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Araştırma Makalesi/Reserach Article

Performance Evaluation of Drip Irrigation Systems on Production of Tomato in Ayaş, Ankara

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Abstract

In the study, the performances of drip irrigation systems used by farmers growing tomatoes were evaluated. For this purpose, the technical performance of some drip irrigation systems in the villages of Ayaş district of Ankara province in the Central Anatolia Region was evaluated. To measure the performance of drip irrigation systems, 4 lateral drip lines on each manifold and 4 drippers on each lateral were taken into account. The Uniformity Coefficient (CU), Distribution Uniformity (DU), Emission Uniformity (EU), Absolute Emission Uniformity (Eua), Water Application Efficiency (Ea), Actual Application Efficiency of Lower Quarter (AELQ) and Potential Application Efficiency of Lower Quarter (PELQ) were found as 81-94%, 63-91%, 58-88%, 94.5-100%, 30-64%, 33-61% and 53-79%, respectively. The CU and EUa values obtained in the study were above the acceptable values in all tests. While DU values were below the acceptable limit in the 4 farmer fields tested, EU values were only within the acceptable range in one test plot. The difference between AELQ and PELQ values in the tested drip irrigation systems was found to be high. This showed that drip irrigation systems were not operating well. Accordingly, low performance indicators were obtained due to the insufficient flow of the water supplied from the wells, the mistakes in the irrigation system caused by the design and the habits of the farmers.
Keywords: drip irrigation, performance, water distribution, irrigation efficiency, tomato

Ankara Ayaş'ta Domates Yetiştiriciliğinde Kullanılan Damla Sulama Sistemlerinin Performanslarının Değerlendirilmesi

Öz

Çalışmada domates yetiştiren çiftçilerin kullandığı damlama sulama sistemlerinin performansları değerlendirilmiştir. Bu amaçla, İç Anadolu Bölgesinde Ankara ili Ayaş ilçesine bağlı köylerde bulunan bazı damla sulama sistemlerinin teknik performansları değerlendirilmiştir. Damla sulama sistemlerinin performansını ölçmek için her bir sekonder boru hattına bağlı 4 lateral hattı ve her lateralde 4 damlatıcı noktası dikkate alınmıştır. Tekdüzelik Katsayısı (CU), Dağılım Tekdüzeliği(DU), Emisyon Tekdüzeliği (EU), Mutlak Emisyon Tekdüzeliği (Eua), Tarla Su Uygulama Randımanı (Ea), Alt Çeyrek Gerçek Uygulama Randımanı (AELQ) ve Alt Çeyrek Potansiyel Uygulama Randımanı (PELQ) sırasıyla %81-94, %63-91, %58-88, %94,5-100, %30-64, %33-61 ve %53-79 olarak bulunmuştur. Çalışmada elde edilen CU ve EUa değerleri tüm testlerde kabul edilebilir değerlerin üzerinde elde edildi. Test edilen 4 çiftçi tarlasında DU değerleri kabul edilebilir sınırın altındayken, EU değerleri yalnızca bir test alanında kabul edilebilir değerde bulundu. Test edilen damla sulama sistemlerinde AELQ ve PELQ değerleri arasındaki farkın yüksek olduğu görülmüştür. Bu da damla sulama sistemlerinin iyi çalışmadığını göstermiştir. Sonuçta, sulama kuyularından sağlanan suyun yetersiz debiye sahip olması, sulama sisteminde tasarımdan kaynaklanan hatalar ve çiftçilerin alışkanlıkları nedeniyle düşük performans göstergeleri elde edilmiştir.
Anahtar Kelimeler: damla sulama, performans, su dağılımı, sulama verimliliği, domates

Introduction

The Mediterranean climate zone which is one of the regions most affected by global climate cahnge and water resources are also decreasing significantly. While the increasing population and industrialization increase the demand for water, it also creates a significant pressure on the irrigated agriculture because of excess water use in agriculture. Efficient and sustainable use of water resources is inevitable for safe food and environmental issues in the future. In many studies conducted in recent years, new irrigation systems and irrigation methodologies have been developed and proposed for the efficient use of water resources in agriculture. In addition, it has been reported that pressurized irrigation systems increase irrigation water use efficiency (Fereres et al., 1982; Ibragimov et al., 2007; Darouich et al., 2014; Qureshi et al., 2015; Gültekin and Ertek 2018;), reduce labor costs in agriculture (Michael, 2008; Woltering et al., 2011; Tagar et al., 2012) and provide more effective fertilization (Lamm et al., 2003; Yan et al., 2018; Fan et al., 2020). On the other hand, the higher initial investment cost of pressurized irrigation systems, clogging problems and the requirement of periodic maintenance are important shortcomings for the farmers.

Turkey is one of the countries most felt that the agricultural drought and especially in the Central Anatolia and South East Anatolia regions water resources have decreased to critical levels (Dabanli, 2018). Drip irrigation allows more crops to be grown per unit water and much larger areas to be irrigated with less water. With this aspect of the drip irrigation method, it has a significant effect on increasing the amount of irrigated agricultural land (von Westarp et al., 2004). While The profile of farmers in Turkey is mostly in the form of small-scale family businesses, drip irrigation system in Turkey is mostly used by large scale commercial farmers (Yavuz, 2005). However, farmers at the level of small family businesses use the drip irrigation system without the help of an expert. This often causes insufficient performance from the drip irrigation system. In fact, the amount of irrigation water applied can often be similar to surface irrigation systems. Accordingly, it is very important to reveal how scientific studies, agricultural policies and investments have changed the habits of farmers in order to save water in agriculture, to show whether the effective use of water has reached the goal.

In this study, it was investigated whether the drip irrigation system used by the farmers was compatible with the recommended performance indicators. For this purpose, drip irrigation systems were tested under farmer conditionsThe performance of drip irrigation systems was measured without any intervention in farmer practices, and the effect of irrigation systems on water use efficiency was revealed.

Material and Method

Research area and climate

The research was conducted in Ayaş district of Ankara, located in the Central Anatolia Region. Ayaş; It is 58 km northwest of Ankara and spread over 1158 km^2 area. Typical features of the continental climate are observed in Ayaş, 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 2020a).

The majority of the population of the region is farmers. Vegetables such as melons, tomatoes, onions, beans and squash are widely produced in the district (Table 1). In addition, an application was made to register Ayaş tomato produced in the region as a geographically marked product.

Table 1. Mostly produced vegetables in Ayaş district (Anonymous, 2020b)

Vegetables	Production Area (ha)	Production Amount (tons)
Melon	1060	11660
Tomato	556	18033
Onion	350	14591
Watermelon	150	4125
Beans (Fresh)	120	1620

Drip irrigation system performance measurements were made in the field of 10 farmers in the study. In order to determine the areas where the tests will be carried out, the farmers' experience of using the drip irrigation system (1-5-10 years), the size of the irrigation area (0.1-0.5-1.0-2.0 ha) and their cooperation potential were taken as criteria. For this purpose, the farmer registration system data of Ayaş District Directorate of Agriculture were used to determine the test areas.

Implementation of the measurements in drip irrigation systems

In the tested drip irrigation systems, two sub-units (secondary pipe-manifold) representing the study area were selected. One of the subunits was chosen to be closest to the control unit and the other to the farthest from the control unit. 4 different laterals were selected on each secondary pipe (manifold) selected. These were the first laterals on the manifold, at 1/3 and 2/3 distances from the beginning of the manifold and the laterals at the end of the manifold. The first or second dripper at the entrance of the lateral, the drippers at the distances of 1/3, 2/3 of the lateral and the dripper at the end of the lateral (Uygan and Çetin, 2015). Thus, 16 test points were selected in each sub-unit (Figure 1).

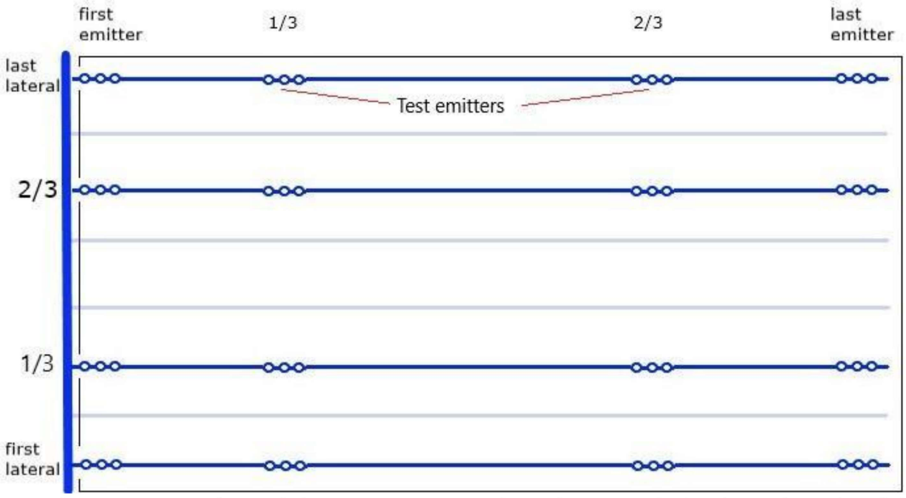

Figure 1.Schematic representation of the measurement locations made in the sub-unit of the drip irrigation system.

The flow rates of the drippers at the test points on the laterals were measured volumetrically. Each dripper flow was measured 2-5 times; the average flow rate of a dripper was determined, after discarding the highest and lowest values. Based on the measurement values obtained, 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 calculated using the approach given by Kanber et al (1996).

$$CU = 100\left(1.00 - \frac{\sum_{i=1}^{n} |(q_i - \underline{q})|}{\underline{q} \times n}\right) \quad (3)$$

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

CU is classified as CU> 90% very good, CU = 80-90% good, CU = 70-80 medium, CU = 60-70 poor and CU <60 very poor / unacceptable.

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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).

$$DU = 100\frac{q_{lq}}{\underline{q}} \quad (4)$$

In the equation, q_{lq} refer to the lower quarter average emitter flow rate, l h^{-1}, , $\underline{q}$ indicates the average emitter flow, l h^{-1}. The evaluation of distribution uniformity was made according to Merriam and Keller (1978). Accordingly; DU <70% unacceptable, DU= 70-80% poor, DU= 80-86% acceptable, DU= 86-90% good, DU= 90-94% very good, and DU> 94%.

Emission Uniformity (EU)

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

$$EU = \left[1 - 1.27\frac{Cv}{N^{0.5}}\right] \frac{q_{min}}{\underline{q}} \quad (5)$$

EU: Emission uniformity, %; N: number of drippers evaluated; q_{min}, minimum emitter flow rate, l h^{-1}; $\underline{q}$, average emitter flow rate, l h^{-1}.

Absolute Emission Uniformity (Eua)

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

$$E_{ua} = \left(\frac{100}{2}\right)\left(\frac{Qn}{Qa} + \frac{Qa}{Qx}\right) \quad (6)$$

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}.

Pressure Variations in Lateral And Manifold Pipes (ShM ve ShL):

Pressure variations were calculated for both manifold and lateral lines. For this purpose, the equations given by Kanber et al (1996) were used. In the study, the inlet and outlet pressures of the manifold pipe, the inlet and outlet pressures in the first, 1/3, 2/3 lateral and last lateral connected to the manifold pipe were measured. Needle-tipped digital manometers developed for this purpose were used in pressure measurements.

$$S_{hM} = \frac{(H_{m1} - H_{m4})}{H_{m4}} \quad (7)$$

$$S_{hL} = \frac{(H_{L1} - H_{L4})}{H_{L4}} \quad (8)$$

In equality; ShM Secondary (manifold) pressure change in pipe, bar; H_{m1}, pressure at the manifold inlet, bar; H_{m4}, outlet pressure at the manifold end, bar; ShL measures the pressure change in the lateral, and HL_1 shows the pressure of the first dripper on the lateral as bar; HL_4 indicates the outlet pressure of the dripper at the end of lateral as bar.

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.

Application Efficiency (Ea), 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).

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

$$\underline{d} = \underline{q} \times T \times \frac{1}{A} \quad (13)$$

$$AELQ = 100 \frac{SMD}{\underline{d}} \quad (11)$$

In the equality: MAD, the amount of water allowed to be consumed or the amount of moisture consumed in the soil, mm; d, 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.

Results and Discussion

Some Soil and Water Properties of Test Plots

Some physical and chemical properties of the soils were determined in the farmer plots where the tests were carried out. For this purpose, disturbed and undisturbed soil samples were taken from soil profiles (0-0.3, 0.3-0.6, 0.6-0.9 m).

In soil samples, pH, soil structure, salinity-alkalinity, field capacity, wilting point, volume weight analyzes were made.

Decagon brand dual head automatic infiltration device was used for infiltration tests (Cobos et al., 2015).

The approaches given by Kanber (2010) were used in the selection of test locations and evaluation of the data in the tests performed in the areas where the drip irrigation system was installed.

The irrigation water analyzes used by farmers in the research are given in Table 2.

Table 2. Irrigation water analysis

Test No	Water Source	pH	EC dS m^{-1}	SAR	Irrigation water class
T_1	Deep Well	7.22	6.55	1.19	T_4A_1
T_2	Deep Well	7.72	1.51	1.52	T_3A_1
T_3	Deep Well	7.44	2.85	3.83	T_4A_2
T_4	Stream water	7.77	2.48	3.74	T_4A_1
T_5	Stream water	7.74	0.44	0.55	T_2A_1
T_6	Deep Well	7.70	1.44	1.47	T_3A_1
T_7	Deep Well	7.51	4.2	0.54	T_4A_1
T_8	Dam / Pond	8.58	0.42	0.67	T_2A_1
T_9	Dam / Pond	8.61	0.4	0.53	T_2A_1
T_{10}	Deep Well	7.76	0.73	2	T_2A_1

In the research, it was determined that river water was used in two parcels, dam / pond water in two parcels, and deep well water in six parcels.

The PH values of the irrigation water varied between 7.22-8.61 and EC values between 0.4-6.55 dS m^{-1}.

While there was no problem in terms of alkalinity in irrigation water, high salinity (T_4A_1, T_4A_2) was determined in 4 irrigation water.

Soil samples were taken at 0-30, 30-60, 60-90 cm depths of the soil in tomato growing areas in order to evaluate the performance of drip irrigation systems (Table 3).

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Table 3. 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	0-30	1.17	32.62	17.2	C		0.64	7.6	1.01	35.6
	30-60	1.11	32.71	17.8	C	2.5	0.66	7.9	0.96	38.1
	60-90	1.27	37.56	17.3	CL		0.72	8.1	0.76	44.7
T_2	0-30	1.24	32.77	17.1	CL		1.99	7.3	1.44	24.9
	30-60	1.20	39.69	21.1	C	5.2	1.3	7.5	0.87	25.5
	60-90	1.21	39.41	21.2	C		0.8	7.6	0.97	25.5
T_3	0-30	1.31	32.68	17.6	CL		1.2	7.3	1.99	1.9
	30-60	1.29	32.46	17.2	CL	4.8	1.97	7.4	1.20	1.2
	60-90	1.33	27.78	15.1	SCL		2.4	7.5	1.20	1.2
T_4	0-30	1.19	39.91	21.2	C		1.46	7.7	1.20	7.0
	30-60	1.18	32.58	17.3	C	4.9	1.45	7.7	1.01	8.1
	60-90	1.29	26.91	14.9	SCL		0.99	7.9	0.69	5.9
T_5	0-30	1.30	32.61	17.4	SC		1.12	7.7	0.87	8.9
	30-60	1.20	32.40	17.1	C	2.2	0.74	7.9	0.73	11.6
	60-90	1.20	39.60	21.4	C		0.6	8.3	0.30	18.9
T_6	0-30	1.26	32.28	17.2	CL		1.95	7.7	1.51	26.1
	30-60	1.19	39.72	21.2	C	5.3	1.27	7.8	0.91	26.8
	60-90	1.20	28.61	15.2	CL		0.78	8.0	1.02	26.8
T_7	0-30	1.25	38.10	19.2	C		1.43	7.9	1.74	23.4
	30-60	1.33	27.52	15.1	SCL	2.7	1.94	7.8	0.98	26.3
	60-90	1.31	34.65	14.4	CL		1.6	7.7	0.91	36.0
T_8	0-30	1.25	38.77	20.2	C		1.34	8.0	1.15	1.5
	30-60	1.27	40.15	17.0	C	0.3	0.67	7.8	0.52	1.2
	60-90	1.29	36.43	19.7	C		0.66	7.9	0.29	3.8
T_9	0-30	1.27	29.86	15.4	CL		3.59	7.9	3.17	3.7
	30-60	1.33	38.45	19.5	C	3.5	1.68	7.8	1.50	3.8
	60-90	1.27	34.21	19.9	C		1.7	7.9	0.82	4.3
T_{10}	0-30	1.29	32.59	17.8	SC		0.62	7.4	1.01	5.9
	30-60	1.23	31.85	17.2	CL	4.8	0.69	7.6	0.71	11.5
	60-90	1.34	27.15	15.9	SCL		0.83	7.8	0.57	8.7

In the examined test plots; soil structure was generally clay and loamy-clay structure, infiltration rate (I) varied between 0.3-5.3 mm h^{-1}. Organic matter amounts were between 0.22-3.17%, lime amounts were between 1.2-44.7%. In the research, it was determined that the soil of the study area was suitable for tomato cultivation (Hanson et al., 2000; Zucco et al., 2015) and the infiltration rate of the soil was suitable for the drip irrigation systems commonly used in the region.

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Current Situation of The Drip Irrigation Systems

Table 4. Drip irrigation system controller elements

Test no	Hydrocyclone	Sand-Gravel Filter	Fertilizer tank	Sieve filter	Water meter	Manometer
T_1	-	-	+	-	-	-
T_2	-	+	+	-	-	-
T_3	-	-	+	-	-	-
T_4	-	+	+	-	-	-
T_5	-	-	+	-	-	-
T_6	-	+	+	-	-	-
T_7	-	-	+	-	-	-
T_8	-	-	+	-	-	-
T_9	-	-	+	-	-	-
T_{10}	-	-	+	-	-	-

+ : have, -: not have

While the number of irrigation in tomato production areas were between 13-21, the irrigation period was between 8-12 hours. Irrigation practices varied according to the habits of the farmer, the capacity of the water source and the size of the irrigated area. The characteristics of the drippers used in the test plots, the number of irrigation and irrigation durations are given in Table 5.

Table 5. Features of drippers used in test plots, number of irrigation and irrigation durations

	Dripper flow ($l\ h^{-1}$)	Dripper range (m)	Num. of irrigation per season	Avr. irrigation duration per irrigation (h)
T_1	4	0.25	20	8
T_2	4	0.25	13	10
T_3	2	0.25	16	8
T_4	4	0.25	18	10
T_5	4	0.25	21	10
T_6	4	0.25	13	10
T_7	2	0.25	13	12
T_8	2	0.25	15	8
T_9	4	0.25	15	8
T_{10}	4	0.25	4	12

The measured average dripper flow rates and dripper pressures are given in Table 6.

Table 6. Average dripper flow rates and dripper pressures

Test no	Natural flow rate of the dripper, (q) (Lh^{-1})	Measured actual emitter flow rate, (q_{ort}) (Lh^{-1})	Average dripper pressure, (h_{ort}) (atm)
T_1	4	2.65	0.55
T_2	4	3.01	0.95
T_3	2	1.70	1.04
T_4	4	2.00	1.62
T_5	4	2.06	0.76
T_6	4	2.84	0.43
T_7	2	2.56	0.33
T_8	2	3.46	1.05
T_9	4	3.45	0.63
T_{10}	4	3.58	1.29

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In heavy textured soils with low infiltration rate, high dripper flow rates may cause surface flow. On the other hand, as the flow rate decreases, the problem of clogging of the drippers is more frequent. For this reason, the operating pressure in pressurized irrigation systems should not be less than 1 atm (Yıldırım and Korukçu, 1999).

In the region where the project is carried out, drippers with a flow rate of 2-4 l h^{-1} are widely used in irrigation systems. The average dripper flow rates were measured between 1.70-3.46 l h^{-1} in the parcels where 2 l h^{-1} drippers were used, while the average dripper flow rates were measured between 1.83-5.0 l h-1 in the parcels where 4 l h^{-1} drippers were used. It can be said that the measured low and high flow rates are caused by the uneven operating pressure, the slope of the land and the clogged or problematic drippers. Average dripper pressures varied between 0.32-1.62 atm. Dripper pressures were measured below the accepted operating pressure (1 atm) in 6 plots and 1 atm and above in 4 plots.

The Results of Performance Indicators

Emitter flow coefficient of variation (Cv)

The dripper flow coefficient of variation (Cv) for the tested parcels varied between 0.07 and 0.23 and their classifications were made according to ASAE (1998) and given in Table 7.

Table 7. Evaluation of emitter flow rate variation coefficients, (ASAE, 1998)

Test no	Cv	Classification
T_1	0.19	Unacceptable (>0.15)
T_2	0.07	Moderate (0.05-0.07)
T_3	0.10	at the limit (0.07-0.11)
T_4	0.09	at the limit (0.07-0.11)
T_5	0.16	Unacceptable (>0.15)
T_6	0.11	Bad (0.11-0.15)
T_7	0.10	at the limit (0.07-0.11)
T_8	0.23	Unacceptable (>0.15)
T_9	0.12	Bad (0.11-0.15)
T_{10}	0.15	Bad (0.11-0.15)

The dripper flow rate variation coefficients were determined to be moderate in 1 parcel, limit value in 3 test plots, bad in 3 test plots and unacceptable in 3 test plots (Table 7).

In parcels classified as unacceptable, dripper flow rates varied in a wide range. For example, it has been determined that the dripper flow rate varies between 1.6-4.0 l h^{-1} in T_1 parcel and 2.1-4.4 l h^{-1} in T_8.

In addition, the T8 parcel was the parcel with the most insufficient irrigation. The emitter flow rate variation coefficients obtained in the study were found to be lower than the values recommended in ASAE 1998. This shows that there is a problem of uniformity in drippers.

CU, DU and Eua performance parameters

The CU, DU and Eua parametres was determined in the drip irrigation systems tested for the evaluation of irrigation water distributions (Table 8).

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Table 8. Some performance indicators of the tested drip irrigation systems

Test no	CU, %	Classification	DU, %	Classification	EU, %	Classification	E_{ua}	Classification
T_1	84.5	Good (80-90)	74.6	Weak	58.8	Below recommended limit	99.1	Very good
T_2	94.3	Very good (>90)	91.4	Very good	87.7	Within the recommended limit	96.0	Very good
T_3	91.8	Very good (>90)	87.4	Good	78.7	Below recommended limit	94.6	Very good
T_4	92.9	Very good (>90)	88.4	Good	82.8	Below recommended limit	97.1	Very good
T_5	87.2	Good (80-90)	80.2	Acceptable	73.8	Below recommended limit	94.5	Very good
T_6	91.2	Very good (>90)	84.5	Acceptable	74.7	Below recommended limit	97.2	Very good
T_7	91.7	Very good (>90)	86.9	Good	83.1	Below recommended limit	96.3	Very good
T_8	81.4	Good (80-90)	62.8	Unacceptable	58.8	Below recommended limit	99.7	Very good
T_9	90.1	Very good (>90)	76.1	Weak	70.7	Below recommended limit	97.7	Very good
T_{10}	87.7	Good (80-90)	64.2	Unacceptable	58.4	Below recommended limit	100.0	Very good

Evaluation of the performance indicators obtained in the study was made according to ASAE (1998). Christeansen uniform distribution coefficient (CU) values of the test plots varied between 81.4-94.3% and are given in Table 8. Accordingly, T_2, $T_{3,}$ $T_{4,}$ $T_{6,}$ $T_{7,}$ $T_{9,}$ T_{10} test plots were very good, while other tests were in the good class. The distribution uniformity (DU) values of the test plots varied between 62.8-91.4%. Accordingly to this, parcels T_8, T_{10}, parcels were "unacceptable", T_1, T_9 parcels "weak", T_5, T_6 parcels "acceptable", and other parcels were classified as good and very good. Accordingly, it was observed that irrigation was carried out at weak and unacceptable levels in 4 test plots. DU values were found to be lower than CU values as expected in test plots. In the study, $T_{7,}$ $T_{8,}$ $T_{9,}$ T_{10} test plots were in homogeneous class in terms of topography, while the others were in a very sloping or rugged class. In the results obtained, the EU values of the test plots varied between 58.4.3-87.7%. According to evaluation criteria, EU values were within the recommended limit values in the T_2 test and below the limit values in other tests. Absolute Emission Uniformity (Eua) values for the tested plots varied between 94.5-100%. The E_{ua} value was found to be over 90% in all tested parcels. Accordingly, it has been determined that the irrigation systems are suitable for absolute emission uniformity. When the performance indicators obtained were evaluated together, the performances of drip irrigation systems in terms of CU and Eua were found to be suitable according to the values recommended in ASAE (1998). However, Du and EU indicators were generally below the recommended values.

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Ea, PELQ and AELQ parametres

The application efficiency (Ea) of an irrigation system is defined as the percentage of total water applied accumulated in the plant root zone. The most important factors affecting field irrigation efficiency are irrigation method, soil type and amount of irrigation water applied. When Table 10 is examined, the application efficiencies varied between 29.5% and 63.6%.

PELQ is an indicator of how well the system can apply water under optimum operating conditions. PELQ can be achieved when the average lower-quarter water depth stored and infiltrated equals the allowable moisture deficit. PELQ values in all plots are lower than 80%. Low PELQ indicates design problems in the system.

Table 9. Potential application efficiency of lower quarter (PELQ)

Test no	E_a, %	PELQ, %	AELQ, %
T_1	29.5	52.9	34.0
T_2	33.7	78.9	33.7
T_3	46.7	70.8	51.6
T_4	63.6	74.5	61.2
T_5	57.6	66.4	57.6
T_6	41.2	67.3	41.2
T_7	33.4	74.8	33.4
T_8	44.7	52.9	50.0
T_9	41.4	63.6	44.5
T_{10}	60.1	52.5	60.1

AELQ is an indicator of operational and management status in irrigation systems (Bhavan & Maro, 1991). AELQ is the ratio of the water infiltrated and stored in the root zone in the lowest irrigated sub-quarter of the field to the average depth of irrigation water applied and expressed as a percentage. Actual application efficiency (AELQ) in the lower quadrant indicates both homogeneity of water distribution and adequacy of irrigation (Merriam and Keller 1978). The difference between (PELQ) and (AELQ) is a measure of irrigation system performance. Low PELQ indicates planning problems in the irrigation system (Merriam and Keller 1978).In the measurements made, the application efficiencies varied between 33.4% and 61.2%.

Conclusion

Performance analysis of drip irrigation systems in 10 tomato gardens belonging to farmers was conducted in the study conducted in Ayaş district of Ankara province. Through face-to-face interviews and surveys with farmers, information about drip irrigation knowledge, training they received, farming experiences and habits were tried to be obtained. Most of the farmers have done the irrigation with well water. However, it has been observed that some farmers back up the water in the artificial water collection ponds they set up at the beginning of the field due to insufficient well water during dry periods and used this water for irrigation.

All of the farmers declared that they prepared the drip irrigation systems themselves and that they did not conduct a technical study on this issue. In addition, farmers have declared that they do not use chemical washing to prevent dripper clogs. The control unit of the drip irrigation system in the test plots was either absent or insufficient. In the interviews with the farmers, it was seen that the farmers preferred the drip irrigation system in terms of facilitating labor rather than the high irrigation efficiency. In this case, some of the problems seen in drip irrigation systems has led to disregard.

Pressurized irrigation systems are important for using water resources effectively. However, using pressurized irrigation systems cannot guarantee efficient use of water resources. It is very important that the irrigation system is designed taking into account the soil and plant characteristics and its periodic maintenance is carried out. Whether state-sponsored or not, all pressurized irrigation systems should be projected by experts and on-site checks should be made at certain times. In addition, it was observed that the pipes and connection equipment used in the irrigation systems did not comply with the quality standards. Sub-industry production goods used in this area should also be controlled and monitored.

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Data Availability Statement
No data, models, or code were generated or used during the study

Authors' Contributions

While GKB, CG, PBA and TY took part in the field studies of the project, RG took part in the field studies, statistics and evaluation parts. RG drafted the manuscript. All authors read and approved the final manuscript.

Conflicts of Interest Statement

The Author(s) declare(s) that there is no conflict of interest

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