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ASSESSMENT OF SPRINKLER IRRIGATION SYSTEMS FOR SUGAR BEET IRRIGATION IN KARAMAN PROVINCE, TÜRKİYE

Şaban Hamur, Bilal Acar*
* Dept. of Farm Buildings and Irrigation, Faculty of Agriculture, University of Selçuk, Konya, Türkiye
* *Correspondence author. E-mail*: biacar@selcuk.edu.tr

Keywords:*Sprinkler Irrigation Types, Sugar Beet, Water Productivity, Irrigation System Cost*

ABSTRACT

The research was performed to evaluate sprinkler irrigation systems using in sugar beet irrigation at Karaman province of Türkiye. In such study, irrigation ratio (IR), irrigation number (IN), irrigation interval (II), irrigation duration (ID), irrigation water amount (I), fresh root yield (FRY), seasonal electricity consumption (SEC), seasonal labor cost (SLC), and water productivity, WP, were researched. In results, IR was calculated as 100% in research sites. IN and II were found as 9-12, and 7-20 day, respectively depending on characteristics of the irrigation systems. ID for each irrigation event in period of maximum vegetation cover was 5-6 h. The I values in whole crop growth cycles was between 623 mm and 864 mm with an average of 761 mm depending on sprinkler system designs. Average FRY was found as 90 t/ ha. WP varied from 9.7 kg/m^3 to 13 kg/m^3. SEC was calculated as 290 USD/ha and SLC was found as about 176 USD/ha. Although installation cost was 10% higher in permanent system than portable or movable or semi-portable sprinkler irrigation system, irrigation labor cost was notable better in permanent sprinkler irrigation system over portable and semi-portable sprinkler irrigation systems. The study clearly showed that Irrigation cost was maximum share within whole production costs. The correct design and management of the irrigation systems are very important for reducing irrigation energy cost consequently sustainable sugar beet production.

INTRODUCTION

Water is the most important input in agriculture, and agriculture is the greatest water user with 70% water use in world general, and 90% water utilization in developing countries (Dwivedi et al. 2015), and even more than 80% in Middle Anatolian Region, Türkiye.

Irrigation can be defined as ‘ applying of water to the soil for purpose of storage water available for plant growth, to dilute in or remove excess salts from rooting depth, to make crop insurance against to short period of drought, to adjust temperature of soil and air by making suitable environment for plant development, to decline of soil cracking and to ignore tillage pans’ (Pachore & Deshpande, 2019).

Correct water management is strongly recommended for optimal crop production particularly in water scant climates. Irrigation method is important but possible the most important target is proper agricultural water management.

Sugar beet is known as high water use crop and water consumption of such crop depends on various factors such as environmental conditions, cultivar, crop growing cycles, vegetation cover, and availability of moisture within rooting systems. In general sugar beet consumes water from 100 cm soil depth. Evapotranspiration is around 8 mm/day in the period of full crop cover (Anonymous, 2012). The vegetation cycle of sugar beet for Kütahya province of Türkiye was around 183 day (38-day in initial stage, 92-day in vegetation and yield formation stage, and 53-day in maturity stage). In such environment, total applied water for sprinkler-irrigated sugar beet was 975 mm (143 mm in initial, 622 mm in vegetation and yield formation, and 210 mm in maturity stage). Evapotranspiration, and root yield were around 1000 mm, and 128 t/ha, respectively (Özbay & Yıldırım, 2018). In study performed at semi-arid Konya province of Türkiye (Süheri et al. 2007), applied water, crop water use, and root yield of drip-irrigated sugar beet crop for full irrigation treatment in 2005 and 2006 growing seasons were found as about 1123 and 972 mm, 1177 and 1002 mm, and 92 and 68 t/ha, respectively.

The main goal of irrigation is to improve water productivity. The preference of pressurized irrigation systems is one of the practical ways for increasing water application performance. Those systems could be more economical under uses in huge agro-lands (Razzaq et al. 2018). The sprinkler is irrigation system is very common worldwide including Russian Federation. The main reasons in widely preference of such system are easy water management in irrigation areas, spraying water onto the soil / crop surface almost like a natural rain with well uniformity, and high level of adaptation for different soil topography (Kruzhilin et al. 2018). Land slope, and sprinkler arrangement affect water distribution homogeneity. The maximal watering uniformity can be obtained from sprinklers working with suggestions of firms (Zhang et al. 2018). In addition, water distribution performance of sprinklers is highly affected from working pressure, sprinkler arrangement, sprinkler type, nozzle diameter, nozzle number, riser head, quality of the system installation and management as well as some environmental conditions such as wind speed, and wind direction (Kay, 1988; Yacoubi et al. 2012; Acar, 2019; Alashram et al. 2021).

Seyedzadeh et al. (2021) reported that level of the experiences of the farmers in irrigation system utilizations is one of the most important actors affecting irrigation efficacy. In that regard, improving farmer's skills in water management particularly at farm levels causes improving irrigation productivity.

Like Konya plain, Karaman province is also very successful in sugar beet farming. Sugar beet requires plenty efforts for obtaining satisfactory production.

The aim of the current study is to assess irrigation program for sprinkler-irrigated sugar beet plant for different sprinkler designs at Karaman region, Türkiye.

MATERIAL AND METHODS

This study was performed at 12 farms using sprinkler irrigation system for irrigation of sugar beet in Karaman province, Türkiye. The sprinkler systems were movable in 4-farms (A), semi-movable in 6-farms (B), and solid-set in 2-farms (C) at research areas. The sources of the irrigation water for all examined farms were groundwater.

The research farms are situated in Middle Anatolia Region, 1033 m above the sea level with average of 326 mm annual rainfall (Anonymous, 2020).

Figure 1. The locations of Karaman province (Anonymous, 2020)

The design type of the sprinkler irrigation system was considered in comparison of the system installation cost. In that regard, the layouts of the systems were determined and installation cost was calculated by considering the whole components of the system individually.

In research site, irrigation ratio was calculated as;

$$IR = \frac{Ia}{Ca} \times 100 \quad (1)$$

where; IR- Irrigation ratio, %; Ia- Irrigated area, ha; and Ca-Command area, ha.

The number of the irrigation and time of the each irrigation process were determined from information of farmers by face-to face site visits. The sprinklers were rotary type in all research areas. The seasonal irrigation time was obtained from sum of the irrigation times including watering at germination during the whole crop growth cycles. The multiplying seasonal irrigation duration (h) with sprinkler precipitation rate (mm/h), total seasonal applied water was determined. The sprinkler precipitation rate was calculated by;

$$Pr = \frac{q_s}{ss \ x \ ls} x \ 1000 \quad (2)$$

where; P_r- sprinkler precipitation rate (mm/h); q_s- sprinkler flow rate (m^3/h); ss- sprinkler spacing (m), and ls-lateral spacing (m).

The seasonal applied water was calculated as;

$$I = Pr \ x \ t \quad (3)$$

where; I- seasonal applied water (mm), and t- seasonal irrigation time (h).

Water productivity was calculated by;

$$WP = \frac{y}{ET} \quad (4)$$

where; WP- water productivity (kg/m^3); y-root yield (kg); and ET-Evapotranspiration (mm).

RESULTS AND DISCUSSIONS

1- Irrigation Ratio, IR

In this study, it was calculated as 100%. It means that all farm lands are irrigated in research site. In a study performed by Cihan & Acar (2016), IR varied from 132% to 192% at irrigated areas of Ova Water User Associations, Konya, Türkiye. The reason behind value greater than 100% was stated as irrigated areas were higher than command area.

2- Characteristics of Sprinklers

In research sites, when we consider operating pressure of 250 kPa, flow rates of sprinklers for A, B, and C design are 2.2, 2.4, and 1.2 m^3/h, respectively. In all three designs, sprinkler arrangement was 12 x 12 m. In accordance of sprinkler flow rates and sprinkler arrangement, the precipitation rates for A, B, and C design were calculated as 15.3 mm/h, 16.7 mm/h, and 8.3 mm/h, respectively. In study farms, soil water intake rates is about 19 mm/h, and all sprinkler precipitation rates are lower than that upper threshold value boundary so sprinklers have been well-operted in all systems.

3-Number of Irrigation, IN, and Irrigation Interval, II

The irrigation number, IN, for sprinkler irrigated sugar beet in resaech farms was found as 12 including 2 irrigation events during harvest cycle. The depending on the crop growth cycles, soil properties particularly atmospheric conditions II varied from 7 to 20-day. In recent years, due to the rapid increase in petrol costs, farmers would like to save water consequently irrigation energy. Therefore, farmers have to use even sprinkler or drip irrigation system with maximal benefit.

4-Root Yield, Applied Water, I, Crop Water Consumption, ET, and Water Productivity, WP

Average root yield of examined farms was around 90 t/ha. It is greater than some worldwide studies (El-Kassas et al. 2008; Mehanna et al. 2020). In accordance of net return of famers, not only fresh root yield is important, but also polar value, PV), (sugar content) is very important. Standard value of PV is 16 and correction factor, CF, is 1.0 for PV 16. In our research farms, PV was found as an average of 17.5 so CF is about 1.094 (17.5/16.0) so fresh root yield was multiplied with 1.094. In the other word, farmers had money for 98 t/ha instead of 90 t/ha.

In accordance of information obtained from farmers, irrigation times, Ta, for A, B design was 52 h, and 75 h for C design. In research sites, farmers have applied water around 5-6 h by sprinkler irrigation system in each irrigation process during the intense water demand period of July and August. The farmers have well experiences about all farming activities including irrigation water management.

By multiplying seasonal irrigation time with sprinkler precipitation rates, irrigation water (I) for sugar beet was found 796 mm, 864 mm, and 623 mm, respectively for A, B, and C design. Those values are less than the finding of Özbay&Yıldırım (2018). The reasons could be differences between the environmental conditions, water management level, and cultivars. In regard to water saving, C design was found superior over A, and B design.

Sugar beet consumes 65 mm water from the soil water reservoir in study environment. By addition of 65 mm water utilization from soil profile, to applied irrigation water amount, ET values sprinkler-irrigated sugar beet for A, B, and C design were found 861 mm, 929 mm, and 688 mm, respectively.

WP varied from 9.7 kg/m^3 to 13.01 kg/m^3 depending on the sprinkler system designs with an average of 11.0 kg/m^3. El-Kassas et al. (2008) reported that value 7, 10, and 17 kg/m^3 for three different irrigation intervals namely 3, 5, and 7-day at Egypt conditions. The value obtained current study is inline with finding of El-Kassas et al. (2008).

5- Preference of Sprinkler Irrigation System Design

One of the major problems in sugar beet farming in our region is finding the irrigation labour, and movement of laterals from one side to other side for portable or semi-portable systems after completing irrigation at one set. Even irrigation labour cost is very high in irrigation season in our region. Therefore, C design, permanent sprinkler irrigation system, was found superior over A and B designs. The use of C design is getting popular in irrigation of sugar beet crop resulting notable savings in labour cost consequently minimizing crop production costs.

6- Seasonal Electricity Consumption, SEC, and Seasonal Labour Costs, SLC

In all examined farms, electricity has used for taking water from ground water resources. SEC was calculated as 290 USD/ ha, and is highly relevant to the depth of well, irrigation time for each irrigation process, and performance of pumps. Acar&Direk (2020) underlined that share of irrigation energy cost is maximal among all crop production inputs in Türkiye particularly in semi-arid Middle Anatolia region.

Sugar beet production requires intensive manual works during crop vegetation cycles. SLC was found as about 176 USD/ha in whole growing period.

7- Designs of Sprinkler Irrigation Systems

In all examined farms, diameter and lengths of the main lines were 125 mm, and between 30-120 m, respectively. The lateral lines were 75 mm in diameter with 250-1000 m in length. Sprinkler arrangements were 12 x 12 m in whole sugar beet farms in research sites (Table 1).

Table 1

Characteristics of sprinkler systems using sugar beet irrigation

Farms	Main Line		Laterals		Sprinkler Arrangements
	Diameter (mm)	Lenght (m)	Diameter (mm)	Lenght (m)	(mxm)
1	125	30	75	300	(12x12)
2	125	80	75	650	(12x12)
3	125	60	75	750	(12x12)
4	125	120	75	1000	(12x12)
5	125	100	75	800	(12x12)
6	125	40	75	450	(12x12)
7	125	75	75	350	(12x12)
8	125	90	75	400	(12x12)
9	125	70	75	300	(12x12)
10	125	65	75	250	(12x12)
11	125	65	75	500	(12x12)
12	125	85	75	400	(12x12)

The sprinkler systems (A, B, and C designs) used for sugar beet irrigation in Karaman province were shown in Figure 2-4.

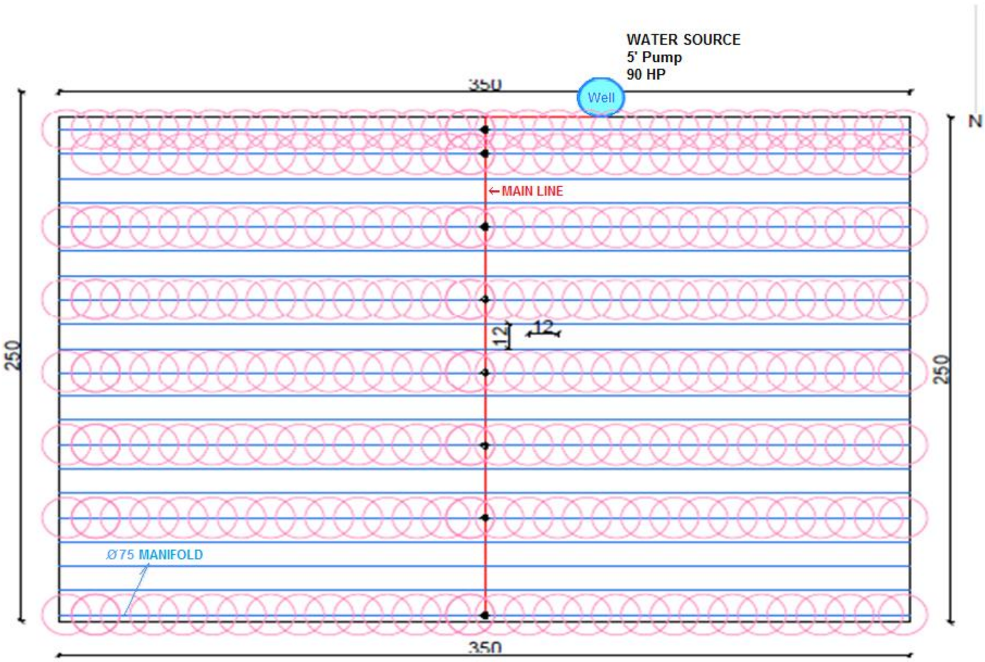

Figure 2. A sample design of portable sprinkler irrigation system (A-Design)

In fig 2, the land size is 8.75 ha (250 m x 350 m) and water is taken from groundwater by deep well. The sprinkler arrangement was 12 m x 12 m with nozzle diameter of (4.5 x 3.5) mm.

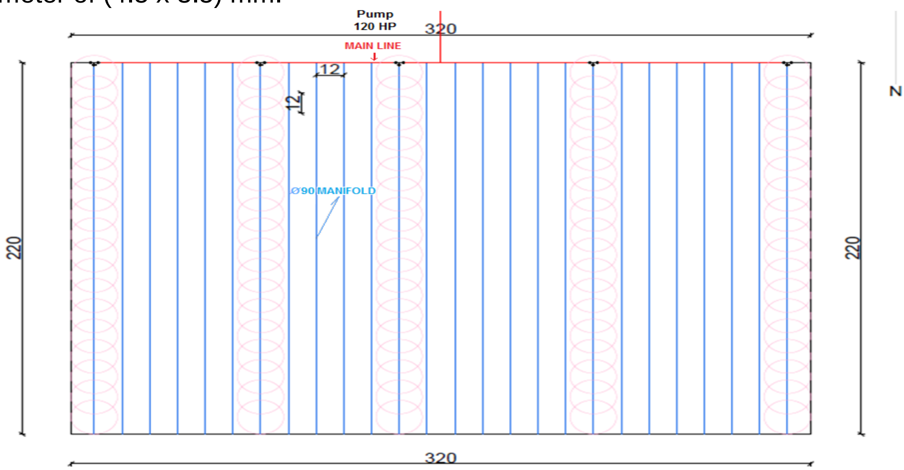

Figure 3. A sample design of semi-portable sprinkler irrigation system (B-Design)

In fig 3, the land size is 7.04 ha (220 x 320) m and water is pumping from groundwater by deep well. The sprinkler arrangement was (12 x 12) m with nozzle diameter of (5.0 x 3.2) mm.

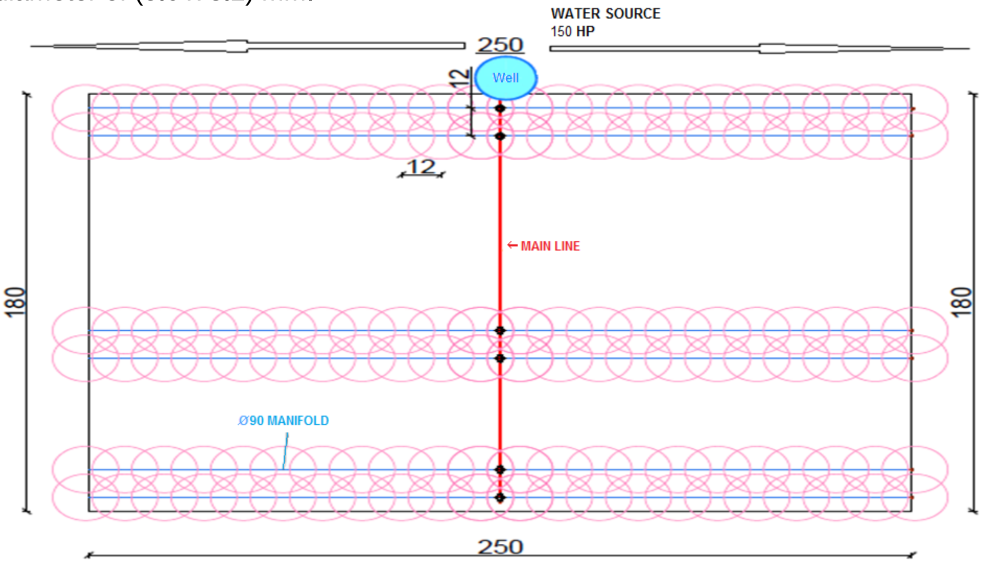

Figure 4. A sample design of permanent sprinkler irrigation system (C-Design)

Although installation cost of C design is almost 10% higher than A and B designs, it is great interest in our study region. The reason behind is very little or almost none irrigation labor requirements during the irrigation events since the system is permanent so no need to carry system components from one side to other side after ending each irrigation process. Irrigation labor cost is very high in Türkiye particularly in our study region. Labor productivity especially in irrigation event is very important role to play in minimizing production cost consequently maximizing net return of farmers.

The other one of the most important advantages of C design is resulting softening soil surface with one-irrigation after the seed sowing so it has great contribution on high germination performance of sugar beet seeds. By considering the low labor cost or low production cost as well as increase the germination rates of sugar beet seeds, C design has used with an increase rate in our region.

8- Common Problems in Irrigation and Their Solutions

The major problem is break down or burning pumps in very intense irrigation periods of July-September. Under this case, irrigation process could be very stressful. Even, repair of the pumps sometimes takes much time so some delay could be in irrigation. That case directly affects the crop growing performance. Thus, age pumps should be fixed before the irrigation season. If possible low performance-pumps should be changed with brandy ones.

CONCLUSIONS

Irrigation is the backbone of he sustainable crop production in water shortage climates. Sprinkler irrigation system is very favourable for sugar beet irrigation in research environment. The sprinkler irrigation system design affects the installation cost as well as irrigation labour cost. The permanent sprinkler irrigation systems having low flow rates of sprinklers have great contributions on irrigation labour saving. It also facilitates the reductions in times used in irrigation processes. Thus, permanent sprinkler irrigation systems are highly recommended to ignore the irrigation labour cost or minimizing total crop production costs.

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CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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ON TWO POLYCELIS SPECIES FROM ROMANIA – *POLYCELIS PANTHERINA* SP. NOV. AND *POLYCELIS FELINA LOMENSIS* BABALEAN, 2019 WITH EMENDATION AND COMPLETION OF THE 2019 NOMENCLATURAL ACT UNDER ARTICLE 10.1 (PLATYHELMINTHES, TRICLADIDA, PLANARIIDAE)

Babalean Anda Felicia[1*]
[1*]University of Craiova, Faculty of Horticulture, Craiova
* *Correspondence author. E-mail*: anda_babalean@yahoo.com, anda.babalean@ucv.ro

Keywords*: Polycelis, Ijimia, freshwater worms*

ABSTRACT

This paper presents a new Polycelis species – Polycelis pantherina from S-W Romania, which can be separated from all the other Polycelis species by the general habitus and especially by the reproductive biology – asexual population with reproduction by fission/fragmentation. The description of the subspecies Polycelis felina lomensis Babalean, 2019 is emended and completed according to ICZN art. 10.1 The subspecies Polycelis felina lomensis is elevated at the species rank by reassigning it from the genus Polycelis to the genus Ijimia: Ijimia lomensis.

INTRODUCTION

Polycelis Ehrenberg, 1831 is a genus of free-living flatworm belonging to the family Planariidae Stimpson, 1857. The distinctive morphological character of the genus Polycelis is the presence of numerous eyes (oceli) “arranged in a row at the anterior end. “(Kenk, 1973).

During time, the systematic of the genus based on morphology suffered several changes, with the creation of the subgenera Polycelis Ehrenberg, 1831, Ijimia Bergendal, 1890 and Seidlia Zabusov, 1911. They can be separated by the characteristics of the copulatory apparatus: Polycelis – thin muscular coat of the male part of the genital atrium, lack of adenodactyls; Ijimia - thin muscular coat of the male part of the genital atrium, adenodactyls present; Seidlia – thick muscular coat of the male part of the genital atrium, adenodactyls absent. (Kenk 1953, Kenk 1973, Kawakatsu & Mitchell 1998). Sluys et al. (2009) recognize *Polycelis*, *Ijimia* and *Seidlia* as distinct genera within Planariidae.

In Romania, the genus Polycelis is represented by three species: *Polycelis nigra* (O.F. Müller, 1773), *Polycelis tenuis* Ijima 1884 and *Polycelis felina* (Dalyell, 1814) (Năstăsescu 1976). Babalean (2019) described the subspecies *Polycelis felina lomensis*.

MATERIAL AND METHODS

The specimens described as *Polycelis pantherina* were collected by author during October 2021 – late July 2022, with a paint brush, under immersed pebbles and brick debris, from a small collector of a large limnocrene spring (Fig. 1), outskirts of locality Dăbuleni (Izvoarelor Street), SW Romania, as follows:

- 14 October 2021 – 16 specimens fixed in absolute ethanol
- 08 March 2022 – 78 specimens fixed in Beauchamp solution
- 24 May 2022 – 2 specimens fixed in absolute ethanol
- 28 July 2022 – 1 specimen fixed in absolute ethanol for histology

The fixed specimens are deposited in author private collection at University of Craiova and will be shared (donated) between Grigore Antipa Museum Bucharest and Naturalis Biodiversity Centre Leiden.

Figure 1. The sampling sites at Dăbuleni

RESULTS AND DISCUSSIONS

Results

Systematic according to Sluys et al. 2009

Ord. Tricladida Lang, 1884

Subord. Continenticola Carranza, Littlewood, Clough, Ruiz-Trillo, Baguñà, Riutort, 1989

Fam. Planariidae, 1857