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WATER APPLICATION PERFORMANCE OF DRIP IRRIGATION SYSTEMS USED IN SUGAR BEET PRODUCTION IN SEMI-ARID KONYA PROVINCE, TÜRKİYE

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ABSTRACT

In this research, water application performance of drip irrigation systems for sugar beet irrigation at two different areas namely Sarayönü and Altınekin, located at Konya province of Türkiye, was assessed. In that context, 10 drip irrigation systems in different farms were examined. Uniformity Coefficient (UC) and Emission Uniformity (EU) as watering uniformity indicators were studied. In addition, amount of applied water by farmers and irrigation water use efficiency (IWUE) were also investigated. In results, UC values were determined between 86.64 % and 98.20 % so watering performance of tested drippers varied from GOOD to EXCELLENT accordingly. EU values were calculated between 82.41 % and 97.80 % so watering uniformity varied from GOOD to EXCELLENT in accordance of EU values. The applied water by farmers was between 626 mm and 932 mm and IWUE varied from 6.9 to 9.6 kg/m^3. As a result, design of drip irrigation systems and operational performance were stated as main factors for differentiation in water application homogeneities.

INTRODUCTION

It is possible to say that drip irrigation has the maximal water application performance among all irrigation methods under proper management (Irfan et al. 2014). Comparison to surface irrigation systems, drip irrigation may result 20–80 % yield increase as well as 30–70 % water saving (Shamshery et al. 2017); and even up to 90–95 % water application efficacy could be obtained under proper management (Goyal, 2013). The emitters are heart of drip irrigation systems and variations in emitter flow rates affect directly amount of water applied to the plants (Khalifa, 2020). Consequently, there is a relationship between emitter discharge and system working pressure for lateral tube with non-pressure compensating emitters (Mistry et al. 2017).

The main target in irrigation process is application of water as uniform as possible across the whole field. It is not possible to get 100 % water uniformity in reality due to the head losses through the pipe lines. Scientifically, high uniform water application means variations in emitter flow rates less than 10 % (Omofunmi et al. 2019; Trivedi & Gautam, 2019) and it is accomplished by correct design of the drip irrigation systems, installation of whole parts with great care and correct management of irrigation systems (Luquet et al. 2005; Hanson & May, 2007; Mostafa & Thörmann, 2013; Raphael et al. 2018; Acar, 2020; Ardey, 2021; Acar et al. 2022; Acar et al. 2023). In order to learn drippers' watering performance, emitter flow test is needed in number and position of emitters as suggested by researchers (Goyal, 2013).

Sugar beet is one of the most common industrial field crops in Middle Anatolia Region specifically in Konya plain of Türkiye. Irrigation is of vital importance for obtaining economical yield from such crop. It is sensitive to the water deficiency in vegetative cycle (Sadeghian & Yavari, 2004; Rinaldi & Horemans, 2012), and there is a positive relationship between water use and root development (Davidoff & Hanks, 1989; Rinaldi & Horemans, 2012). In case of non-application of irrigation water sufficiently during vegetation cycles, serious yield losses can be observed (Pidgeon et al. 2001). For example, high water stress in rooting environments of sugar beet in some crop growing cycles resulted high yield losses in some parts of the North-East France and Belgium (Jones et al. 2003).

In this current research, water application uniformity of drip irrigation systems and water use of drip-irrigated sugar beet were studied comprehensively at semi-arid Konya-Sarayönü and Konya-Altınekin regions of Türkiye.

MATERIAL AND METHODS

Sarayönü and Altınekin are two of the well-known sugar beet production locations in Konya province. In this research, 10 different drip irrigation systems, 4 in Sarayönü and 6 in Altınekin, were examined in regard to water distribution uniformity and seasonal applied water for sugar beet irrigated by drip irrigation systems under farmer's practices. A sample layout of the drip irrigation system and characteristics of all examined drip systems were given in Figure 1 and Table 1. The nine lateral tubes were new and one was 2 years aging in the examined drip irrigation systems. All laterals were oval type having inline emitters without pressure compensating.

Water measurement tests in drippers

Flow tests of emitters were performed using 100-250 mL capacity of plastic containers in a total 36 drippers: 12 (4 close to the lateral head, 4 close to the mid-section of the lateral pipe and 4 close to the end of the lateral pipe) in the lateral tube nearby head of manifold, 12 (4 close to the lateral head, 4 close to the mid- section of the lateral pipe and 4 close to the end of the lateral pipe) in lateral pipe on mid-section of the manifold, and 12 (4 close to the lateral head, 4 close to the mid-section of the lateral pipe and 4 close to the end of the lateral pipe) in lateral pipe on end of the manifold. After 36 containers were placed under those selected 36 drippers, the system was operated for 15 minutes. The volume of water collected in plastic containers was measured with a graded cylinder.

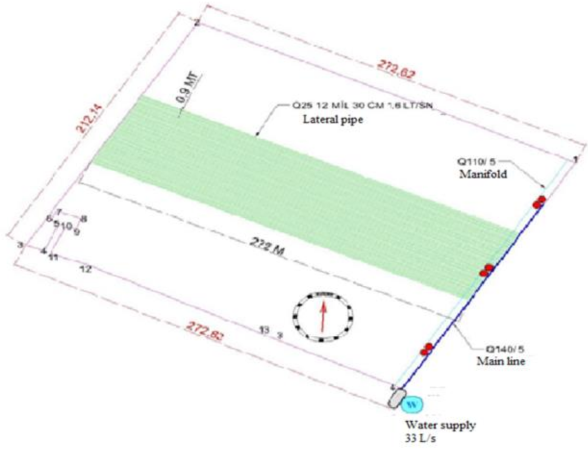

Figure 1. A sample layout of the drip irrigation system

Table 1

Components of drip irrigation systems

Farm No.	Emitter Flow Rate (L/h)	Emitter Space (cm)	Lateral Space (cm)	Main Line Diameter (mm)	Manifold Diameter (mm)	Lateral Diameter (mm)
1	1.6	30	90	140	110	22
2	1.6	30	90	125	110	22
3	1.6	30	90	125	90	25
4	1.6	30	90	125	90	25
5	1.6	30	90	125	90	25
6	1.6	30	90	125	90	25
7	1.6	30	90	125	90	22
8	1.6	30	90	125	90	25
9	1.6	30	90	140	90	25
10	1.6	30	90	125	110	25

Average dripper flow rate

The mean flow rates of emitters were computed by following formula (Zamaniyan et al. 2014);

$$q_{avr} = \frac{1}{n}\sum_{i=1}^{n} q_i \quad (1)$$

where;
q_{avr}- Mean emitter flow rate (L/h)
q_i- Individual emitter flow rate (L/h), and
n- Total number of emitters

Determination of emitter water application uniformity

In that context, two well-known uniformity indicators, CU and EU were considered. The CU was computed using following formula (Wu & Gitlin, 1973) as suggested by Christiansen (1942);

$$CU = \left[1 - \left(\frac{\Delta q}{q_{avr}}\right)\right] x100 \quad (2)$$

where;
CU- Uniformity Coefficient, %
Δ_q – Average of absolute deviation from each discharge from average emitter flow rate L/h, and
q_{avr}– Average emitter discharge, L/h

The watering performance was classified in accordance of CU (Table 2).

Table 2

Relationships between CU and water distribution class
(Asif et al. 2015; Jatoth et al. 2017).

CU (%)	**Water distribution class**
> 90	Excellent
80 – 90	Good
70– 80	Moderate
60 – 70	Poor
< % 60	Not Acceptable

EU was calculated using following formula (Wilcox & Swailes, 1947; Zamanian et al. 2014).

$$EU = \frac{q_{a\%25min}}{qavr} x100 \quad (3)$$

where;
EU- Emission Uniformity (%), and
$q_{a\%25\ min}$ – Mean 25 % of low dripper flow rates (L/h).

The watering uniformity was classified in accordance of EU (Table 3).

Table 3

Relationships between EU and watering uniformity class

EU (%)	(Merriam & Keller, 1978; Kumari et al. 2018)
< 66	Poor
66-70	Poor
70-79	Acceptable
80-84	Good
84-90	Good
>90	Excellent

Applied water for sugar beet under farmer conditions

Irrigation durations of sugar beet during the vegetative cycle were summed in first. In addition, irrigation time for germination of sugar beet seeds by sprinkler systems was added to the applied water with drip system during the plant growing period. By summing up the applied water by both sprinkler and drip systems, total applied water for sugar beet was determined.

Fresh root yield of sugar beet

By recording the fresh root yield from farmers, fresh root yields of each examined farms were determined from studied sugar beet producers by physical field visit.

Irrigation water use efficiency (IWUE)

For determination of IWUE, fresh root yield was divided to total volume of applied water as suggested by Pinnamaneni et al. (2020);

$$IWUE = \frac{Y}{I} \quad (4)$$

where;
IWUE- Irrigation water use efficiency (kg/m^3),
Y-Fresh root yield (kg); and
I- total applied irrigation water (m^3).

RESULTS AND DISCUSSIONS

Analysis of emitter flow rates

The lowest and the highest dripper flow rates were found 1.17 and 1.56 L/h, respectively (Figure 2). Considering that the dripper flow rate catalog values of the emitters used in the farms where the study was conducted are 1.6 L/h, it was determined that average dripper flow rates obtained from the studied farms were lower than this value in all drip irrigation systems. The difference between average flow rates was more than 10 % in the majority of farms. In accordance of Omofunmi et al. (2019) and Trivedi & Gautam (2019), irrigation water was not applied to the plants with high uniformity by farmers.

CU and Water Application Class

The CU values were calculated as 91.15, 98.14, 95.10, 96.96, 97.67, 97.50, 94.83, 86.64, 98.20 and 92.77 %, respectively (Figure 2). Since UC values were higher than 90 % in farms numbered 1, 2, 3, 4, 5, 6, 7, 9, and 10, the dripper water application performance in these farms was classified as EXCELLENT, while the CU value of farm numbered 8 was 86.64 %, and the irrigation water application status in such farm was found as GOOD (Asif et al. 2015; jatoth et al. 2017).

In some studies on CU in Türkiye; for example, it was found as 52-85 % in drip irrigation systems used in olive groves around Izmir province (Acar et al., 2015); 80-96 % in Kırklareli region (Özer et al. 2020); and 68-84 % in drip irrigation systems used for corn irrigation in Çumra district of Konya (İnciman & Acar, 2020).

EU and Water Application Class

EU was calculated between 82.41 and 97.80 %; according to these values water distribution uniformity is between GOOD and EXCELLENT (Merriam and Keller, 1978; Kumari et al. 2018). In previous studies in Türkiye, EU values were found to be 68–96% in Kırklareli region (Özer et al. 2020), and 44–71% in Çumra location of Konya province (İnciman & Acar, 2020). The EU values obtained from current study are generally found to be higher than the findings stated in previous studies. The possible reasons for the differences between the study results are differences in system design as well as system managerial quality.

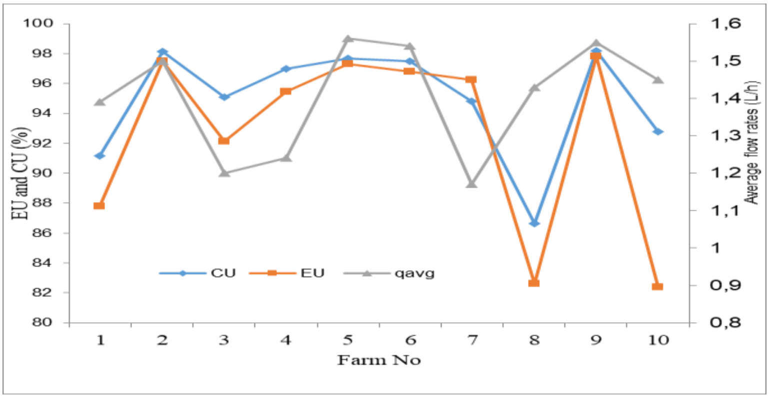

Figure 2. Mean dripper flow rates, UC and EU

Sugar beet root yields

In examined farms, sugar beet fresh root yields were 65, 75, 60, 60, 70, 70, 60, 70, 75, and 80 t/ha, respectively (Figure 3). In general, sugar beet root yields are equal or higher than Turkish average of 60 t/ha. The reasons could be that sugar beet is one of the main agricultural production in the region, climatic conditions are quite suitable for sugar beet farming and farmers have a deep-rooted experience in all field crops cultivation particularly sugar beet growing.

Applied water and IWUE

Total applied water under farmer's practices and IWUE values are given in Figure 3. When it is examined, seasonal applied water to sugar beet plants under farmer conditions varied between 626 mm and 932 mm. Due to the climate change negative effects and increase of irrigation energy cost, farmers have applied water to the sugar beet plants more productivily.

In examined sugar beet farms, IWUE values were calculated to be between 6.86 and 9.58 kg/m^3 (Figure 3). The average IWUE value for such plant irrigated by drip irrigation system in Bursa conditions was found to be 9.70 kg/m^3 (Yetik & Candoğan, 2022). The IWUE values obtained from research farms are generally around 8.5 kg/m^3 and slightly lower than value reported by Yetik & Candoğan (2022). In result, we can say this current value is satisfactory under farmer water application conditions.

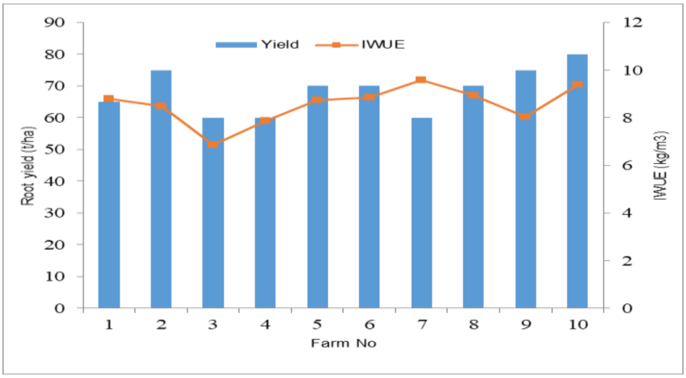

Figure 3. Fresh root yield and WUE

CONCLUSIONS

In current study, in accordance of CU values, emitter watering performance were found between GOOD and EXCELLENT. Similarly, water application class varied from GOOD to EXCELLENT in accordance of EU values. The amount of applied water to the sugar beet irrigated with drip irrigation system was found to be 626-932 mm. We can recommend more widespread use of water-saving irrigation technologies such as drip and sprinkler irrigation systems under well management in the irrigation of plants with high water consumption such as sugar beet in agro-production areas having arid and semi-arid regions such as Konya plain where water resources are limited. In order to deduce more accurate outcomes, it is recommended to perform field research relevant to water-yield relationships of sugar beet.

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CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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