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Araştırma Makalesi/Research Article

Root Yield and Quality of Sugar Beet Under Drip and Sprinkler Irrigation with Foliar Application of Micronutrients

Selçuk Özbay* **Murat Yıldırım**

Canakkale Onsekiz Mart University, Agricultural Faculty, Irrigation and Farm Structures Department, Canakkale, Turkey.
*Corresponding author: selcukozbay043@hotmail.com

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Abstract

This field study was conducted to determine the effects of different irrigation methods on the yield and quality of sugar beet (*Beta vulgaris* L. cv.esperanza) in Altıntas-Kutahya, Turkey during 2016 growing season. The experimental design was randomized complete block design with three replications. In two irrigation methods; sprinkler and drip irrigation, full water requirement of sugar beet was meet throughout the whole growing season. In sub-plots, irrigation programs were applied together with foliar application with a mixture of humic acid (humic and fulvic acid 15%, water soluble K_2O(0.03%) 2 L ha^{-1}, 20-20-20+TE 2.5 L ha^{-1} and micronutrients (0.8%B, 1.5%Cu, %5 Fe, %3 Mn, 0.2% Mo, 4% Zn) 0.5 kg ha^{-1}. The irrigation methods has significant effects on root and sugar yield. In drip irrigation system, the amount of irrigation water and evapotranspiration were almost 11% lower than the sprinkler irrigation. Water use efficiency in drip irrigation method increased up to 15.2 kg m^{-3} by saving water in the root zone of sugar beet. Results also indicated that drip irrigation with foliar application of micronutrients had a significant effect on the root and sugar yield. Generally, it could be recommended that drip irrigation was an effective method in sugar beet production for more root and sugar yield and also saving water. The results presented have important implications for maintaining plant quality and yield, and show the need to adjust the irrigation schedule to avoid yield loss.
Keywords : Sugar beet, Drip irrigation, Sprinkler irrigation, Foliar, Micronutrients.

Damla ve Yağmurlama Sulama Sitemlerinde Mikrobesin Maddelerinin Yaprağa Uygulanması ile Şekerpancarında Kök Verimi ve Kalitesi Üzerine Etkisi

Öz

Bu çalışma, farklı sulama yöntemlerinin şekerpancarı (*Beta vulgaris* L. cv.esperanza) bitkisinin verim ve kalitesi üzerine etkilerini belirlemek amacıyla Kütahya ilinin Altıntaş ilçesinde arazi koşullarında 2016 yılında yürütülmüştür. Araştırma tesadüf blokları deneme deseninde üç tekrarlı olarak yürütülmüştür. Yağmurlama ve damla sulama sistemlerinde bitkinin su ihtiyacı tüm gelişim döneminde tam karşılanmıştır ve alt konularda aynı sulama programlarına devam edilmiş fakat yaprak gübreleme uygulaması gerçekleştirilmiştir. Yaprak gübresinde; hümik ve fülvik acit %15, suda çözünebilir K_2O(0.03%) 2 L ha^{-1}, 20-20-20+TE 2.5 L ha^{-1} ave mikrobesin elementleri (0.8%B, 1.5%Cu, %5 Fe, %3 Mn, 0.2% Mo, 4% Zn) 0.5 kg ha^{-1} uygulanmıştır. Farklı sulama yöntemleri şekerpancarı kök ve şeker verimini önemli derecede etkilemiştir. Damla sulama sisteminde, uygulanan sulama suyu miktarı ve buna bağlı olarak bitki su tüketim değeri yaklaşık %11 oranında daha az olmuştur ve bitki su kullanım randımanı 15.2 kg m^{-3} olarak, yağmurlama sulama sistemine göre daha yüksek olmuştur. Damla sulama sistemi ile yaprak gübrelemesinin yapılması kök ve şeker veriminde önemli bir etkiye sahip olmuştur. Genel olarak, damla sulama sistemi şeker pancarı kök ve şeker veriminde önemli bir artış sağlarken, aynı zamanda suyu tasarruflu kullanan bir sistemolmuştur. Bu, bitki verim ve kalitesinin üst düzeyde sağlanması için düzenli sulaman önemini göstermektedir.
Anahtar kelimeler : Şekerpancarı, Damla sulama, Yağmurlama sulama, Yaprak gübrelemesi, Mikrobesin elementleri

Introduction

Sugar beet has a crucial importance in human nutrition and raw material of sugar (Mustafa, 2003) and the most sugar beet cultivation occurs in Russia ,the European Union and the United States . Russia was the largest producer with 39.3 million metric tons of production in 2016. France (33.6 million tons), the United States (29.8 million tons), Germany (22.8 million tons) and Turkey (16.5 million tons) are the other four largest producers of sugar beet in the world (Anonymous, 2018). Sugar beet in Kutahya was produced from the farmland of 1530 da (1da = 1000m^2) and the average yield was 5.37 t da^{-1} in 2016 (Anonymous, 2017). Pejic et al., (2011) reported that sugar beet cannot meet water requirement to provide its uniform development because of the inadequate rainfall during the growing period so that irrigation is a necessity in the development period and water demand of sugar beet has the most critical point in summer period to get a uniform yield, especially in July and August (Bosnjak, 2001). It is estimated that in the future, the effect of water scarcity will be more severe (Suheri, 2007). Mahmoodi et al., (2008) indicated that irrigation had a key role in obtaining sufficient amounts of sugar beet, especially in the Mediterranean area. Irrigation water is a limited resource in the Mediterranean climate and often used for products having high economic value so that it is necessary to meet full water requirement in drought conditions to get an economical yield from sugar beet (Tognetti et al. 2003). Pidgeon et al.(2001) and Jaggard et al.(1998) reported that the drought in climate has recently been an important constraint in the cultivation of sugar beet and also because of drought stress in England there was a serious yield loss of sugar beet (Richter et al., 2001). However, in contrast to this idea, Urbano and Arroyo (2000) said water deficit in some phenological periods of sugar beet did not cause significant loss in yield and quality of sugar beet.

Sharmasarkar et al. (2001a) compared the drip irrigation and surface irrigation methods to control the amount of NO_3 and applied it in a suitable level to the field. As a result, they determined that drip irrigation system had an advantage and produced 3-28% higher root yield and sugar content and also 168 kg N ha^{-1} was the most suitable dosage for N application in sugar beet production in drip irrigation system. Turhan and Piskin (2005) obtained the highest sugar beet yield at the level of 120 kg K_2O ha^{-1} (74.790 t ha^{-1}) fertilization and Esmaeili (2011) obtained the highest root yield at the dosage of 150 kg N ha^{-1} . Sharif and Eghbal (1994) indicated that the application of 150 kg N ha^{-1} on seven different varieties of sugar beet gave the highest root and sugar yield. Masri and Hamza (2015) reported that the foliar application of micronutrients as 100Zn+100Mn+100Fe+1000B (ppm) or 150Zn+150Mn+150Fe+1500B (ppm) increased sugar beet root weight by 21.54%, root yield by 28% and sugar yield by 24%. Rassam et al. (2015) recommended the application of foliar spray of micronutrients including %3Fe ($FeSO_4$), %1 Zn ($ZnSO_4$), %2.5 Mn ($MnSO_4$), %2Cu ($CuSO_4$), %2B (H_3BO_3) apply once 45 days after planting as a concentration of 2 L ha^{-1} since giving the highest root yield for sugar beet. Uçan and Gençoğlan (2004) obtained the highest water use efficiency (WUE) as 27.7 kg m^{-3} at the lowest level of irrigation. Sharmasarkar et al. (2001b) reported that the highest WUE varied between 9.6 and 10.6 kg m^{-3}. Fabeiro et al. (2003) obtained WUE values for sugar beet as between 13.3-17.5 kg m^{-3} . Kaffka et al. (2003) obtained WUE values as between 9.29-10.68 kg m^{-3} . Therefore, the general values of water use efficiency for sugar beet changed between 10 and 17.5 kg m^3.

Dunham (1993) said that research results carried out on sugar beet irrigation were a little bit confusing since some of them say water stress results in a significant decrease in yield of sugar beet, while others say exactly opposite, that is, not have any significant effects on the yield of it. For this reason, a number of studies have recently been carried out on water conservation by proper irrigation management in agriculture. With the reduction of water resources, in agriculture, the application of suitable irrigation methods has become a necessity for the protection of water resources and the reduction in contamination of chemicals into groundwater. The most difficult point, in agriculture, is to obtain more yield with less water, which may be possible to increase the water use efficiency of the plant (Masri et al., 2015).

Increasing the efficiency of cultural practices applied in agriculture such as fertilization and irrigation and getting an economical yield and selling products at market value will be possible with regular irrigation application. Therefore, this study was carried out to determine the effects of sprinkler and drip irrigation methods with and without foliar spraying of micronutrients on the yield and quality parameters of sugar beet.

Materials and Methods

Experimental site and soil description

The field experiment was carried out in a farmland in Altıntas, Kutahya-Turkey in 2016. Altıntas is located in the $39^0 41'$ N Lat. and $29^0 38'$E Long. West part of Turkey and elevation is 1010 m. The soil texture in the site was a clay-loam and physical properties are bulk density (1.83 g cm^{-3}), saturated hydraulic conductivity of soil (5.22 mm $h-^{1}$), field capacity (46.3%) and wilting point (35.6%).

Climate parameters; temperature, relative humidity, wind speed, rainfall and evaporation from Class-A pan from sowing to harvest are presented in Table 1. As seen in the table, rainfall amount (202.2 mm) , during the crop growing period, is not enough to get an economical yield from sugar beet, that's why, irrigation is a necessity to ensure uniformity in sugar beet growth. Sowing pattern in both sprinkler and drip irrigation system was 45x20 cm. Buffer strips between plots were 2 m and between blocks were 1m. In the sprinkler irrigation system, in order to prevent the drift of sprinklers to the drip irrigation plots, sprinkler heads were located at the edges and sides in running at the angles of 90 ^{o} and 180^{o}. Irrigation water was sprayed at a pressure of 2.5 atm. The discharge and wetting diameter were 1.25 m^3 h^{-1} and 26 m, respectively. In the drip irrigation system, polyethylene drip lines of 16 mm in diameter had in-line type emitters. The distance between emitters along the drip line was 0.33 m and the discharge of one emitter was 4 L h^{-1} under the running pressure of 1.5 atm.

The experimental design was a randomized complete block design with three replicates. Each plot in all treatments took the same recommended amount of fertilizer; 137.6 kg N ha^{-1} , 184 kg P ha^{-1} were applied and N was applied at three times, first at planting then on the 15th and 20th day following. Foliar spray of micronutrients were applied once after 40 days after sowing and twice after 75 days after sowing. Mixture of micronutrients contained humic acid (organic matter 15%, humic and fulvic acid 15%, water soluble K_2O (0.03%) 2 L ha^{-1}, 20-20-20 TE (NPK) 2.5 kg ha^{-1} , and micronutrients (0.8% B, 1.5%Cu, %5 Fe, %3Mn, 0.2%Mo, %4 Zn) 0.5 kg ha^{-1}. In the control treatment, there was no foliar spraying of micronutrients in both irrigation methods.

Table 1. Some climate parameters of site from sowing to harvest (2016).

Climate parameters*	April	May	June	July	August	Sep.	Oct.
Mean Temperature,(°C)	21.7	21.0	27.9	30.4	29.9	25.3	19.9
Max. Temperature,(°C)	29.6	29.6	34.2	38	36.2	32.2	28.2
Min. Temperature,(°C)	-0.6	4.5	6.5	10.7	10.9	4.1	0.6
R. humidity (%)	57.9	68.7	59.5	56.8	64.5	66	69.6
Wind Speed (m/s)	1.6	1.6	1.9	1.9	1.7	1.4	1.3
Rainfall(mm)	28.8	55.6	53.1	2.7	20.6	38.2	3.2
Evaporation,(mm)		110.7	195.7	235.5	171.8	113.2	71.1

* Data measured at 2 m

Irrigation treatments

In this experiment two different irrigation methods; sprinkler and drip irrigation systems were used and water requirement of crops in both systems were meet for the whole growing season.

DF : Drip irrigation with foliar spraying of micronutrients
DNF : Drip irrigation without foliar spraying of micronutrients
SF : Sprinkler irrigation with foliar spraying of micronutrients
SNF : Sprinkler irrigation without foliar spraying of micronutrients

The present study was conducted to determine the effects of irrigation and micronutrients on quantitative and qualitative yield of sugar beet and to compare drip and sprinkler irrigation performances in water saving and yield of sugar. All treatments took the same amount of water for 20 days after sowing to establish root development, then irrigation water was applied to treatments. The irrigation scheduling program for both irrigation systems was determined by using standard program of IRSIS (Irrigation Scheduling Information System) using Penman-Monteith equation. The program uses the climatic data, soil properties (field capacity and wilting point etc.) and plant properties (K_c taken from Ilbeyi, 2001) to estimate the actual evapotranspiration (ET_a).

Water Use Efficiency (WUE) (kg m^{-3}) (Hillel and Guron, 1975) were estimated as;

$$WUE = Y/ET$$

Where ; Y is yield kg ha^{-1} and ET is evapotranspiration (mm).

Leaf Area Index (LAI): Three plant samples from each plot were selected randomly for leaf area measurements. The green leaves were separated and leaf area was determined using a CI-202 portable laser area meter in cm^2. The Leaf Area Index (LAI) was determined by the following equation (Kar and Kumar, 2007);

$$LAI = \frac{Measured\ \ leaf\ \ area\ \ of\ 3\ plants}{Ground\ area\ covered\ \ by\ 3\ plants}$$

Sugar yield: Sugar analysis was done in Kutahya Sugar Factory. Sucrose content (%) was measured with a polarimeter after extraction of sugar from the pulp with lead acetate (Carruthers and Oldfield (1960). Sugar yield (kg ha^{-1}) was determined according to the equation given by (Suheri, 2007);

$$SY = \frac{SC}{100}.Root\ yield\ (kg\ da^{-1}\ )$$

Where; SY: Sugar yield (kg da^{-1}), SC : Sugar content (%)

Fresh and dry weights (root and leaf) were determined separately by weighing. After that, they were all oven-dried to a constant weight at about 70 ^{0}C for two days to determine the dry weight of whole plants in each treatment. Crop development parameters in each stage had been observed for the whole growing period. Representative three samples in the center rows from each plot were used to measure the quantitative and qualitative parameters, including root yield and sugar content. Sugar beet was harvested by hand on Oct. 20th (183 days old). Harvested roots for each sub-plot were weighed and adjusted to tons per hectare. Total soluble solids were determined on a blended composite using a portable hand-held refrectometer (Serico Shanghai E-Reliance International Co.,Ltd.China).

Statistical analysis: Data; yield and quality parameters were analyzed using ANOVA and Multi Dimensional Scale (MDS). After ANOVA test, means were separated by Duncan's multiple range test at the probability level of 1% and 5%.

Results and Discussion

Irrigation water, evapotranspiration and yield: The irrigation amounts (I), evapotranspiration (ET), water use efficiency (WUE), root yield, sugar content, sugar yield and total soluble solid parameters are given in Table 2. During the experiment, full water requirement was meet in both sprinkler and drip irrigation systems under with and without foliar spray of micronutrients.

Table 2. Irrigation depth (I), Evapotranspiration (ET), Water Use Efficiency (WUE), Yield (Y), Sugar Content (SC), Sugar Yield (SY), Total Soluble Solids (TSS)

Irrigation Treatments	Micronutrients appliation	I (mm)	ET (mm)	WUE kg m^{-3}	Y (kg da^{-1})	SC (%)	SY (kg da^{-1})	TSS Brix (20^{0}C)
SF	With foliar spray of micronutrients	975	1002	12.6	12831^{ab}	15.65^{b}	1950	17.3
SNF	Without foliar spray of micronutrients				12464^{b}	16.28^{a}	2088	19.3
DF	With foliar spray of micronutrients	867	894	15.2	13899^{a}	16.16^{a}	2246	17.2
DNF	Without foliar spray of micronutrients				13216^{a}	16.66^{a}	2201	16.7

Water applications commenced in the initial stage and continued to almost one month ago before harvesting date. During the whole growing period, the amount of irrigation water and evapotranspiration were 975 mm and 1002 mm in the sprinkler irrigation and those values were 867 mm and 894 mm in the drip irrigation system, respectively. Even though water requirement was compensated fully for both irrigation systems. Excess water application as 108 mm occurred in the sprinkler irrigation system. Therefore, eventhough having the highest amount of applied water, sprinler irrigation system could not produce higher yield rather than the drip irrigation system. The highest root yield (13899 kg ha^{-1}) was obtained from drip irrigation system with foliar spray of

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micronutrients. Therefore, sugar beet root yield, sugar content and yield were significantly increased by drip irrigation system. Tognetti et al. (2003) reported that drip irrigation in sugar beet production insreased water use efficiency, which also may promote nutrient use and thus this situation accelarated root maturation. Therefore, because of those advantages of drip irrigation system, yield in both root and sugar content were higher as compared with the sprinkler irrigation system. Furthermore, in the drip irrigation system, the increment in the yield of sugar beet was highest with the foliar application of micronutrients as compared by sprinkler irrigation, and strangely sugar content was low in the treatment of foliar application of micronutrients in sprinkler irrigation. In other treatments, there was no significant effect on the sugar content, even though the yield increased when foliar application of micronutrients in drip irrigation system was done. Therefore, as the yield increased in drip irrigation sytem an increment in total sugar yield has been achieved. The main reason of the highest root (13216 kg da^{-1}) and sugar yield may mostly due to the movement of N and P fertilizers in the soil in drip irrigation system and this increment in yield also (13899 kg da^{-1}) was mainly because of the some advantages of the drip irrigation system and the application of micronutrients increased a little bit also in drip irrigation system. Rassam et al.(2015) reported that the foliar application of micronutrients must be applied as a concentration of 2 L ha^{-1} in order to achieve maximum sucrose and white sugar content by applying once 45 days after planting. Hence, when we compare drip and sprinkler irrigation systems, drip irrigation has an important impact on the movement of fertilizers in the root zone.

Drip irrigation system in sugar beet production will have benefit for producers through higher production per hectare and restricted water in the root zone, it will safe guard water quality, and also environmental safety increases by drip irrigation system. Hence it will be more effective for sustainable agriculture. Dry matter in sugar beet increased in drip irrigation system with foliar application of micronutrients (Table 2). Therefore, it was more effective in the formation of dry matter in sugar beet, although there was adverse effect in the sprinkler irrigation. The role of micronutrients in increasing dry matter and root yield in sugarbeet was reported by Abd El-Gawad et al.(2004), Amin et al.(2013) and Mekki (2014). The mature sugar beets indicated that foliar spray of micronutrients had a positive effect on the root yield and its efficiency increased with the proper management of drip irrigation system.

Results indicated that drip and sprinkler irrigation with foliar application of micronutrients had a significant effect on root fresh and dry weight, on contrary to that, sprinkler and drip irrigation without foliar spray of micronutrients were more effective on leaf development and also leaf area was the highest in the sprinkler with and drip without foliar application of micronutrients (Table 3). The results obtained from this experiment were well agree with Rassam et al.(2015), they mentioned the sugar content was not affected but the highest root yield was obtained from drip irrigation system.

Table 3. Root and leaf of sugar beet development parameters under the treatments

Treatments	Root fresh weight (g sugar $beet^{-1}$)	Root dry weight (g sugar $beet^{-1}$)	Leaf fresh weight(g)	Leaf dry weight(g)	Root height (cm)	Root Dia. (cm)	Leaf area (cm^2)	LAI
SF	1598.2[a]	427.6[a]	212.2[a]	77.5[a]	27.9	14.7[a]	3803.6	4.18
DF	1695.0[a]	408.9[a]	141.7[b]	48.1b[b]	28.0	13.7[b]	3089.3	3.40
SNF	1259.8[b]	295.1[b]	132.1[b]	48.43[b]	27.3	13.2[b]	3313.4	3.64
DNF	1313.0[b]	384.1[b]	204.6[a]	69.8[a]	27.4	13.2[b]	3554.6	3.91

Sprinkler Irrigation System : The sugar beet completed its whole growing period within 183 days (Fig.1). The initial stage lasted 38 days and in this period it required irrigation water of 143 mm to complete its establishment period. The mean weight of tuber and leaves, respectively, reached 66g and 139.5 g in the initial stage, in which period to reach the total weight of 205.5 g it required irrigation water of 143 mm.

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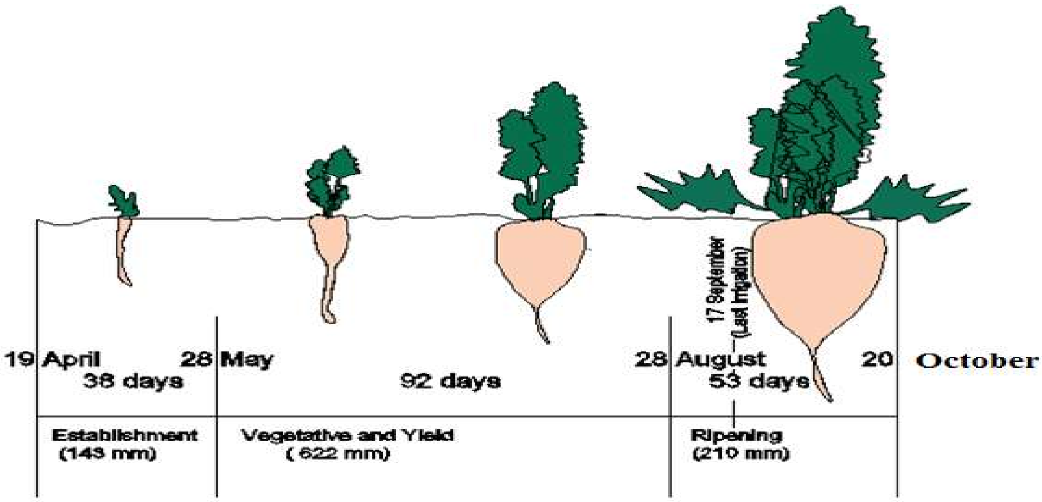

Figure 1. Growing periods of sugar beet and applied water in the sprinkler irrigation

The middle part of the growing period (vegetative and yield formation periods) lasted 92 days, in which period the applied amount of water was 622 mm. In the vegetative growing period, full water requirement of sugar beet needs to be meet since it is particularly sensitive to water deficit in this period. When full water requirement is not meet in the middle stage, it causes a reduction in yield, but an increase in sugar concentration. At the end of the vegetative period root and leaf weights,respectively, reached to 942.3 g and 529.3 g by adding irrigation water of 622 to initial stage.

The ripening period lasted 53 days and during this period applied water was 210 mm. Irrigation was discontinued almost one month ago to increase sugar concentration of sugar beets. At the end of the ripeing period total weights of tuber and leaves were 1363.4 g and 329.5 g, respectively. Irrigation water of 975 mm was applied for the whole growing period to reach those weights in sugar beet. The WUE value was 12.6 kg m^{-3} in the sprinkler irrigation but the highest WUE with 15.2 kg $m^{-3}$was obtained by drip irrigation system, which was mainly due to the lower irrigation quantities. All development stages as the tube and leaves of sugar beet under sprinkler irrigation system was given in figure 2. Wright (1982) reported that after planting of sugarbeet, within 30 days, root hairs and leaves occurs in the early stages. Therefore, in the early stage of the development, the tuber and leaf weights were 66 g and 139.5 g, almost toward the end of June, respectively. Wright (1982) said the development of sugar beet tube and leaves accelerate after 30 days of planting and leaf development reached its maximum value on between 90th and 120th day (Doorenbos and Kassam, 1979; Wright, 1982). The graph depicts the crop stages of sugar beet in whole growing period.

In this study, leaf weight reached to its maximum value 529.3 g on the 131th day, after that day due to leaf senescence, it started decreasing and dropped to 212.2 g on the 183th day and in that day, it completed its development. Irrigation was terminated almost one month ago before harvesting to increase sugar concentration, that's why, the fresh weight of tuber dropped to 1296.1 g. Dried weight of sugarbeet was 423.3 g, hence it consisted of water (67.1%) and dry matter (32.9%), and also weight of leaves was 458 g, of which consisted of 89.5 % water and 10.5 % dry matter.

Drip Irrigation System : In the drip irrigation system, total amount of irrigation water applied and evapotranspiration were 867 mm and 894 mm for the whole growing period. All growing stages and water consumptions were given in figure 3. The initial period lasted 38 days and applied water was 127 mm, in which period tuber weight was 51.5 g and leaves were 114.9 g so that total weight of it after applying water of 127 mm caused to reach 166.4 g. The sugar beet completed its vegetative period in 92 days. In the vegetative and yield formation period, the applied water was 553.2 mm. Even though this amount was lower than the amount applied in the sprinkler irrigation,the development parameters (tuber and leaves weights) of sugarbeet were more higher those obtained in the sprinkler irrigation (Fig.4). The tuber and leaves weights were 1276.4 g and 509.2 g, respectively. In the ripening period, the applied water was 186.8 mm and before harvesting irrigation was terminated one month ago.

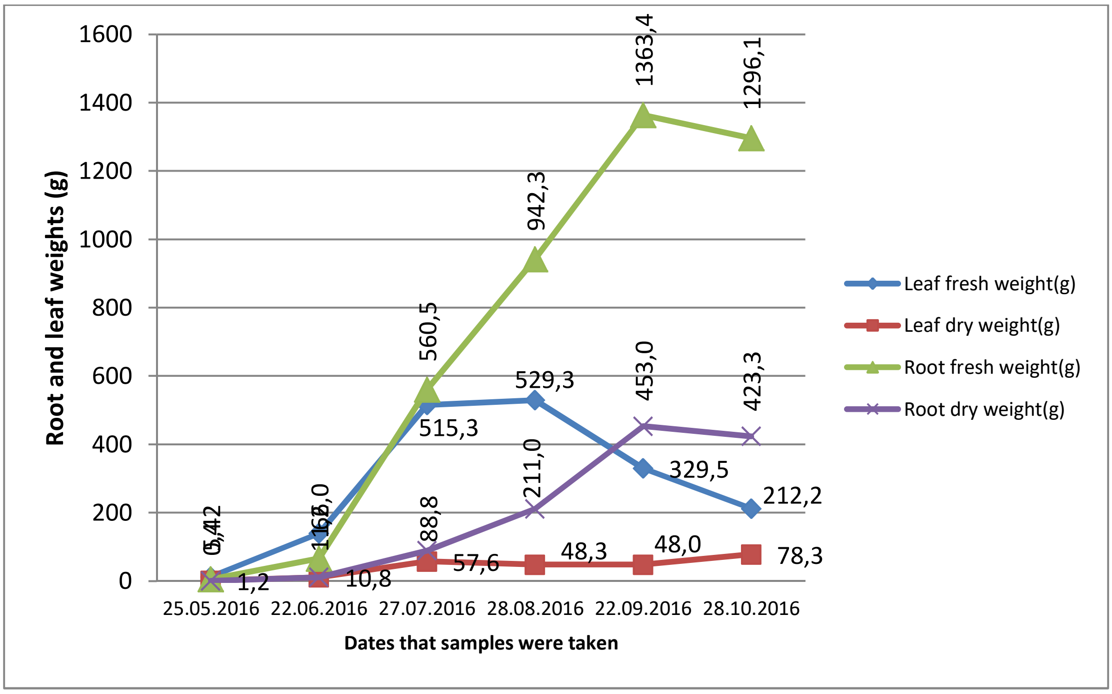

Figure 2. Changes in root and leaf of sugar beet during crop-growing season under sprinkler irrigation

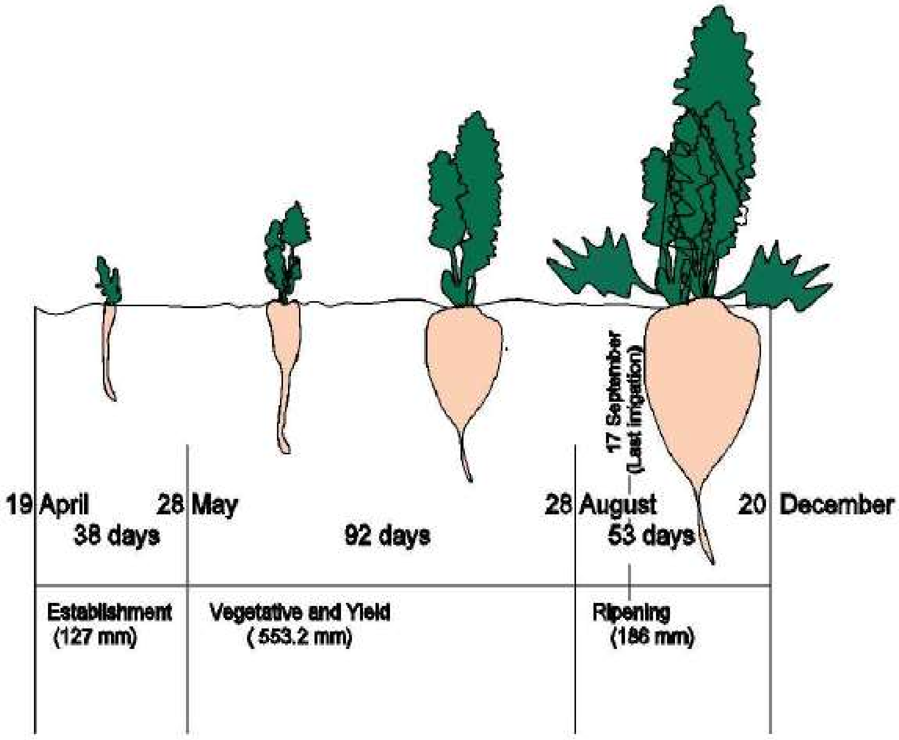

Figure 3. Growing periods of sugar beet and applied water in drip irrigation

In contrast to sprinkler irrigation, tuber weight continuously increased up to the harvesting date as 1358.8 g, but leaf weight from August to October decreased from 509.2 g to 204.5 g due to leaf senescence. In the drip irrigation system a tuber of sugar beet consisted of 68.5% water and 31.5% dry matter and leaves consisted of 88.5% water and 11.5% dry matter, while the weight of it was 509.2 g in the vegetative period.

Masri et al., (2015) applied irrigation water of 596.4 mm by drip irrigation system and average root yield was 1.15 kg sugar beet^{-1}, and when applied irrigation water of 685.9 mm in sprinkler irrigation, the average root weight was 1.04 kg sugar beet^{-1}, but the yield of white sugar was the same as about 9 t ha^{-1} in both irrigation methods, hence there was no change in sugar yield. In this experiment, we obtained the average root yield as 1.36 kg sugar beet^{-1} by applying irrigation water of 867 mm with drip irrigation system and sugar yield was 22.46 t ha^{-1}. Even though these values fluctuate according to literatures, the values we obtained from this experiment were slightly a little bit above the average. Therefore, drip irrigation system has an advantage to produce higher root yield and sugar content, and also to save water in plants root area.

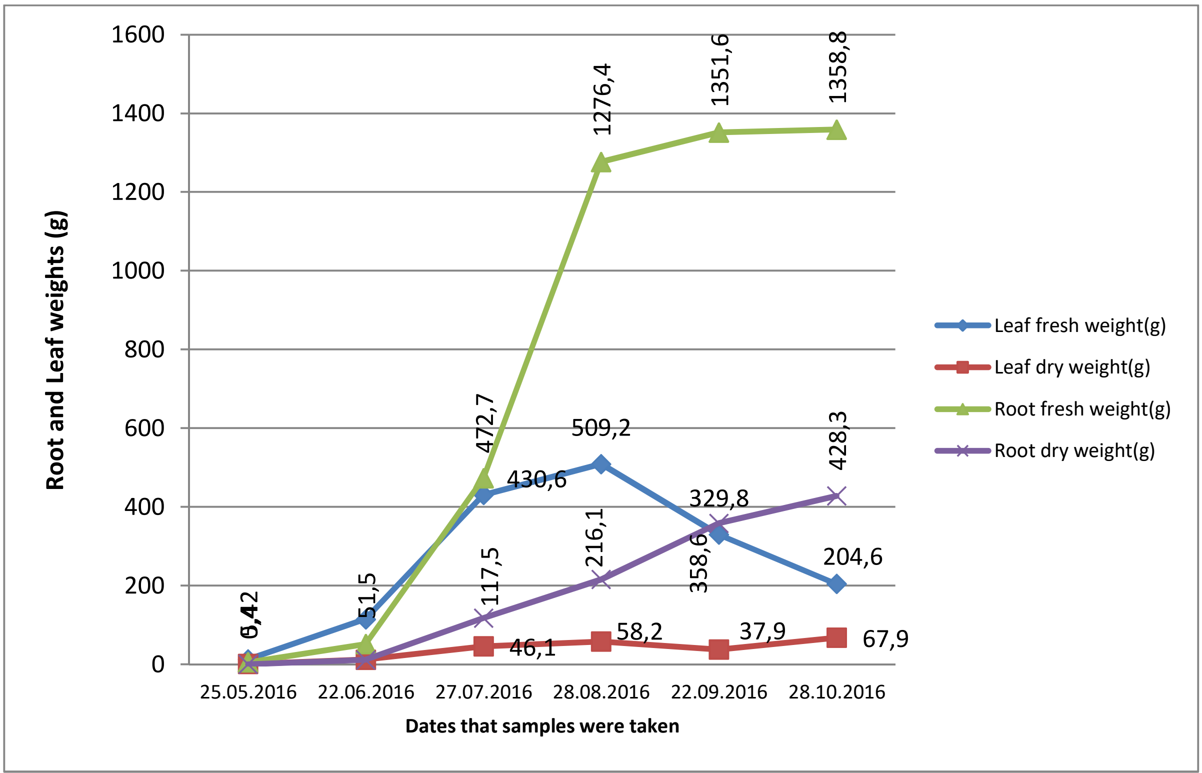

Figure 4. Changes in root and leaf of sugar beet during crop-growing season under drip irrigation

Conclusions

Agriculture in developing countries will need to produce more crop per drop and at the same time, farmers will face increasing competition for scarce freshwater resources from industry and domestic users. Under those conditions, irrigation water management is even more important because of environmental concerns.

In this experiment, plant development and yield were significantly affected by drip irrigation system, in which irrigation water applied was 867 mm. Sugar beets in drip irrigation system, were irrigated with 11% less water as compared with sprinkler irrigation system. The root and sugar yield are among the most important components in sugar beet production (Rassam et al., 2015). Therefore, drip irrigation system in the experiment increased the yield of sugarbeet and application of micronutrients with foliar spraying provided an increment in the root and sugar yield of sugar beet. The highest root yield was obtained from drip irrigation system. However, there were no significant effect of the foliar spray of micronutrients on the sugar content.

Stegmen and Bauer (1997) reported vegetative growth is particularly sensitive to internal water deficits and the loss of turgor pressure. Loss of turgidity causes leaf stomata to close, with a subsequent decline in photosynthetic efficiency, which results cause loss of potential yield. Therefore, the application of water as 867 mm by drip irrigation system makes sugar beet cells to become turgid in the whole growing period, hence, this amount of irrigation water prevents the loss of root and sugar yield. If water scarcity exists, the amount of water applied by drip irrigation in vegetative and yield formation period as 553.2 mm has a crucial importance on the yield of sugar beet to get an economical yield. In comparison of drip and sprinkler irrigation systems in terms of both N-fertilizers and foliar spray of micronutrients, it is clear that fertilization and foliar spray of micronutrients in drip irrigation system have more effect on the root and sugar yield of sugar beet. Hence, these results can be considered as a strategy for water management in sugar beet (*Beta vulgaris* L. cv. esperanza) irrigated by drip irrigation system.

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