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ORIGINAL ARTICLE

Effect of different managements with drip irrigation (tape)

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Abstract

Conventional irrigation methods to new methods have been altered with respect to reduction of water resources and climate change. Considering the corn cultivation development, applying modern irrigation methods namely drip irrigation with the aim of improving the efficiency of water consumption as well as the zone under cultivation has been investigated. In this research, the performance of corn (SC 704) in various managements of drip irrigation (by strip method) both in single-row and double-row planting patterns was considered with a variety of densities. This test was carried out on random complete blocks in the form of a 3-repetitive Split Design in Isfahan-Iran during the years 2018–2019. Four irrigation levels containing: 80, 100 and 120% of full water requirement with drip irrigation (strip) and 100% of water requirement with normal drip irrigation were utilized. The results indicated that applying the aforementioned drip tapes and different surface treatments with soil and water monitoring, the water consumption of corn seasonal irrigation can be saved by 81, 71, 61, 52 and 36% compared to normal drip irrigation without soil, water and root monitoring, respectively. Seasonal yield (Kc), the yield response coefficient (Ky), and pan coefficient (Kp) for corn were 0.80, 0.76 and 0.97, respectively.

Keywords Climate change · Water resources · Soil and water monitoring · Corn · Drip irrigation (tape) · Yield

Introduction

Water and nutrients can be conserved by drip irrigation and improved water consumption efficiency (WCE), productivity, and yield. By declining runoff, evaporation and deep penetration, drip irrigation may decrease water shortage nearby the root area. The impact of drip irrigation on farm economics and management for various crops worldwide was investigated (Andrade et al. (1999); Eslamian et al. 2018a, b; Bansal et al. 2021; Wang et al. 2021a; Ostad-Ali-Askari 2022a). Many researches have been conducted in the field of corn irrigation both in Iran and the world (Gao et al. 2021; Yan et al. 2021; Wang et al. 2021b; Guo et al. 2021; Gheysari et al. 2021; Cakmakci and Sahin. 2021; Bai and Gao. 2021; Zou et al. 2020; Chen et al. 2020; Jacques et al. 2018; Shayannejad et al. 2022; Ramesh et al. 2023a, b; Ostad-Ali-Askari et al. 2017a). For instance, high plant density can obtain increased yield and water consumption efficiency of corn utilizing optimal quotas and irrigation regimes, mostly in semi-arid weather (Wang et al. 2021b). The application of various water volumes on WUE and corn yield is discussed. The impact of irrigation intervals and fertilization on energy consumption and corn grain yield

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was studied. The results indicated that nitrogen fertilization treatments lead to more corn energy consumption compared to field manure or zero nitrogen treatment, also coordinating water and nitrogen supply levels is an effective approach to improve crop production and crop water efficiency (QI et al. 2020). The application of various levels of irrigation water including a variety of percentage of corn water requirement was studied utilizing manifold irrigation methods and the total corn grain was more corn water application for 100% (full water requirement) (Bozkurt et al. 2011; Singh Brar et al. 2016). Some researchers have remarked that corn cultivation needs a lot of water for irrigation and mostly sensitive to drought and lack of water (Karam et al. 2003; Cucci et al. 2019; Kresović et al. 2016; Oktem 2008; Setter et al. 2001; Sah et al. 2020; Schussler and Westgate 1991; Cakir 2004; Nafchi et al. 2022). Scheduling reduced irrigation for a corn crop without declining yield is a challenging task (Lamm et al. 1995, 2014). In addition, reduction of maize yield was considered by Nesmith and Ritchie (1992) due to water deficit during the flowering period. Lack of irrigation and increased irrigation cycle decrease the yield of the crop indicating various sensitivities in different stages of growth (Oktem et al. 2003; Farre´ and Faci 2009). According to Iran is one of the dry and semi-arid regions due to the average precipitation in Iran, which is lower than the world average. In its different parts, the temporal and spatial distribution of precipitation is uneven. Water resource management is very important considering the need for irrigation for food security, (Mirzaei et al. 2019; Ostad-Ali-Askari, 2022b; Fattahi Nafchi et al. 2022; Fatahi Nafchi et al. 2021; Nafchi et al. 2021). One of the management features is considered to be the use of modern irrigation methods. Poor irrigation reduces yield and water consumption efficiency are shown in previous research compared to adequate irrigation. In areas where temperature, evaporation and transpiration are high, low irrigation should not be conducted on crops like corn (Musick and Dusek 1980). Corn yield was gained from the lowest to the highest value, respectively, in dry, low and full irrigation, (Herger and colleague 1993; Huang et al. 2002). Water consumption, efficiency of water use and corn yield have been reported in many researches (Howell et al. 1998; Hillel and Guuron 1973). Use of modern irrigation methods is recommended to enhance the efficiency of water consumption, such as drip irrigation for corn cultivation. This type of system directly transfers water and nutrients to the plants, saving water consumption and increasing crop yield (Gencoglan 1996; Tiwari et al. 2003). Placing with high uniformity on the field during the irrigation period, drip irrigation supplies the amount of water needed by the plant at the right time (El-Hendawy et al. 2008). The use of drip irrigation develops the cultivated area, crop yield and water consumption efficiency (Sivanappan 2004).

The use of drip irrigation system (strip tape) saving water consumption is a proper irrigation method for farms, mainly in corn cultivation. This article has been carried out to consider and fulfill an adequate strip irrigation system so as to decline costs and boost water use and increase crop yield and water consumption efficiency in corn cultivation.

Methodology

This study was performed on a farm in Isfahan province in Iran. The soil texture of the farm was sandy clay loam (Table 1).

The amount of irrigation was assessed based on the water requirement in each stage. Fertilization of the total amount of nitrogen (350 kg/ha), phosphorus (57 kg/ha) and potassium (22 kg/ha 71) was done according to the recommendations of the soil laboratory (Table 1). Approximately half of the phosphorus and potassium amounts were used before planting and the rest during the irrigation period. *N* was used as 33% of the total application at seedling, seven-leaf and flowering stages. In the strip irrigation system with 75% (T3 treatment), 100% (T2) and 125% (T1), complete irrigation is required and in the normal linear drip irrigation system with 75% (T6), 100% (T5) and 125% (T5) (T4) and surface irrigation was investigated as T7 treatment. Agricultural tools were used to conduct tillage, leveling and furrowing for drip and surface irrigation were and the field was accumulated for cultivation. The plot size was 6 m × 3.6 m (Fig. 1). The well supplies the source of water then after filtering and passing through main and secondary pipes, it entered the drip irrigation system. A 16 mm valve was used at the beginning of each tape pipe so as to manage drip systems (Fig. 1). Where, ND is the required water depth in the root zone (mm), yfc and yw are the soil water content at field capacity and measurement time (%), RD is the root depth (mm) and bulk density (g cm 73), IWR is the irrigation water requirement at the time of irrigation (mm), dn is the net water requirement to get the field capacity conditions in the root area (mm), *n* is the number of various days between the last (the day that was decided). for irrigation) and soil water measurement on the day of irrigation, IWV is the volume of irrigation water in liters, late, the net water requirement of corn at the beginning of the irrigation period (mm) or one day after soil water

Table 1 Crop factor (Kc) for various growth stages of sweet corn

Crop stage	Duration (days)	Kc value
Initial	20	0.39
Crop development	30	0.81
Midseason	40	1.15
Late season	10	0.69

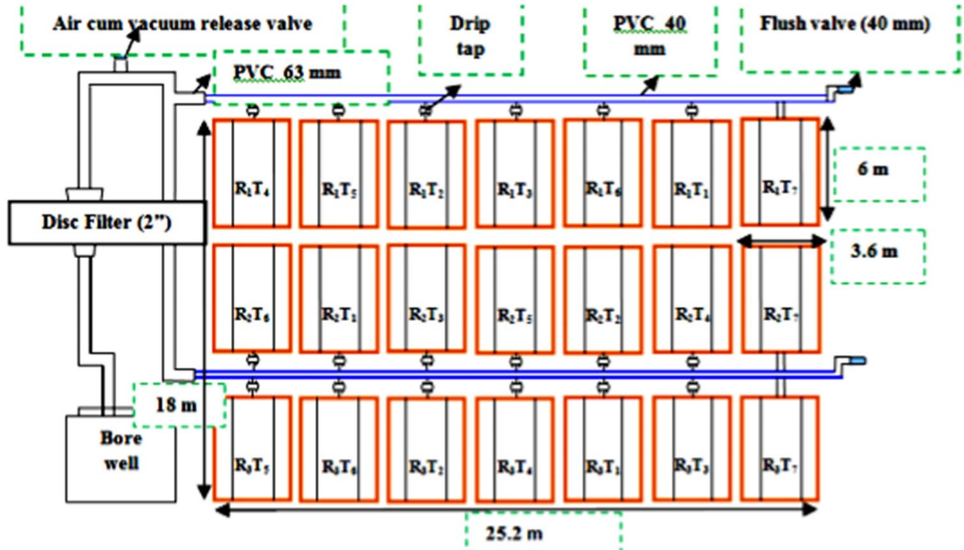

Fig. 1 Farm overview

measurement (mm). Ea is the efficiency of application and A is the area under drip irrigation (m^2). Data were analyzed applying ANOVA followed by Duncan's multiple range tests. Expressions were evaluated important at *p* 5 0.05 and 0.01 using the MSTAT-C.

Results and discussion

The amount of green seeds was considered to be higher than surface irrigation in drip irrigation systems (both conventional and tape). Crop yield was evaluated with Bhatt (2012) indices and stress conditions.

The highest yield of 13.92 tons per hectare was obtained which were related to the plant density of 125% and from 85,000 plants per hectare. On the other hand, with the application of low irrigation treatments, the yield decreased significantly. In a way that 0.435 tons per hectare was the minimum yield belonging to ET 50% and the plant density is 85000 plants per hectare. The results are Similar to those of Musick and Dusek (1980), as well as Howell et al. (1998). From the upper levels of the soil in the absence of water stress, food and water are absorbed for the roots of plants. 40% of the water absorbed to the plant is given in the soil profile which is considered the first 25 cm of the root zone of plants. Thus, in this research, it was considered that with better use of nutrients and water in the soil, the yield in ET treatment will increase by 125%. Also, according to the 125% ET treatment, the highest performance, the maximum yield should be obtained if 100% of the water required by the plant is given. It is possible that this yield difference could be due to the regional climatic conditions that were peculiar to obtain the actual water requirement of the corn used from the drip irrigation system, it cannot be directly calculated from the Penman-Muntit formula and the plant coefficient (Kc) use. Therefore, ET 125% is possibly measured as real requirement of corn in the region. Based on the results, the amount of irrigation less than ET 100% applying the drip irrigation system reduces the yield in subtropical and tropical areas. Therefore, it is not recommended to use drip irrigation for corn in these regions.

According to Table 2, the yield of cob corn in conventional (T4) and tape (T1) drip system with 125% irrigation is the highest value of 19.88 and 19.74 tons per hectare, respectively (Table 2). The yield of corn in the surface irrigation system (T2) is 17.21 tons per hectare, which is significantly the lowest. These results are consistent with the findings of Bozkurt et al. (2011). Karam et al. (2003) observed a decrease in grain yield under water stress conditions too. Also, the highest yield of corn fodder was considered in the regular drip system (22.93 tons per hectare) and strip system (22.58 tons per hectare). Irrigation strategies on yield and energy consumption of drip irrigated maize grown on clay soils was considered in southern Mediterranean climate of Turkey (Javadinejad, et al. 2019a; Razmi et al. 2022; Ostad-Ali-Askari 2022c, d, f). While the lowest with 50% partial root zone drying was 375 mm, the highest water consumption for drip irrigation was 677 mm. It was expressed the highest energy efficiency was 1.77 kg/m73 for drying 100% partial root area, while the lowest was for drip irrigation with 1.54 kg/m73. The obtained results for corn water consumption and WUE differed from those previously reported, possibly due to differences in soil, irrigation management, and weather conditions. Increasing corn yield are compatible in drip irrigation with the findings of Viswanatha et al. (2000), and SharanaBasava et al. (2012). Currently, 30,000 hectares of Isfahan province use a number of different irrigation systems under pressure, which are fed

Table 2 Effect of the type of irrigation systems (conventional drip and tape and surface) on corn yield

Treatments		No. of kernels cob^{-1}	Green cob yield (t.ha^{-1})	Green fodder yield (t.ha^{-1})
T1	DI at 125% PE with drip tape system	670.86	19.54	22.31
T2	DI at 100% PE with drip tape system	586.07	17.43	20.97
T3	DI at 75% PE with drip tape system	527.98	15.97	18.97
T4	DI at 125% PE with conventional inline drip system	681.9	19.97	22.35
T5	DI at 100% PE with conventional inline drip system	600.654	17.09	21.66
T6	DI at 75% PE with conventional inline drip system	542.98	15.09	19.08
T7	Surface irrigation at 0.8 IW/CPE	458.09	13.99	17.5
	SEd	27.76	0.98	0.86
	$CD_{(P=0.05)}$	55.98	1.76	1.93

DI Drip irrigation

by the expansion of water resources. Therefore, research is required in this region where maize is cultivated in areas with low precipitation and restricted water resources during the growing period. In addition, the water requirement of corn for different pressure irrigation systems has not been investigated. The agricultural organizations, local farmers, planning and decision-making of water resource managers are considered to be necessary to anticipate the response of corn to various levels of water consumption under manifold irrigation methods**.**

The weight of 10 cobs was significantly impacted by drought stress (p 5.01). The lowest and highest weight of 10 ears related to T1 and T5 treatments (CFI) were 1067 and 1758 g, respectively, in 2008; and 1029 and 1706 g in 2009, respectively. No remarkable distinctions were observed based on 10-ear weight among T3, T4 and T5 treatments (CFI) in 2008 or 2009. Our results for various corn yield parameters were similarly alike to the results of Karemi and Gomrakchi (2006), Dagdelen et al. (2006) and Oktem (2008). Yield and growth are decreased in water shortage conditions. A significant decrease was investigated in the height of the plant as well as the number of leaves in surface irrigation in comparison with drip irrigation with 100% irrigation requirement. This happens when it comes to adequate water supply in drip irrigation and crop reduction in surface irrigation for water stress (based on Hariguchi 1986). Drip irrigation system saves water consumption owing to addressing the right requires of the plant in comparison with to surface irrigation. Observing in this research, in drip irrigation the soil moisture is constantly near the field's capacity because of the low frequency of irrigation. According to Table 3, the height of the corn plant is the highest in normal drip and strip irrigation systems and the lowest in surface irrigation (Table 3). The reasons why this assessment may be the use of drip irrigation is possibly absorbing more nutrients for growth effectively (Ayotamuno et al. 2007) as well as getting enough soil moisture for growth (Pattanaik et al. 2003). In this irrigation system nutrients are considered to be available to the plant (Anitta Fanish and Muthukrishnan 2011).

An important increase on the yield parameters was observed on drip irrigation treatments (length, girth and

Table 3 Impact of drip tape and traditional inline drip irrigation system on yield parameters of sweet corn

Treatments		Plant height (cm)	Fresh cob length (cm)	Fresh cob girth (cm)	Fresh cob weight (g)
T1	DI at 125% PE with drip tape system	238.86	21.54	18.31	422.45
T2	DI at 100% PE with drip tape system	219.07	19.43	16.97	377.96
T3	DI at 75% PE with drip tape system	192.98	17.97	15.97	365.09
T4	DI at 125% PE with conventional inline drip system	241.9	22.97	18.35	436.98
T5	DI at 100% PE with conventional inline drip system	225.654	20.09	16.66	397.98
T6	DI at 75% PE with conventional inline drip system	198.18	17.09	16.18	350.98
T7	Surface irrigation at 0.8 IW/CPE	184.09	16.99	14.5	306.12
	SEd	8.71	0.80	0.68	15.23
	$CD_{(P=0.05)}$	19.98	1.73	1.49	34.87

DI Drip Irrigation

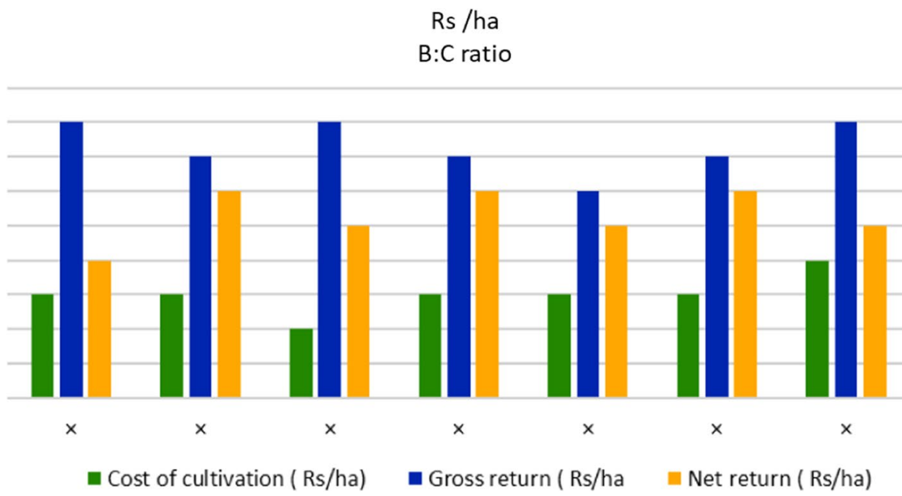

Fig. 2 Economics of drip tape and conventional inline drip irrigation systems in sweet corn cultivation. 1 USD = Rs. 67.00

weight of ears). The surface irrigation treatment observed the lowest values of these parameters. With increasing water deficit the ear weight and length were reduced (e.g., Oktem 2008; Kirtok 1998; Jacobs and Pearson 1991; Eck 1985). Karam et al. (2003) concluded that corn yield is reduced under water deficit. The results of the present study showed (Fig. 2) that drip systems have higher net efficiency than surface irrigation (Fig. 2). Also, the highest net return for the entire variable cost was strip drip irrigation with 125% irrigation (T1) in comparison with other treatments (Similar to the results of Maisiri et al. 2005).

Conclusion

This study in a semi-arid area indicated that maize is suitable for SDT irrigation methods under various irrigation regimes with comparison with CFI methods to save water consumption and also improve grain and cob water consumption. So, instead of using CFI, farmers may use these methods to produce corn to increase their irrigation efficiency and yield. The method of strip drip irrigation with various water supply treatments is considered simple and appropriate for applying in corn production by local farmers in semi-arid areas with restricted water. T3 (80% ETa) SDT treatment showed 61% water saving (599 mm) and higher grain and cob consumption compared to T5 (100% ETa) had unsupervised CFI method (1547 mm). The most optimal method was T3 for using in regions with partially restricted water supplies. This research showed that in regions with relatively harsh water constraints, T2 treatment (60% ETa) with water savings of approximately 70% (449 mm) may be possible, and using the irrigation methods and strategies described, conventional irrigation methods with low water efficiency can be renewed and save more irrigation water. This can also result to an increase in the amount of land under corn cultivation, creating more jobs and increasing the income of local farms. Moreover, the yield response coefficient (Ky) of maize was 0.80. This amount can be utilized for irrigation management in semi-arid areas in low irrigation conditions. In fact, maize with a Ky value 51 shows a high tolerance to water deficit. Seasonal corn yield (Kc) and pan coefficients (Kp) in a semi-arid region were 0.76 and 0.97, respectively. Based on results obtained, pan evaporation of 0.97 classes can be an acceptable and practical value for the actual evapotranspiration of corn in semi-arid climate.

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Author's contributions All authors designed the study, collected data, wrote the manuscript and revised it.

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Data availability All the data, including the experimental measurements, the data used for formulating empirical relations, and the code processing the data that support the findings of this study, are available from the corresponding author upon reasonable request.

Declarations

Conflict of interest There is no conflict of interest.

Consent to publish All authors agree to publish this manuscript. There is no conflict of interest.

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