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Effect of Subsurface Drip Fertigation on Cane Yield, Water Use Efficiency and Economics of Sugarcane

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Fifty one On-farm demonstrations on subsurface drip fertigation (SSDF) were carried out in 51.62 hectares of farmers' fields in fifteen villages of Sivagangai district, Tamil Nadu from 2009- 10 to 2010-11 under Tamil Nadu-Irrigated Agriculture Modernization and Water Bodies Restoration and Management (TN – IAMWARM) Project. Two methods of sugarcane cultivation viz., SSDF and conventional method were compared by using the varieties Co 86032, Co91017. Co 96125, Co 99012 and Co 92102. The results revealed that adoption of SSDF recorded significantly higher number of internodes per cane and individual cane weight than that of conventional method. Subsurface drip fertigation registered a mean cane yield of 113.9 t ha^{-1} which was significantly higher than surface irrigation with conventional fertilizer application (86.8 t ha^{-1}) . The average yield increment under SSDF was 30.8 per cent compared to conventional method of cultivation during the period of study. The total water requirement under SSDF was lesser (1730 mm) than conventional method (2499 mm) and thus a substantial quantity of water saving by 30.7 percent due to SSDF was observed. The higher cane yield coupled with enormous quantity of water saving under SSDF resulted in higher water use efficiency of 65.8 kg $ha^{-1}mm^{-1}$ but it was only 34.8 kg ha^{-1} mm^{-1} in conventional method of sugarcane cultivation. In addition, higher economic benefits like total income, net income and benefit cost ratio were also associated with SSDF during study than surface irrigation with band application of fertilizers. Adoption of SSDF also gained an additional mean net income of Rs 51,036 ha^{-1} than normal method of cultivation.

Key words: Sugarcane, SSDF, cane yield, water use efficiency, economics

Sugarcane is one of the most important sugar crops of India which plays a vital role in both agricultural and industrial economy of our country. The conventional irrigation and fertilizer application methods in sugarcane lead to considerable loss of water and leaching of nutrients resulting in low productivity. Fertigation, a modern technique of application of both water and fertilizers through irrigation is proved to be very effective in achieving higher yield and water use efficiency as these crucial inputs are delivered precisely in the effective crop root zone as per the crop needs and crop developmental phases. Subsurface drip fertigation (SSDF) is an efficient means for applying water and nutrients below the surface soil through drip irrigation and fertigation system which has enormous potential to increase cane yields besides saving water and fertilizer.

Manimuthar sub basin is one of the sub basins in Tamil Nadu with a drainage area of 16751 ha. This basin comprises of four minor-basins viz. Manimuthar, Virisuliyar, Thirumanimuthar and Palar and spreads over in six taluks in three districts of Tamil Nadu namely Madurai, Sivagangai and Ramanathapuram. A World Bank aided Tamil Nadu-Irrigated Agriculture Modernization and Water Bodies Restoration and Management (TN – IAMWARM) Project is being implemented with the major objectives to promote water saving technologies, to enhance crop and water productivity and to increase the cropped area by diversification in this sub basin area. Therefore an attempt was made to study the performance of SSDF in comparison with the conventional method of sugarcane cultivation in the Manimuthar sub basin area.

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Materials and Methods

Fifty one On-farm demonstrations on subsurface drip fertigation (SSDF) were carried out in 51.62 hectares of farmers' fields in fifteen villages of Sivagangai district, Tamil Nadu from February 2009 to June 2011 under Tamil Nadu-Irrigated Agriculture Modernization and Water Bodies Restoration and Management (TN – IAMWARM) Project. Two methods of sugarcane cultivation viz., SSDF and conventional method were compared by using the varieties Co 86032, Co 91017. Co 96125, Co 99012

and Co 92102 and the locations were taken as replications for statistical analysis. The major soil type of the study area was sandy clay loam in nature and the soil fertility status were low in nitrogen, high in phosphorus and potash. The season of planting of cane in the study area was mainly late season (April, May) In SSDF, drip irrigation was laid out at 25 cm depth below the soil surface with a spacing of 150 cm and planting was taken up on double sides of trenches under paired row method. Drip irrigation was scheduled once in two days based on the crop requirement. The blanket recommended dose of fertilizer at 275: 62.5: 112.5 NPK kg ha^{-1} was applied as fertigation which was carried out through ventury assembly once in 8 days starting from 16 DAP to 210 DAP (25 times). For fertigation, water soluble fertilizers like ammonium phosphate (12:61:0), sulphate of potash (0:0:50) besides commercial fertilizers namely urea and Muiate of potash were used. For conventional method of cultivation, planting was carried out in ridges and furrows with a spacing of 80 cm solid rows. The same quantity of fertilizer was applied as band application and irrigation was given as per farmer's practice as and when needed by the crop. The total water use was calculated by adding irrigation water applied and effective rainfall. The details of field demonstrations in the study area are furnished in Table 1. Biometric observation on yield attributes and cane yield were recorded and economics worked out.

Results and Discussion

Yield attributes

The results of the study clearly indicated the superiority of SSDF over conventional method of sugarcane cultivation in both the years of study (Table.2). Adoption of SSDF recorded significantly higher number of internodes per cane (27.2) and individual cane weight (1.50 kg) than conventional method (20.8 and 1.24 kg, respectively). The higher yield attributes under SSDF might be due to the continuous supply of required quantity of water and nutrients below the root zone of the crop which reflected on the better and early conversion of tillers to millable canes. On an average, SSDF recorded an increase of 25.8 and 23.6 per cent number of internodes $cane^{-1}$ and individual cane weight, respectively than conventional irrigation and band application of fertilizers. Similar results of higher yield attributes of sugarcane under SSDF than conventional method was documented by Mahesh (2009). Significant improvement in yield attributes of sugarcane by SSDF over conventional method as reported by Sathyaraj (2010) was also in conformity with the present investigation.

Table 1. Details of field demonstrations on SSDF in the study area

Particulars	2009-10	2010-11	Total
Area of demonstrations (ha)	21.02	30.60	51.62
Number of farmers	23	28	51
Number of villages	6	15	21
Name of the villages	Namanur Karuthampati Perunkudi Kadamuthanpatti Alavakotti Lakshimapuram	Theralur Pulikulam Perambuvayal Poosalkudui Vasanthani Sevalpatti Meiyapattti Chandrampatti M. Kovilpatti Namanur Vaiyapuripatti Mettupatti Sirumaruthur Kirungakottai Ulagampatti	-
Total rainfall during the cropping period (mm)	846.9	1321.2	
Sugarcane varieties used	Co 86032, Co91017.	Co 86032, Co99012 Co 96125 and Co 92102	-

Cane yield

In the present study, cane yield of sugarcane was substantially increased due to the adoption of SSDF (Table 2). Averaging over locations, SSDF registered a mean cane yield of 113.9 t ha^{-1} which was significantly higher than surface irrigation and normal fertilizer application (86.8 t ha^{-1}). The average yield increment by SSDF was 30.8 per cent than

Table 2. Comparison of cane yield, water use and economics of sugarcane under SSDF and conventional method

Particulars	2009-10		2010-11		Pooled Mean	
	SSDF	Conventional method	SSDF	Conventional method	SSDF	Conventional method
No. of internodes cane^{-1}	26.8	21.3	27.6	20.4	27.2	20.8
SEd	1.73		1.61		-	-
CD (P= 0.05)	3.60		3.30			
Individual cane weight (kg)	1.52	1.27	1.48	1.21	1.50	1.24
SEd	0.112		0.108	-	-	
CD (P= 0.05)	0.230		0.222			
Cane yield (kg ha^{-1})	112.7	87.5	115.1	86.18	113.9	86.8
SEd	5.41		6.23	-	-	
CD (P= 0.05)	11.07		12.84			
Percent yield increase	29.0	-	32.6	-	30.8	-
Total water use (mm)	1714	2456	1746	2542	1730	2499
Percent water saving by SSDF	30.2	-	31.3	-	30.7	-
Water use efficiency (kg ha^{-1}mm^{-1})	65.8	35.6	65.9	34.1	65.8	34.8
Cost of cultivation(Rs ha^{-1})	83,562	81,438	92,594	89,852	88,058	85,645
Gross income (Rs ha^{-1})	2,25,353	1,75,000	2,30,153	1,73,600	2,27,753	1,74,300
Net income (Rs ha^{-1})	1,41,790	93,562	1,37,592,	83,748	1,39,691	88,655
Additional net income by SSDF (Rs ha^{-1})	48,228	-	53,844	-	51,036	-
Benefit - Cost ratio	2.69	2.15	2.48	1.93	2.58	2.04

conventional method of cultivation during the period of study. Higher cane yield under SSDF was mainly due to the availability of sufficient sunlight with better aeration coupled with continuous and favourable availability of soil moisture and nutrients throughout the crop growth period. Similar results of 46.6 and 44.0 percent higher cane yield under SSDF with 120 cm and 180 cm lateral spacing respectively than surface irrigation was reported by Mahesh (2009). Khadagave (2005), Kumari *et al.* (2008) and Sharala *et al.* (2010) also observed higher cane yield with drip fertigation. Sathyaraj (2010) also found that SSDF with 100 per cent water soluble fertilizers registered significantly higher cane yield than surface irrigated sugarcane variety CO 86032.

Water use studies

The water use studies of both the cultivation methods clearly indicated the beneficial effect of SSDF in terms of water saving and higher Water Use Efficiency (WUE) (Table 2). The mean total water use under SSDF was 1730 mm which was considerably lesser than conventional method which utilized 2499 mm water. Thus a substantial quantity of water saving by 30.7 per cent was noticed due to the adoption of SSDF. The higher cane yield coupled with enormous quantity of water saving under SSDF resulted in higher water use efficiency in both the years of experimentation. The mean WUE of SSDF was 65.8 kg ha^{-1}mm^{-1} while it was only 34.8 kg ha^{-1} mm^{-1} in conventional method of sugarcane cultivation. The increase in WUE under SSDF was mainly due to the excellent performance of the crop and improvement in yield by effective utilization of available water and nutrients supplied at regular intervals throughout the crop period to meet the crop demand. Similar increase in WUE by 65 per cent under 120 cm lateral spaced sub surface drip fertigated sugarcane was also reported by Mahesh (2009).

Economic analysis

The economic analysis of both the methods of cultivation (Table.1) revealed that though the cost of cultivation was comparatively higher under SSDF it was found to be economically better than normal method of cultivation. Subsurface drip fertigation fetched a mean gross income of Rs. 2,27,753 ha^{-1} as against only Rs 1,74,300 ha^{-1} under furrow irrigated cane. In addition, higher net income and benefit cost ratio were also associated with SSDF during the study. Higher net income and Benefit Cost ratio of Rs 139,691 ha^{-1} and 2.58 were registered by SSDF as compared to Rs 88,655 ha^{-1} and 2.04 respectively under conventionally irrigated and fertilized sugarcane. Thus it is evident that adoption of SSDF gained an additional mean net income of Rs 51,036 ha^{-1} than normal 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. The economic superiority of drip fertigation over conventionally cultivated sugarcane was also documented by Dhanalakshmi (1999), Shinde *et al.* (2001) and Sathyaraj (2010). Economic feasibility of adoption of drip fertigation on other wide spaced crops like hybrid cotton (Veeraputhiran and Chinnusamy, 2005), chilli (Selvakumar, 2006) and tomato Kavitha *et al.* (2007) are also in line with the findings of this investigation.

Thus it can be concluded that SSDF is more

productive and economically feasible as it improves the yield by 30.8 per cent, fetches higher monetary benefits besides saving substantial quantity in irrigation water (30.7 per cent) and enhanced WUE.

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