International Journal of
Agriculture, Environment and Food Sciences
e-ISSN : 2618-5946
www.jaefs.com
JAEFS

Research Article
Int J Agric Environ Food Sci 6 (1): 172-181 (2022)

Evaluation of performance indicators for some drip irrigation systems used in cherry orchards in Ankara province

Rohat Gultekin[1,*] **Ceren Gorgisen**[1] **Gonca Karaca Bilgen**[2]
Pinar Bahceci Alsan[1] **Tugba Yeter**[1]

[1]Research Engineer, Soil, Fertilizer and Water Resources Central Research Institute, Ankara, Türkiye
[2]Research Engineer, General Directorate of Agricultural Research and Policies, Ankara, Türkiye

*Corresponding Author: rohatgultekin@gmail.com

Citation
Gultekin, R., Gorgisen, C., Karaca Bilgen, G., Bahceci Aslan, P., Yeter, T. (2022). evaluation of performance indicators for some drip irrigation systems used in cherry orchards in Ankara province. Journal of Agriculture, Environment and Food Sciences, 6 (1), 172-181.
Doi
https://doi.org/10.31015/jaefs.2022.1.22

Received: 21 December 2021
Accepted: 16 March 2022
Published Online: 30 March 2022
Revised: 02 April 2022

Year: 2022
Volume: 6
Issue: 1 (March)
Pages: 172-181

Available online
http://www.jaefs.com
https://dergipark.org.tr/jaefs

Abstract
In this study, performance tests of drip irrigation systems were carried out in cherry orchards of some farmers in Ankara. Accordingly, measurements were made on the day of irrigation in the lateral and manifold pipes of the drip irrigation systems used by the farmers. Within the scope of the research, Distribution Uniformity, Emission Uniformity, Application Efficiency, Potential and Actual Application Efficiency measurements were made in drip irrigation systems in 10 different cherry orchards. For this purpose, 4 different dripper points were determined on at least 4 lateral lines in each manifold line. Each lateral pipe and dripper point was chosen to be at the beginning of the line, 1/3 of the line, 2/3 of the distance and at the end of the line. Measurements were made on farmers' irrigation days and under farmer conditions. According to the obtained results, the CU value was between 77.5%- 93.0%, DU value between 60.1%- 86.9%, EU value between 56.7%- 84.5% and CV value between 0.09- 0.28. As a result of the research, it has been determined that there are important design and application problems in drip irrigation systems.

Keywords
Cherry orchard, Water management, Irrigation performance, Water distribution

Introduction
Due to the increasing population, the demand for food is constantly increasing. To meet the increasing food demand, more agricultural production and more agricultural irrigation are required. However, due to climate change and the increase in water use in other sectors, irrigation water resources in agriculture are gradually decreasing. This situation requires more efficient use of water in agriculture. 74% of water resources in Turkey are used in agriculture. This rate is well above the European average and it is predicted that the water rate in the agriculture sector will decrease to 64% in the near future (Anonymous, 2022). Despite the decrease in the amount of water to be used in agricultural irrigation, water resources should be used with high efficiency by using pressurized irrigation systems for sustainable production. The use of pressurized irrigation systems should be increased in order to irrigate more agricultural areas with less water in agriculture. With the decrease in the costs of pressurized irrigation systems in the near future, it is expected that a significant part of the irrigated agricultural lands will be irrigated with pressurized systems.

One of the most important ways to save water in agriculture is to use pressurized irrigation systems. (Ibragimov et al., 2007; Darouich et al., 2014; Qureshi et al., 2015; Gültekin and Ertek 2018). It is also important to operate the pressurized irrigation system correctly, to distribute the water homogeneously in the field, to meet the plant water requirement on time and at an optimum level. The benefits of pressurized irrigation systems have been demonstrated in many studies carried out under controlled trial conditions (Woltering et al., 2011; Tagar et al., 2012; Yan et al., 2018; Fan et al., 2020). However, the use of pressurized irrigation systems in agriculture cannot guarantee the effective use of water resources. The maintenance needs of the irrigation system and the competencies of the users are also very important. Especially in smallholders, pressurized irrigation systems are managed as a continuation of old habits. This situation may prevent the potential of the system to be utilized sufficiently and may cause excessive or insufficient irrigation. This situation may prevent the potential of the system to be utilized sufficiently and may cause excessive or insufficient irrigation. In addition, since the control unit elements (filter, manometer, fertilizer tank, etc.) that should be used in the irrigation system are often neglected, water application efficiency decreases and the economic life of the irrigation system may decrease. Considering the decrease in water resources and the high costs of pressurized irrigation systems, it is clear that the system should be well planned and supervised in terms of engineering.

In this study, the performance tests of drip irrigation systems in cherry orchards were measured under farmer conditions. Accordingly, some performance parameters (irrigation efficiency, water uniformity, etc.) were measured after the design, application and technical examination of the drip irrigation system of 10 different farmers.

Material and Method

Experimental site

The research was conducted in 2018 in Ayaş district of Ankara, located in the Central Anatolia Region, longitude 40.01° N and latitude 32.19° E. Typical features of the continental climate are observed, with cold winters and hot and dry summers. The altitude is 910 meters, the annual average temperature is 11.4 Cº, the average relative humidity is 54%, and the annual average rainfall is 439.7 mm (Anonymous, 2021a). The most cherry production in Ankara is made in Ayaş district. In addition, intensive vegetable and fruit production is carried out in the region (Anonymous 2021b).

Some physical and chemical properties of the soils of the trial plots were analyzed. For this purpose, disturbed and undisturbed soil samples were taken from soil profiles (0-0.3, 0.3-0.6, 0.6-0.9 and 0.9-1.2 m). the soil texture of the study area was generally clayey and the water used in irrigation was suitable for irrigation in terms of irrigation water quality.

Measurements and analysis

In the tested drip irrigation systems, 4 different laterals on each secondary pipe (manifold) were selected. These were the first laterals on the manifold, at 1/3 and 2/3 distances from the beginning of the manifold and last laterals at the end of the manifold. Selected emitters were first or second dripper at the entrance of the lateral, at the distances of 1/3, 2/3 of the lateral and at the end of the lateral. Thus, 16 test points were selected in each sub-unit (Figure 1).

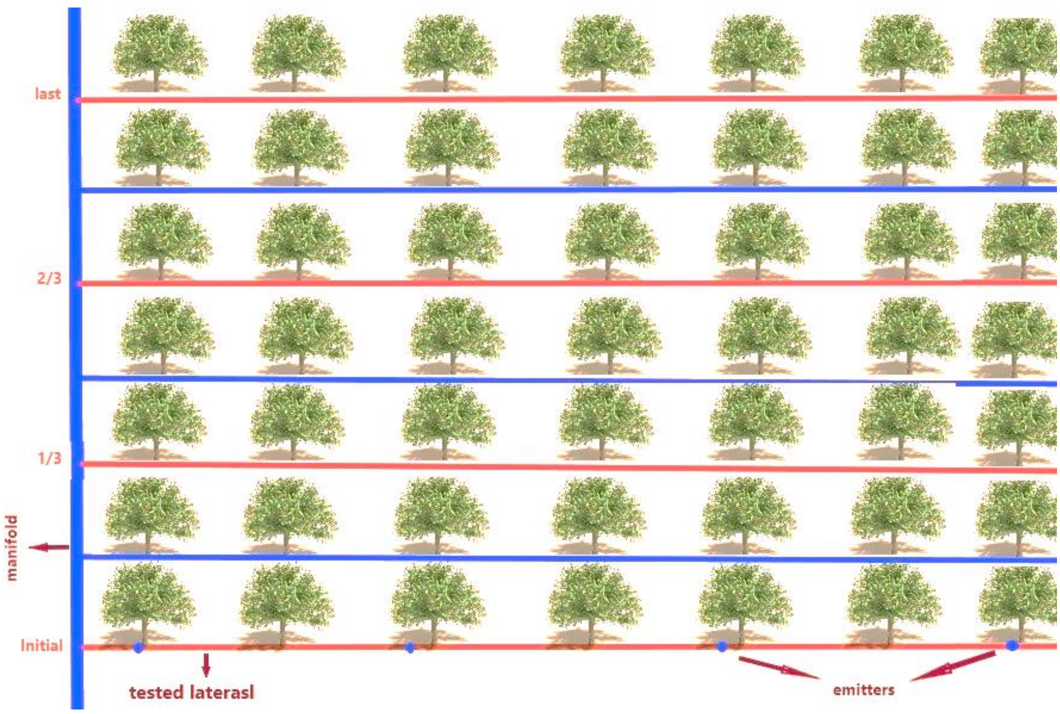

Figure 1. Schematic representation of the measurement locations made in the sub-unit of the drip irrigation system.

The flow rates of the drippers at the test points on the laterals were measured volumetrically. Each dripper flow was measured 5 times; the average flow rate of a dripper was determined. According to field measurements, the following performance parameters were calculated (ASAE, 1991 ve 1998; Kanber et al., 1996; Burt et al., 1997; Ortega et al., 2002).

Coefficient of variation (Cv)

$$Cv = \frac{Sd}{qa} \quad (1)$$

$$Sd = \frac{\sqrt{((q1^2+q2^2+......+qn^2-nqa^2)/(n-1))}}{qa} \quad (2)$$

$$qa = \frac{1}{n}\sum_{n=1}^{n} q_i \quad (3)$$

Where; *Sd*: Standard deviation; *qa*: Average flow rate of tested drippers *(l h^{-1}); q1, q2 …… qn*: flow rates of the drippers tested. In point source drippers, dripper flow rate variation coefficient (Cv) is classified as Cv <0.05 very good, Cv = 0.05-0.07 medium, Cv = 0.07-0.11 at the border, Cv = 0.11-0.15 bad and CV> 0.15 unacceptable. (ASAE, 1998).

Uniformity Coefficient (CU)

Uniformity coefficient (Christiansens, 1942) was measured according to equation as follows:

$$CU = 100\left(1.00 - \frac{\sum_{i=1}^{n}|(q_i-\bar{q})|}{\bar{q}\times n}\right) \quad (4)$$

Where; *n*, number of observations or number of drippers used in evaluation; q_i dripper flow, l h^{-1}; $\bar{q}$, average dripper flow, l h^{-1}.

Distribution Uniformity (DU)

Distribution Uniformity was determined as another index of application co-distribution. It was calculated as the ratio of the average value (sub quarter average flow rate) of the lowest 1/4 of the emitter flow rates considered in the evaluated sub-unit to the average flow rate for the sub-unit (James 1988; Kanber et al., 1996).

$$DU = 100\frac{\overline{q_{lq}}}{\bar{q}} \quad (5)$$

In the equation, $\overline{q_{lq}}$ refer to the lower quarter average emitter flow rate, l h^{-1}, , $\bar{q}$ indicates the average emitter flow, l h^{-1}.

Emission Uniformity (EU)

It was determined using the approach given by Keller and Karmeli (1974). For this purpose, the equation below was used.

$$EU = \left[1 - 1.27\frac{Cv}{N^{0.5}}\right]\frac{q_{min}}{\bar{q}} \quad (6)$$

where *N*: number of drippers evaluated; q_{min}, minimum emitter flow rate, l h^{-1}; $\bar{q}$, average emitter flow rate, l h^{-1}.

Statistical Uniformity (Us)

It was calculated using the equation given below according to the principles given by Bralts and Kesner (1983).

$$Us = 100\ (1 - C_v) = 100\ \left(1 - \frac{S_d}{\bar{q}}\right) \quad (7)$$

Absolute Emission Uniformity (Eua)

It was calculated with the equation suggested by Sivanappan and Padmakumari (1980).

$$E_{ua} = \left(\frac{100}{2}\right)\left(\frac{Qn}{Qa} + \frac{Qa}{Qx}\right) \quad (8)$$

Where, *Qn*= minimum emitter discharge in the subunit, l h^{-1}, *Qa* = average emitter discharge in the subunit, l h^{-1}, *Qx* = maximum emitter discharge in the subunit, l h^{-1}

Application Efficiency (Ea)

It was determined according to the following equation according to ASAE (1991 and 1998) and Kanber et al (1996).

$$Ea = 100\left[Vr\ \frac{1-Pd}{Va}\right] \quad (9)$$

In the equation, *Vr*, the required amount of water, m^3; *Va*, the total amount of water applied, m^3; (1-Pd), irrigated root zone,% (percentage of wetting); *Pd*, unwetted area,%; *Qa*, Actual flow rate of irrigation system, m^3 h^{-1}; T, irrigation time, h.

Potential Application Efficiency of Lower Quarter (PELQ) and Actual Application Efficency of Lower Quarter (AELQ)

It was determined using the approaches given by Merriam et al. (1980).

$$PELQ = 100\ \left(\frac{MAD}{\bar{d}}\right) \quad (10)$$

$$\bar{d} = \bar{q} \times T \times \frac{1}{A} \quad (11)$$

$$AELQ = 100\ \frac{SMD}{\bar{d}} \quad (12)$$

Where: MAD, the amount of water allowed to be consumed or the amount of moisture consumed in the soil, mm; $\bar{d}$, the average depth of water applied, mm; T, irrigation time, h; A, area wetted by drippers, m^2; the SMD indicates the missing moisture amount, mm, at the desired soil depth to be irrigated.

Wetting Pattern (P)

The wetting pattern was determined by measuring the width of the wet strip that occurs along with the lateral(s) of the land surface 24 hours after irrigation. The wetting rate was calculated using the equation given below.

$$P = 100\ \frac{A_w}{S_a \times S_w} \quad (13)$$

$$A_w = W \times S_w \quad (14)$$

Where, A_w is the wetted area, m^2; P is wetting percent, %; S_a, tree row spacing, m; S_w, tree-to-row distance, m; W is the width of the wet strip, m;

Storage Efficiency (Es)

The equation given by James (1988) and Kanber et al. (1996) was used in the calculations.

$$E_s = 100 \times \frac{S_{rz}}{SMD} \quad (15)$$

In the equation, S_{rz} is the amount of water stored in the root zone (or soil depth to be wetted) during irrigation, mm; SMD, the amount of water missing in the root zone before irrigation (the amount of water required to bring the current humidity to field capacity), mm.

Maximum Irrigation Depth (Imax)

It was calculated using the following equation according to ASAE (1991 and 1998).

$$\text{Imax} = y\,(AW)\,\frac{Z.P}{100} \qquad (16)$$

In the equation, y is the amount of water allowed to be consumed before irrigation, %; AW, available water capacity, mm/m; Z is soil to be wetted or root depth, m; P, wetting percent, %

Emitter Performance Coefficient of Variation (V_{pf})

The emitter performance variation coefficient was determined using the equation specified in ASAE (1991).

$$V_{pf} = \left(C_v{}^2 - V_{qh}{}^2\right)^{1/2} \qquad (17)$$

V_{pf} (%) Classification was made according to ASAE (2003). Accordingly; V_{pf} > 0.20 unacceptable, 0.15–0.20 poor, 0.10–0.15 acceptable, 0.05–0.10 good, < 0.05 excellent

Emitter Discharge Coefficient of Variation Due to Hydraulics (V_{qh})

This performance measure was determined using the following approach described in ASAE (1991).

$$V_{qh} = X \times V_{hs} \qquad (18)$$

where X is the emitter discharge exponent and Vhs; hydraulic design coefficient of variation were determined using equations 1, 3 and 4 respectively.

Drip systems having good emission uniformity indicate that water and injected fertilizer are distributed evenly throughout the cherry orchards. Emission Uniformity Rating was defined as 90 - 100% Excellent, 80 - 90% Good 70 - 80% Fair, < 70% Poor

Results and Discussion

The irrigation water analyses used by farmers in the research are given in Table 1.

Well water was used for irrigation in all plots where the studies were carried out. The PH values of the irrigation water varied between 7.09-7.51 and EC values between 0.59-4.33 dS m^{-1}. While there was no problem in terms of alkalinity in irrigation water, high salinity (T_4A_1) was determined in 1 irrigation water.

Soil samples were taken at 0-0.3, 0.3-0.6, 0.6-0.9, and 0.9-1.2 m depths of the soil to evaluate the performance of drip irrigation systems (Table 2). The characteristics, irrigation numbers, and irrigation times of the drippers used in the trial plots are shown in Table 3.

In the examined test plots; soil structure was generally clay and loamy-clay structure, infiltration rate (I) varied between 0.9-7.7 mm h^{-1}. Organic matter amounts were between 0.22-1.75%, lime amounts were between 3.5-53.4%. The number of irrigation in cherry orchards was between 2-5, the irrigation duration was between 8-24 hours. Irrigation practices varied according to the habits of the farmer, the capacity of the water source, and the size of the irrigated area. It was observed that the soils on which the tests were carried out generally had a clayey texture and were poor in organic matter. Accordingly, it was determined that the water uptake rate of the soil was generally low. It has been determined that the runoff, which is frequently seen in the test areas, is caused by the long irrigation time and high flow drippers.

Dripper Flow Rates and Dripper Pressures

The measured average dripper flow rates and dripper pressures are given in Table 4.

Table 1. Irrigation water analysis results

Test Farmer No	Water Source	pH	EC dS m^{-1}	SAR	Irrigation water class
T_1	Deep Well	7.51	0.76	0.88	T_3A_1
T_2	Deep Well	7.09	0.59	0.69	T_2A_1
T_3	Deep Well	7.30	0.64	1.21	T_2A_1
T_4	Deep Well	7.47	1.75	0.72	T_3A_1
T_5	Deep Well	7.45	4.33	0.84	T_4A_1
T_6	Deep Well	7.37	1.12	1.56	T_3A_1
T_7	Deep Well	7.32	1.00	1.90	T_3A_1
T_8	Deep Well	7.39	0.82	1.40	T_3A_1
T_9	Deep Well	7.30	0.64	1.21	T_2A_1
T_{10}	Deep Well	7.22	2.00	0.58	T_3A_1

Table 2. Soil properties of the examined test plots

No	Depth (cm)	Bulk density (gr cm^{-3})	Field capacity	Fading point	Structure	Infiltration (mm h^{-1})	EC (dS m^{-1})	PH	Organic Matter (%)	Lime Amount (%) (Çağlar, 1949)
T_1	0-0.3	1.23	27.08	20.3	CL	1.5	1.14	8.0	1.75	10.1
	0.3-0.6	1.17	36.72	19.0	C		1.44	7.4	1.00	9.5
	0.6-0.9	1.21	36.82	19.4	C		1.31	7.4	0.85	10.0
	0.9-1.2	1.18	40.22	19.9	C		1.06	7.4	0.79	11.4
T_2	0-0.3	1.26	27.55	15.2	SCL	7.7	0.5	7.5	0.94	8.0
	0.3-0.6	1.22	28.80	16.7	CL		0.39	7.6	0.51	6.3
	0.6-0.9	1.24	28.56	14.2	CL		0.49	8.0	0.49	9.0
	0.9-1.2	1.33	24.7	14.9	L		0.44	8.0	0.41	18.0
T_3	0-0.3	1.2	36.72	19.0	C	4.6	0.48	7.4	1.20	7.4
	0.3-0.6	1.2	40.34	19.9	C		0.6	7.8	1.09	7.0
	0.6-0.9	1.28	38.87	20.2	C		0.49	7.9	0.87	8.2
	0.9-1.2	1.25	37.15	21.3	C		0.41	7.7	0.77	8.7
T_4	0-0.3	1.27	32.23	16.77	SCL	8.4	0.56	8.0	1.20	21.0
	0.3-0.6	1.28	27.93	13.66	SCL		0.37	8.1	0.44	21.8
	0.6-0.9	1.24	27.65	12.8	SCL		0.35	8.1	0.36	19.7
	0.9-1.2	1.32	25.33	14.89	SCL		0.56	8.0	0.22	22.5
T_5	0-0.3	1.13	48.25	25.54	C	4.2	0.71	8.0	1.33	33.1
	0.3-0.6	1.27	29.03	15.41	CL		0.88	8.1	0.95	41.4
	0.6-0.9	1.24	32.12	16.85	CL		0.85	8.1	0.90	44.6
	0.9-1.2	1.21	32.18	15.18	CL		0.98	8.1	0.67	48.7
T_6	0-0.3	1.13	48.25	25.54	C	1.2	0.7	8.2	1.36	33.8
	0.3-0.6	1.27	29.03	15.41	CL		0.9	8.3	0.97	42.2
	0.6-0.9	1.24	32.12	16.85	CL		0.9	8.2	0.92	45.5
	0.9-1.2	1.21	32.18	15.18	CL		1.0	8.2	0.68	49.7
T_7	0-0.3	1.16	36.57	20.56	C	5.1	0.64	8.0	1.42	5.5
	0.3-0.6	1.27	37.39	20.16	C		0.55	7.8	0.48	7.2
	0.6-0.9	1.26	40.38	20.1	C		0.64	7.7	0.54	6.9
	0.9-1.2	1.28	38.92	20.2	C		0.56	7.9	0.36	7.9
T_8	0-0.3	1.15	50.09	20.44	C	0.9	0.52	8.0	0.67	8.9
	0.3-0.6	1.13	49.13	20.13	C		0.37	8.1	0.50	5.5
	0.6-0.9	1.17	42.45	19.28	C		0.42	8.2	0.43	3.5
	0.9-1.2	1.24	40.42	20.92	C		0.46	8.1	0.33	5.4
T_9	0-0.3	1.19	37.34	19.07	C	1.4	0.46	8.1	1.49	14.4
	0.3-0.6	1.18	37.42	18.8	C		0.49	8.0	0.84	25.2
	0.6-0.9	1.29	37.54	16.57	C		0.54	7.9	0.64	27.2
	0.9-1.2	1.23	45.84	21.4	C		0.61	8.0	0.66	27.7
T_{10}	0-0.3	1.19	34.89	22.15	C	1.7	0.45	7.4	1.17	39.7
	0.3-0.6	1.18	37.08	18.91	C		0.61	7.3	0.86	51.8
	0.6-0.9	1.29	40.36	27.13	C		1.39	7.6	0.73	53.4
	0.9-1.2	1.23	35.42	21.42	C		1.15	8.0	0.95	48.1

Table 3. Features of drippers used in test plots, number of irrigation and irrigation durations

	Emitter flow (L h^{-1})	Emitter range (m)	Num. of irrigation per season	Avr. irrigation duration (h)
T_1	4	0.20	3	12
T_2	4	0.25	3	12
T_3	4	0.20	3	8
T_4	4	0.25	5	12
T_5	4	0.25	4	8
T_6	4	0.25	3	10
T_7	4	0.33	4	12
T_8	4	0.25	4	24
T_9	4	0.33	4	12
T_{10}	4	0.25	2	24

Table 4. Average dripper flow rates and dripper pressures

Test no	Natural flow rate of the dripper, (q) (L h^{-1})	Measured actual emitter flow rate, (q_{avr}) (L h^{-1})	Average emitter pressure, (h_{avr}) (atm)
T_1	4	2.30	0.42
T_2	4	2.41	0.32
T_3	4	5.58	0.42
T_4	4	3.01	0.56
T_5	4	5.08	0.37
T_6	4	4.53	0.56
T_7	4	5.00	0.33
T_8	4	2.35	0.61
T_9	4	4.65	0.52
T_{10}	4	1.83	0.33

In the study, the average emitter flow rates were measured between 1. 83-5.58 l h^{-1}. Average dripper pressures varied between 0.32-0.61 atm. Dripper pressures were measured below the accepted operating pressure (1 atm) in all plots. In heavy textured soils with low infiltration rates, high dripper flow rates may cause surface flow. On the other hand, the clogging problem is more common as the flow rate decreases. Therefore, the operating pressure should not be less than 1 atm (Yıldırım and Korukçu, 1999). Accordingly, while it was determined that some drippers had a much higher flow rate due to production, it was determined that some drippers operated with a low flow rate due to clogging or low pressure.

Emitter Flow Coefficient of variation (Cv)

The dripper flow coefficient of variation (Cv) for the tested parcels varied between 0.09 and 0.28 and their classifications was made according to ASAE (1998) and given in Table 5. Cv values were determined as at the limit in 1 plot, and unacceptable in the others. In parcels classified as unacceptable, dripper flow rates varied in a wide range.

Most of the drip irrigation systems used in the cherry orchards where the research was conducted were older than 4-5 years. In the research, it has been determined that the periodic maintenance of drip irrigation systems is generally ignored by the farmers. Therefore, CV values of irrigation systems in all test areas were found to be insufficient. The Cv values obtained in the study were higher than Camp et al. (1997); Gil et al. (2008) and Elamin et al. (2017).

Evaluations of water distribution and water use efficiency

Some parameters showing the efficiency and suitability of drip irrigation systems used in cherry orchards were calculated (Table 6).

Table 5. Evaluation of emitter flow rate variation coefficients, (ASAE, 1998)

Test no	Cv	Classification
T_1	0.09	at the limit (0.07-0.11)
T_2	0.28	Unacceptable (>0.15)
T_3	0.17	Unacceptable (>0.15)
T_4	0.21	Unacceptable (>0.15)
T_5	0.16	Unacceptable (>0.15)
T_6	0.18	Unacceptable (>0.15)
T_7	0.17	Unacceptable (>0.15)
T_8	0.20	Unacceptable (>0.15)
T_9	0.21	Unacceptable (>0.15)
T_{10}	0.21	Unacceptable (>0.15)

Table 6. Some performance indicators of drip irrigation systems

Test no	CU, %	DU, %	EU, %	Us, %	Eua, %	Ea, %	PELQ, %	AELQ, %	I_{max}, mm	Es, %	P, %	Vpf, %	Vqh, %
T_1	93.0	86.9	84.5	91.2	95.8	74.1	76.0	74.1	20.3	55.9	21.2	0.08	0.11
T_2	77.5	70.6	64.2	71.8	100.0	71.4	57.8	71.4	17.3	91.3	22.6	0.27	0.04
T_3	86.5	72.2	66.2	83.1	97.7	83.2	59.6	87.8	25.1	133.2	18.8	0.14	0.60
T_4	82.9	73.0	68.1	78.7	98.9	80.2	61.2	80.2	17.4	88.4	18.8	0.12	0.09
T_5	87.4	81.7	76.7	84.2	96.6	92.2	69.0	92.2	16.7	91.1	10.6	0.15	0.17
T_6	85.4	72.8	68.6	81.7	97.7	66.6	61.7	66.6	17.5	68.0	15.8	0.14	0.03
T_7	86.1	60.1	56.7	82.7	99.8	88.8	51.1	88.8	28.5	94.0	22.6	0.17	0.11
T_8	84.4	73.4	67.9	80.4	98.6	73.8	61.1	73.8	26.6	145.7	13.6	0.18	0.04
T_9	82.9	69.3	64.1	78.6	98.7	75.8	57.7	75.8	21.8	117.5	16.1	0.20	0.07
T_{10}	83.1	75.4	69.1	78.9	98.0	70.1	62.2	69.1	19.3	136.6	20.4	0.20	0.08

CU values of the test plots varied between 77.5-93.0%. In the tests, it was determined that the CU values were generally acceptable. Obtained CU values showed similarities with Safi et al. (2007); Ella et al. (2009); Elamin et al. (2017) at similar operating pressures, but lower than Jamrey and Nigam (2018)

As an indicator of uniformity, the DU is a very sensitive parameter and takes into account only the lowest quarter of the observed discharges in relation to the average discharge. This is different from the coefficient of uniformity, which takes into account all observed discharge values in relation to the mean.

In the study, DU values varied between 60.1-86.9%, as expected, DU values were found to be relatively lower than CU. Accordingly, only two of the irrigation systems were rated as "good" and the others had lower performance values. In the study, lower DU values were obtained than Camp et al. (1997); Jamrey and Nigam (2018); and higher than Ella et al. (2009). When the results of the study were evaluated, the slope of the land and the pressure changes in the irrigation system were seen as important factors on DU.

In the results obtained, the EU values of the test plots varied between 56.7-84.5%. According to evaluation criteria, EU values were within the recommended limit values in the T_1 test and below the limit values in other tests. In the study, lower EU values were obtained than Camp et al. (1997); Jamrey and Nigam (2018); Uygan and Çetin (2015) and higher than Ella et al. (2009).

In the research, while Us values varied between 71.8-91.2%, Eua values varied between 95.8-100%. In terms of US, the measurement made on only one test was evaluated as "good". On the other hand, Eua values were good and above in all tests. Accordingly, it has been determined that the irrigation systems were suitable for absolute emission uniformity. Eua values were similar or higher than most research findings (Noori and Al Thamiry, 2012; Mistry et al. 2017; Abdulhadi and Alwan 2020).

Ea is an indicator of how well irrigation water has been applied. In the study, Ea value was determined to be "good" and above in only two tests. This means that in most tests the irrigation was insufficient or the root zone of the plant was not sufficiently wetted.

PELQ is a measure of how well the system performs when optimum water is applied in the plant root zone and AELQ is an indicator of operation and management status in irrigation systems (Bhavan and Maro, 1991). For systems, Potential Application Efficiency (PELQ) in the lower quartile ranged from 51.1-76.0%, and Actual Application Efficiency of the Lower Quarter (AELQ) ranged from 66.6-92.2%. The AELQ values obtained in the study were found to be similar to Uygan and Çetin (2015) and higher than Zare et al., (2020), the PELQ values were found to be lower than Uygan and Çetin (2015) and higher than Zare et al., (2020). The smaller the difference between AELQ and PELQ, the better the system operates (Ashiri et al., 2014). It will be seen that this difference is not low in all drip irrigation systems examined. In this case, it can be said that the tested drip irrigation systems are not well operated or not properly designed.

The maximum irrigation depth (I_{max}) is used to calculate the application efficiency and is converted to the net irrigation requirement when multiplied by the irrigated area. In the tests performed, the I_{max} value varied between 17.3 and 28.5. Obtained Imax values were found suitable according to the soil types (Hezarjaribi, 2008).

The storage efficiency (Es) indicates how well the system uses the available root zone storage capacity to store water to meet crop needs. Es values in the tested areas varied between 55.9-145.7%. An Es value of more than 100 indicates excessive irrigation in the root zone of the plant, while values below 100 indicate insufficient water needs (Anyoji and Wu, 1994; Irmak et al. 2011).

In drip irrigation system planning, it is extremely important to determine the wetting area percentage (P) correctly. This rate generally varies between 30-70% of the total area, especially in orchards. For this reason, the percentage of the wetting area should be at least 30% in project designs. However, this value can be taken as the lower limit of 25% in humid regions and 35% in very arid regions (Keller and Bliesner, 1990). Wetting percentages (P) in the tested plots were found to be between 10.6% and 22.6%. The reason for the wetting area ratio to vary in such a wide range was due to the different tree-planting spacings, the differences in the lateral spacing, and the differences in the amount of irrigation water applied. The fact that the wetting rate was lower than 30% in all irrigation systems where the tests were carried out showed that the system design and irrigation practices were faulty.

Emitter performance coefficient of variation (V_{pf}) is a measure of dripper flow variability due to dripper wear, clogging, water temperature and dripper construction characteristics. In previous similar studies, it was reported that V_{pf} values were between 0.027 and 0.275 and V_{qh} values were between 0.019-0.047 (Camp et al. 1997; Safi et al. 2007). The V_{pf} values obtained in the study ranged from 0.08 to 0.27. Emitter discharge coefficient of variation due to hydraulics (V_{qh}) values were between 0.03-0.17. Accordingly, 4 of the tested systems were within the acceptable limit, while the others were below the acceptable limit. According to these findings, it was determined that there was a problem in terms of pressure homogeneity and hydraulic uniformity in the system.

Conclusion

The drip irrigation system is one of the most effective irrigation methods that saves water. Dripper technologies, which are continuously developed to increase irrigation efficiency, and soil and plant moisture monitoring devices provide a great convenience for users. The infiltration properties of the soil, plant water requirement, the quality of the material used, climatic characteristics of the region, user's knowledge level and habits may affect the performance of the irrigation system.

In this study, the performance tests of drip irrigation systems in cherry orchards belonging to farmers were measured. It has been tried to demonstrate how effectively drip irrigation systems are used without interfering with the irrigation habits of the farmers. According to the findings obtained in the study, CU values in drip irrigation systems were generally found to be appropriate, DU values were low except for 2 parcels, especially because the sloping structure of the land was ignored. System performances were sufficient in terms of absolute emission uniformity. However, only one parcel was sufficient for Us and Eu. In the study, it was seen that there was sufficient irrigation application in only 2 test plots. The difference between AELQ and PELQ was huge. This indicates that the drip irrigation system is not well operated or well designed. In the observations made in the cherry orchards, it was seen that the drip irrigation systems were installed on the land by the farmers and they did not have any technical knowledge. Therefore, the design of the system was poor. Es values were very high especially due to dripper flow rates that are not compatible with the infiltration rate of the soil and very long irrigation time. This situation causes water losses by deep infiltration or surface run-off. Wetting rates of the irrigation system were also below 30% in all systems. This is technically undesirable. However, wetting rates were found to be low due to the fact that farmers generally used only one lateral. Irrigation systems tested for Vpf and Vqh were generally at or below the limit value. Pressures at the dripper point varied considerably, as the operating pressure of the system was generally low.

The effectiveness of pressure irrigation systems in conserving water largely depends on the habits and skills of the users. This study showed that user-related problems (design, operation) are very important in drip irrigation system performance. For this reason, it is necessary to benefit from engineers who are experts in irrigation in the stages of designing the drip irrigation system and applying it to the field.

Compliance with Ethical Standards

Conflict of interest

The authors declared that for this research article, they have no actual, potential or perceived conflict of interest.

Author contribution

The contribution of the authors to the present study is equal. All the authors read and approved the final manuscript. All the authors verify that the Text, Figures, and Tables are original and that they have not been published before.

Ethical approval

Ethics committee approval is not required.

Funding

This study was financially supported by the General Directorate of Agricultural Research and Policies, Ankara, Turkey (Project no: TAGEM/TSKAD/G/17/A9/P3/409).

Consent for publication

Not applicable.

Data Availability Statement

No data, models, or code were generated or used during the study.

Acknowledgements

The authors would like to thank the General Directorate of Agricultural Research and Policies and Soil, Fertilizer and Water Resources Central Research Institute for their support.

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