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EFFECT OF LOW COST DRIP TAPE IRRIGATION SYSTEM ON YIELD AND ECONOMICS OF SWEET CORN

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Abstract

A study was conducted to determine the effect of low cost drip tape irrigation system on yield and economics of sweet corn in comparison to conventional inline drip irrigation and surface irrigation systems during 2013-14 at Coimbatore, India. The treatment comprises of two drip irrigation systems with three irrigation levels *viz.*, 75, 100 and 125% of pan evaporation (PE) from Class A Pan evaporimeter. Plant height, fresh cob length, girth, number of kernels per cob and single fresh cob weight and yield were higher at 125% PE in conventional in line drip irrigation system and it was statistically at par with drip irrigation at 125% PE in low cost drip tape irrigation system. Water saving was 36, 49 and 62% at 125, 100 and 75% PE, respectively under conventional in line drip irrigation system and drip tape irrigation system as against the surface irrigation. The cost of low cost drip tape system was 68% lower than the conventional inline drip system. The results of the research indicated that based on net income, B:C ratio and GM/TMV ratio, adoption of low cost drip tape irrigation system at 125% PE was found to be best for small and marginal farmers with substantial yield and income compared to conventional inline drip system.

Introduction

Sweet corn is cultivated as a popular vegetable and ranks second in farm values and fourth in commercial values among all commercial crops in India. The productivity potential of sweet corn is higher than that of wheat and nutritive value is superior to rice on account of which it will no longer be considered a ‘coarse grain’ but a ‘nutritious grain’ (Batra, 2002). Technological innovations are to be exploited to achieve the objective of higher productivity and better water use efficiency. It is possible to achieve optimum quality and quantity of crop production per unit area if a proper irrigation method is applied along with other agronomic practices.

Adoption of modern irrigation techniques need to be emphasized to increase water use efficiency. Drip irrigation is the most effective way to convey water and nutrients directly to plants and not only save water but also increases yields of vegetable crops (Tiwari *et al.*, 2003). Because drip irrigation is capable of applying small amounts of water where it is needed and to apply it with a high degree of uniformity and frequently, these features make it potentially much more efficient than other irrigation methods (El-Hendawy *et al.*, 2008).

Adoption of drip irrigation might help in raising the irrigated area, productivity of crops and water use efficiency (Sivanappan, 2004). Drip irrigation has the potential for improving two of the most common contributing factors to N leaching (i.e) over fertilization and over irrigation. Irrigation application can be reduced by 50 to 80 % with drip irrigation compared to surface and overhead sprinkler irrigation (Locascio *et al.*, 1989).

The development of low-cost drip tape irrigation system, an irrigation method that is suited for small fields, would help in saving irrigation water over conventional drip systems. Therefore this study was undertaken to find out the efficient drip irrigation system at an affordable cost for higher yield and economics of sweetcorn.

Materials and Methods

This study was conducted during 2013-14 at farmer's field, Pudhupalayam, Tamil Nadu, India. The experimental field is located at Coimbatore (altitude: 426.7 m: 11°83' N and 76°71'E) in the western Zone of Tamil Nadu. The texture of the experimental field was sandy clay loam. Field capacity of the soil was 23.15% (dry basis), permanent wilting point was 11.73% and bulk density of the soil was 1.61 g/cm^3. The air temperatures were all above 19°C while the relative humidity was below 91% during experiment period.

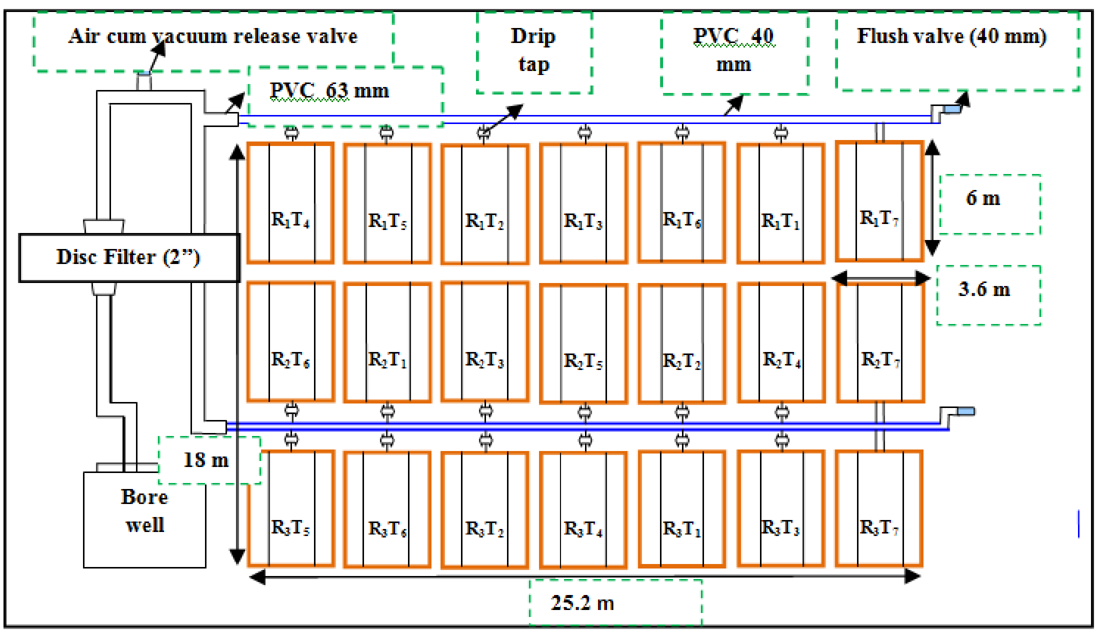

Fig 1. Layout of the experimental field

The quantity of water applied once in two days through drip was calculated by using the following formula;

Volume of irrigation (V) = (2 days CPE Ч Kp Ч Kc Ч Wp Ч A) - ER

Where, V is the Volume of water required in litres, CPE is the Cumulative pan evaporation for two days (mm), Kp is the Pan factor (0.8), Kc is the Crop factors, A is the Area (m^2), Wp is the Wetted percentage (80%), ER is the Effective Rainfall (mm).

Hybrid sweet corn variety (*Zea mays* L. *Saccharata),* Sugar 75, was used as the test crop. The experiment was laid out in a randomized block design with three replications. The treatment comprises of two drip irrigation systems with three irrigation levels *viz.*, 75, 100 and 125% of evaporation from a Class A Pan evaporimeter. The treatments were T_1, T_2 and T_3- Drip irrigation at 125, 100 and 75% PE with drip tape system, respectively and T_4, T_5 and T_6- Drip irrigation at

125,100 and 75% PE with conventional inline drip system, respectively and T_7- Surface irrigation (5 cm depth) at 0.8 IW/CPE ratio. The experimental field was thoroughly ploughed using tractor drawn tiller and then properly leveled. After leveling the field ridges and furrows were formed 75 cm apart to accommodate surface irrigated (furrow) crop. Broad beds were formed in the dimension of 120 cm width, 30 cm furrow and 15 cm height. Buffer channels were formed to control the lateral seepage of water from one plot to another plot. The plot size was 6 m × 3.6 m (Fig. 1.).

The water source from bore well was pumped through 7.5 HP motor and it was conveyed to the main field using 63 mm OD PVC pipes after filtering through disc filter. From the main line, sub mains of 40 mm diameter PVC pipes were connected. Drip tape lateral of 16 mm OD (250 micron wall thickness of seamless tube) was fixed in the sub mains with a lateral spacing of 150 cm. Similar to drip tape, conventional in line drip system was laid at 150 cm spacing. One lateral was placed in every paired row. The conventional in line drip lateral has 40 cm emitter spacing with 4 lph discharge, whereas, drip tape lateral had emitting point spaced 45 cm apart with a discharge rate of 8 litre per hour (lph) at 1 kg cm^{-2}. Flow from sub main to laterals was regulated with a provision of 16 mm tap in order to regulate the irrigation scheduling and the laterals were closed with end cap. After installation trial run was conducted to assess the uniformity coefficient of the system.

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

Crop stage	Duration (days)	K_c value
Initial	20	0.40
Crop development	30	0.80
Mid season	40	1.15
Late season	10	0.70

(FAO, 1991)

The total water use inclusive of effective rainfall in furrow irrigation was 429 mm whereas it was 274 mm at 125% PE, 220 mm at 100% PE and 165 mm at 75% PE under both conventional in line as well as drip tape system. The data obtained from the experiments were analysed with ANOVA and LSD tests using AGRES statistical analysis software package.

Results and discussion

Number of kernels green cob^{-1} (50.00 and 48.84%) was higher in both conventional drip system and drip tape system over surface irrigation. Brahma Bhatt (2012) stated that the marked improvement in yield attributes could be ascribed to overall improvement in vigour and crop growth, as reflected by improved dry matter accumulation, CGR, LAI and stem diameter. Any stress imposed during this period greatly affects kernel set. Andrade *et al.* (1999) demonstrated that a limited partitioning of dry matter to reproductive tissues during the critical period (silking) results in low numbers of kernel set.

Green cob yield of 19.88 t ha^{-1} was observed higher in irrigation at 125% PE with conventional inline drip system (T_4) which was comparable to irrigation at 125% PE with drip tape system (T_1) (19.74 t ha^{-1}) followed by drip irrigation at 100% PE in both conventional inline drip irrigation (T_5) (17.68 t ha^{-1}) and drip tape system (T_2) (17.21 t ha^{-1}). Significantly lower green cob yield was recorded in surface irrigation at 5 cm depth with 0.8 IW/CPE ratio (T_7) (13.56 t ha^{-1}) (Table 1.). This was in concordance with findings of Bozkurt *et al.* (2011) showing that the corn grain yield was significantly increased by the irrigation level. Highest yield, averaging 10.4 t ha^{-1} was registered under drip irrigation at 120 % of evaporation from a Class A Pan. Karam *et al.* (2003) reported that grain yield was reduced by 37 % under water stress conditions. This reduction was due to a decline of 18 % kernel weight and 10 % in kernel number as a response to water deficit. Drip irrigation scheduled at 125 % PE registered significantly higher green fodder yield in both conventional inline drip system (22.93 t ha^{-1}) and drip tape system (22.58 t ha^{-1}), which was 32.54 and 30.52 % more than surface irrigation, respectively.

The increase in green fodder yield was mainly due to significant increase in dry matter accumulation in leaf and stem and total dry matter production of plant. The present findings are in accordance with Viswanatha *et al.* (2000), who reported the maximum stover yield by drip irrigation scheduled at 0.8 E_{pan} over 0.4 and 0.6 E_{pan} on red sandy loam soil of Bangalore. Sharana Basava *et al.* (2012) reported that significant increase in green cob yield at 120 % Epan followed by 100% Epan levels over 80 and 60%.

Table 1. Effect of drip tape and conventional inline drip irrigation system on yield of sweet corn

	Treatments	No. of kernels cob^{-1}	Green cob yield (t ha^{-1})	Green fodder yield (t ha^{-1})
T_1	DI at 125 % PE with drip tape system	680.67	19.74	22.58
T_2	DI at 100 % PE with drip tape system	589.47	17.21	20.97
T_3	DI at 75 % PE with drip tape system	528.67	15.34	18.97
T_4	DI at 125 % PE with conventional inline drip system	686.00	19.88	22.93
T_5	DI at 100 % PE with conventional inline drip system	600.43	17.68	21.52
T_6	DI at 75% PE with conventional inline drip system	543.33	15.59	19.18
T_7	Surface irrigation at 0.8 IW/CPE	457.33	13.56	17.30
	SEd	27.25	0.74	0.87
	CD $_{(P = 0.05)}$	59.37	1.61	1.90

DI - Drip Irrigation

It is a well known fact that under reduced moisture (stress) condition all the growth factors are affected adversely to a great extent. This was evident from the significant reduction in plant height and number of leaves with surface irrigation as compared to drip irrigation scheduled at 100 % PE. This was the consequence of higher relative plant water content in drip irrigation scheduled at 100 % PE over surface irrigation. The reduction in dry matter production was due to relative moisture stress in the surface irrigation (Hariguchi, 1986).

The total water requirement under both conventional inline drip and drip tape system was 274.42, 219.54 and 164.65 mm at 125, 100 and 75 % PE respectively which leads to water saving of 36.02, 48.81 and 61.61 % compared to surface irrigation. The water saving under drip irrigation was due to low application rate at frequent intervals matching the actual crop water needs at various stages. Under drip irrigation, only a portion of the soil surface around the crop was wetted whereas under surface irrigation the entire field was wetted. Under drip irrigation, irrigation was practiced frequently once in two days due to which the soil moisture was always maintained closer to the field capacity.

Higher plant height of 241.40 cm was found in conventional inline drip system at 125 % PE. This was comparable with drip irrigation at 125 % PE with drip tape system with plant height of 238.10 cm. Surface irrigation at 5 cm depth (0.8 IW/CPE ratio) recorded significantly lower plant height of 184.09 cm (Table 2). Higher frequency of irrigation and increased availability of soil moisture under drip irrigation might have led to effective absorption and utilization of available nutrients and better proliferation of roots resulting in quick canopy growth (Ayotamuno, 2007). The highest increase in vegetative growth in this treatment might be due to the availability of soil moisture at optimum level (Pattanaik *et al.*, 2003) and application of sufficient nutrients in a readily available form that would have accelerated the production of growth regulators such as auxins (IAA) and cytokinins which in turn stimulated the action of cell elongation and cell division and resulted in increased plant height (Anitta Fanish and Muthukrishnan, 2011).

Table 2. Effect of drip tape and conventional 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)
T_1	DI at 125% PE with drip tape system	238.10	21.29	18.37	432.17
T_2	DI at 100% PE with drip tape system	219.28	19.59	16.87	387.31
T_3	DI at 75% PE with drip tape system	192.29	17.56	15.41	345.09
T_4	DI at 125% PE with conventional inline drip system	241.40	22.20	18.81	446.63
T_5	DI at 100% PE with conventional inline drip system	225.95	20.16	16.89	397.77
T_6	DI at 75% PE with conventional inline drip system	198.16	17.73	15.50	350.88
T_7	Surface irrigation at 0.8 IW/CPE	184.09	16.13	14.66	305.17
	SEd	8.74	0.80	0.69	15.90
	CD $_{(P = 0.05)}$	19.03	1.74	1.49	34.64

DI - Drip Irrigation

Drip irrigation treatments had significant influence on yield parameters. Drip irrigation at 125% PE with conventional inline drip system has registered significantly higher fresh cob length, girth and fresh single cob weight of 22.20 cm, 18.81cm and 446.63 g, respectively which were comparable with drip irrigation at 125% PE with drip tape system (fresh cob length-21.29 cm, fresh cob girth-18.37 cm and single fresh cob weight-432.17g). Significantly lower fresh cob length, girth and fresh cob weight (16.13, 14.66 and 305.17 g, respectively) were noticed under surface irrigation treatment. Ear length decreased with increasing water deficiency. Single fresh ear weight values decreased under deficit irrigation (Oktem, 2008). Eck (1985) stated that water deficiency at grain filling period reduces kernel weight per ear values. The potential yield of maize is determined by kernel weight, it is a certainty that shortage of water stress reduces grain yield by reducing kernel weight per ear (Kirtok, 1998). Karam *et al.* (2003) reported that grain yield reduced to 37 % under water stress conditions.

Drip irrigation scheduled at 125 % PE recorded higher net returns in both drip tape system and conventional inline drip system over surface irrigation (Fig. 2). This is attributed to higher sweet corn fresh cob yield in this treatment. Highest B:C ratio of 3.74 and 3.35 was registered in drip irrigation at 125 % PE in both drip tape and conventional inline drip system respectively. Surface irrigation recorded lower B: C ratio of 3.27. Drip irrigation at 125 % PE with drip tape system had the highest net returns per total variable cost (2.28) compared to other treatments. This result was similar with findings of Maisiri *et al.* (2005) findings. Low cost drip system with granular fertilizer gave the highest gross margin to total variable cost (GM/TVC) ratio of 2.47. This was followed by low cost drip with fertigation with a GM/TVC ratio of 2.37 and the least ratio was found in low cost drip with no fertilizer treatment.

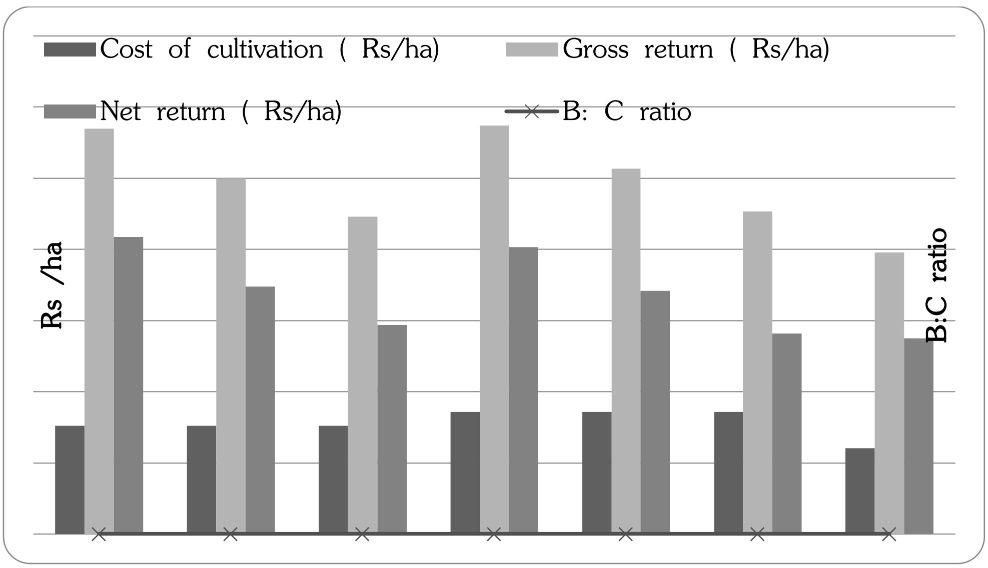

Fig.2. Economics of drip tape and conventional inline drip irrigation systems in sweet corn cultivation. 1 USD = Rs. 67.00

Conclusion

The cost of the drip tape is cheaper when compared to conventional inline drip system. Hence this is highly affordable for small and marginal farmers who cannot make higher investment for conventional inline drip system. Besides cheaper cost & drip tape system has water saving benefits and distribution uniformity equivalent with that of conventional inline drip system. Hence drip tape system is technically feasible and economically viable for substantial yield and income of the small and marginal farmers.

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