and water distribution class based on the dripper flow rates (Goyal, 2007).

In this research, EU is expressed as;

$$\%EU = \frac{q_{\%25}}{q_a} x100$$

Where; EU- Emission uniformity, %, $q_{\%25}$- Average of low quarter, L h^{-1} and q_a- average flow rate, L h^{-1}. The results were compared by using the Table. 2.

Tab. 2

Evaluation of emission uniformity by different standards

EU, %	Classification by Merriam and Keller (1978)	Classification by Instituto de Reforma Y Desarrollo Agrario, IRYDA (1983).
<70	Poor	Unacceptable
70–80	Acceptable	Poor
80–86	Good	Acceptable
86–90	Good	Good
90–94	Perfect	Perfect
>94	Perfect	Perfect

RESULTS AND DISCUSSION

The research soils in 0-50 cm depth are predominantly Sandy-Clay- Loam (SCL) and Sandy-Loam (SL). According to the texture, soils are suitable for vegetable production.

The salt content of soils was in all research greenhouses was lower than the threshold value of 4 dS/m so all soils were not hazardous for the vegetable production. Electrical conductivity of water resources varied from 432 to 866 µmmhos/cm. The salt concentrations at 1, 4, 5, 6, and 8 water supplies varied from 250 to 750 µmmhos/cm so that such irrigation water is second class in respect to salinity hazard (C_2). In 2, 3, 9, 10 and 11 systems, irrigation water is classified as third class, C_3 (Farouk, 1998). This means that this water had moderately salinity hazard to those greenhouse plants.

In Antalya province, greenhouses have poor drainage system and are covered by glass or plastic covers. To reduce the soil salinity level of not harmful for most plants, rainfall should be diverted to the greenhouses in winters or leaching should be performed during the inactive plant growth periods.The tested laterals were obtained from 4 different firms and all lateral lengths were lower than the maximum allowable lengths by firms. The ages of laterals in used systems were between 1 and 17 year. The life of those laterals has improved by proper maintenance and repair.

In examine drip systems, only two systems had greater flow rate than the suggested flow rate of at 100 kPa pressure (Fig.3). In such systems, the possible reason might be that maintenance and repair works have made properly and working pressure was higher than 15 and 20 mH_2O (higher than optimum acceptable level of 10 mH_2O). To increase the flow rates in such systems, the farmers have applied some chemicals that were also beneficial for crops.

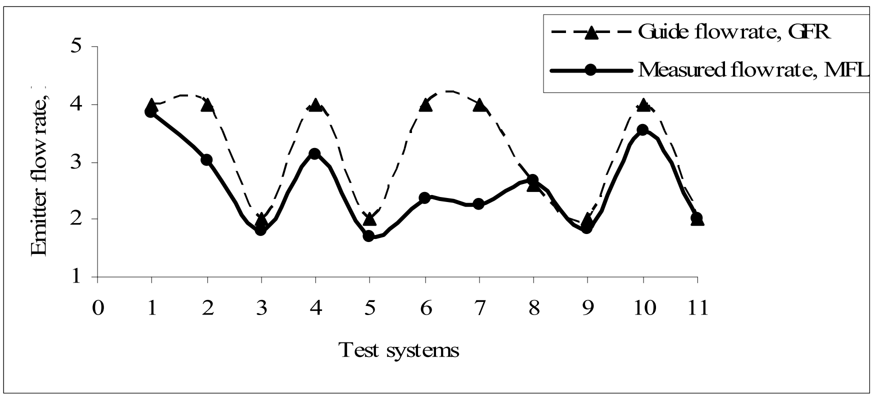

Fig. 3. Guide and actual measured flow rates

As we all know that acid injection through the system causes reduction in pH and dissolves calcium carbonate precipitation in emitters. In system 2, irrigation interval was observed three days and 5 L/ ha PHO_3 and 15 L/ha HNO_3 were applied in each irrigation during the vegetation periods May-June 2007. The treatments were found efficient way for preventing the emitter clogging resulted from chemical composition of irrigation water and meeting the plant nutrients.

UC values and water distribution class are presented in Table 3. The highest UC was measured from greenhouse 8 as 90% (perfect distribution) and most values varied from 80% to 90%. Those values were seen quite well and high UC in those systems might be resulted from the periodically maintenance and properly design of systems.

The UC values obtained from the present study is agreement with Bağdatlı and Acar (2009), but lowers than findings of Bozkurt (1996).

Tab. 3

Uniformity coefficient (UC) and water distribution level

Farm No	UC, %	Water Distribution Class	Working Pressure (Atm.)
1	88	Good	1.5
2	77	Acceptable	2.0
3	86	Good	1.5
4	85	Good	-
5	82	Good	-
6	82	Good	-
7	85	Good	-
8	90	Perfect	1.5
9	56 (60<)	Unacceptable	1.5
10	86	Good	2.0
11	87	Good	1.5

The EU values are presented in Table 4. The EU values varied from 41% to 92% depending on the tested systems. According to this, water distribution varied from poor and perfect and unacceptable to good for Merriam and Keller (1978) and IRYDA (1983), respectively.

Tab. 4

Emission uniformity and water distribution class

Farm No	EU (%)	Classification by Merriam and Keller (1978)	Classification by IRYDA (1983)
1	85	Good	Acceptable
2	67	Poor	Unacceptable
3	92	Perfect	Good
4	81	Good	Acceptable
5	84	Good	Acceptable
6	79	Acceptable	Poor

7	85	Good	Acceptable
8	90.1	Perfect	Good
9	41	Poor	Unacceptable
10	79.8	Acceptable	Poor
11	91	Perfect	Good
Average	80	Good	Acceptable

The lowest EU values were calculated from 2 and 9 irrigation systems so that such systems should be changed or if possible some processes are needed. If this trend continues, crop production will be adversely affected from non-uniform water applications. In general, maintenance and repair works have to be performed with great care periodically. Ortega *et al.* (2002) tested 100 systems and found the EU as an average of 84%. This value was almost similar to our study average of 80%.

CONCLUSIONS

The UC values can be determined very easily by use of graphical method and is highly recommended. In general, pressure in laterals was between 15 and 20 mH_2O that was higher than the optimum acceptable level of 10 mH_2O. For sustainable energy use, pressure of 10 mH_2O is strongly recommended. To determine the UC and EU values more accurately, emitter flow rate should be measured in all emitters (if possible).

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