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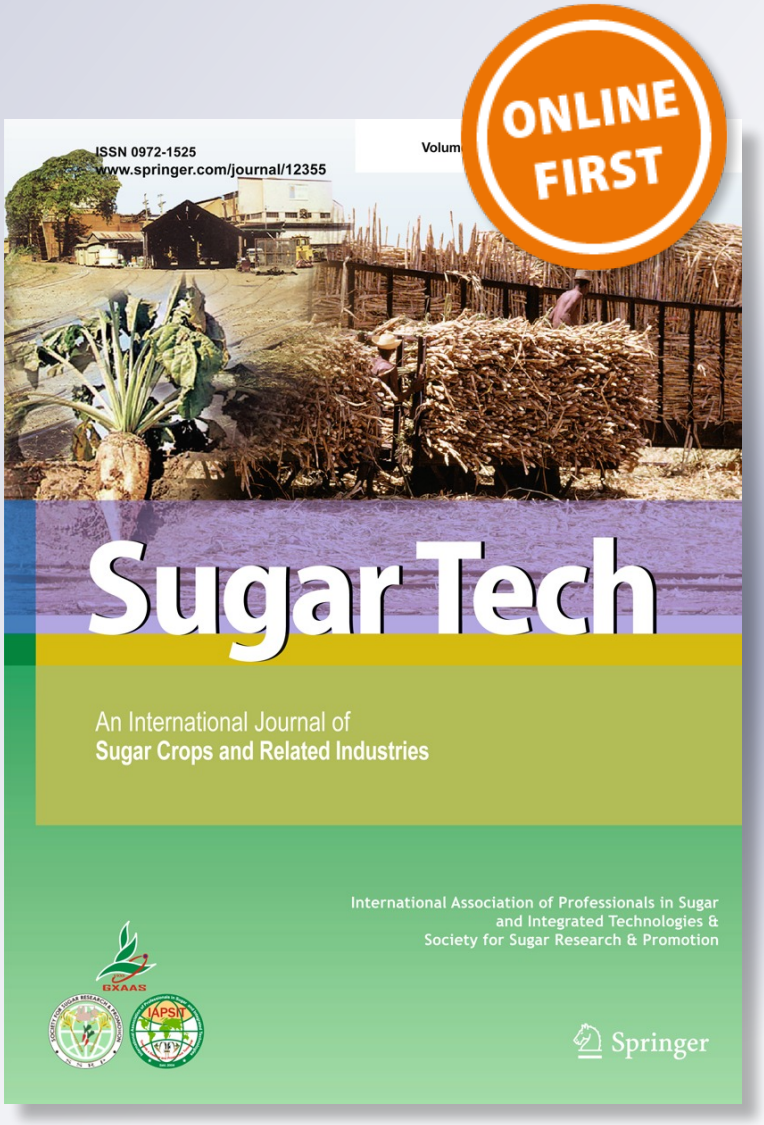

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SHORT COMMUNICATION

Sustainable Sugarcane Initiative (SSI): A Methodology of 'More with Less'

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Abstract Sugarcane is a significant crop in contributing to the country's economy and farmers' livelihood development. In India, sugar is a 550 billion rupees worth industry, supporting more than 50 million farmers. There is a growing demand for sugar in India. Hence, there will be more and more stress on the sugarcane eco-system in future. But, the present scenario of cane cultivation is not sustainable enough to meet this demand as the input and labor costs are increasing and the national mean cane productivity (2007–10) is at 66.9 t ha^{-1} only. So, it is necessary to improve the cane productivity in a sustainable way with minimum usage of inputs through some alternate methods on the principles of "more with less". A research study with the objectives of developing a methodology for sustainable sugarcane productivity was carried out at International Crops Research Institute for the Semi-Arid Tropics during 2008–11. As a result, a methodology was evolved encompassing six principle components, including improved bud chip method, under a concept called "Sustainable Sugarcane Initiative (SSI)". The evaluation trials conducted on the principle components revealed the optimum size and age of the bud chips (4–10 months old) and suitable media combination (cocopith + sawdust) for raising better seedlings. SSI field trials resulted in about 20 % higher yields. The state governments are showing interest in covering larger areas under SSI. SSI method can revamp the sugarcane sector by its merits like ensuring of quality seed materials, increase in yield and income generating opportunities.

Keywords Sugarcane · Sustainability · Bud chip · Productivity · More with less

Sugarcane is a significant crop in terms of its contribution to the national economy and livelihood support to millions of farmers. In India, sugar is a 550 billion rupees worth industry and more than fifty million sugarcane farmers and their dependents and a large mass of agricultural laborers are involved in sugarcane cultivation, harvesting and ancillary activity (Sugar Economy 2011). There is a growing demand for sugar in India, the largest sugar consuming country in the world. According to the Agriculture Outlook prepared jointly by Paris-based Organization for Economic Cooperation and Development (OECD) and Food and Agriculture Organization (FAO), the sugar demand in India has been growing steadily at about four per cent per year over the past 10 years (PTI 2011). Hence, there will be more and more stress on the sugarcane eco-system to meet this growing demand in future. While the area and production of cane follow an 'up and down' cycle in every 3–4 years, the mean productivity of 11 major sugarcane producing states in India is at 66.9 t ha^{-1} only (Sugarcane statistics 2011). Cane cultivation is facing a rough path ahead due to increasing input and labor costs and lack of any alternate innovative technologies to boost the productivity. So, it is essential not only to increase the cane productivity but also to maintain it sustainably by conserving scarce resources over a period of time. To achieve this, there is a strong need for some alternate methods of cane production that should improve the cane yield on the principles of "more with less".

(1US $ = 55 Indian Rupees)

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The World Wide Fund for Nature (WWF) Project at International Crops Research Institute for Semi Arid Tropics (ICRISAT) was running a project on producing more food grain with less water by advocating System of Rice Intensification (SRI) method based on the above mentioned principles. By witnessing the success of SRI in farmers' fields, there were attempts to apply those principles on other crops like wheat, finger millet, pigeon pea etc., with considerable success. Hence, in the year 2008, it was decided to conduct a study to know whether similar principles would help in improving the productivity of sugarcane.

A thorough literature search and visits to innovative sugarcane farmers' fields revealed that the propagation of sugarcane crop using bud chip, instead of cane setts, can be an effective method to conserve large quantities of seed canes. It was also found through literature that raising seedlings from these bud chips and transplanting them young into main field help in boosting the yield, apart from reducing the labor and conserving other inputs, similar to the practices of SRI. Bud chip as a material suitable for planting has a long and interesting history dating back to the early 50's.

Van Dillewijn (1952), the noted sugarcane physiologist, found that a small volume of tissue and a single root primordium adhering to the bud were enough to ensure germination in sugarcane. In order to reduce sett borne infection of red rot, Rao et al. (1974) attempted to use the buds instead of setts for drenching with fungicides to increase permeability. Ramaiah et al. (1977) carried out a detailed experiment with three varieties (Co 419, Co 975 and Co 997) under bud chip and normal methods of cultivation. The analysis brought out the usefulness of the method in saving the seed cane enormously. Gokhale (1977) reported the bud chip method as a new technology that saved enormous amount of seed cane for planting. Narasimha Rao (1977) reported that commercial planting could be practiced with bud chip raised seedlings and the resultant crop with high and synchronous tillering with heavier canes led to higher yields and better recovery.

Spaced Transplanting (STP) method was developed by Srivastava et al. (1981), in which single bud nursery was raised and 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. Nagendran (1988) reported 'bud chip seedlings transplanting technique' as most suitable for adoption in the wet lands of Cauvery delta. Narendranath (1992) emphasized that the bud chip raised seedlings were three times more cost-effective than the way sugarcane was normally planted. Prasad and Sreenivasan (1996) used the bud chip method as a technology for easy transport of cane seed material.

Though the success was reported by many in the past, there was neither any effort further to improvise this method nor any attempt to upscale it in larger area. An opportunity of raising the seedlings under nursery as an income generating activity in rural area was also broadly overlooked. Hence, it was decided to develop a concept by incorporating this method along with other practices in order to properly implement them in farmers' fields for a better yield and income. It was also decided to evaluate this methodology by vetting them through some scientific experiments and field trials and document those results in a proper shape. This paper narrates the experience gained in the process of development and evaluation of this methodology.

Various farm based practices were considered towards improving the cane productivity on the principles of 'more with less'. The experiences of innovative cane farmers were also taken into account. A methodology was evolved encompassing six principle components similar to the case of SRI. The details of these practices were documented properly to conduct further evaluation experiments and field trials. The concept and the principle practices developed are briefly explained in next section.

An evaluation study was conducted over some of the principle practices through in-house experiments and field trials. In the in-house experiments conducted at ICRISAT, tests were done to identify the appropriate conditions that improve the efficiency of germination and quality of sugarcane seedlings (variety: Co 86032) raised from bud chips. In order to standardize the practice, it was necessary to identify the appropriate age and size of the bud chips, best combination of mediums and optimum size of the pro-tray cavities (in which seedlings are raised with the help of mediums) for a better germination and growth of the seedlings. Hence, following experiments were conducted on the above mentioned aspects.

Age of the bud chips: Normally bud chips with less than 2 months and more than 10 months old are not used by the farmers in the nursery. However, in order to select appropriate age of the bud chips, 2, 4 and 6 months old bud chips (Treatments) were selected and their germination potential was studied in the first experiment.

Size of the bud chips: Bud chips are normally removed from cane using a machine called Bud chipper. The size of bud chip obtained by this process is called normal size (with the length and width of about 2 and 1.25 inches respectively, having the bud in the middle). In the earlier experiment normal sized bud chips were studied. In this experiment, germination potential of two different sizes (one-fourth and half of the normal size) were studied. In each category, three different age groups (2, 4 and 6 months old bud chips) were considered. This was intended to know the impact of reduction in sizes of bud chips on the germination of seedlings.

Mediums for raising seedlings: Though many mediums are used in the nursery, Cocopith (Coconut coir waste) is the primary medium used to raise cane seedlings. But there is a need to identify best combinations of mediums, considering the issues like costs and availability of the mediums. So, in this third experiment, treatments were formulated by combining different mediums like Cocopith, Vermicompost, Pressmud, Farm Yard Manure (FYM) and Sawdust in 1:1 ratio and their impact on germination of seedlings was studied.

Size of the pro-tray cavities: Pro-trays with the cavities of two sizes viz, a smaller size with a volume of 4.72 cm^3 and a bigger size with a volume of 7.05 cm^3 are normally used in nurseries. Considering the economy and space related issues, it was intended to study the impact of different sizes of pro-tray cavities on the germination of seedlings in this fourth experiment.

Under field trials, experiments were carried out in farmers' fields in Medak district of Andhra Pradesh, India. For this purpose, about 25 farmers were selected during 2010–11 spring season. Seedlings (variety: Co 86032) were produced in the nursery supported by the project and 5,000 seedlings were distributed to each of these 25 farmers, sufficient to transplant in one acre following 5 × 2 feet spacing. Technical support and troubleshooting measures were given and data collections were carried out. The data on savings in seed materials, growth parameters like number of tillers, individual cane weight and yields were collected. The tillers counts were taken 120 days after planting (on completion of tillering stage) and the individual cane weights were taken 30 days prior to harvest. For the purpose of comparison, similar data were collected from the fields of 15 adjacent conventional farmers at the same time intervals. These two sets of farmers followed same nutrient, plant protection and water management practices except for the difference in the nature of seed materials (nursery raised seedlings vs setts) and spacing followed in the main field (5 × 2 vs 4 × 1 feet). Major results obtained from the above mentioned experiments are discussed in the following section.

As mentioned above, a methodology of 'more with less' was developed based on the related literature review and experiences of innovative sugarcane farmers. Inspired by the success of 'SRI', earlier promoted under the WWF-ICRISAT project, this newly developed concept was termed as 'Sustainable Sugarcane Initiative' (SSI). Thus, SSI is a method of sugarcane production that involves the use of less seeds, less water and appropriate utilization of fertilizers and land to achieve more yields.

The principle components that govern SSI are:

1. Raising nursery using single budded chips
2. Transplanting young seedlings (25–35 days old)
3. Maintaining wide spacing (5 × 2 feet) in the main field
4. Providing sufficient moisture and avoiding flooding of fields
5. Encouraging organic methods of nutrient, plant protection and other intercultural practices
6. Practicing intercropping for effective utilization of land

Table 1 Germination percentage of bud chips (normal size) as per their age

Treatments	Germination (%)	Mean germination (%)
T1 (2 months old)	80	82
T2 (4 months old)	83	
T3 (6 months old)	82	

Though STP method and the bud chip method followed in SSI are looking similar, there are some basic differences. In STP method, the seedlings are raised over FYM mixed raised bed in open space (Hunsigi 2001), whereas in SSI they are raised in multi-cavity plastic pro-trays filled with cocopith. The bud chips filled in trays are covered with polythene sheets to induce faster germination. Raising seedlings in pro-trays help in better germination and easy transplantation apart from saving the seed canes and developing damage free quality seedlings. The results of in-house experiments conducted at ICRISAT are given below.

In this experiment, normal sized bud chips (with the length and width of about 2 and 1.25 inches respectively) were used. Among the three age groups (Treatments), 2 months old bud chips showed quick growth initially and resulted in 80 % germination level at the end as shown in Table 1. The 4 and 6 months old bud chips resulted in slightly higher germination percentage (83 and 82 % respectively). The 6 months old bud chips showed slow growth initially. Though the results are not significantly different, bud chips with the age of less than 4 months can be avoided due to their higher mortality rate.

In this experiment, bud chips of one-fourth (1/4th) and half (1/2) of normal size resulted in mean germination percentage of 44 and 66 % respectively, as shown in Table 2. The results showed that reducing bud chip size brought down the germination percentage, compared to the germination percentage (82 %) of normal sized bud chips in the earlier experiment. The germination percentage further went down in the seedlings raised form older bud chips. Hence, it can be interpreted that the bud chips of normal size and of 4–6 months age are preferable for raising seedlings.

Table 2 Germination percentage of 1/4th and 1/2 sized bud chips as per their age

Treatments	Germination (%)	Mean germination (%)
T1 (1/4th of normal size, 2 months old)	64	44
T2 (1/4th of normal size, 4 months old)	46	
T3 (1/4th of normal size, 6 months old)	22	
T4 (1/2 of normal size, 2 months old)	72	66
T5 (1/2 of normal size, 4 months old)	60	
T6 (1/2 of normal size, 6 months old)	66	

Table 3 Germination percentage of seedlings in different combinations of mediums (1:1 ratio)

Treatments	Germination (%)	Ranking
T1 (cocopith + vermicompost)	85	2
T2 (cocopith + pressmud)	82	4
T3 (cocopith + FYM)	78	6
T4 (cocopith + sawdust)	88	1
T5 (vermicompost + pressmud)	82	4
T6 (vermicompost + FYM)	73	7
T7 (vermicompost + sawdust)	82	4
T8 (sawdust + pressmud)	84	3
T9 (sawdust + FYM)	80	5
T10 (pressmud + FYM)	82	4

Table 3 shows the results of different combinations of mediums (Treatments). This was intended to identify the best supporting combinations of mediums. As it revealed, cocopith + sawdust combination resulted in the highest germination of 88 % and ranked first among all. Combinations of cocopith + vermicompost and sawdust + pressmud have also resulted in comparatively higher germination percentages of 85 and 84 % respectively. Hence, depending on their availability, all these three combinations can be considered for using as mediums in raising sugarcane seedlings.

As it is shown in Table 4, there was no significant difference in the germination percentage of the seedlings raised in two different sizes of cavities of pro-trays (4.72 and 7.05 cm^3). Hence, smaller size trays can be used for raising the nursery, considering the factors like cost and occupation of space.

As far as experiments at farmers' fields were concerned, among the different practices suggested under SSI, it was initially planned to study the impact of bud chip seedlings and wider spacing on cane yield, compared to the conventional method of sett planted, closed spacing cane cultivation. Under SSI, seedlings raised from bud chips were transplanted into the main fields (of 25 SSI farmers) at 5 × 2 feet spacing and in conventional method normal three budded setts were planted (in 15 conventional farmers' fields) at a spacing of 4 × 1 feet. All other parameters like application of water, nutrients and plant protection measures were followed similarly in both the sets of farmers.

Table 4 Germination percentage of bud chips grown in different sizes of the cavities of pro-trays

Treatments	Germination (%)
T1 (smaller sized, 4.72 cm^3)	82
T2 (bigger sized, 7.05 cm^3)	82

Table 5 Growth and yield parameters of sugarcane in SSI and conventional farmers' fields

Sl. no.	Methodology	Spacing in the main field (feet)	Mean No. of tillers $clump^{-1}$	Mean weight of individual canes (kg)	Mean yield (t ac^{-1})
1	SSI	5 × 2	7.71	1.97	55.32
2	Conventional	4 × 1	4.98	1.53	46.00

Saving in seed materials: In conventional method, about 3–4 tonnes of seed canes are used to plant in an acre (with the spacing of 4 × 2 feet). At an average cost Rs. 2,500 per ton, it would cost Rs. 8,000–10,000 per acre for a farmer. But, under SSI, the seedlings were transplanted @ 5,000 per acre (5 × 2 feet spacing). On receiving each seedling @ Rs. 1, the cost of seed cane (or seedlings in this case) was reduced to about 50 % for the farmers. Further, they found the task of transplantation much comfortable with less labor compared to conventional method.

Table 5 shows the comparative mean performance of the crops raised by SSI and conventional methods in farmers fields (numbering 25 SSI and 15 conventional). As shown in the table, average number of tillers per clump in SSI method were more (7.71) compared to the conventional practice (4.98), an increase of about 55 %. The average weight of individual canes was also more under SSI (1.97 kg) compared to the conventional canes (1.53 kg). Hence, the yields were found higher (about 20 %) in SSI (55.32 t ac^{-1}) than that of conventional methods (46 t ac^{-1}).

The table shows the number of tillers in the initial stage (120 days) of the crop. Normally, about 20–25 % of them would perish in due course, before they convert themselves into millable canes. But in SSI method, this conversion ratio from tillers to millable canes was found to be high,

and the loss was restricted, due to the practices like transplantation of young seedlings and wider spacing.

Cane cultivation is facing difficulty ahead due to increasing input and labor costs and lack of any alternate innovative technologies. So, it is necessary to improve the cane productivity and maintain it sustainably. Hence, there is a strong need for some alternate methods of cane production based on the principles of "more with less". The WWF project at ICRISAT initiated a study to address this issue in a sustainable way. As a result 'Sustainable Sugarcane Initiative (SSI)', a method of sugarcane production that involves the use of less seeds, less water and appropriate utilization of fertilizers and land to achieve more yields was developed. With six principle practices, including the improvised bud chip method, this was found to improve the cane productivity by conserving the resources. On the process of refining these methods, some experiments and field trials were conducted at ICRISART and Medak district, Andhra Pradesh, India. The results showed that the bud chips with a normal size (with the length and width of about 2 and 1.25 inches respectively) and an age of 4–6 months are preferred for raising seedlings. The cocopith + sawdust (1:1) combination was found to be the best among all the combinations of mediums. Farmers'' field trials showed that the crops under SSI performed better than the conventional method in terms of tillers count (about 55 %), weight of individual canes (about 0.4 kg) and yield (about 20 %). Though this method proved success in the farmers' fields, its large scale adoption needs the support of state governments and private sugar mills. In the 2011 budget session, Tamil Nadu government has announced to bring 14,000 acres under SSI (Revised Budget, 2011). Andhra Pradesh state government has proposed to bring about 10 lakh acres under SRI and SSI by supporting 37 SSI promotion centres with 25 % subsidy (The Hindu, 2011). On the whole there is sufficient interest shown by the state governments in promoting SSI following the positive results demonstrated by the WWF-ICRISAT Project.

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