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Performance evaluation of drip fertigation in Sugarcane and Banana

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Abstract
In sugarcane the experiment consisted of improved water management technology (drip irrigation once in 3 days at 80 per cent PE, fertigation of N and K (275 kg ha^{-1} and 112.5 kg ha^{-1}) in 14 equal splits, with 15 days interval from 15 DAP) and conventional method (0.75 IW/CPE ratio). In banana, consisted of improved water management technology (drip irrigation once in 3 days, application of entire P (35 g plant^{-1}) at 3rd month through band placement, fertigation of N (110 g plant^{-1}) and K (330 g plant^{-1}) in 30 equal splits from 6th week to 35th week after planting and conventional method (1.0 IW/CPE ratio). The results of this study revealed that drip fertigation recorded lower water use of 1601 mm and higher WUE of 78.1 kg hamm^{-1} and 26.3 per cent water saving. The higher yield of sugarcane 125.4 tonnes ha^{-1} was recorded in drip fertigation technology which was 35.8 per cent higher than conventional method. The B:C ratio (2.35) was higher in drip fertigation treatment compared to conventional method. In banana, drip fertigation recorded lower water use of 1650 mm and higher WUE of 12.1 kg hamm^{-1} and 26.3 per cent water saving. The higher yield of banana 20.0 tonnes ha^{-1} was recorded in drip fertigation technology which was 26.4 per cent higher than conventional method. The B:C ratio (4.97) was higher in drip fertigation treatment compared to conventional method.

Keywords: Sugarcane, banana, drip fertigation, yield, water use efficiency, economics

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} reported in Annual report, 2018 [1]. Sugarcane being a giant crop producing huge quantity of biomass generally demands higher amounts of water and nutrient elements. Anonymous (2009) reported that the area under banana was 7.09 lakh hectares in 2008-09 and the production was 26.22 million tonnes in 2008-09 [2]. It contributes more than 2.8% to GDP of agriculture in India. Banana requires large quantity of water during its life cycle. In winter, Sharma and Kispotta, 2016, irrigation is provided at an interval of 7-8 days while in summer it should be given at an interval of 4-5 days [3].

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} reported by Senthilkumar, 2009 [4]. Solomon (2012) told that saves 40-50% irrigation water and enhances nutrient efficiency by 40% [5]. Nanda (2010) reported that the fertigation with conjunctive use of fertilizer nutrients and irrigation water offers the possibility to optimize the water and nutrient distribution over time and space [6]. Sugarcane being a long duration crop requires considerable quantity of water to the extent of 1400 – 1500 mm in the subtropics. The field experiments were conducted at Agricultural Research Station, Bhavanisagar under AICRP- Irrigation Water Management project resulted better performance of drip fertigation compared to conventional method of irrigation in sugarcane.

Materials and Methods

The improved water management technologies in sugarcane and banana were conducted in farmers fields one each at head, middle and tail reaches of kugalur distributory of Lower Bhavani Project canal command areas during 2016 and 2017 under All India Co-ordinated Project on Irrigation Water Management. In sugarcane, the experiment consisted of improved water management technology (drip irrigation once in 3 days at 80 per cent PE, fertigation of N and K (275 kg ha^{-1} and 112.5 kg ha^{-1}) in 14 equal splits, with 15 days interval from 15 DAP) and conventional method (0.75 IW/CPE ratio). The entire quantity of phosphorus (62.5 kg ha^{-1}) applied basally in drip fertigation study.

The experiment consisted of improved water management technology (drip irrigation 48 litres per plant once in 3 days, application of entire P (35 g $plant^{-1}$) at 3rd month through band placement, fertigation of N (110 g $plant^{-1}$) and K (330 g $plant^{-1}$) in 30 equal splits from 6th week to 35th week after planting) and conventional method (1.0 IW/CPE ratio). The major soil type of the study area was sandy loam in nature and the soil fertility status was low in available nitrogen (235 kg ha^{-1}), medium in available phosphorus (16 kg ha^{-1}), and high in potash (309 kg ha^{-1}). The major soil type of the study area was sandy loam in nature and the soil fertility status was medium in available nitrogen, high in available phosphorus and potash. Two methods of cultivation viz., drip fertigation and conventional method were compared by using the variety CO 86032 (sugarcane) & Kathali (banana).

For sugarcane, drip irrigation laterals were laid with 150 cm lateral spacing and sugarcane sets were planted in paired row planting, 60 cm between rows and 90 cm between 2 pairs of rows. The discharge rate of the dripper was 4 lph and the irrigation was given once in three days and fertigation was given once in 15 days from 15 DAP. For conventional method of cultivation, planting was carried out in ridges and furrows with a spacing of 80 cm solid rows and apply 275 kg of N and 112.5 kg of K in three equal splits at 30, 60 and 90 days. Apply super phosphate (62.5 kg ha^{-1}) along the furrows and incorporate with hand hoe.

For banana, Drip irrigation laterals were laid with 180 cm lateral spacing and 0.6 m lateral spacing and banana were planted with spacing of 1.8 x 1.8 m (triangular geometry planting). The discharge rate of the dripper was 4 lph and the irrigation was given once in three days and fertigation of N (110 g $plant^{-1}$) and K (330 g $plant^{-1}$) in 30 equal splits from 6th week to 35th week after planting. For conventional method of cultivation, planting was carried out in ridges and furrows with a spacing of 1.5 m x 1.5 m and apply 110 g of N and 330 g $plant^{-1}$ of K in three equal splits at 3, 5 and 7th month. The total water use was calculated by adding irrigation water applied and effective rainfall. Yield was recorded and total water used, water use efficiency (WUE) and economics were worked out and presented.

Results and Discussion

Total water used and WUE

The water use studies of both the cultivation methods clearly indicated the beneficial effect of drip fertigation in terms of water saving and higher Water Use Efficiency (WUE) (Table 1). In sugarcane, the mean total water use under drip fertigation was 1601 mm which was considerably lesser than conventional method which utilized 2175 mm water. Thus a substantial quantity of water saving by 26.3 per cent was noticed due to the adoption of drip fertigation. The higher cane yield coupled with enormous quantity of water saving under drip fertigation resulted in higher water use efficiency in both the years of experimentation. The mean WUE of drip fertigation was 78.1 kg $hamm^{-1}$ while it was only 42.5 kg $hamm^{-1}$ in conventional method of sugarcane. The drip irrigation adoption in sugarcane increases water use efficiency by 60-200 per cent by Kaushal *et al.*, 2012 [7]. 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.

In banana, the mean total water use under drip fertigation was 1650 mm which was considerably lesser than conventional method which utilized 2084 mm water. Thus a substantial quantity of water saving by 26.3 per cent was noticed due to the adoption of drip fertigation. The higher cane yield coupled with enormous quantity of water saving under drip fertigation resulted in higher water use efficiency in both the years of experimentation. The results were in accordance with the results of the similar experiment conducted at Agricultural Research Station, Bhavanisagar. The mean WUE of drip fertigation was 12.1 kg $hamm^{-1}$ while it was only 7.1 kg $hamm^{-1}$ in conventional method of banana cultivation. Pramanik and Patra (2016) reported that higher water use and lower irrigation water use efficiency were observed under the conventional surface irrigation [8]. Pramanik *et al*. (2014) observed that the irrigation water-use was found to be highest under the conventional method of irrigation (57.0 cm for plant crop and 33.0 cm for ratoon crop for the lifecycle of the crop [9]. The irrigation requirement of the crop was found to be lower in plants under drip fertigation.

Table 1: Cane yield, water use and economics of sugarcane under drip fertigation (DF) and conventional method (Conv.)

Particular	2016		2017		Mean	
	DF	Conv.	DF	Conv.	DF	Conv.
Cane yield (kg ha^{-1})	120.0	90.0	130.8	94.8	125.4	92.4
Percent yield increase	25.0	-	27.5	-	26.3	-
Total water use (mm)	1609	2200	1593	2150	1601	2175
Percent water saving by drip fertigation	36.7	-	35.0		35.8	-
Water Use Efficiency (kg $hamm^{-1}$)	74.1	40.9	82.1	44.1	78.1	42.5
Gross income (Rs ha^{-1})	276000	207000	333625	241825	304813	224413
Net income (Rs ha^{-1})	144667	90167	205125	126792	174896	108479
Additional net income in DF (Rs ha^{-1})	54500	-	78333	-	66417	-
B:C ratio	2.1	1.77	2.6	2.10	2.35	1.94

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 [10] due to continuous availability of nutrients and resulted in increased cane yield (Sathiyaraj and Sathyapriya, 2017). The drip plots differed numerically with surface irrigated plot with yield levels. The results were in accordance with Parikh *et.al.*, 1996, in plant crop as the resources applied were efficiently being utilized by the crop under drip than under surface irrigation [11].

In table 2, drip fertigation registered a mean cane yield of 125.4 t ha^{-1} which was significantly higher than surface irrigation and normal fertilizer application (92.4 t ha^{-1}). Similar significant yield increase for drip fertigation was obtained in the experiment conducted at Agricultural Research Station, Bhavanisagar. Veeraputhiran *et al*. (2012) reported that subsurface drip fertigation registered a cane yield of 113.9 t/ha which was significantly higher (30.8 per cent) than conventional method. The average yield increment by drip fertigation was 58.9 per cent over conventional method of cultivation [12].

In the present study, yield of banana was substantially increased due to the adoption of drip fertigation (Table 2). Averaging over locations, drip fertigation registered a mean yield of 20.0 t ha^{-1} which was significantly higher than surface irrigation and normal fertilizer application (14.7 t ha^{-1}). The average yield increment by drip fertigation was 26.4 per cent over conventional method of cultivation. Higher yield under drip fertigation was mainly due to the availability of sufficient sunlight with better aeration coupled with adequate availability of soil moisture and nutrients throughout the crop growth period.

Thadchayini and Thiruchelvam (2005) reported 31% higher banana yield in drip irrigation compared to surface irrigation [13]. The yield improvement under drip irrigation was mainly due to the maintenance of soil near field capacity throughout the growth period [14] in the active root zone, leading to low soil suction, which thereby facilitated better water utilization, higher nutrients uptake and excellent maintenance of soil-water-air relationship with a higher oxygen concentration in the root zone (Raina *et al*., 2011).

Table 2: Comparison of yield, water use and economics of Banana under drip fertigation (DF) and conventional method (Conv.)

Particular	2016		2017		Mean	
	DF	Conv.	DF	Conv.	DF	Conv.
Yield (t ha^{-1})	21.2	15.2	18.8	14.2	20.0	14.7
Percent yield increase	28.3	-	24.5	-	26.4	-
Total water use (mm)	1640	2100	1660	2067	1650	2084
Percent water saving by drip fertigation	28.0	-	24.5		26.3	-
Water Use Efficiency (kg $hamm^{-1}$)	12.9	7.2	11.3	6.9	12.1	7.1
Gross income (Rs ha^{-1})	846667	606667	659167	495833	752917	551250
Net income (Rs ha^{-1})	694567	469750	508333	357917	601450	413833
Additional net income in DF (Rs ha^{-1})	224817	-	150417	-	187617	-
B:C ratio	5.57	4.44	4.37	3.60	4.97	4.02

Economics

In sugarcane, drip fertigation fetched a mean gross income of Rs. 3,04,813 ha^{-1} as against Rs 2,24,413 ha^{-1} under conventional method. In addition, higher net income and benefit cost ratio were also associated with drip fertigation. Higher net income and Benefit Cost ratio of Rs 1,74,896 ha^{-1} and 2.35 were registered by drip fertigation as compared to Rs 1,08,479 ha^{-1} and 1.94 respectively under conventionally irrigated and fertilized sugarcane. Thus it is evident that adoption of drip fertigation gained an additional mean net income of Rs 66,417 ha^{-1} than conventional method. The extra expenditure needed to meet the cost of drip fertigation over conventional method of sugarcane cultivation was very well compensated by the enhanced cane yield.

In banana, drip fertigation fetched a mean gross income of Rs.7,52,917 ha^{-1} as against Rs 5,51,250 ha^{-1} under conventional method. In addition, higher net income and benefit cost ratio were also associated with drip fertigation. Higher net income and Benefit Cost ratio of Rs 6,01,450 ha^{-1} and 4.97 were registered by drip fertigation as compared to Rs 4,13,833 ha^{-1} and 4.02 respectively under conventionally irrigated and fertilized banana. Thus it is evident that adoption of drip fertigation gained an additional mean net income of Rs 1,87,617 ha^{-1} than conventional method. The extra expenditure needed to meet the cost of drip fertigation over conventional method of banana cultivation was very well compensated by the enhanced yield. Basavarajappa *et al*. (2010) who found that the highest net returns and the benefit cost ratio were obtained in the drip irrigation treatment which received irrigation at 100% of crop ET and the lowest were obtained in the furrow irrigation treatment [15]. Shashidhara *et al*. (2007) found that drip irrigation had higher benefit cost ratio as compared to surface irrigation [16].

Conclusion

Drip fertigation with applying precise amounts of water and fertilizer nutrients over surface irrigation and conventional soil fertilization for sugarcane and banana production. It is concluded from the study that drip irrigation favourably influenced the yield which resulted in higher irrigation WUE against lower amounts of water applied. Moreover, benefit-cost ratios with different discount rates indicated that drip investment in sugarcane is economically significant.

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