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# Evaluation of furrow and drip irrigation tape methods in sugar beet fields

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## ABSTRACT

Due to water scarcity, sustainable development of drip irrigation tape is essential in Iran. A number of drip irrigation tape systems used in sugar beet fields in Isfahan and Chaharmahal and Bakhtiari provinces were evaluated and were compared with furrow irrigation method for two years. Actual water use efficiency in lower quarter, water use efficiency potential, dropper uniformity in lower quarter, absolute water output uniformity of droppers, Christiansen's uniformity coefficient, uniformity of water distribution as well as the quantity and quality of sugar beet were investigated in this study. Orion and Afshari cultivars were planted on 0.4 m rows. Actual water use efficiency varied in the range of 49-74.5%. Average uniformity of distribution coefficient of the droppers was 73.8% and Christiansen's uniformity coefficient was 82%. Drip irrigation tape system had significant difference with furrow irrigation method in terms of water use efficiency for sugar yield and white sugar content ($p \leq 0.05$). Average water use efficiency for sugar yield and white sugar content in drip irrigation tape were 0.91 and 0.65 Kg $m^{-3}$, respectively, and for furrow irrigation system were 0.78 and 0.53 Kg. $m^{-3}$, respectively. Both irrigation systems had no significant difference in terms of root yield and sugar beet quality.

**Keywords**: drip irrigation tape, sugar beet, water use efficiency

## INTRODUCTION

Due to water scarcity and consumption of more than 93% of total water in agriculture, in 2021, this sector will face 54 billion $m^3$ water shortages in Iran (Salemi *et al*. 2011). One of the most important strategies for water conservation is to select a proper irrigation method. Selection of the proper irrigation method which can contribute to water reduction crisis is essential and to achieve this goal, the use of micro-irrigation method has a special place. For sugar beet irrigation, traditional surface irrigation methods are usually used in Iran. However, in recent years, the usage of drip irrigation method has been increased remarkably in order to increase water use efficiency (WUE). Currently, efforts are focused on increasing yield per unit area and less attention has been paid on increasing productivity per unit of irrigation water. However, in Iran, efforts should be focused on increasing the productivity per unit of water consumption and also efficient use of limited water resources. 186000 hectares are devoted to sugar beet cultivation which is one of the main crops in sugar production (Sadreghaen *et al*. 2009). In study by Sadreghaen and Akbari (2013), effects of sugar beet sowing pattern and irrigation management on drip irrigation tape efficiency was evaluated. Results showed that the highest and the lowest root yield was achieved in single row irrigation between two sowing rows and every other irrigation tape pattern, respectively. The average potato yield and WUE in sprin-

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kler and drip irrigation tape systems were 5.2 and 9.2 Kg $m^{-3}$ of water, respectively. Results also showed that yield increase in row sowing methods is not only dependent on system type but also on farmer's management. Drip irrigation tape system usage in sugar beet fields resulted in more than 19% reduction in irrigation compared with sprinkler method and also increased WUE by 107% (Ghadami Firuzabadi 2005). In another study, effects of irrigation systems on WUE, yield, and quality were evaluated at Mazrae Nemooneh Institute of Astan Quds Razavi. Results showed that the pressurized irrigation system had no significant effect on yield and quality of sugar beet, but its application led to an increase in WUE. In this study, using drip irrigation tape system with dropper's nozzle located at 20 and 100 cm interval distance resulted in 10.6 and 18.4 Kg/$m^3$ WUE in root yield and furrow irrigation method, respectively. Results showed that using drip irrigation tape system with one meter distance resulted in 2.3 net profit equal to furrow irrigation (Karimzadeh Moghaddam 2002). Another study conducted on variety PP22 (multigerm) showed that the uniformity coefficient (UC) of the tapes made by Iran and the imported ones was 97 and 98%, respectively. The amount of water consumption was 58% of total surface irrigation water. Average WUE in drip irrigation tape was 90.74% and in furrow irrigation was 52%. The highest WUE in white sugar yield and root yield were observed in every-other- row drip irrigation and the lowest amount was in furrow irrigation system. The highest white sugar percentage was found in every- other- row drip irrigation (Hossain Abadi and Ghaemi 2004). In a study conducted by South Plume Engineering Company (Anonymous 2001), drip irrigation tape system was evaluated in sugar beet fields in Borojen, Chaharmahal and Bakhtiari province. Results showed that at the end of the growing season, drip irrigation tape application decreased water consumption from 9000 $m^3$ $ha^{-1}$ in conventional method to 3500 $m^3$ $ha^{-1}$ in drip irrigation tape system which also resulted in labour cost decrease. Significant difference ($P < 0.05$) was found between drip irrigation tape and furrow irrigation methods in terms of sugar yield and white sugar content and drip irrigation tape system increased WUE by 36% (Eckhoff and Bergman 2001). In a study carried out in Wyoming, US, it was showed that root yield, sugar content and soil nitrate content were higher in drip irrigation tape compared with furrow irrigation (Tognettia *et al*. 2003). Research conducted in California showed that drip irrigation tape caused a remarkable decrease in sugar beet water consumption compared with other methods. Applied irrigation twice a week and irrigation tape depth was resulted in 6928 Kg $ha^{-1}$ sugar production with significant difference with daily irrigation and 12 inches tape depth. Although the overall trend showed an increase in sugar yield in drip irrigation tape but this trend was not significant (Hanon and Kaffka 2004). Turkey's researchers in Anatolian heartland studied the effects of three irrigation levels (75 and 50% of SWD, and complete irrigation) in drip irrigation tape system on sugar beet yield and reported that the highest sugar beet yield in terms of energy production was achieved in 75% irrigation. Furthermore, this method conserved 11.2% of total energy input, 16.1% of energy used for irrigation and 21.2% of total fuel consumption (Topak *et al*. 2010). Another study evaluated the effects of water deficiency on sugar beet root yield, quality and WUE in drip irrigation tape for two years in semi-arid region of Antalya in Turkey. The highest WUE was observed in low irrigation (75% of full irrigation) and the lowest in full irrigation. Increase in water irrigation resulted in root yield and white sugar reduction. Results showed that sugar beet irrigation with drip irrigation tape system at 75% (of full irrigation) had significant advantageous in terms of providing limited water irrigation. Also from an economical point, 25% water conservation led to only 6.1% net income reduction (Topak *et al*. 2011). In a study conducted in Greece, the effects of drip irrigation tape and subsurface drip tape on sugar beet yield under 80 and 100% irrigation levels were evaluated and results showed that subsurface irrigation led to higher yield (22.2%) and sugar content (Sakellariou-Makrantonaki 2003). Also, subsurface irrigation (80% level) conserved more water without yield reduction. Rinaldi and Vittorio (2006) study also showed an increase in fresh root weight, total dry matter, yield, sucrose content, and WUE in autumn sugar beet using drip irrigation system. Togenttia *et al*. (2003) studied the effects of low irrigation (50, 75, and 100% evapotranspiration) in two low pressurized sprinkler irrigation and drip irrigation tape systems on physiological and technical properties of sugar beet (gas exchange, leaf photosynthetic rate, stomatal conductance, leaf relative water content, and sucrose accumulation) in Molise, Italy. Results showed that drip irrigation tape was more suitable for sugar beet fields in arid and semi-arid regions compared with sprinkler irrigation. In a study by Ghamarnia *et al*. (2012),

**Table 1**. Results of soil and water analysis

| Field location | Saturation (%) | Soil salinity (dS/m) | Water salinity (dS/m) | Organic carbon (%) | Total nitrogen (%) | Absorbed potassium (mEq/kg) | Absorbed phosphorus (mEq/kg) | Acidity | Sand (%) | Silt (%) | Clay (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Khorasgan | 59 | 1.28 | 5.32 | 0.78 | 0.078 | 700 | 7.3 | 7.1 | 69 | 20 | 11 |
| Mobarakeh | 56 | 1 | 2.5 | 0.75 | 0.085 | 650 | 7.4 | 6.9 | 50 | 26 | 24 |
| Boldaji | 41 | 0.47 | 0.4 | 1.44 | 0.144 | 301 | 15.1 | 7.3 | 44 | 43 | 13 |
| Frardonbeh | 40 | 0.44 | 0.5 | 1.35 | 0.132 | 320 | 14.2 | 7.2 | 40 | 42 | 18 |

effects of different irrigation methods on root yield and sugar content was significant. The highest sugar (4.501 t $ha^{-1}$) and root (39.15 t $ha^{-1}$) yield were obtained in drip irrigation tape system with 100% water supply. Because of the significant effects of drip irrigation tape on WUE and sugar beet quantity and quality in above researches, this study was conducted to evaluate the effects of drip irrigation tape in two provinces for two years. Distribution uniformity, potential and actual WUE, were measured and the system performance type was determined. As sugar beet purchase from farmers is based on sugar yield, the best treatment is the one which increases sugar yield. However, sugar yield has more theoretical importance and after sugar beet processing in the factory, white sugar yield remains. This study aims to determine WUE in sugar yield and white sugar content in terms of technical consideration to improve effectively the operational management of these systems.

## MATERIALS AND METHODS

In this study, drip irrigation system and its effects on WUE and sugar beet quantity and quality indices were evaluated for two years (2005-06) in four sugar beet fields including Khorasgan region (in east Isfahan), Mobarakeh region (in south western Isfahan), Chaharmahal and Bakhtiari (in Boldaji region, 100 km south Shahrekord), Faradonbeh region (in 60 km south eastern Shahrekord). Boldaji and Faradonbeh (Chaharmahal and Bakhtiari province), and khorasgan and Mobarakeh (Isfahan province) are the major sugar beet production regions. Selected fields were located around Isfahan sugar factory, Nagsh Jahan sugar factory, and Shahrekord Sugar Company. Table 1 shows the results of soil and water analysis for two provinces.

The aim of irrigation system evaluation can be summarized in two characters including actual system performance and maximum system efficiency (potential yield). The greater difference between actual performance and maximum system efficiency means that the system failed to reach its maximum efficiency, and the problem is from designing and also to a higher extent from management (Keller and Karmeli 1974).

*Determination of comparison criteria among different methods*

In this study, main concepts such as actual system performance, the maximum system efficiency, and water distribution uniformity were used (Qasemzadeh Mojaveri 1990). In most previous studies conducted on evaluation and determination of pressurized irrigation in Iran and around the world, these concepts were used for evaluation of irrigation system in normal operational conditions. Using infiltration opportunity and infiltration testing data through input-output, cumulative diffusion equation, infiltration group, and diffusion equation were determined (using infiltration curves provided by U.S. Soil Conservation Service) and infiltration depth in 3 m interval cracks were calculated and was stored in a descending order. Distribution uniformity was measured through calculating the minimum quarterly infiltration depth to total quarterly infiltration depth ratio (Willardson and Bishop 1967). Hydraulic measurements including dropper's discharge, dropper's pressure and distribution uniformity were measured using SCS method (Keller and Karmeli 1974). After running above measurement, Application Efficiency of Low Quarter (AELQ), Potential Efficiency Low Quarter (PELQ), emission uniformity of low quarter (EUm), absolute emission uniformity (EUa), Christiansen's uniformity coefficient (CUc), and distribution uniformity (DU) were calculated (Keller 1979; Merriam and Keller 1978).

$$\text{WUE} = \frac{\text{crop yield}}{\text{volume of irrigation water}} \qquad (1)$$

Equation 1 was used for sugar yield and white sugar content estimation in both irrigation methods. Irrigation water was measured by volume water metter for drip irrigation system and by WSC flume for furrow irrigation (closed furrows in Khorasgan and Mobarakeh, and opened furrows in Boldaji and Faradonbeh). The experiment constituted the measurement of tape discharge at first, second, and third quarter (60-70 mm), root yield via composite sampling, qualitative characters by making brei from harvested samples and note taking in all stages (from sowing till harvest). A total of 30 irrigation tapes were randomly selected and discharge rate was measured.

Sowing was carried out by monogerm planting machine in 5.2 hectares using two monogerm seed varieties. Seeds were placed in depths of 2-3 cm with 5 cm distance and two levels of density (65000 plants per hectare in Boldaji and Faradonbeh, and 75000 plants per hectare in Khorasgan and Mobarakeh) were applied. Tape irrigation was placed between two planted rows. The distance between rows was 40 and 60 cm and tape length was 60 m. Water outputs were embedded at 30 cm intervals and system operating pressure was in the range of 0.5-0.88 atmosphere. To control pests such as carderina, *ncanescens* (*Lixus*), leafhopper vector curly top and leaf aphids, spraying was performed during the growing season. One lit/ha Calixin and Actin fungicide was used against curly top, powdery mildew, and root rot diseases. Based on soil analysis, 200 kg/ha NPK fertilizer was applied. Fertilizer tank was used for urea fertilizer (350 kg/ha) distribution. All above operations were carried out in furrow irrigation field (control) close to drip irrigation tape field. Roshd and Zarbar fertilizers (5 lit/ha) were used twice in a foliar spray mode. Both harvest and sampling were carried out in September of each year. Nine samples were taken from 4 $m^2$ drip irrigation tape and check fields and were sent to Sugar Technology Laboratory for brei making. Boldaji field with an area of about nine hectares (4 ha drip irrigation tape and 5 ha furrow irrigation), Fardonbeh with an area of about 10.5 ha (4 ha drip irrigation tape and 6.5 ha furrow irrigation), Khorasgan with an area of about 5 ha (3 ha drip irrigation tape and 2 ha furrow irrigation), and Mobarakeh with an area of about 30 ha (25 ha drip irrigation tape and 5 ha furrow irrigation) were evaluated simultaneously. Universe variety with 100000 plant/ha density was planted in these fields. Thinning and weed control operations were carried out when needed and spraying was performed against pests and diseases. Harvest took place in late October.

## RESULTS AND DISCUSSION

*System evaluation indices*

In the first year of the experiment, this efficiency was 49 and 59% for Boldaji and Khorasgan fields, respectively and in the second year it was 63 and 74.5% for Faradonbeh and Mobarakeh fields, respectively. The reasons for low AELQ value especially in Chaharmahal and Bakhtiari province was due to management problems in system exploitation. Due to prolonged irrigation in the fields (6-8 days), WUE was considered as AELQ in low quarter (PELQ).

*Discharge uniformity*

Discharge uniformity in lower quarter (EUm), absolute uniformity of water withdrawal (EUa), Christiansen's uniformity coefficient (CUc), uniformity water distribution (Du) were determined (Table 2-5).

According to the results obtained in Boldaji region, average output uniformity in low quarter was 67.3%. Absolute uniformity of droppers output was 68.1% which was lower than Christiansen's uniformity coefficient. These values

**Table 2**. Discharge uniformity in lower quarter (EUm), absolute uniformity of water withdrawal (EUa), Christiansen's uniformity coefficient (CUc), uniformity water distribution (Du) results in the first year

| Field | EUm (%) | EUa (%) | CUc (%) | DU (%) |
|---|---|---|---|---|
| Boldaji | 70 | 69 | 82 | 75 |
| | 78 | 78.4 | 83.7 | 77.4 |
| | 59 | 61.5 | 71 | 60 |
| | 60 | 63.6 | 69 | 56.9 |
| Average | 66.7 | 68.1 | 76.4 | 67.3 |

**Table 3**. Discharge uniformity in lower quarter (EUm), absolute uniformity of water withdrawal (EUa), Christiansen's uniformity coefficient (CUc), uniformity water distribution (Du) results in the second year

| Field | EUm (%) | EUa (%) | CUc (%) | DU (%) |
|---|---|---|---|---|
| Faradonbeh | 82 | 85 | 92 | 88.8 |
| | 74 | 76.2 | 84.2 | 78 |
| | 72 | 74 | 77 | 68 |
| | 76 | 79 | 83 | 73.4 |
| Average | 76 | 72.5 | 84 | 78 |

**Table 4**. Discharge uniformity in lower quarter (EUm), absolute uniformity of water withdrawal (EUa), Christiansen's uniformity coefficient (CUc), uniformity water distribution (Du) results in the first year

| Field | EUm (%) | EUa (%) | CUc (%) | DU (%) |
|---|---|---|---|---|
| Khorasgan | 70 | 73 | 80 | 72.2 |
| | 79 | 87 | 90 | 86.1 |
| | 82 | 84 | 89 | 80.5 |
| | 64 | 69 | 74 | 63.9 |
| Average | 73.7 | 76 | 82.5 | 75.7 |

**Table 5**. Discharge uniformity in lower quarter (EUm), absolute uniformity of water withdrawal (EUa), Christiansen's uniformity coefficient (CUc), uniformity water distribution (Du) results in the second year

| Field | EUm (%) | EUa (%) | CUc (%) | DU (%) |
|---|---|---|---|---|
| Mobarakeh | 79 | 80 | 85 | 79.1 |
| | 80 | 77 | 92.5 | 89.6 |
| | 82.5 | 81 | 90 | 86.1 |
| | 74 | 76.9 | 84.1 | 77.9 |
| Average | 78.9 | 79 | 85.4 | 83.2 |

were 78 and 72.5%, respectively in Faradonbeh. Christiansen's uniformity coefficient and water output uniformity in low quarter in Boldaji were 76.4 and 84, respectively and in Faradonbeh region were 66.7 and 76%, respectively (Tables 2-3). However these traits values were higher in Mobarakeh than Khorasgan. Output uniformity in Mobarakeh was in the range of 70-90% and CUc coefficient was also high (CUC > 85). Based on SCS definition if the dropper output uniformity is less than 70%, the performance will be poor (Qasemzadeh Mojaveri 1990). Distribution uniformity coefficient was higher than 67% which is acceptable. Uniformity coefficient in low quarter (EUm) was lower than 70% in Boldaji (poor performance) and in other fields it varied between 70 and 90% which requires network design control and regular system cleaning. In these fields, dropper clog and their high coefficient of variations resulted in inconsistency of water distribution in different parts of the field. This problem was also occurred in a study conducted in Arak (Baradaran Hezaveh *et al*. 2006). Despite technical descriptions of these droppers in their factory's catalogue, droppers output had 4 per mil $h^{-1}m^{-1}$ water outlet difference. Two times measurements showed 2.9-5.4 per mil variation in tape output (average CV of 30%) which was in contrast with Hossain Abadi and Ghaemi (2002) results. Measurements showed that droppers located in closer distance to main tapes had higher output compared with droppers located in middle parts. Due to economic problems, only one tape was used for two planting rows in early growth stages which brought major problems for germination. To supply seed moisture requirement, tapes were displaced by workers repeatedly which damaged them rapidly and led to inconsistent germination and density. For example, uneven distribution of water in Boldaji and Fardonbeh fields caused difference in root growth rate and yield so that it varied in the range of 2.5-5 Kg/$m^2$. Difference in water irrigation volume in furrow irrigation method in two provinces was due to climatic difference of these two provinces with higher water consumption in Isfahan province.

### *Water use efficiency results*

The minimum water consumption in drip irrigation tape was in Boldaji field (first year) and the maximum water consumption in furrow irrigation was in Mobarakeh (second year) (Fig. 1-2). The total irrigation water consumption in khorasgan and Mobarakeh in furrow and drip irrigation tape systems were 11700 and 7100 $m^3$/ha and in Boldaji and Faradonbeh were 9250 and 6300 $m^3$/ha, respectively. These results support Karimzadeh Moghaddam (2002) results. Table 6 shows that not only root yield, sugar yield, and white sugar yield indices were higher in the first year in Boldaji but also their difference was significant. As Table 7 indicates no significant difference was found between two irrigation methods for evaluated parameters in the second year which is

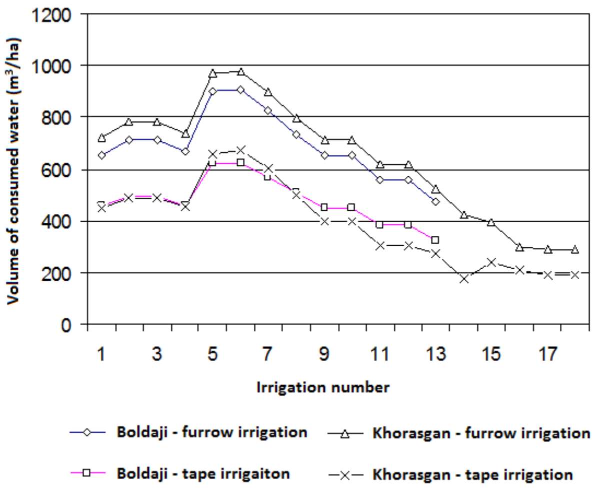


**Fig. 1**. The amount of irrigation water for irrigation tape and furrow irrigation methods in the first year

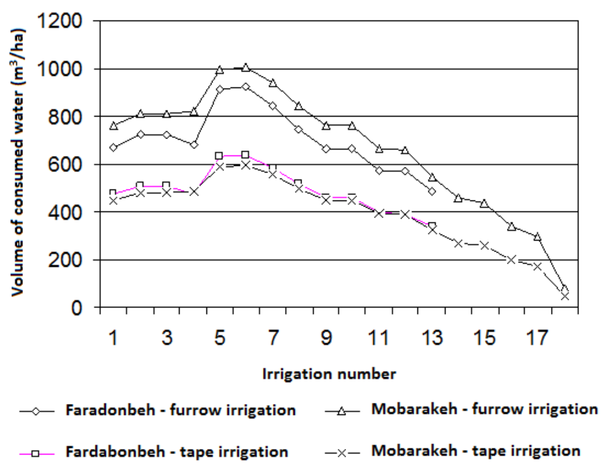


**Fig. 2**. The amount of irrigation water for irrigation tape and furrow irrigation methods in the second year

**Table 6**. Mean comparison of agronomical traits and quality of sugar beet in furrow and drip irrigation tape methods in Boldaji and Khorasgan regions in the first year.

| Region | Irrigation method | Irrigation water volume ($m^3$/ha) | Root yield (t/ha) | Sugar content (%) | Sugar yield (t/ha) | Sodium content (meq/g syrup) | Potassium content (meq/g syrup) | Amino nitrogen (%) | White sugar (%) | White sugar yield (t/ha) | Syrup purity (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Boldaji | Drip irrigation tape | 6223 | 27.91 | 17.53 | 4.89 | 1.02 | 5.39 | 2.06 | 14.85 | 4.13 | 84.64 |
| | Furrow irrigation | 9003 | 39.66 | 17.12 | 6.77 | 1.56 | 5.49 | 2.39 | 14.19 | 5.61 | 82.79 |
| | t-test | - | * | N.S | * | N.S | N.S | N.S | N.S | * | N.S |
| Khorasgan | Drip irrigation tape | 7000 | 35.95 | 15.62 | 5.61 | 1.35 | 6.87 | 4.12 | 13.03 | 4.68 | 87.32 |
| | Furrow irrigation | 11550 | 37.21 | 15.52 | 5.77 | 1.61 | 7.09 | 3.91 | 11.66 | 4.34 | 74.70 |
| | t-test | - | N.S | N.S | N.S | N.S | N.S | N.S | N.S | N.S | N.S |

* significant at 5% probability level, ns = non significant

**Table 7**. Mean comparison of agronomical traits and quality of sugar beet in furrow and drip irrigation tape methods in Boldaji and Khorasgan regions (second year).

| Region | Irrigation method | Irrigation water volume ($m^3$/ha) | Root yield (t/ha) | Sugar content (%) | Sugar yield (t/ha) | Sodium content (meq/g syrup) | Potassium content (meq/g syrup) | Amino nitrogen (%) | White sugar (%) | White sugar yield (t/ha) | Syrup purity (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Faradonbeh | Drip irrigation tape | 6400 | 38.21 | 17.65 | 6.74 | 1.06 | 5.65 | 2.15 | 14.72 | 5.62 | 86.52 |
| | Furrow irrigation | 9200 | 39.78 | 17.21 | 6.85 | 1.42 | 5.47 | 2.41 | 14.11 | 5.61 | 83.21 |
| | t-test | - | N.S | N.S | N.S | N.S | N.S | N.S | N.S | N.S | N.S |
| Mobarakeh | Drip irrigation tape | 7100 | 38.33 | 18.79 | 7.20 | 0.95 | 7.26 | 5.06 | 15.23 | 5.83 | 77.06 |
| | Furrow irrigation | 12000 | 39.21 | 18.60 | 7.29 | 1.13 | 7.16 | 6.41 | 15.42 | 6.04 | 78.91 |
| | t-test | - | N.S | N.S | N.S | N.S | N.S | N.S | N.S | N.S | N.S |

* significant at 5% probability level, ns = non significant

**Table 8**. Effect of irrigation method on WUE of sugar yield and sugar extraction (Kg/$m^3$)

| Treatment | Boldaji (first year) | | Khorasgan (first year) | | Faradonbeh (second year) | | Mobarakeh (second year) | | Average | |
|---|---|---|---|---|---|---|---|---|---|---|
| | WUEsy | WUEwsy | WUEsy | WUEwsy | WUEsy | WUEwsy | WUEsy | WUEwsy | WUEsy | WUEwsy |
| Drip irrigation tape | 0.78 | 0.75 | 0.80 | 0.50 | 1.05 | 0.74 | 1.01 | 0.61 | 0.91 | 0.65 |
| Furrow irrigation | 0.75 | 0.62 | 0.67 | 0.37 | 0.88 | 0.61 | 0.82 | 0.50 | 0.78 | 0.53 |
| t-test | N.S | N.S | * | * | * | * | * | * | - | - |

* significant at 5% probability level, ns = non significant
WUEway = water use efficiency on white sugar yield
WUEsy = water use efficiency on sugar yield

in contrast to those reported by Eckhoff and Bergman (2001). However these results are similar to Hanon and Kaffka (2004) and karimzadeh Moghaddam (2002) who reported non-significant effect of pressurized system on quality and quantity of sugar beet. Table 8 shows that WUE had maximum effect on sugar yield and white sugar yield under drip irrigation tape system in Faradonbeh and minimum effect in furrow irrigation in Khorasgan. Significant difference was found for WUE effect on sugar yield and sugar extraction yield between two irrigation methods in both years in all fields except Boldaji field in the first year which corroborates with previous studies (karimzadeh Moghaddam 2002; Hossain abadi and Ghaemi 2004). Table 8 also shows the effect of irrigation methods on the WUE of sugar yield and sugar extraction.

## CONCLUSION

Average AELQ in Boldaji and Faradonbeh was 49 and 63, respectively and in Khorasgan and Mobarakeh was 59 and 74.5, respectively. Average CUc, EUa, EUm, and DU percentage in Chaharmahal and Bakhtiari were 80, 70, 71.4, and 72.5, respectively and in Isfahan were 84, 77.5, 76.4 and 79.5, respectively. Lower results obtained in Chaharmahal and Bakhtiari province indicates that the implementation of this system and the farmers usage was not sufficiently accurate. Results of this study showed that drip irrigation system had no significant effect on quality and quantity of sugar beet but it increased significantly WUE. The lowest volume of irrigation water in drip irrigation tape was in Boldaji field (first year) and the highest was in furrow irrigation in Mobarakeh (second year). WURsy and WUEwsy had the highest value in drip irrigation tape system in Faradonbeh and the lowest in furrow irrigation system in Khorasgan.

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