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Studies on sustainable sugarcane initiative (SSI) technology in north eastern agro climate zone of Tamil Nadu

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Abstract
Field experiments were conducted at North-eastern Agro Climatic Zone of Tamil Nadu to find out the influence two methods of sugarcane cultivation on cane productivity. The experiments were conducted in farmer's holdings in hands with sugar factory during 2012 to 2014. Each experimental plot is large sized with more than 0.40 ha non- replicated with sub surface drip irrigation system. The results indicated higher plant height at harvest stage under SSI method (276cm) than conventional system (Sett) of sett planting (247cm).Study found that sugarcane yield was higher under SSI method (143 t ha^{-1}) as compared to conventional method (126 t ha^{-1}) in main crop. Likewise, SSI registered higher sugar yield (15.30 t ha^{-1}) than conventional system (11.48 t ha^{-1}). Total water consumption and water productivity of SSI method showed less water consumption of 1669 mm and more water productivity of 8.57 kg/m^3 as compared to conventional system of planting (1787 mm and 7.04 kg/m^3 respectively).SSI method of crop establishment also recorded Rs.33,100 as additional income than conventional method with a B: C ratio of in the main crop of 1.97 and 1.80 respectively. Similar trend was also noticed in sugarcane ratoon crop yield, water productivity and net profit.

Keywords: Sugarcane, bud chip seedlings, setts planting, drip irrigation and productivity

1. Introduction
Sugarcane is cultivated as an industrial crop and nearly engaged 50 million farmers across India and classified as important commercial crop. On dependency of the sugar industry, nearly 5 million people for employment as generated by 529 sugar factories and allied industries (Anonymous, 2015) [2]. Sugarcane crop owes greater role in the states like Uttar Pradesh, Maharashtra and Tamil Nadu in India in terms of area under cultivation and contribution to their economy. (Chandal *et al*., 2017) [5]. Sugarcane production in India was fluctuating from 306 to 362 million tones in the past five years. Likewise, productivity at the farm level was also very low and its is declining with average cane productivity of 69 t ha^{-1} (Anonymous, 2018) [3]. Besides, sugarcane cultivation in India is facing variety of challenges that includes escalated cost of production due to raise in input costs and soil health deterioration which leads to less profitability in cane farming.In semi-arid regions of countries like India, over exploitation ground water leads to serious threat to environment and sustainability. In addition, water is increasingly becoming a major limiting factor for sugarcane farming, since it is water guzzling crop and going to be crisis in future, which lead to shrinkage of area under cultivation (Narayanamoorthy, 2004) [8].
The sugarcane production will be expected to decrease to 30 per cent in future as a result of climatic change (Zhao and Yang-Rui, 2015) [17]. At this juncture, a best management practices to use resources as need based and to conserve the water, inputs, labour, energy and nutrient mining is essential to step up sugarcane farming in India. SSI is composite of well proven practices to address the above issues. Hence, the present study was undertaken at farmers holding to find out the effect of establishment methods under drip irrigation on cane productivity with scientific validation for further adoption at farmers end.

2. Materials and Methods
Field experiments were conducted at Villupuram district of Tamil Nadu during the year 2012 to 2014, (main and ratoon crops) under two method of sugarcane cultivation *viz.*, Sustainable

Sugarcane Initiative (SSI) and conventional sett (CS) planting with an objective to increase the productivity and profitability. The experiments were conducted in ten locations of Rajashree Sugars and Chemicals Limited (RACL) command area with two methods of cultivation at farmer's field as participatory research with farmers. Each experimental plot sized with more than 0.4 ha in each location of the farmer's field for both the seedlings (SSI) and sett planting under drip irrigation system. The components of SSI *viz*., planting of single seedling at wider spacing (5'x2') with drip fertigation were demonstrated in comparison with setts planted under drip irrigation (conventional method). The experiment was statistically conducted in randomized block design with SSI and conventional method in ten farmers location as replication. The soil of the experimental field was slightly saline in nature with pH ranged from 7.5 to 8.1, bulk density ranged from1.25 to 1.29 g/cm^3 and electrical conductivity was 0.11 to 0.23 dS/m^{-1}. The soil depth was 70 cm with infiltration rate of 0.7 cm hr^{-1} and organic carbon content and 0.58 to 0.64 per cent respectively.

The drip fertigation system was installed to supply adequate water and fertilizers @ 275: 63: 115 kg. of N, P_2O_5 & K_2O/ha as per TNAU recommendation with split application at weekly intervals. Decomposed farm yard manure @ 12.5 t ha^{-1} applied at last ploughing. The drip laterals were laid using drip laying machine and placed the laterals at 5 feet between rows and 6 inch depth. The pre-emergence spraying of atrazine @ 2.5 kg with 500 litres of water ha^{-1} was done using hand operated pneumatic knapsack sprayer to control of weeds at 3 days after planting. The good agricultural practices were followed as per the crop production guide (CPG, 2014) and SSI method was adopted on the basis of methodology developed by ICRISAT (Biksham Gujja *et al.*, 2009) [4].

Chip bud seedlings of sugarcane cultivar Co 86032 @30 days old were planted in wider row spacing and adopting 150 x 60 cm between the rows to a depth of 3-5 cm. The main crop sugarcane was planted during middle of the November to December 2012 and harvested at December 2013 to January 2014. Then, ratoon crop was allowed to grow immediately after harvest of the main crop and harvested at December, 2014 to January 2015. The crop water requirement (litres day^{-1}) applied through drip irrigation was calculated based on the climatological approach method as described by Allen *et al*. (1998) [1]. The drip irrigation was operated for 4-6 hours based on soil type and stage of the crop on alternate days. The observation on plant height at harvest stage, number of internodes cane^{-1}, number of millable cane clump^{-1}, individual cane weight and cane yield were recorded and analyses was also done for qualitative parameters. The cost benefit ratio was also worked out based on the market price of sugarcane. The water productivity was estimated based on ratio of cane yield and total water consumed and expressed as kg/ m^3.

3. Results and Discussion

3.1. Growth characters

Among the 10 locations of the experimental plots, 11.8% plant height increase in SSI system was observed over conventional system of planting (Table 1). In ratoon crop also, SSI method registered higher plant height of 276 cm than conventional method of 247 cm (Table 2).Growth of sugarcane in terms of plant height showed significant improvement was due to wider spacing coupled with more aeration and solar radiation. Propagation by chip bud seedlings had recorded higher growth attributes as compared to sett planting is tandem with the findings of Vijayakumar and Suresh, 2011 [16]. The findings of Srivastava *et al.* (1981) [13]; and Patnaik *et al*., 2016 [11] reported that single bud seedlings were transplanted in the main field with wider spacing within the row to facilitate availability of abundant solar radiation and soil aeration to enhance high levels of tillering and growth in sugarcane.

Table 1: Growth, yields attributes and yield of sugarcane in two methods of sugarcane cultivation (Main crop) during 2012-13.

Name of the location	Plant height (cm)		Inter node length (cm)		Inter node plant^{-1} (Nos.)		Single cane weight (kg)		Millable cane Clump^{-1} (Nos.)		Cane yield (t ha^{-1})		Sugar yield (t ha^{-1})	
Method	SSI	Sett	SSI	Sett	SSI	Sett	SSI	Sett	SSI	Sett	SSI	Sett	SSI	Sett
Pidagam	270	225	15.9	11.3	25.1	19.7	1.55	1.3	16.1	14.2	144	130	15.12	11.22
Rettanai	254	237	12.7	10.8	24.3	11.1	1.32	1.15	15.3	12.56	126	109	13.35	10.3
Pidagam	276	257	14.9	11.9	19.5	12.7	1.6	1.41	17.9	14.6	152	136	17.12	12.74
Kannathal	303	267	12.5	10.3	26.5	22.2	1.13	1.08	14.3	11.7	117	99	12.32	8.57
Solapundi	267	233	13.2	10.7	25.1	19.4	1.38	1.17	15.8	13.2	140	116	15.67	11.1
Solaganur	278	246	14.5	11.2	24.3	17.9	1.51	1.3	16.6	14.9	146	128	15.66	11.96
Solaganur	248	231	13.8	9.3	26.5	18.9	1.56	1.31	17.9	14.1	154	138	17.05	13.19
Kaspakaranai	289	259	14.5	11.1	24.3	19.5	1.5	1.49	15.9	14.8	148	141	13.68	12.73
Manadagapattu	286	256	13.5	9.8	22.5	19.7	1.61	1.53	17.1	16.2	157	133	16.89	11.61
Narasinganur	286	266	12.7	10.1	22.6	18.3	1.55	1.4	15.7	14.3	143	127	16.16	11.64
Mean	276	247	13.8	10.7	24.1	17.9	1.5	1.3	16.3	14.0	143	126	15.3	11.5
SEd	2.98		0.29		0.74		0.04		0.74		2.98		0.51	
CD (p=0.05)	6.40		0.62		1.59		0.1		1.58		6.4		1.09	

Table 2: Growth, yield attributes and yield of sugarcane under two methods of sugarcane cultivation (Ratoon crop) during 2013-14.

Name of the location	Plant height (cm)		Inter node length (cm)		Inter Node plant^{-1} (No.)		Single cane weight (kg)		Millable cane Clump^{-1} (No.)		Cane yield (t ha^{-1})		Sugar yield (t ha^{-1})	
Method	SSI	Sett	SSI	Sett	SSI	Sett	SSI	Sett	SSI	Sett	SSI	Sett	SSI	Sett
Pidagam	288	266	15.1	12.8	28.5	27	1.69	1.41	17.9	14.8	151	126	16.84	13.46
Rettanai	275	268	13.4	11.9	23.2	20.3	1.27	0.93	15	12.5	125	96	14.00	10.25
Pidagam	284	276	14.1	12.6	26.8	25.5	1.55	1.3	17	14.1	142	128	15.80	13.57
Kannathal	308	296	13.9	11.8	22.5	20.1	1.03	0.9	14.2	12	111	93	12.27	9.44
Solapundi	269	252	14.8	11.6	23.1	22	1.39	1.23	16.5	13.8	137	115	16.98	12.71
Solaganur	285	276	14.9	12.3	30.5	26.5	1.41	1.28	17.8	14.1	158	133	19.56	16.10
Solaganur	268	256	14.1	10.9	28.5	24	1.6	1.35	17.2	13.9	139	127	16.19	13.46

Kaspakaranai	271	263	14.7	12.4	31.5	27.5	1.69	1.42	18	15.7	150	129	18.49	14.36
Manadagaattu	286	276	14.1	13.1	28.3	23	1.56	1.35	16.8	13.4	152	124	16.69	13.06
Narasinganur	276	269	13.2	11.4	26.5	22.5	1.48	1.37	15	13.1	139	120	15.98	12.36
Mean	281	270	14.2	12.1	26.9	23.8	1.47	1.3	16.5	13.7	140	119	16.3	12.9
SEd	1.57		0.23		0.33		0.04		0.55		1.93		0.31	
CD (p=0.05)	3.37		0.49		0.71		0.08		1.17		4.15		0.66	

3.2 Yield attributes

The yield attributing parameters like inter-node length under SSI system (13.82cm) registered higher value than conventional system (10.71 cm). It was 29.0% increase in inter nodal length. Number of internodes per plant (24.07), single cane weight (1.47 kg) and number of millable canes per clump (16.26) were found to be higher under SSI method than sett planting (Table 1). Initial crop establishment with optimum plant population owing wider spacing and more aeration facilitated by supply of nutrient and water at active root zone has influenced the yield attributes. Mother shoot pruning on 25-30 days after planting, triggered the synchronized tillers with vigorous growth and development. The results were in conformity with the findings of Singh *et al.* (2010) [12] and Biksham Gujja *et al*. (2009) [4].

Sugarcane yield was higher under SSI method (143 t ha^{-1}) as compared to conventional method (126 t ha^{-1}) in main season trial. it was 13.5 % yield increase than conventional method. In ratoon crop also found that similar trend on yield attributes and cane yield was recorded under two methods. Based on the overall mean values SSI method recorded higher cane yield than conventional method of sett planting. Synchronized millable cane, no. of internodes and individual cane weight due to mother shoot pruning on 25-30 days after planting with vigorous growth and development. Planting of seedlings enhance cane productivity. These seedlings produced early tillers, well developed stalks with higher cane yield compared to direct planting as reported by Tamilselvan, 2006 [14]. In sett planting, primary tillers may be dominated among the tertiary tiller results fast outgrowth of cane as compared to bud chip method (Vijayakumar and Suresh, 2011) [16].

Based on the overall mean values, SSI registered 140 t ha^{-1} than conventional method 119 t/ha. It was 19.65 % yield increase under SSI method of planting than conventional system of sett planting in ratoon crop due to maintenance of optimum plant population under SSI method (Table 2). The favorable influence on cane weight was occurred due to supply of required quantity of water and nutrients at right time to the right place. The results were in conformity with the findings of Padmaja and Kannan (2011) [9].

3.3. Cane sugar and sugar yield

SSI registered more sugar yield of 15.30 t ha^{-1} than conventional system of 11.48 t ha^{-1} due to higher yield and improved qualitative parameters values. In ratoon crop also SSI recorded more sugar yield of 16.28 t ha^{-1} (Table 3) than conventional system (12.88 t ha^{-1}) due to synchronized maturity of millable canes and improved qualitative parameter. Pandian and Anbumani (2015) [10] found that seedlings planting under sub surface drip fertigation have increased the juice purity, polarity percentage and crystal cane sugar due to synchronized millable canes and plant hygiene.

3.4. Water productivity and economics

SSI method showed less water consumption of 1669 mm and more water productivity of 8.57 kg/m^3 compared to conventional system of planting 1787 mm and 7.04 kg/m^3 (Table 3). In sugarcane ratoon 1807 mm of water consumed with water productivity of 7.78 kg/m^3 under SSI than conventional method of planting 6.60 kg/m^3 (Table 4) due to higher yield and early maturity of the crop under SSI as reported by Loganandhan *et al*., (2012) [7].

Based on the overall mean values SSI recorded Rs.33,100 as additional net income than conventional method with a B:C ratio of 1.97 and 1.80 respectively. Based on the overall mean values SSI recorded net return and B:C ratio values (Rs.182090 and 2.25) than conventional method (Rs.139380 and 2.04) respectively in ratoon crop (Table 3&4). The results were in conformity with the statement of Vinodgoud, (2011) [15] SSI are one such methodology that helps improve the cane productivity and reduce the costs of cultivation.

Table 3: Water productivity and economics of sugarcane in two methods of planting (Main crop) during 2012-13.

Name of the location	Total water consumed including ER (mm)		Water productivity (Kg/M ^{3})		Net return (Rs./ha)		B:C. ratio (Rs.)	
	SSI	Sett	SSI	Sett	SSI	Sett	SSI	Sett
Pidagam	1695	1780	8.5	7.3	164200	136500	1.98	1.84
Rettanai	1675	1800	7.52	6.06	131800	98700	1.83	1.65
Pidagam	1600	1720	9.5	7.91	178600	147300	2.04	1.89
Kannathal	1695	1800	6.9	5.5	115600	80700	1.75	1.55
Solapundi	1640	1750	8.54	6.63	157000	111300	1.95	1.71
Solaganur	1600	1720	9.13	7.44	167800	132900	2.0	1.82
Solaganur	1600	1760	9.63	7.84	182200	150900	2.06	1.91
Kaspakaranai	1705	1850	8.68	7.62	171400	156300	2.01	1.93
Manadagapattu	1750	1840	8.97	7.23	187600	141900	2.08	1.87
Narasinganur	1725	1850	8.29	6.86	162400	131100	1.98	1.81
Mean	1669	1787	8.57	7.04	161860	128760	1.97	1.80

Table 4: Water productivity and economics of sugarcane under two methods of planting (Ratoon crop) during 2013-14.

Name of the location	Total water consumed including E.R. (mm)		Water productivity (Kg/M ^{3})		Net return (Rs. ha^{-1})		B:C. ratio (Rs.)	
	SSI	Sett	SSI	Sett	SSI	Sett	SSI	Sett
Pidagam	1880	1880	8.03	6.70	196800	151800	2.31	2.10
Rettanai	1900	1900	6.58	5.05	150000	97800	2.09	1.80
Pidagam	1820	1820	7.80	7.03	180600	155400	2.24	2.18
Kannathal	1700	1700	6.53	5.47	124800	92400	1.96	1.76

Solapundi	1850	1850	7.41	6.22	171600	132000	2.20	1.98
Solaganur	1720	1720	9.19	7.73	209400	164400	2.36	2.16
Solaganur	1760	1760	7.89	7.22	218900	153600	2.51	2.13
Kaspakaranai	1750	1750	8.57	7.37	195000	157200	2.30	2.13
Manadagaattu	1840	1840	8.26	6.74	198600	148200	2.32	2.08
Narasinganur	1850	1850	7.51	6.49	175200	141000	2.21	2.04
Mean	1807	1807	7.78	6.60	182090	139380	2.25	2.04

Conclusion

From the study, it could be concluded that Sustainable Sugarcane Initiative practices along with drip fertigation enhances the cane yield significantly over the conventional system. Apart, observed that qualitative increment under SSI over conventional sett planting under drip irrigation. Ratoon performance shows its stability in maintenance of plant population number of millable cane/clump and juice quality.

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