Available online at www.ijpab.com

DOI: http://dx.doi.org/10.18782/2320-7051.7128

ISSN: 2320 – 7051

Int. J. Pure App. Biosci. **6 (6):** 1360-1365 (2018)

Research Article

International Journal of Pure & Applied Bioscience

OPEN ACCESS

Water Productivity and Yield of Sugarcane under Drip Fertigation

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Received: 10.11.2018 | Revised: 22.12.2018 | Accepted: 27.12.2018

ABSTRACT

A field experiment was conducted during 2015-16 and 2016-17 at Regional Sugarcane and Rice Research Station, Rudrur to study the effect of drip fertigation on yield and water productivity of sugarcane. The test variety '93 V 297' was planted in wider rows (150 cm). The experiment was designed with four treatments viz., drip fertigation with 75% RDF (F_1), drip fertigation with 100% RDF (F_2), drip fertigation with 125% RDF (F_3) and surface irrigation with soil application of RDF (F_4). The results revealed that, drip fertigation with 125% RDF showed 26 % increase in cane yield of plant crop, 47 % increase in cane yield of ratoon crop over surface irrigation with soil application of fertilizers. The higher net returns of Rs.79,584/- and Rs.78,851/- obtained with plant and ratoon crop, respectively with drip fertigation @125% RDF over surface irrigation with soil application of fertilisers. The drip irrigation used less quantity of water (1236 mm) and saved 20 % water over surface irrigation method. The highest water productivity (13.6 and 7.6 kg m^{-3}) recorded with 125 % RDF which was 40 and 83 % higher over surface irrigation with soil application of fertilizers in plant and ratoon crops, respectively. Hence, Drip fertigation with 125% RDF through water soluble urea and MOP applied at weekly intervals starting from 45 DAP to 180 DAP was found suitable for productive sugarcane cultivation in Northern Telangana Zone.

Key words: *Drip Fertigation, Nitrogen, Potassium, Sugarcane, Water Productivity.*

INTRODUCTION

Sugarcane (*Saccharum officinarum* L.) is an important cash crop in India grown in an area of 49.54 lakh hectares with a production of 22.17 lakh tonnes and productivity of 63.3 tonnes ha^{-1} [1]. In Telangana region, sugarcane grown in an area of 0.35 lakh hectares with a production of 3950 lakh tonnes and productivity of 79.80 tonnes ha^{-1} [4]. Sugarcane being a giant crop producing huge quantity of biomass generally demands higher amounts of water and nutrient elements. A large number of research experiments have clearly demonstrated that for producing higher cane and sugar yields on a sustainable basis, application of adequate amounts of fertilizer nutrients viz. nitrogen, phosphorus and potassium is essential. Sugarcane is a high bio-mass producer in a sense that it is one of the most photo-synthetically efficient C_4 plants.

Cite this article: Prabhakar Reddy T., Kamalakar, J., Reddy, K.P.C., Ramulu, V. and Lakshmi, D.V., Water Productivity and Yield of Sugarcane under Drip Fertigation, *Int. J. Pure App. Biosci.* **6(6):** 1360-1365 (2018). doi: http://dx.doi.org/10.18782/2320-7051.7128

The conventional irrigation and fertilizer application methods in sugarcane lead to considerable loss of water and leaching of nutrients resulting in low productivity. Drip fertigation, one of the potential technologies offers the great scope to increase cane productivity up to 200-220 t ha^{-1} [15], saves 40-50% irrigation water and enhances nutrient efficiency by 40%[16]. Fertigation with conjunctive use of fertilizer nutrients and irrigation water offers the possibility to optimize the water and nutrient distribution over time and space[11]. Sugarcane being a long duration crop requires considerable quantity of water to the extent of 1400 – 1500 mm in the subtropics[16]. Keeping these facts in view, the present study was carried out to study the effect of water and fertilizer management under drip irrigation on water productivity and yield of sugarcane.

MATERIAL AND METHODS

A field experiment was conducted at Regional Sugarcane and Rice Research Station, Rudrur during 2015-16 and 2016-17 seasons comprising of plant and ratoon crops, respectively. Soil of the experimental site is silty clay loam. The experiment was designed with four treatments viz., drip fertigation with 75% RDF (F_1), drip fertigation with 100% RDF (F_2), drip fertigation with 125% RDF (F_3) and surface irrigation with soil application of RDF (F_4) (Soil application of recommended dose of fertilizer 250-100-120 kg N, P_2O_5 and K_2O ha^{-1} with surface irrigation). Under drip fertigation treatments (F_1, F_2 and F_3), nitrogen and potassium applied through fertigation and basal application of entire quantity of phosphorus (SSP) by soil application. Urea and muriate of potash (MOP) are the cheap and easily available sources of nitrogen and potassium respectively and are easily soluble in water and together applied through drip. Fertigation schedule was started at 45 days after planting (DAP) with a weekly interval and continued up to 180 days after planting. Thus, N and K fertilizers in different doses were applied through drip in 17 equal splits.

The land was prepared by ploughing with tractor drawn disc plough followed by disc harrowing and passing cultivator twice to bring the soil to fine tilth. The laterals were placed at 1.50 m apart. Drip was operated daily to replenish 100% evaporation losses taking into account rain fall, pan and crop co-efficients. Early maturing sugarcane variety '93 V 297'was planted in wider rows (150 cm) using three budded setts @ 40,000 ha^{-1} in the month of December during both the years. All other agronomic practices like hand weeding, earthing up, trash twist propping etc, were carried out according to recommendations. Growth and yield attributing parameters viz., plant height, cane girth, inter nodal length, number of millable canes and cane yield were recorded at harvest by following standard procedures[9].

Economic Analysis: The prices of the inputs that were prevailing at the time of their use were taken into account to work out the cost of cultivation. Gross returns were calculated using the cane yield (t ha^{-1}) and the prices of crop commodities at the time of marketing in each year. The net return per hectare was calculated by deducting the cost of cultivation from gross returns per hectare. The benefit to cost ratio was calculated as follows:

$$\text{Benefit to cost ratio} = \frac{\text{Net returns (Rs. ha}^{-1}\text{)}}{\text{Cost of cultivation (Rs. ha}^{-1}\text{)}}$$

RESULTS AND DISCUSSION

Growth and yield parameters: Results revealed that drip fertigation @ 125 % RDF at weekly intervals recorded higher yield parameters of plant and ratoon cane at harvest *viz.*, plant height (3.38 and 2.98 m), cane girth (2.16 and 2.12 cm), intermodal length (14.01 and 13.69 cm), number millable canes (68.84 and 71.20) and cane yield (153.9 and 92.56), respectively (Table 1 & 2). Drip fertigation

with 125% RDF showed 4, 12 and 25% increase in cane yield of plant crop and 4, 13 and 47 % yield increase in cane yield of ratoon crop over 100%, 75% and surface irrigation with soil application of fertilizers, respectively. Due to the improved plant-water-nutrient status under surface drip fertigation system, all the plant growth and yield characters *viz.,* plant height, cane girth, inter nodal length and number of millable canes were increased numerically which ultimately resulted in increased production of cane yield.

The higher cane yield was mainly due to the availability of higher moisture with better aeration coupled with water soluble nutrients in all the stages of cane growth. These favourable environments resulted in better and earlier conversion of tillers to millable cane and the early vigor was maintained during the crop growth period due to continuous availability of nutrients and resulted in increased cane yield[14]. The drip plots differed numerically with surface irrigated plot with yield levels. The results were in accordance with Parikh *et al.*[12], in plant crop and Bangar and Chaudhari[3] in ratoon crop and as the resources applied were efficiently being utilized by the crop under drip than under surface irrigation. Similarly, the significantly higher nutrients uptake by the crop under drip fertigation was recorded than crop under surface irrigation according to Fujiyama and Naga[7].

Urea and muriate of potash (MOP) are the cheap and easily available sources of nitrogen and potassium respectively and are easily soluble in water and together they can be applied through drip. These sources contain higher percentage of nutrients. On the other hand the costly and heavy investment on the use of graded soluble fertilizers can be avoided, which are also known to contain the heavy elements to achieve higher solubility may impare the nutrients uptake and affect the crop growth and yield when used for longer period. These results confirm with findings of Ferguson *et al.*[6], Nadagouda[10] and Patel[13].

Table 1: Effect of Fertigation schedule on cane yield of plant sugarcane (values are pooled data of 2015-16 and 2016-17)

Drip Fertigation Treatments	No. of tillers at 120 DAP (000/ha)	No. of tillers at 210 DAP (000/ha)	Plant height (meters)	Cane girth (cm)	Av.internodal length (cm)	NMC (000/ha)	Cane yield (t/ha)
F1- 75% RDF	1.11	0.63	3.27	2.09	12.97	62.54	137.4 (4)
F2- 100% RDF	1.18	0.69	3.35	2.12	13.56	65.40	147.6 (12)
F3- 125% RDF	1.28	0.72	3.38	2.16	14.01	68.84	153.9
F4- Surface Irrigation	1.01	0.59	3.19	2.04	12.31	56.61	123.5 (25)

Note: Figures in parentheses are the per cent decrease in cane yield over 125 % RDF.

Table 2: Effect of fertigation schedule on cane yield of ratoon sugarcane (values are pooled data of 2015-16 and 2016-17)

Drip Fertigation Treatments	No. of tillers at 120 DAP (Lakh/ha)	No. of tillers at 210 DAP (Lakh/ha)	Plant height (meters)	Cane girth (cm)	Av.internodal length (cm)	NMC (000/ha)	Cane yield (t/ha)
F1- 75% RDF	1.15	0.96	2.82	2.08	12.68	67.65	81.86 (4)
F2- 100% RDF	1.10	0.97	2.95	2.12	13.24	68.60	89.18 (13)
F3- 125% RDF	1.21	0.99	2.98	2.12	13.69	71.20	92.56
F4- Surface Irrigation	1.09	0.90	2.76	2.04	12.24	61.95	63.19 (47)

Note: Figures in parentheses are the per cent decrease in cane yield over 125 % RDF.

Water Productivity: The drip irrigation used less quantity of water (1236 mm) and saved 20 % water over surface irrigation method. The highest water productivity (13.6 and 7.6 kg m^{-3}) recorded with 125 % RDF which was 40 and 83 % higher over conventional surface irrigation with soil application of fertilizers with plant and ratoon crops, respectively (Table 3 & 4). The total water use was higher in plant crop compared to ratoon crop. The drip irrigation adoption in sugarcane increases water use efficiency by 60- 200 per cent by Kaushal *et al.*[8], The increase in productivity recorded under surface drip irrigation system was mainly due to better performance of the crop and increased yield by effective utilization of available water and nutrients that were supplied at regular intervals throughout the crop period to meet the crop demand.

Table 3: Amount of water applied and water productivity of plant sugarcane under drip fertigation (values are pooled data of 2015-16 and 2016-17)

Treatments	Irrigation water applied (mm)	Total water consumed (ER*+ water applied)		Water Productivity (kg/m^3)
		mm	M^3	
F_1-Drip fertigation with 75% RDF	853	1236	12360	12.0 (24)
F_2-Drip fertigation with 100% RDF	853	1236	12360	12.2 (29)
F_3-Drip fertigation with 125% RDF	853	1236	12360	13.6 (40)
F_4- Surface irrigation with soil application of RDF	1020	1403	14030	9.7

Note: Includes an amount of 383 mm of effective rainfall out of total rainfall 454 mm received during the crop period.
Figures in parentheses are the per cent increase in water productivity over surface irrigation (F_4).

Table 4: Amount of water applied and water productivity of ratoon sugarcane under drip fertigation (Values are pooled data of 2015-16 and 2016-17).

Treatments	Irrigation water applied (mm)	Total water consumed (ER*+ water applied)		Water Productivity (kg/ m^3)
		mm	m^3	
F_1-Drip fertigation with 75% RDF	692	1218	12180	6.72 (62)
F_2-Drip fertigation with 100% RDF	692	1218	12180	7.32 (76)
F_3-Drip fertigation with 125% RDF	692	1218	12180	7.60 (83)
F_4- Surface irrigation with soil application of RDF	997	1523	15230	4.15

Note: Includes an amount of 526 mm of effective rainfall out of total rainfall 836 mm received during the crop period.
Figures in parentheses are the per cent increase in water productivity over surface irrigation (F_4).

Economic Analysis: Sugarcane crop under surface irrigation recorded lower gross returns due to the lower yield compared to the drip fertigation plots. Among the drip fertigation treatments the results revealed that application of 125 % RDF (N & K) fertigated at weekly intervals from 45 to 180 days (17 equal splits) recorded higher net returns (Rs. 2,42,184 ha^{-1}) followed by 100 % RDF (Rs. 2,29,780 ha^{-1}), 75 % RDF (Rs. 2,29,780 ha^{-1}), and surface irrigation with soil application of fertilizers (Rs. 1,62,600 ha^{-1}). The higher net returns of Rs.79,584/- and Rs.78,851/- obtained with plant and ratoon crop, respectively with drip fertigation @125% RDF over surface irrigation with soil application of fertilisers. Drip fertigation @ 125% RDF at weekly intervals recorded higher benefit cost ratio (2.43 and 1.75) while the lowest (1.99 and 1.24) was recorded under surface irrigation with soil application of fertilisers in plant and ratoon crop, respectively (Table 5 & 6).

The economic evaluation of the drip fertigation system in comparison with the present surface irrigation and soil application of fertilisers indicated that drip irrigation with fertigation at weekly intervals of nitrogen (urea) and potassium (MOP) from 45 days after planting/ratooning to 180 days in 17 equal splits and basal application of entire

quantity of phosphorus (SSP) could gain higher net returns and BC ratio. The economic returns are much higher in drip fertigation plots compared to the general practices followed by most of the farmers particularly in ratoon crop. Therefore, the present research can intervene in modification to the package presently followed by the farmers through possibility of introducing the drip component and fertigation at weekly interval only nitrogen and potassium upto six months crop instead of stopping the top dressing at 4 months which helps to keep the green cane in the fields for long time and helps to get higher yields even under late harvesting. These results also confirms with Dobermann *et al.*[5], Bachchhav[2] and Nadagouda[10].

Table 5: Economics of sugarcane plant crop under different treatments (Values are pooled data of 2015-16 and 2016-17)

Treatments	Cost of Cultivation (Rs/-)	Gross Returns (Rs/-)	Net Returns (Rs/-)	BC Ratio
F1- 75% RDF	1,63,980	3,72,650	2,08,670	2.27
F2- 100% RDF	1,66,940	3,96,720	2,29,780	2.38
F3- 125% RDF	1,69,906	4,12,090	2,42,184	2.43
F4- Surface Irrigation	1,63,940	3,26,540	1,62,600	1.99

Table 6: Economics of sugarcane ratoon crop under different treatments (Values are pooled data of 2015-16 and 2016-17)

Treatments	Cost of Cultivation (Rs/-)	Gross Returns (Rs/-)	Net Returns (Rs/-)	BC Ratio
F1- 75% RDF	1,47,069	2,37,394	90,325	1.61
F2- 100% RDF	1,50,392	2,58,622	1,08,230	1.72
F3- 125% RDF	1,53,714	2,68,424	1,14,710	1.75
F4- Surface Irrigation	1,47,392	1,83,251	35,859	1.24

CONCLUSION

Drip fertigation with 125% RDF through water soluble fertilizers applied at weekly intervals starting from 45 DAP to 180 DAP was found suitable for productive sugarcane cultivation in Northern Telangana Zone. The higher net returns of Rs.79,584/- and Rs.78,851/- obtained with plant and ratoon crop, respectively with Drip fertigation @125% RDF over surface irrigation with soil application of fertilisers.

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