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 of 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/m³ as compared to conventional system of planting (1787 mm and 7.04 kg/m³ 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, sets 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) [5]. 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) [3]. 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) [5]. 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 (Narayamooorthy, 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) [13]. 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 Rajashekar 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 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 from 1.25 to 1.28 g/cm3 with infiltration rate of 0.7 cm/hr. The soil depth was 70 cm with infiltration rate of 0.7 cm/hr 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, P2O5 & K2O/ha as per TNAYU 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-emergency 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 agronomic practices were followed as per the crop production guide (CPG, 2014) and SSI method was adopted on the basis of methodology developed by ICRISAT (Bikshu Gjija 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/m3.

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 [10]. 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                      | SSI                     | SSI                           | SSI               | SSI                 |
| Pidagam              | 270               | 225                    | 15.9                     | 11.3                    | 25.1                          | 19.7              | 1.55                | 1.3                 |
| Rettainai            | 254               | 237                    | 12.7                     | 10.8                    | 24.3                          | 11.1              | 1.32                | 1.15                |
| Kannathal            | 303               | 267                    | 12.5                     | 10.3                    | 26.5                          | 22.2              | 1.13                | 1.08                |
| Solapundi            | 267               | 233                    | 13.2                     | 10.7                    | 25.1                          | 19.4              | 1.38                | 1.17                |
| Solaganur            | 278               | 246                    | 14.5                     | 11.2                    | 24.3                          | 17.9              | 1.51                | 1.3                 |
| Solaganur            | 248               | 231                    | 13.8                     | 9.3                     | 26.5                          | 18.9              | 1.56                | 1.31                |
| Kaspaikanaru         | 289               | 259                    | 14.5                     | 11.1                    | 24.3                          | 19.5              | 1.5                 | 1.49                |
| Manadagapattu        | 286               | 256                    | 13.5                     | 9.8                     | 22.5                          | 19.7              | 1.61                | 1.53                |
| Narasinganpur        | 286               | 266                    | 12.7                     | 10.1                    | 22.6                          | 18.3              | 1.55                | 1.4                 |
| Mean                 | 276               | 247                    | 13.8                     | 10.7                    | 24.1                          | 17.9              | 1.5                 | 1.3                 |
| SEδ                  | 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 (Nos.) | Single cane weight (kg) | Millable cane Clump-1 (Nos.) | Cane yield (t ha-1) | Sugar yield (t ha-1) |
|----------------------|-------------------|------------------------|--------------------------|-------------------------|-------------------------------|-------------------|---------------------|
| Method               | SSI               | Sett                   | SSI                      | SSI                     | SSI                           | SSI               | SSI                 |
| Pidagam              | 288               | 266                    | 15.1                     | 12.8                    | 28.5                          | 27                | 1.69                | 1.41                |
| Rettainai            | 275               | 268                    | 13.4                     | 11.9                    | 23.2                          | 20.3              | 1.27                | 0.93                |
| Pidagam              | 284               | 276                    | 14.1                     | 12.6                    | 26.8                          | 25.5              | 1.55                | 1.3                 |
| Kannathal            | 308               | 296                    | 13.9                     | 11.8                    | 22.5                          | 20.1              | 1.03                | 0.9                 |
| Solapundi            | 269               | 252                    | 14.8                     | 11.6                    | 23.1                          | 22                | 1.39                | 1.23                |
| Solaganur            | 285               | 276                    | 14.9                     | 12.3                    | 30.5                          | 26.5              | 1.41                | 1.28                |
| Solaganur            | 286               | 256                    | 14.1                     | 10.9                    | 28.5                          | 24                | 1.6                 | 1.35                |
3.2 Yield attributes

The yield attributing parameters like inter-node length under SSI system (13.82 cm) 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)[13]. 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 millable cane, no. of internodes and individual cane weight than conventional method of sett planting. Synchronized overall planting of seedlings planting under sub surface drip fertigation have 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) [19].

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/m³ compared to conventional system of planting 1787 mm and 7.04 kg/m³ (Table 3). In sugarcane ratoon 1807 mm of water consumed with water productivity of 7.78 kg/m³ under SSI than conventional method of planting 6.60 kg/m³ (Table 4) due to higher yield and early maturity of the crop under SSI as reported by Loganandan 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.

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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/M³) | Net return (Rs./ha) | B:C. ratio (Rs.) |
|----------------------|----------------------------------------|-----------------------------|---------------------|-----------------|
|                      | SSI | Sett | 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/M³) | Net return (Rs. ha⁻¹) | B:C. ratio (Rs.) |
|----------------------|------------------------------------------|-----------------------------|-----------------------|-----------------|
|                      | SSI | Sett | 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 |
| Location     | 1850  | 1850  | 7.41  | 6.22  | 171600 | 132000 | 2.20  | 1.98  |
|--------------|-------|-------|-------|-------|--------|--------|-------|-------|
| 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  |
| Kaspakarani   | 1750  | 1750  | 8.57  | 7.37  | 195000 | 157200 | 2.30  | 2.13  |
| Manadagattu   | 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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