Natural Resource Management Center
(NRMC) Kolkata

First National Seminar on

SUSTAINABLE SUGARCANE INITIATIVE, SSI

A Methodology to Improve Cane Productivity

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Venue: Freeman Hall, TNAU, Coimbatore, Tamil Nadu

SEMINAR PAPERS

Organized by
AgSri, Sugarcane Breeding Institute (SBI) & NRMC (NABARD)

Contents

Sustainable Sugarcane Initiative, SSI -An opportunity to improve the quality and productivity of sugarcane while reducing the impact on natural resources

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Introduction

Sugarcane is an important commercial crop of India next only to cotton and it is one crop that spreads across both in the tropics and the subtropics. Sugarcane area hovers around 5 million ha every year with a cane production of 350 million tonnes or thereabout, ranking second in the world after Brazil. The sugar industry is expanding over the years tremendously. In 1950 there were only 138 sugar mills which grew to 571 by 2005. The number has crossed to more than 600 as per the current figures. Out of these 600 and odd sugar factories, around 55 % are in the co-operative sector, 35 % in the private sector and 10 % in the public sector. However not all these sugar factories are functioning. According to a Government report, there are 162 sugar mills, which can be considered as sick and are not functioning due to various reasons (Press Trust of India / New Delhi, November 23, 2010) indicating the kind of crisis the industry is facing. Of these 162 sick mills, 139 are in the cooperative sector while the rest 23 are in the private sector. The main reasons for sickness of these sugar mills, as adduced by the Government, are non-availability of adequate raw material, poor recovery from sugarcane, lack of modernisation, high cost of working capital, control of molasses, lack of professional management and over-staffing. Besides, high state advised prices of sugarcane by some states are responsible for sickness of some sugar mills. These are issues to be addressed in all seriousness since the sugar industry's contribution, to the Indian economy is presently enormous with its total turnover of over Rs. 55,000 crores per year. The annual economic contribution of the sugar industry to the national exchequer through taxes amounts to more than Rs. 2800 crores annually.

Coming to sugarcane agriculture, one of the most important achievements during the past century has been the development of high yielding varieties through interspecific hybridisation, which has made possible the expansion of the sugar industry as stated above. The present day cultivated sugarcane (*Saccharum* spp. hybrid) constitutes man-made hybrid derivatives involving *Saccharum officinarum,* the original sugarcane and *S. spontaneum,* the wild species, that has given biotic and abiotic stress resistance and seed fertility that is essential for breeding. Apart from this, there had also been incorporation of a few gene complexes from the now defunct cultivated species *S. barberi* (North Indian cane) and *S. sinense* (Chinese cane). These two species are considered to have arisen through natural hybridisation between Saccharum *officinarum* and *S. spontaneum*, leading us to the conclusion that sugarcane is essentially derived from *Saccharum officinarum* and *S. spontaneum.* The first commercially successful first generation inter-specific hybrid (*S. officinarum* x *S. spontaneum)* in the world, Co 205 was developed and released for cultivation in subtropical India by Sugarcane Breeding Institute (then known as Imperial Sugarcane Breeding Station), Coimbatore, the world leader in sugarcane breeding.

This was followed by Co 213, Co 214, Co 281, Co 285, Co 290, Co 312, Co 1148 etc., which completely revolutionised the sugar industry in the northern belt. The recently released sub-tropical varieties such as Co 0118 and Co 0238 are gaining popularity now. Among the varieties developed by the Institute for tropical India, Co 419, Co 453, Co 740, Co 997, Co 62175, Co 6304 etc. became extremely popular across the southern, western, central and the coastal states in the earlier years. The variety Co 86032 notified for release in the year 2000 now occupies more than 90 % of the area in Tamil Nadu and around 55 % in the entire tropical belt. With the launching of fluff supply programme during the mid seventies as a parallel channel of breeding with emphasis on location specific varietal development, a number of varieties like Viswamitra, Krishna, Co 86V96, CoJn 86141 and CoM 0265 have become popular in one are more states of the tropical belt. Similarly in subtropical belt, varieties

from this stream, like CoS 767, CoS 8432, CoS 8436, CoS 88230, CoSe 92423, CoSe 95422, CoH 119, CoJ 85 and CoP 9301 are being cultivated.

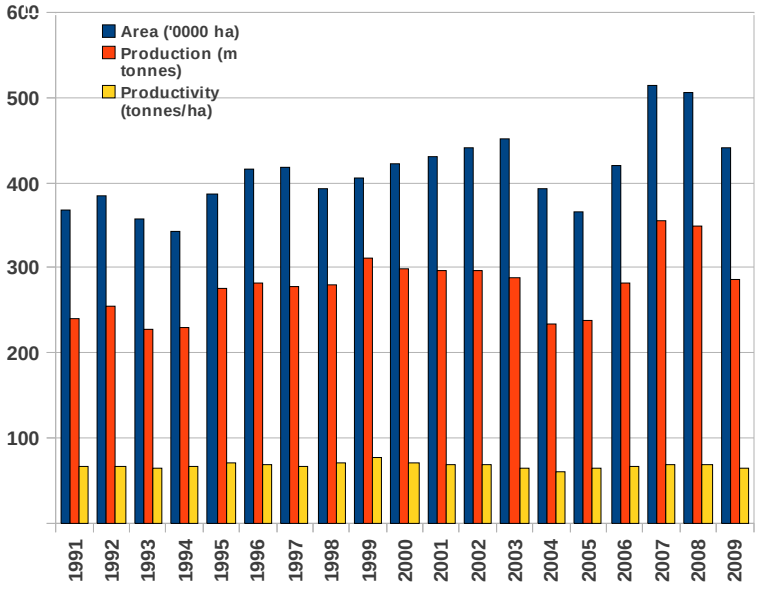
In many of the sugarcane growing countries of the world, Co canes became extremely popular in the earlier years. There a number of varieties like Co 419, Co 421, Co 527, Co 945 (number one variety in Kenya occupying 25% area - *http://www.epzakenya.com/UserFiles/File/Kenyasugar.pdf*), Co 997, Co 6806 (number one variety in Sudan - *http://www.sugarcaneres.sd/doc/annualreport2006-2007.pdf*), Co 7219 and CoC 671 which are still being grown especially in the African countries. There is a great clamour for Coimbatore canes in the African countries especially in the context of supply of varieties from Sugarcane Breeding Institute being discontinued for the past 3-4 decades as a policy decision by Government of India and the inability of these countries to get good varieties from other sources like Australia, Mauritius, Brazil or South Africa.

Present scenario of cane and sugar

Sugarcane is a versatile crop and is one of the most efficient converters of solar energy into dry matter. In spite of this inherent nature of sugarcane to have high productivity levels, the sugar industry quite often faces major problems. Cycles of surplus and shortage are not uncommon. Many a times the industry faces heavy losses. For instance, during the last crushing season ending October, 2010, around 300 small and mid-size sugar factories, representing 40 per cent of India's 24.2 million tonnes of sugar output, faced a financial crisis due to losses in cane crushing (August 15, 2011, Business Standard). According to this report, the situation is likely to worsen in the ensuing season.

Sugar production this year is estimated officially at 26-26.5 million tonnes, up from 24.2-24.5 in 2009-10. In 2010-11, sugarcane was planted in 4.98 million hectares across the country. Area under sugarcane in the new crop year that starts in October 2011 is expected to increase by around 8 -10 per cent because of good price to growers and relatively favourable weather conditions. These developments are bound to have an impact on sugar economy of the Nation. The loss for the first eight months during the current crushing season, as estimated by ISMA, is Rs 3,200 crores, at an average of Rs 400 crores per month. Apart from other necessary interventions like policy initiatives and financial support that are needed, it is imperative to increase the productivity levels of sugarcane if the industry is to come out of the red.

Fig.1 Sugarcane area, Production and Productivity in India during the past two decades



In this context it is pertinent to have a look at the trend in cane area, production and productivity in India during the past two decades (Fig. 1). It is quite evident that the production is very closely related to the extent of area planted ($r = 0.91$ and $R^2 = 0.83$). The productivity level, on the other hand, shows that there had not been much of an improvement over the past 20 years, the average hovering around 67 tonnes/ha, with a high of 76.5 during 1999 and a low of 59.4 during 2004. It is to be noted that in spite of significant advances in crop husbandry during these two decades, the cane productivity has

remained stagnant. Given the biotic and abiotic stress factors, continuous degradation of soils, varietal deterioration, erratic rain fall and a plethora of other factors, sustaining the productivity level itself has become a serious challenge for the researchers and most of the research efforts undertaken are geared towards solving these problems, seriously limiting initiatives to increase productivity levels.

Needless to say, ways and means have to be found out to change the situation for the better. There can be many solutions, scientific and otherwise, that can improve the productivity levels of sugarcane and turn the fortunes of both the farmers and the industry. 'Sustainable Sugarcane Initiative' (SSI) is one method that has caught the imagination of all the stake holders, especially the farmers, because of its proven ability to increase the productivity at reduced inputs. SSI addresses the most important aspect of the sugar industry, the supply and the quality of raw material.

SSI – Genesis

SSI is a continuum of SRI (System of Rice Intensification) that was promoted by WWF-ICRISAT project. The System of Rice Intensification is a methodology developed by Fr. Henri de Laulanié in the 1980's in Madagascar. It was a bottom up approach of farm practices and by 1994 the philosophy was scientifically validated. The recent research also found that in 1905 the farmers in Tamilnadu have developed similar practice which used less seeds, less water, wide spacing and intercultivation (http://sri-india.110mb.com/newsletter/SRI%20issue%206%20(17-05-09).pdf). The farmers published a detailed manual calling it *gaja* planting. So Indian farmers have tried many things in improving the productivity much before. SRI has been a phenomenal success in improving rice productivity through out the world following the promotion of this philosophy by 'Africare' in the African Sahel, 'Oxfam America' in Southeast Asia and the 'Worldwide Fund for Nature (WWF)' in India. Both SRI and SSI are methodologies that depart from conventional cultivation. Sustainable Sugarcane Initiative is nothing but building on experiences and putting together of various dimensions that include farm based innovations. Also, SSI as a concept, gives enough room for further improvement of the component practices, that is, the methodology is capable of evolving.

The most important aspect of SSI methodology is the practice of transplanting bud chip raised seedlings, instead of the normal sett planting. This component itself has evolved over a period of around 60 years. The noted Sugarcane Physiologist, van Dillewijn was the first to suggest in 1952 that a small volume of tissue and a single root primordium adhering to the bud are enough to ensure germination in sugarcane. After a long gap of 22 years, the idea was picked up by research workers at Andhra Pradesh. In order to reduce sett borne infection of red rot, Narasimha Rao and Satyanarayana working at Anakapally Sugarcane Research Station, reported in 1977 that drenching of three budded setts in fungicide solution before planting did not control diseases owing to ineffective permeation of the solution whereas in bud chip the permeation was complete and there was disease control in the seedling raised crop.

The year 1977 marked real use of bud chips for commercial planting and saw the designing of bud chipping machine at Andhra Sugars. Ramaiah, Narasimha Rao and Prasad carried out a detailed experiment at Andhra Sugars, Tanuku with three varieties (Co 419, Co 975 and Co 997) under bud chip and normal methods of cultivation. Their analysis brought out the usefulness of the method in saving the seed cane enormously. Later, Narasimha Rao, in the same year, working as Advisor to Andhra Sugars, in a report published in 'The Hindu' told 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. The method was tried in 400 acres in Andhra Sugars. Gokhale, also in 1977, reported that the bud chip method was a new technology that saved enormous amount of seed cane for planting.

Fascinated by the work done by Andhra Sugars, Tanuku in fabricating the bud chip machine,

during the year 1978, Balasundaram, then working as Head of Kannur Station (vested with the responsibility of maitaining and utilising the world repository of sugarcane germplasm) of Sugarcane Breeding Institute, explored the possibility of using the machine for seed cane saving in the precious germplasm material. Yet another significant development during 1981 was the technique of **S**paced **T**rans**P**lanting (STP) of Indian Institute of Sugarcane Research (IISR), Lucknow in subtropical region where quite a lot of seed cane is unnecessarily being used for planting.

At Mayiladuthurai in Tamil Nadu, Nagendran and Sekar, working then at NPKRR Cooperative Sugar Mills reported in an article published in 'The Hindu' during 1988 that 'bud chip seedlings transplanting technique' as most suitable for adoption in the wet lands of Cauvery delta. The very good foundation laid earlier at Tanuku Sugars, encouraged Narendranath to go in far 500 acres of sugarcane with bud chip raised seedlings. He emphasised that it was three times more cost-effective than the way sugarcane is normally planted. In his ISSCT presentation during 1992, he reported that for seven weeks there was a saving in management costs on 99 acres, since one acre nursery was sufficient to produce seedlings for planting 100 acres.

At Sugarcane Breeding Institute, Prasad and Sreenivasan during 1996, reported use of the bud chip method as a low cost technology for exchange of cane seed material. This facilitated easy carrying and transport of Co canes as bud chips in carton boxes across the country for the regular varietal development programme. During 2007, Jeypore Sugars, Chagallu, Andhra Pradesh used of single bud setts for raising seedlings in trays was started with the aim of saving one month time in preparing the main field which is normally wet during December - January. The factory started with 40,000 seedlings during 2007- 08 and went on to produce 4 lakhs in 2008 - 09, 27 lakhs in 2009-10 and 50 lakhs in 2010-11.

Outside India, at least there are two known cases of seedling raising for sugarcane cultivation. Thomas, in 1984, reported planting of three months old seedlings at the rate of 14285 per ha with a spacing of 1.4 m x 0.5 m in South Africa. In 1995, Tianco in Philippines, used 40 days old seedlings raised in polybags and found that yields were 11 % higher, millable canes were 17 % lower but individual canes were 34 % heavier as compared to normal method of cultivation.

The year 2009 marked watershed in the history of bud chip method. Inspired by the success of 'System of Rice Intensification' under WWF-ICRISAT project, Biksham Gujja and his Team extended the concept to sugarcane and the 'Sustainable Sugarcane Initiative' was thus born (WWF-ICRISAT, 2009). The first detailed manual on SSI with clear concepts was released to public in May 2009. Though bud chip was known, but the work at WWF-ICRISAT project and the manual have put it as a package and contextualised it taking the experience of SRI. Bud chip method is one of the six principles of the SSI package. Other five principles and practices are wide spacing, intercropping, reduction of water use and reduction of chemical inputs. The combination effect of these six practices will give optimum results. However farmers depending on their time, capacity and resources will adapt these practices. It is knowledge intensive and it is process which will evolve depending upon the agro-climatic, soci-economic conditions. The method was taken up on a fairly large scale in several states and training on the methodology was given to farmers from the states of Tamil Nadu, Andhra Pradesh, Maharashtra, Punjab and Orissa under the WWF-ICRISAT project.

The WWF-ICRISAT project on SSI envisaged combining useful components of sugarcane cultivation in a synergistic way. Drip irrigation and wide row spacing were two elements that started gaining ground during the late 90's. These two methods gave the farmers the practical options of using water judiciously and raising an intercrop as an additional and a quicker source of income. There was also the realisation that continued use of inorganic inputs has wrought havoc on soil health. Putting together these various dimensions along with raising seedlings through bud chip, the SSI was conceptualised and implemented during 2009 and 2010. This generated massive interest among the farmers and they started practicing the methodology with great enthusiasm. As the adage goes 'seeing is

believing' both the farmers and the industry realised the great potential of of this methodology and by 2011, SSI has become nationally accepted. Although it is not a finished product, the results there for every one to see and as already mentioned it is capable of evolving and getting fine tuned.

Saving in seed cane and water

Apart from higher productivity, SSI results in enormous seed cane saving and in water productivity. With the current seed rate of 5 - 8 tonnes per ha depending upon the inter row spacing, the saving could be as high as 4 tonnes at the minimum for every ha of cane planted. With around 5 million ha being planted every year in India, there is the possibility of saving 20 million tonnes of cane that could go for crushing, benefiting both the farmers and the industry - working out to around 4000 crores of rupees every year.

According to the website http://www.waterfootprint.org/, the water footprint (water requirement to produce certain quantity of product) for sugarcane is 175 lit per kg of cane or 1500 lit per kg of sugar (at 11% recovery), as compared to 3400 lit for rice and 1300 lit for wheat to produce one kg of grain. The estimate for sugarcane should have been based on furrow irrigation and normal spacing. With drip irrigation and wide row spacing, the water requirement for sugarcane cultivation is expected to be much lower. Water saving according to Jain irrigation website (www.jains.com/PDF/crop/sugarcane%20cultivation.pdf) is to the tune of 40 to 70 %. In addition, nursery raising would substantially reduce the water intake of young crop that would otherwise stand in the field for around 30 days, requiring at least five irrigations. Although SSI with drip irrigation system as a component brings down the water requirement, there is need to generate authentic information on the quantity of water saved through drip irrigation and seedling raising.

Tillering potential

The increase in productivity that results in SSI is mainly because of robust root system and vigorous growth of the plant. The special feature of the system is that the plant has enormous potential for tillering which has to be tapped properly. Tillering in sugarcane comes from the bottom most six internodes which are highly compressed. The buds from these six internodes in the mother shoot are capable of giving six primary tillers and again these primary tillers in turn are capable of giving six secondary tillers each (1 + 6 + 6x6 = 43), theoretically speaking. If tertiary tillers are also produced the number could be enormous. But in practice, even if four tillers are produced from the mother shoot and if they give again four tillers each, then the total tillers emerging would be 21 (i.e. 1+4+ 4x4). It is extremely important to harness the full potential of tillering in SSI.

As mentioned earlier, SSI is not a finished product. It is evolving. In order to upscale and further modify through experience the stakeholders need to do the following.

a) more demonstrations at different agro-climatic zones

b) training and knowledge dissemination particularly in the regional languages

c) developing required tools and update

d) research on varietal response to the SSI

The national level dialogue which is being organized in Coimbatore from 24-25the August will facilitate a discussion and start a process for evolving national road map for up-scaling the SSI. AgSri in partnership with NABARD and SBI is organizing a national level seminar to facilitate the dialogue which hopefully helps in evolving a road map for taking up SSI at national level with specific targets.

The Seminar

The National Seminar being conducted at Tamil Nadu Agriculture University on 24th and 25th of August, 2011 will go a long way in refining SSI and taking it forward to greater heights through dialogue among various stake holders. The Seminar is sponsored by National Resource Management Centre (NRMC) of NABARD and co-hosted by Sugarcane Breeding Institute, Coimbatore and AgSri, Hyderabad. The overall goal of the Seminar is "to improve the cane productivity in India by promoting SSI".

About 100 participants from major sugarcane producing states are attending the Seminar. The delegates include individual farmers, non-governmental and community based organisations (NGOs/CBOs), Sugar factories, research and extension agencies, Govt. organisations and NABARD officials. The Seminar Schedule is based on themes that consist of - understanding principles and practices of SSI, identifying issues and constraints to adopt it in different agro-climatic conditions, research and extension, policy requirements, institution building, technical manpower requirements and convergence of Industry, farmers and academic Institutions and so on.

The Seminar is expected to deliberate on

1. Establishing more SSI demonstration sites in all sugarcane growing states. Based on the results setting up specific targets for each state/ mill in promoting SSI.
2. Training and knowledge sharing and dissemination particularly in regional languages.
3. Required tools, machines in order to help in up-scaling SSI.
4. Research on varietal response to the SSI.
5. Networking in creating multidisciplinary and multidimensional approach to SSI.
6. Policy framework to mobilise required human and financial resources to up-scaling SSI including a mechanism to certify the sugarcane production.

Conclusion

Sustainable Sugarcane Initiative is a good opportunity to improve the quality and productivity of Sugarcane cultivation. At the same time India can address the most important issues such water crisis, ecological foot print of agriculture. For long time the field based approaches which improve productivity have been neglected. SRI which is a major success story in rice production has inspired in putting SSI together. The components of SSI are nothing new, but the methodology is a serious effort in conceptualising the already available farm practices and putting them into practice in a synergistic way. The seedling raising methodology has a long history and many people have contributed to its evolution, culminating in the WWF-ICRISAT project named as SSI that encompassed not only seedling raising but also wide row spacing, water saving, intercropping and organic inputs. Saving of seed cane and water through SSI could be enormous. Tillering potential in SSI is quite impressive and its full potential is yet to be harnessed. SSI has proven its merits, but there are a number of areas where further research is needed to put SSI on a still larger perspective. The present dialogue is expected to set the tone for carrying forward this path breaking methodology.

The national seminar is great opportunity for all stakeholders to provide their inputs in improving SSI. The seminar may want to come out with specific targets for improving the sugarcane production through SSI. This paper is meant to help the discussions at the seminar to evolve a required institutional and financial frame work to meet the targets for next five years. There are also efforts at international level in bringing up standards for producing sugarcane. SSI is the first step towards standardisation of sugarcane cultivation focusing improving productivity while reducing the agriculture foot print on planet earth.

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Sustainable Sugarcane Initiative, SSI
- A Methodology for improving yields

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Traditionally, sugarcane is grown using stem cuttings called setts. The setts having two or more buds are buried in the ground at closer row spacing of 1.5 to 2.5 feet with a seed/ sett rate of 3 to 4 t/ acre. It is labour intensive and high water consuming crop, as the fields are flooded for irrigation. Initially the crop is very dense and looks lush green but gradually many tillers die for want of sufficient sunlight and adequate nutrition and number of millable canes will drastically come down. Despite high inputs, the average productivity of sugarcane is low in most of sugarcane growing states, which is hovering between 40-80 t/ha. The average cane weight varies from 0.5 to 1 kilogram in most cases. The cost of cultivation ranges from Rs.30,000 to 50,000 per acre in different regions. While the demand for sugar and its by-products is increasing, sugarcane cultivation is facing many problems. Cane cultivation has become uneconomical to farmers due to rising costs of cultivation, improper cultivation practices, growing water scarcities, unavailability of good quality seed material, increased pest – pathogen pressure, unpredictable climatic aberrations and non-remunerative price due to regulations by the government.

The sugar industry is also facing problems such as inadequate cane supply for crushing due to reduction in area under sugarcane, labour scarcity for harvesting, competition from other highly remunerative crops like Rice and Maize, timely availability of seed material at the onset of season, high seed rate requirement leading to inadequate coverage of targeted area, poor cane quality due to untreated and under grade seed material used by farmers, poor sugar recovery and inability to practice mechnisation due to closer spacing. Under these circumstances, both farmers and sugar industry are in distress. This crisis calls for alternate options and approaches to sugarcane cultivation to make it viable and remunerative to both farmers as well as sugar industries. Sustainable Sugarcane Initiative, SSI, is one such methodology that helps improve the cane productivity and reduce the costs of cultivation, thus addressing the problems of sugar sector to a large extent.

Sustainable Sugarcane Initiative, SSI

SSI is a method of sugarcane production which involves using less seeds, less water and optimum utilization of fertilizers and land to achieve more yields. The genesis of SSI has been explained in detail in the seminar paper. SSI projects sugarcane cultivation in a new paradigm of 'more with less'. It encompasses all better agronomic operations from seed material to harvesting of crop and provides farmers a full package of technologies for saving the inputs and improving the yields. It is a combination of cane planting innovations and water saving practices that have great potential for meeting the growing demands of sugar sector players looking for increased revenues and profitability. It also addresses the bigger picture of improved natural resource exploitation, reduced environmental footprints and improved livelihoods of farmers by means of technologies that are as appropriate and effective at household farm level. All better management practices are packaged in SSI around six basic principles for easy understanding and promotion for field adoption, influenced by success of the System of Rice Intensification (SRI) methodology.

SSI principles

1. Raising nursery using single budded chips
2. Transplanting young seedlings (25-35 days old)
3. Maintaining wider spacing (4-9X2 feet) in the main field

4. Providing sufficient moisture to plants & avoiding flooding of fields
5. Encouraging application of organic manures, better cultural and plant protection measures
6. Practicing intercropping to utilize land effectively

All these principles when followed through appropriate technologies in combination, they work in a synergistic way to save inputs and achieve higher yields per unit area. Hence, it is important to understand each one of them well to plan implementing them.

Single budded chips

In the conventional method of sugarcane cultivation, 2-3 budded setts (seeds) are used for propagation. In SSI, single budded chips are used for developing nursery and later transplantation. Buds are chipped from 7 to 9 months old healthy canes with good internode length (7 to 8 inches) and girth using an implement called Bud Chipper, which comprises a handle and a cutting blade fixed on a wooden plank. Buds treated with fungicides and pesticides to avoid disease and pest attack are used to grow seedlings in the nursery and used as planting stock.

Using bud chips grown plants saves seed requirement considerably. In sett planting the seed rate is 3-4 t/acre but in SSI about 50 kg of buds is sufficient for one acre, as after chipping the remaining cane is available for crushing. The incidence of seed borne pests and diseases can be controlled effectively by treating the bud chips, which is otherwise difficult in large quantities of setts. Large areas can be covered with small quantities of seed material under this method. It is very useful to propagate superior and expensive varieties with low seed requirements.

Transplanting young seedlings

Normally, sugarcane setts are planted directly in the well wetted main field. SSI method involves raising of plants from single buds in a nursery and about a month old seedlings are transplanted in the main field. Young seedlings are raised in the nursery using trays in cocopith media. Growing seedlings in the nursery have several benefits. It ensures selection of good seed material, raising of uniform and robust stock of planting material, optimum percentage of plant population with very low mortality and saving of water which normally would have been used for irrigating the field sown with setts until their germination and establishment in traditional method. It also helps in gaining about one month of planting season where previous crop is harvested late or the fields are wet due to late rains during north-ease monsoon, as it very often happens in coastal areas of Andhra and Tamil Nadu.

Wider spacing in the field

In conventional method, the distance between two rows is maintained at 45 to 75 cm (1.5- 2.5 ft). Normal population expected is 44,000 canes per acre. For that, 16,000 three budded setts or 24,000 two budded setts are required. Whereas in SSI, wide spacing of 5X2 feet is maintained in the main field. Therefore, only 4,000 to 5,000 single buds are used to achieve 45,000 to 55,000 millable canes due to more tillering resulted from wider spacing. In addition, there is a great scope for air and sunlight entering into the crop canopy and photosynthetic activity is increased resulting in increase in length and girth of canes.

Water management

In conventional flooding method water is always applied more than the biological demand of the crop which may affect the crop growth. In SSI better water management is a crucial issue. It is always emphasized to provide sufficient moisture, rather than inundating the field with water. In SSI crop is in

wide rows and water can be given in channels along with the rows. About 40% of water is saved in this method by following measures like raising of nursery, following furrow or alternate furrow irrigation, optimum application of water by reducing periodicity and quantity of water. In drip system, irrigation efficiency improves up to 90% and there is very large saving in water besides saving electric power in pumping.

Encouraging environmentally friendly cultural practices

In SSI, inorganic practices like application of chemical fertilizers and pesticides are discouraged. Farmers are encouraged to practice measures like incorporation of organic manures, application of bio-fertilizers and use of bio-control measures for plant protection. Integrated approach is encouraged to deal with pest and diseases. Gradual reduction of inorganic inputs and adoption of organic methods can be tried by farmers for long term benefits. Inorganic fertilizers should always be applied mixing with farm yard manure. Applying organic manures at the time of field preparation and incorporation of green manures into the soil enables supply of sufficient quantity of nutrients to plant growth. Application of bio-fertilizers like Azospirillum, Phosphobacteria @ 5 kg/acre would also improve the crop growth. This can be applied in the sides of furrows and incorporated into the soil while earthing up.

Intercropping

Wide spacing in SSI provides interspaces in sugarcane field for intercropping of short duration crops and helps in optimum utilization of land. In addition to effective utilization of land, this practice would reduce the weed growth up to 60 % and give extra income to farmers. It acts as live mulch and preserves moisture. Green manures raised as intercrop can improve the soil fertility on incorporation. Crops like wheat, potato, cow pea, french bean, chick pea, water melon, brinjal etc., can be intercropped with sugarcane.

Table 1: Comparison between SSI and conventional method

Particulars	Conventional method	SSI method
Planting material (Setts / buds)	48,000 buds (16,000 three budded setts) of 3-4 tonnes per acre	5000 single budded chips (50 kg per acre)
Nursery	Sett planting	Raising of Seedlings from bud chips
Quality of plants	No Grading	Grading is done after nursery
Planting	Direct planting of 2-3 budded setts in the main field	Transplanting of 25-35 days old young bud chip seedlings
Spacing	1.5 to 3.0 ft between rows	5 -9 ft between rows
Water requirement	More (flooding of field)	Less (maintenance of moisture in the furrows, drip, etc)
Plant mortality	High	Low
No. of tillers per plant	Less	More (15-25)
No. of millable canes achieved per clump	4 -5	9-10
Accessibility to air and sunlight	Low	High
Scope for intercrop	Less	More

Benefits of SSI

- Seed cost can be reduced up to 85%
- Better germination/ sprouting percentage
- Reduction in the plant mortality rate in the field
- It is easy to transport the young seedlings for longer distance
- Intercultural operations can be carried out easily due to wider spacing
- Increases in the length and weight of each cane
- High number of millable canes
- Reduction in the duration of crop
- Increased water use efficiency
- Improvement in accessibility to nutrients with optimum use of fertilizers
- More accessibility to air and sunlight
- Reduction in cost of cultivation
- Extra income from intercrops
- Easy to propagate new varieties

Industries can promote SSI in their operational areas to improve productivity and quality of cane and run the factories for longer period. Farmers can raise their own planting stock, as it has been demonstrated already in states like Andhra Pradesh, Uttar Pradesh, Maharashtra, Odisha, etc. NGOs have greater role in promoting SSI methodologies. Establishing decentarlised nurseries and information centres to propagate SSI practices will enable faster scaling up of SSI in the country.

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Bud chip nurseries – history, methods of raising, results of germination studies

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Sugarcane (*Saccharum* spp. hybrid) is commercially planted using setts at the rate of 6-8 tonnes/ha amounting to around 10% of total produce. This large mass of planting material poses a great problem in transport, and storage of seed cane as well as leads to reduced viability of buds resulting in poor germination. The tissue culture technique owing to its cumbersome outfit and physical limitation is gradually being realised to be uneconomical to farmers and sugar industry. Another viable alternative to reduce the mass and quick multiplication of seed is bud chip technology. In this, nursery raised from plant growth regulator (PGR) treated bud chips, preferably in small plastic cups, tray and transplanting them in the field proved economically viable than traditional method of planting using two to three bud setts. The returns are relatively better with bud chips raised crop with a substantial saving in the seed material used for planting. The left-over cane could be utilised for crushing since it remains a full cane except for the scooped up bud portions.

History

It was van Dillewijn (1952) who first suggested that a small volume of tissue and a single root primordium adhering to the bud are enough to ensure germination in sugarcane. He has also stated that where growing conditions are favorable, cutting with only one bud did well as seed material. After a long gap of 22 years, the idea was picked up by Narasimha Rao and Satyanarayana (1974) who were working on control of red rot in seed cane. Their work established that sugarcane can be grown from bud chip raised seedlings instead of setts. The bud chip machine was fabricated by Andhra Sugars and Ramaiah *et al*. (1977) demonstrated the method for commercial planting by carrying out a detailed experiment at Andhra Sugars, Tanuku with three varieties, Co 419, Co 975 and Co 997 under bud chip and normal methods of cultivation. Their analysis brought out the usefulness of the method in saving the seed cane enormously. Gokhale (1977) conducted field experiment and reported that the bud of sugarcane removed with cortical portion, excluding the pith, could be successfully used as seed material for planting sugarcane.

Fascinated by the work done by Andhra Sugars, Tanuku in fabricating the bud chip machine, during the year 1978, Balasundaram (Pers. Communication), used the machine for seed cane saving in *Saccharum officinarum, a* precious germplasm material.

Another significant development was the technique of Spaced Trans Planting (STP) of Indian Institute of Sugarcane Research (IISR), Lucknow in subtropical region where quite a lot of seed cane is unnecessarily being used for planting. In this technique, single bud nursery is raised and settlings transplanted in the field with wider spacing within the row to facilitate availability of abundant solar radiation and soil aeration that enhances high levels of tillering (Srivastava, Narasimhan and Shukla 1981).

Extensive work has been done using different types of seed cane materials such as single bud settlings, bud chip raised seedlings, 1-3 bud setts for crop establishment then determining the effect of the planting material on growth and yield of sugarcane in India (Reddy *et al*., 1986). It was observed that, due to saving in seed material, the maximum net returns were obtained with bud chips raised seedlings.

At Mayiladuthurai in Tamil Nadu, Nagendran and Sekar (1988) working at NPKRR Cooperative Sugar Mills reported that 'bud chip seedlings transplanting technique' as most suitable for

adoption in the wet lands of Cauvery delta. The very good foundation laid earlier at Tanuku Sugars, encouraged Narendranath (1992) to go in far 500 acres of sugarcane with bud chip raised seedlings. He added that for seven weeks there was a saving in management costs on 99 acres for every 100 acres, since one acre nursery was sufficient to produce seedlings for planting 100 acres.

Tianco (1995) in Philippines, used 40 days old seedlings raised in polybags and found that yields were 11 % higher, millable canes were 17 % lower but individual canes were 34 % heavier as compared to normal method of cultivation.

Ramamoorthy and Ramanujam (1993) developed simple chemical methods for bud encapsulation. Encapsulation of a sugar cane propagule (bud chip) bearing an axillary bud with 2% agar gel slurry maintained viability and hastened the sprouting process to produce a relatively long shoot when planted.

At Sugarcane Breeding Institute, Prasad and Sreenivasan (1996), used the bud chip method as a low cost technology for exchange of cane seed material. This facilitated easy carrying and transport of Co canes as bud chips in carton boxes across the country for the regular varietal development programme. The performance of bud chips as seed materials was evaluated at the Bangladesh Sugarcane Research Institute using sugarcane cultivars Isd-16, Isd-18 and Isd-19 (*Iqbal et al.,* 2002). Greater germination was obtained with single bud chips than with the conventional three-bud setts.

Field experiments conducted by Tamilselvan (2006) using different planting methods, revealed that planting seedlings grown on raised bed or polybags for 40 days at 80 x 25 cm spacing could enhance cane productivity. These seedlings produced 63 % more early tillers, well-developed stalks with high juice content and cane yield of 108 tonnes ha^{-1} compared to 55 tonnes ha^{-1} with direct planting of chip buds.

Inspired by the success of 'System of Rice Intensification' under WWF-ICRISAT project, Biksham Gujja and his Team extended the concept to sugarcane and the 'Sustainable Sugarcane Initiative' was born (WWF-ICRISAT, 2009). The method using bud chip raised seedlings was taken up on a fairly large scale in several states and training on the methodology was given to farmers from the states of Tamil Nadu, Andhra Pradesh, Maharashtra, Punjab and Orissa under the WWF-ICRISAT project.

In view of manifold benefit of "Bud chip technology", extensive research work is being carried out at the Indian Institute of sugarcane Research, Lucknow to explore the physio-biochemical basis of bud chip viability for long duration storage, its treatment, storability, raising of seedlings and their establishment in farmers field. In recent past, several experiments were conducted to maintain the viability of bud chips for long duration storage. Bud chips stored in polyethylene bags after fungicide treatment and stored at low temperature conditions (10 $\pm 1^{o}C$) exhibited about 80% bud germination after 10 days of storage than one stored at room temperature (about 40%). In bud chips moisture content was within the range of 70-77 % during storage similar to 0 day moisture content.

The inducing effect of ethephon (2-chloroethyl phosphonic acid) @ 100 mg per litre and calcium chloride (0.1%) on the sprouting and early growth of sugarcane bud chips and a few physio-biochemical parameters which regulate the process of shoot emergence was also studied. Soaking of bud chips in ethephon and calcium chloride solutions promotes better sprouting, rooting activity, plant vigor and tillering by altering some of the key biochemical activities essential for their early growth and better establishment compared to untreated bud chips (Jain et al., 2010 a &b, 2011).

Methods of raising bud chip settlings

- Select freshly harvested sugarcane stalks free from disease /pests (at 10 month's age)
- Scoop out bud chips with the help of hand operated bud scooping device.

- Soak bud chips in specially formulated plant growth regulator (PGR) solution for 2 hrs.
- Treat with fungicide, Bavistin (0.1%) for 20 min.
- Keep under fan to dry if it is stored for long distance transport (even for 8-10 days).
- Store in perforated polyethylene bags after fungicide and hormonal treatment at low temperature conditions (10±1^{o}C) or in aerated corrugated paper boxes.
- Plant these pretreated bud chips in upright position in plastic cups/trays filled with soil mixture containing soil, organic matter and sand in a ratio of 1:1:1.
- The cups are punctured with a needle at the bottom to facilitate drainage of excess water.
- Regular watering with a rose can is essential. Spraying of nutrients with PGR solution at 3rd week.

Results of germination studies

- Treatment of bud chips with PGRs helps in improving bud sprouting, rooting activity, plant vigor, tillering of bud chip raised settlings under field conditions.
- Establishment and survival of bud chips raised settling were about 80%.

These initial studies have shown that bud chip technology could be one of the most viable and economical alternatives in reducing the cost of sugarcane production, provided necessary precautions are taken in handling and storage of bud chip seed material and their subsequent multiplication in the field. This technique would immensely help sugarcane development workers to exchange their valuable cane seed with less risk, assured survival, and good establishment. Additionally, transporting the treated bud chips instead of whole stalks from one location to other would greatly reduce the chances of transmission of sett-borne diseases and help in seed multiplication of new and improved cane varieties.

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Wider Row Spacing and Drip Irrigation in Sugarcane – Different Spacing Crop Behaviour, Yields and Recommendations

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Spacing for sugarcane has been a subject of study for the past one decade and as a crop, sugarcane was invented in its home of origin as a grassy weed, carpeting the soil, has now been evolved to the spacing of 45 cm, 75 cm, 80 cm, 90 cm, 120 cm and now 150 cm and above successively and successfully.

1) Features of sugarcane as row crop:

a. Sugarcane has the potential for vegetative growth as a continuous row crop.
b. It can be raised in any spacing as a continuous row crop because of the adaptability.
c. Though the cropping geometry has been defined by several authors and differently, the crop has its own potential to adapt itself to various geometries, especially in the tropics.
d. There is a general myth in the southern states of India that the crop is to be raised in rows formed from East to West.
e. Sugarcane has got the tillering potential like any other grass; it tillers till the crop receives sunlight at the base of the cane plant.

2) Spacing for drip irrigation in sugarcane:

a. Points to be considered while planning for wider spacing:

- Some of the physical and physiological factors which normally reduce the tillering ability of cane crop, if could not be overcome, then, it is wise to adopt reduced spacing.
- Wherever the yields of sugarcane farms is less due to salinity or alkalinity or heavy water logging during most part of the year, drought or other reasons like non-availability of labour or inputs or finance that will affect productivity, then it is desirable to reduce the row spacing.
- As spacing is increased, there is always a potential risk of yield reduction. Therefore, unless all the cultivation practices are timely taken up including the season of planting besides fertigation and irrigation, going for higher spacing will be detrimental to cane yield.
- Spacing has to be decided to suit the convenience of the machinery planned – farm machinery available with the farmer, for taking up inter cultural operations.

Choice of spacing to suit interculture machineries:

Sugarcane can be raised in the following spacing under drip irrigation:

Row spacing	Where it can be used?
Single row with 120 cm spacing	Where interculture is to be done with power tiller
Single row with 150 cm spacing	Where interculture is to be done with mini tractor
Single row with 180 cm spacing	Where interculture is to be done with narrow tractors
Single row with 240 cm spacing	Where interculture is to be done with conventional tractors
Double row/ double paired row under 1.2 m x 2.5 m	Where manual harvesting is planned and interculture is to be done with mini tractor

- Any choice of spacing beyond 150 cm plantation in single row will have telling effect on cane yield unless the farmers are capable of realising the cane yield through timely and enhanced management practices.
- The cost of drip system primarily increases with the length of the laterals consumed. Higher the spacing, lesser will be the lateral cost. Therefore, economically optimum spacing has to be decided considering the cost of the lateral.

b. Choice of planting method for wider row under drip irrigation:

Sugarcane can be raised in single row, double row or double paired row method of planting.

- Single row versus double row planting

  Planting under double row method of planting is always better since the method has got the potential to produce higher and early tillers.

- Spacing between the paired row

  Spacing in between the paired row is to be finalised based on the soil type which will decide the wetting pattern of the drippers. It advisable to not to increase the spacing between the drippers beyond 50 cm in sandy soil and row to row spacing on either sides of the lateral in a surface drip system beyond 60 cm to have higher yields.

- Spacing in double paired row system

  It is wise to adopt two paired rows like two railway tracks running parallel. The two lines in each row shall be at a distance of 10 cm (to facilitate better tillering) while the distance between the adjacent rows is to be spaced at 55 cm (to have adequate space for working the soil with implements or tools and to leave the lateral without hitting the cane stools).

c. Lateral spacing, planting method and seed rate:

Whatever is the lateral spacing or the planting method, it will be better to maintain the seed rate at adequate levels – not less than 65000 two budded setts per hectare (10 tonnes of net seed weight). The details are tabulated.

Lateral spacing (cm)	Planting method	Length of furrow in m (per ha)	Seed rate (nos. per m)
135	Paired row	6750	10
155	Paired row	6060	11
195	Double paired row	5125	13
240	Double paired row	4166	15.6

d. Pit method of planting

Pit method of planting is the best method to realise the highest yields. But this method is laborious and has got its own deficiencies like labour consumption, heavy lodging etc. However, with the best practice done, that is all labour oriented, it will give the best yield. The number of pits per hectare, number of pits and number of canes to be maintained are given in the table.

Diameter of pits (cm)	Spacing (cm)	No. of pits	No. of plants to be maintained per pit	No. of canes to be harvested per pit
90	150 x 120	5500	4	20
90	150 x 180	3625	6	28
90	150 x 150	4375	5	23
75	120 x 120	6800	3	15

3) Challenges in wider row planting under Drip Irrigation:

a. Drip system care and maintenance is very vital. If left uncared, wider row planting will report yield reduction.

b. The capital cost is high.

c. The time for taking up planting after installation of the system is more. Therefore advance planning is required.

d. Since the roots do not go deep inside the soil, the crop quickly lodges.

e. Power failure and transformer failure are greater issues in adoption of drip irrigation in India.

f. Surface drip irrigation does not permit high earthing up.

4) Advantages of drip irrigation

Though all the advantages of drip irrigation are with wider row spacing, besides increased yield, the other advantages are given below.

a. Pit system of planting is the best method wherein the highest yield can be achieved.

b. Sugarcane can be harvested within 10 months in tropics.

c. Pit system of planting under drip irrigation can be the choicest method for small farmer.

d. Diesel engines can be perfectly used in pit system of planting.

5. Advantages of wider row spacing under drip irrigation:

a. Sub-surface drip irrigation is the ultimate solution for total mechanisation right from planting till harvest.

b. The longevity of the drip system increases.

c. This is very ideal for continuous ratooning.

d. The drip system can be operated after harvest of cane and therefore the ratoon establishes very well.

e. Sub-surface drip irrigation is the best system for water savings, labour savings and fertilizer efficiency.

6. Choice of varieties for drip irrigation:

Though many varieties are available for sugarcane cultivation under conventional method, since the varieties are bred for conventional planting under 80 cm spacing, it is better to select high and continuous tillering varieties for growing cane under wider row with drip irrigation. Some of the choicest varieties that can be used under drip irrigation are CoA92081, Co86032, CoA90081 and CoV92102.

7. Conclusion

Drip irrigation and wider row of cane planting together. This practice is the ultimate way for mechanisation, be it in a modest way or on a full scale. It is high time, the farmers get used to this technology.

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Tillering in SSI – emergence, factors affecting, constraints and solutions

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Introduction

'Sustainable Sugarcane Initiative', as a methodology capable of transforming sugarcane productivity in a modest way has been demonstrated beyond doubt. The increase in productivity that results in SSI is mainly because of robust root system and vigorous growth of the plant. Planting of nursery raised seedlings in wide row spacing and avoiding excessive moisture creates conditions for good soil aeration and falling of abundant sunlight at the base of the plant which in turn enables excellent root system, extremely good tillering and vigorous growth with thick canes. The special feature of the system is that the plant has enormous potential for tillering which has to be tapped properly to realise the full productivity potential of SSI.

Tillering under conventional system

It would be very interesting to have an idea of the tillering phenomenon under conventional and SSI planting methods. The following Table gives a very rough picture of the level of germination and the number of millable canes produced per bud.

	Approx. no. of buds used or planted /ha	Germination %	No. of germinants	Millable cane population	Tillers/bud
SSI	10000	-	-	120000	12.0
Conventional					
Tropical	75000	50	37500	80000	2.1
Subtropical	100000	40	40000	100000	2.5

The tiller population per bud in SSI will exceed 12 under ideal conditions. In the case of conventional cultivation it could be only around 2 per germinated bud or clump. If we calculate based on the number of buds planted then the millable cane we get ultimately comes to only one per bud planted. This brings home the point that the genetic potential of the bud in producing tillers is fully exploited in SSI where as under conventional planting the millable cane population is more a function of the number of buds planted rather than the inherent capacity of the buds to produce tillers. Needless to say there is a great amount of seed cane saving that could go for crushing.

Synchronous tillering in SSI

Apart from high levels of tillering, synchrony of tillering is a feature of SSI, that results in better sugar recovery. The growth phases in sugarcane are conveniently divided into

		Days after planting	Duration in days
Germination phase	:	30	30
Tillering phase	:	upto 120	90
Growth phase	:	upto 270	150
Maturity phase	:	upto 360	90

The germination phase as a whole in SSI is completed in the trays in a shorter period of around 10-12 days compared to around 30 days under conventional system, where sprouting of all the buds in the setts planted, does not occur simultaneously. Since the germinants emerge in different periods in over 30 days of time, the millable canes produced could not be very synchronous. This means that the individual clumps and hence the millable canes that are produced ultimately vary in their age under normal method of cultivation. Whereas in the case of SSI, the germinants/sprouts emerge within a short period of time and hence the tillering is very synchronous giving a better sugar recovery to the miller. It appears that the increase in sugar recovery would be to the tune of 0.5 % because of synchronous tillering. For a 7500 TCD mill running for 200 days in a year, this works out to an extra sugar production of 7500 tonnes of sugar in a crushing season, which is a very attractive proposition.

Tillering architecture and SSI

Tillering in sugarcane comes from the bottom most six internodes which are highly compressed. In young seedlings, six leaves can be seen corresponding to these six internodes. When the leaves are examined carefully, there is no leaf blades in the first five leaves whereas in the sixth one there is a rudimentary leaf blade. This structure is basic to sugarcane without any variation, when the plants are raised from buds. These six internodes with buds arise more or less at the same place within one cm space in the mother shoot of the young seedlings; so much so all the six internodes are highly compressed within this narrow space and not clearly visible to the naked eye. This can be verified in seedlings upto the age of 25-35 days by removing the entire six bottoms most leaves. These six internodes become visible by around 40-45 days and their compressed nature can be understood when comparison is made with the normal internodes (7^{th} and subsequent ones from the bottom). Tillers start arising at around 50-55 days and continue upto 100-120 days. Tillers do not arise from internodes above these six under normal conditions. Under abnormal conditions like breakage of canes, ESB attack etc. Which leads to damage to the meristematic tissue, there is sprouting from these above six internodes.

Theoretically speaking, the buds from the bottom six internodes in the mother shoot are capable of giving six primary tillers and again these primary tillers in turn are capable of giving six secondary tillers each, giving a tiller count of 43 (ie 1 + 6 + 6x6 = 43). If tertiary tillers are also produced the number could be enormous. But in practice, one is not sure on the maximum number of tillers that can be obtained from even a well grown seedling, planted properly in the field at an appropriate young age. Even if there are only four potential tillers from the mother shoot and if they give again four tillers each, then the total tillers emerging would be 21 (ie 1+4+ 4x4 = 21).

Tillering is an important area that needs intensive research, since under SSI, tillering forms the foundation for obtaining higher productivity. Loosening of soil at an early stage could improve tillering. Normally the first earthing up (half-earthing up) to loosen the soil and convert ridges into furrows and furrows into ridges, is practiced at around 100 days after sett planting. Since tillering starts at around 60 days, it is worthwhile exploring the possibility of advancing half-earthing up by a month or so under SSI method to enhance tillering potential.

Age of seedling to be transplanted

This is another important area where there is need for experimentation. If we look up at the history of seedling raising, the age of seedling has come down to 30-35 days from around 60 days in the beginning. There can be a very positive effect on tillering if very young seedlings are used for transplanting. Recent field experience both in tropics and subtropics show that tillering could be better if seedlings with around 20 days of age are transplanted.

Varieties and tillering

It is a common knowledge that there are large genetic differences for tillering in sugarcane. In rice, under SRI system of cultivation there was an unnecessary controversy that SRI methodology is genotype neutral. That is, whatever is the variety; the grain yield under SRI will be the same. This is far from truth and the contention of genotype-neutrality was not based on scientific evidence. But it could be that the genetic differences are narrowed down under SRI/SSI methodologies. Take for instance CoC 671 with thick canes but less tillering and Co 86032 with not so thick canes but better tillering. It appears that CoC 671 gives good tillering, but not as many tillers as Co 86032 under similar conditions of SSI.

Conclusion

Tillering is a major contributing factor for higher productivity under SSI. Tillering potential under SSI is very high because of transplanting seedlings, wide row spacing and application of moisture to the level needed. Tillering under conventional system is very low, the millable canes resulting more from very high seed rate rather than from the inherent tillering potential of the buds planted. Since germination phase is vey short in SSI, there is synchronous tillering resulting in better recovery. The bottom most six internodes in sugarcane are engineered to produce tillers and the internodes above do not produce tillers unless there is damage to the shoot apex. With only two cycles of tillering from the mother shoots, the number of tillers could easily go beyond 20 per clump if ideal conditions are provided. Tillering could be better if younger seedlings with 20 days of age are planted. There are chances of genetic differences for tillering getting narrowed down under SSI.

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Intercropping in sugarcane - Scope, compatible crops, experiments, experiences and results

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Introduction

Sugarcane is grown commercially in the tropics and subtropics and is known to be one of the oldest cultivated plants in the world. Sugarcane was unknown in the New World until Columbus introduced it on his second voyage in 1493. Sugarcane originated in Asia, probably in New Guinea. Sugarcane is a crop unparalleled in its capacity to trap sunlight energy and has the highest harvest index (ratio of material utilized to material grown in the field) of all crops and potentially the most efficient farm crop on earth in their usage of expensive agricultural inputs. Sugarcane and related species use the C_4 photosynthetic pathway, as distinct from the C_3 (or Calvin cycle) pathway used by most other plants. In terms of efficiency of photosynthesis, the C_4 pathway allows a plant to exploit lower concentrations of carbon dioxide and a greater range of light intensities, while eliminating photorespiration. Many progressive farmers in tropical India have achieved the cane yield up to 300 t/ha adopting improved production technologies. In many tropical countries where annual average yields of about 110 t/ha (including stalks, tops and leaves) have been recorded, translating more than 35 tons of dry solid biomass per ha, correspond to an output of 110 barrels of oil equivalent per ha per year. Besides sugar and ethanol, this biomass, mostly polysaccharides (cellulose and hemi-cellulose), is used as raw material for a large range of by-products including industrial chemicals, paper, particle board, human food supplements, feed additives, plastics, electricity, agrochemicals and drugs. Hence, Sugarcane represents an ideal candidate for natural bio-factory of novel products owing to its large biomass, rapid growth rate, efficient carbon fixation pathway and a well developed storage tissue system through metabolic engineering using molecular tools.

Row Spacing in Sugarcane

Sugarcane is grown in a range of production systems throughout the tropics and subtropics, where the duration of crop growth can vary from as little as 9 months to as much as 36 months. While climate plays a major part in determining the timing of harvest, economic considerations such as planting and harvesting costs and farm management schedules are also important. Productivity of sugarcane is related to final stalk population and is affected by inter-row spacing. Closer row spacing may increase, reduce or have no effect on yield depending upon the conventional row spacing with which comparison is made.

For each kind of plant and soil there should exist a theoretical maximum of the agricultural yield that can be obtained, i.e., each class of soil in each climate is capable, under the best conditions, of producing an exact maximum of well developed sugarcanes, for example, and this maximum can be obtained only under ideal climatic conditions and with perfect cultivation. This maximum also, naturally, can be obtained only by an ideal spacing of the plants, allowing each one to obtain its maximum development; hence, if we have our rows too close together, we shall probably get a greater number of inferior plants, and if we have them too far apart we shall probably get splendid specimens of sugarcane, but the reduced number of these will fail to give us the tonnage we should have obtained with more plants of normal development.

Sugarcane based intercropping systems

Intercropping has many advantages like increased productivity per unit area, better use of available resources (land, labour, time, water and nutrients), reduction in damage caused by pests, diseases and weeds, and socioeconomic factors (greater stability, economics, human nutrition and biological aspects). Initial slow growing nature of sugarcane and wider planting space adopted for its cultivation offer much scope for intercropping. Several short duration crops have been tested as intercrops with sugarcane in tropical India which are listed below:

- Maize, rice, finger millet
- Groundnut, sunflower, sesame
- Blackgram, greengram, cowpea, chickpea, pigeonpea, cluster bean, French bean
- Soybean
- Onion, garlic, coriander, tobacco, amaranthus, tomato, okra, cucumber, radish, turnip, knol khol

A sugarcane based intercropping system has to satisfy any one of the following conditions to be considered advantageous:

i) Intercropping must give full yield of sugarcane and some yield of intercrop

ii) Combined yield of sugarcane and intercrop in intercropping must exceed the yield of sole sugarcane

Most often, the first condition is preferred as any loss in cane yield is not acceptable to both cane growers and sugar factories. Because of this, only an additive system of intercropping is suitable wherein the population of the base crop of sugarcane is maintained at the level of sole cropping to which a lower population of a second crop is added.

Effect of intercrops on sugarcane

Tillering

Sikehi et al (1988) recorded 3.78 tillers for every mother shoot in sole sugarcane at four months after planting which was only 1.98 in sugarcane intercropped with maize. The percentage reduction in sugarcane tiller number was 31.8, 18.3, 29.7, 24.6 and 14.7 when intercropped with sunflower, groundnut, sesame, finger millet and greengram respectively (Kadirvel and Devaraj, 1977). Even with the same intercrop, different cultivars showed varying effect on shoot population of sugarcane. Cultivars with tall and large canopy had more deleterious effect compared to cultivars with dwarf and compact canopy. In general, most of the reports indicate that the tiller number is reduced by intercropping. However, there are some reports which indicate that intercropping either not affected or influenced positively the growth parameters of sugarcane. Kathiresan and Rajasekaran (1990) observed that the tillering capacity of sugarcane intercropped with either blackgram or greengram was more compared to sole sugarcane.

Number of millable canes

Kadirvel and Devaraj (1977) found a reduction of 5.3, 5.6, 3.9, 8.9 and 5.3 per cent in the millable cane population when sunflower, groundnut, sesame, finger millet and greengram were intercropped with sugarcane respectively. Kathiresan and Rajasekaran (1990) reported a reduction of 10.7 and 6.9 per cent in the number of millable canes when sunflower and groundnut were

intercropped in sugarcane respectively. Jayabal et al (1991) reported 27.7 per cent reduction in cane population when Co 1 variety of soybean was intercropped with sugarcane in 1:1 row arrangement. The reduction increased to 46.6 per cent when double rows of Co 1 soybean was grown in between the cane rows. The reduction in cane population was less pronounced with only 14.3 and 18.2 per cent when UGM 27 variety of soybean was intercropped in 1:1 and 1:2 row arrangements respectively.

Deshpande and Nankar (1977) found that intercropping of groundnut did not affect the number of millable canes. Kathiresan and Rajasekaran (1990) reported an increase of 6.7 and 4.6 per cent respectively in the population of millable canes when blackgram and greengram were intercropped with sugarcane. Similarly, Sathyavelu et al (1991) recorded an increase of 4.6, 6.2 and 3.8 per cent in the number of millable canes respectively when blackgram, greengram and groundnut were intercropped with sugarcane.

Single cane weight

In general, the available reports indicate that intercropping has a positive influence on single cane weight. When there is a reduction in the number of millable canes, it is normal to expect an increase in the single cane weight. Sethi and Parashar (1981) reported increase in the single cane weight by 13.4 per cent in sugarcane intercropped with greengram.

On the contrary, Deshpande and Nankar (1977) found that intercropping of groundnut did not affect single cane weight. Narwal and Malik (1981) observed a reduction of 8.3 per cent in the single cane weight when cowpea was intercropped with sugarcane.

Cane yield

There are some instances wherein intercropping had positive influence on cane yield. Kadirvel and Devaraj (1977) observed that the cane yield was 121.5 t/ha when sugarcane was intercropped with greengram while it was 118.2 t/ha in sole sugarcane. Shanthaveerabhadraiah et al (1986) observed 17 per cent more cane yield in sugarcane intercropped with soybean variety Monetta.

In some other instances, intercropping had not affected the cane yield. In such cases, the intercrop was a legume such as blackgram, greengram, pigeonpea, chickpea, soybean or groundnut.

However, there are several reports indicating the negative influence of intercropping on cane yield. In a study on intercropping of maize at different plant densities and with and without N application for maize, with sugarcane, Patil et al (1978) reported a reduction ranging from 5.5 to 31.3 per cent in cane yield. Narwal and Malik (1981) recorded a 11.8 per cent reduction in cane yield when cowpea was intercropped. Naidu et al (1989) observed that growing of two successive intercrops of soybean reduced cane yield particularly where two rows of soybean were planted on both sides of the ridges between cane rows. Planting sugarcane in paired rows adopting 60:120 cm spacing and intercropping three rows of Co 1 soybean in the wider inter-row spaces reduced the cane yield by 9.0 per cent (Sugarcane Breeding Institute, 1990). Jayabal et al (1991) recorded a reduction of 30.5 per cent in cane yield when two rows of Co 1 soybean was intercropped in between cane rows. The reduction was 16.8 per cent when one row of Co 1 soybean was intercropped. They reported that the depressing effect of soybean on cane yield was less with the variety UGM 27. The reduction in cane yield was only 16.8 and 13.1 per cent respectively when two rows and one row of UGM 27 soybean was grown in between cane rows.

Kadirvel and Devaraj (1977) observed that the sugarcane yield was lower by 10.7 t/ha when sunflower was intercropped with sugarcane compared to sole cropping. Pawar and Bhosale (1987) reported a reduction of 14.7 per cent in cane yield due to intercropping of groundnut. In intercropping of sesame with sugarcane, Kadirvel and Devaraj (1977) reported a reduction of 6.1 per cent in cane

yield. The cane yield reduction was 26.6, 13.8, 11.0, 3.7 and 7.3 per cent respectively when okra, cluster bean, French bean, cucumber and radish were intercropped in sugarcane.

Minimising the adverse effect of intercrops on sugarcane

Selection of genotypes

Selection of compatible genotypes of component crops boosts the complementarity to a great extent. Erect growing; short duration and dwarf varieties of crops are more suitable for intercropping than the tall and long duration varieties. Rathi and Tripathn (1974) found that growing of triple gene dwarf wheat varieties (Hira and Moti) was more suitable as compared to semi dwarf varieties (Kalyansona and Sonalika) to get higher yields and profit from sugarcane-wheat intercropping system. Rathi and Singh (1979) favoured a mutant variety of mustard compared to the late maturing variety (Varuna) for intercropping with sugarcane. Kandasami et al (1975) tested two greengram varieties (Hybrid 45 and Pusa Baisakhi) for suitability to intercropping with sugarcane and reported that Pusa Baisakhi proved better than Hybrid 45. While studying the effect of intercropping three different cultivars of soybean with sugarcane, Kailasam (1994) observed that the cane yield reduced significantly when the tall and large canopied Co1 cultivar of soybean was intercropped but the cane yield was not affected when the dwarf and compact canopied PK 472 cultivar of soybean was intercropped.

Fertilizer management

As the component crops included in an intercropping system are not equally responsive to the application of nutrients (Palaniappan, 1985), fertilization of such a system becomes more complex. Fertilizer response of component crops may also change drastically because of interference from other associated species (Beets, 1982). In cereal-legume intercropping, the legume is capable of fixing atmospheric nitrogen under favourable conditions and this reduces the competition for nitrogen with the cereal component (Trenbath, 1976). In the absence of an effective N-fixing system, both cereal and intercrop legume may compete for available soil N (Ofori and Stern, 1987). The competition may also arise because the combined population of component crops often exceeds that of a sole crop. Hence, in intercropping, the nutritional requirements of sugarcane as well as intercrops should be met separately. However, fertilizer doses for intercropping may differ from those recommended for sole cropping.

It has often been assumed that legumes may provide some N benefit to sugarcane when grown as intercrop. Although intercropping of legumes increased the organic carbon, total N and available P content of soil but deriving benefits in sugarcane yield has proved to be difficult, mainly because N effects so often had been confounded with other intercropping effects.

In intercropping systems, the time of fertilizer application to sugarcane plays a significant role in deciding efficiency of applied fertilizer and yield of sugarcane. Sugarcane accumulates hardly two to three t/ha of dry matter till the harvest of intercrops and hence utilizes only a small amount (15 to 20 kg/ha) of soil N. In studies of Verma et al (1985) and Verma and Yadav (1988), fertilizer N applied to sugarcane as basal dose resulted in excessive foliage growth of intercrops because of luxury consumption of N and as a consequence growth as well as yield of sugarcane was adversely affected. Thus, a major portion of N for sugarcane should be applied only after the removal of intercrop. The time and dose of fertilizer application to intercrop may be similar to sole cropping and adjusted to the population.

Plant density and geometry

Several modifications in planting geometry of sugarcane based intercropping systems have been tested. A study by Sugarcane Breeding Institute (1990) showed that the cane yield was almost same when the normal 90 cm uniform row spacing for sugarcane was modified to 60: 120 cm paired row spacing. Such a modification facilitated growing of intercrop only in the wider inter-row spaces, thus minimising the intercrop competition.

Naidu et al (1989) obtained higher return by planting sugarcane in paired rows and intercropping four rows of soybean in the wider inter-row spaces. Similarly, Jayabal et al (1991) found that planting of sugarcane in paired rows adopting a spacing of 30: 130 cm and intercropping of three rows of soybean in the wider inter-row spaces was advantageous. Karamathullah et al (1992) also observed that soybean was best suited for intercropping in sugarcane planted adopting paired row system.

Conclusion

In the context of diminishing labour availability and increasing cost of labour it is always advisable to go in for wider row spacing around 150 cm to facilitate mechanization in farm operations mainly harvesting of canes.

Light energy differs from other resources in that it could not be regarded as a reservoir from which demands could be made as required. It is instantaneously available and to use it for photosynthesis, it has to be intercepted instantaneously. For continued interception and fixation of solar energy, optimum leaf area is essential throughout. This cannot be achieved in monocropping of sugarcane with the adoption of wider row spacing. Again to maintain ecological balance, it would be ideal to intensify cropping with sugarcane both in time and space. Especially under wider row spacing, with adequate availability of soil moisture, nutrients and light during initial crop growth stage, it is advantageous to raise suitable short duration intercrops. This helps the farmer not only to get additional income from the land but also reduces cost of cultivation in managing weeds in the inter-row spaces of sugarcane.

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Sustainable Sugarcane Initiative (SSI) in Uttar Pradesh

(A collaborative project between Triveni Engineering and Industries Limited, Uttar Pradesh and AgSri)

Triveni Engineering and Industries Limited, Uttar Pradesh has entered into a client servicing agreement with AgSri Agricultural Services Private Limited to promote SSI in its cane command area in Uttar Pradesh. As part of Triveni's long term strategy to work with farmers and to improve the sugarcane scenario both for the farmers and factory they have taken maiden pioneering step of implementing SSI in UP with support of AgSri.

There are multifaceted problems which are jeopardising the interest of the factory as well as Sugarcane growing farmers in UP. UP has the highest sugarcane acreage (1.977 million Hectares which is almost 50 % of the total Sugarcane acreage in India) and highest production. However, the yield of sugarcane is significantly low (59.2 tonnes per ha in UP in comparison to 101.4 tonnes per Ha in TN and 90.3 tonnes per Ha in Karnataka) in Uttar Pradesh when compared to other major Sugarcane growing states such as TN, Maharashtra and Karnataka. There are multiple factors ranging from adverse climatic conditions to age old traditional methods of cane cultivation being practiced in Uttar Pradesh which are contributing to this. Sugarcane growing farmers in UP at one end are facing critical problems such as static or declining yield with increasing costs of cultivation making sugarcane cultivation less remunerative for them, inherent risks at every stage right from production to selling, adverse climatic factors and labour availability issues. These factors are pushing them to switch to more remunerative and short duration crops such as Mentha, etc. On the other hand, factories are finding it difficult to survive with low percentage utilisation of their crushing capacity due to non-availability of cane, low sugar recovery, and controlled sugar markets in India.

In the given circumstances, SSI has emerged as a ray of hope both for the sugarcane farmers as well as factory in Uttar Pradesh due to its potential to significantly enhance the profit margins of sugarcane growing farmers (on the principle of "More with Less") and ensure adequate availability of quality cane for factories. Following table briefly describes the status of Sugarcane production in major Sugarcane Growing States:

State Name	Acreage in Thousand Hectares (2009-10)	2009-10		2008-09		2007-08	
		Production (in Million Tonnes)	Yield (Tonnes/Ha)	Production (in Million Tonnes)	Yield (Tonnes/Ha)	Production (in Million Tonnes)	Yield (Tonnes/Ha)
Uttar Pradesh	1977	11.71	59.2	10.90	52.3	12.47	57.2
Maharashtra	756	6.42	84.8	6.06	78.9	8.84	80.9
Karnataka	337	3.04	90.3	2.33	83	2.62	85.6
Tamil Nadu	293	2.97	101.4	3.21	99.7	3.81	107.6
Gujrat	154	1.24	80.5	1.55	70.2	1.52	72
Andhra Pradesh	158	1.17	74.1	1.54	78.5	2.03	82.2
Bihar	116	0.50	43.4	0.50	44.3	0.39	35.8

Source: Indian Sugar, Journal, May 2010

This association started in the year 2008 when Triveni Engineering came to know about SSI initiative of WWF – ICRISAT project. A five member's team from Triveni Sugar's was trained on SSI methodologies in Hyderabad and SSI field trials were conducted in four sugar units of Triveni. One lakh seedlings were raised and planted in 25 acres of land during the first year (2008-09). Inspired with the results, Triveni Sugars decided to go for massive expansion in the year 2010 with planting in 7500 Ha of land. Due to massive targets, technical supervision and support could not be provided to all the

farmers as a result of which there were mixed responses to it. Realizing that technical supervision and support is must in the beginning, a three year collaborative project has been initiated between AgSri and Triveni in the later part of the year 2010, which aims to improve the cane yield and its quality, increase the efficiency of inputs such as water, fertilizers and chemicals to reduce the cost of cultivation, and training and capacity building of Triveni team to achieve the above objectives.

Following are the major highlights of the collaborative project between AgSri and Triveni:

- Training of farmers on SSI methodology and Yield Maximization package of practices
- Round the year technical supervision and support to the farmers implementing SSI
- Seedlings raised by farmers in their own nurseries
- Focus on farmer to farmer transfer of technology
- Study of various inherent factors responsible for yield variation in the state

This year nursery operations have been carried out at farmers place and they have been trained on nursery raising techniques. 50 farmers were targeted in each unit for training and necessary support for nursery raising. Trainings have been imparted to the Triveni senior management as well as field level team to build their capacities to achieve the objectives of partnership.


Training of farmers on Bud Chip Nursery Raising at Ramkola, & Sabitgarh (Uttar Pradesh)

Some of the enterprising farmers have also taken bud chip nursery raising as an income generating activity during the current year and have earned good profits by selling seedlings to other farmers. During the spring season 598 farmers planted seedlings raised through Bud Chip Nursery in 398 Acres of land across 7 units. The results are so far quite impressive, although there are 6 more months left to harvest the crop a distinct difference is visible between the SSI plots and conventional plots. The germination, tillering and crop growth are much better in SSI plots than the sugarcane crops grown under conventional methods.Interestingly, the ratoon crop of last year's SSI plant has performed exceptionally well and most of the farmers are expecting a yield above 150 tonnes/Ha against the average yield of UP which is 59.2 tonnes/Ha. In addition, many farmers were also able to take up Black Gram, Mentha, Chilli, and Capsicum as intercrop with sugarcane in SSI due to wider and uniform spacing and have increases their profit shares significantly.


The opportunities offered by SSI in Uttar Pradesh could be summed up as following:

- Increasing the yield and simultaneously decreasing the cost of cultivation (MORE WITH LESS)
- Intercropping (SSI has offered the possibility of intercropping due to wider and uniform spacing)
- Less input requiring (Significant saving of seed material, fertilizers, chemicals etc.)
- Less water requirement
- Ease in interculture activities.
- Assured availability of good quality and preferred seed varieties
- Excellent performance of the ratoon crop making it highly remunerative for farmers
- Potential to significantly enhance the income of the Farmers with better yield, lesser cost of cultivation and additional income from intercrops

Looking at the performance of the SSI plants in the current year and its potential to significantly increase the income of the farmers it is expected that from next planting season there would be a heavy upsurge in the number of farmers coming forward to take up SSI.

Farmers as well as factory are hopeful that SSI will bring a sweet revolution in Uttar Pradesh mutually benefitting farmers by increasing the returns per unit area as well as factory by ensuring uninterrupted and adequate supply of quality cane throughout the crushing season.

What people have to say about SSI:

"Sustainable Sugarcane Initiative (SSI) has great potential to give additional benefits which are expected to unfold when more and more farmers adopt this technology of growing more with less' across the sugarcane growing states in the country".

Shri. Dhruv Mohan Sawhney,
Chairman and Managing Director,
Triveni Engineering & Industries Ltd.

"SSI is the best ever, among all the methods tried for cane cultivation so far".

Lajpat Singh
Farmer, Luhari Khurd Village, Saharanpur District, Uttar Pradesh

"Neighboring farmers use to comment that I have gone mad and that's why I am breaking my head on this method. Now, the same farmers are approaching me with a request to buy canes raised though SSI method for seed. Also those farmers, who uprooted their SSI plants are repenting now seeing the exceptional crop stand of other SSI ratoons".

Chandrapal Singh
Farmer, Devrala Village, Bulnadshahar District, Uttar Pradesh

"Farmers in the area have realized the benefits of SSI as it saves seed, and other inputs, and in turn has given better yield when compared to general planting methods. They are more inclined towards SSI, especially after seeing the performance of the ratoon crop which is like a bonus for them after getting good yield from the SSI plant crop".

Umrao Singh,
Dariyapur Tugun Village, JP Nagar District, Uttar Pradesh

"SSI has given a new ray of hope to the farmers of Uttar Pradesh. In the days to come majority of the farmers would switch to SSI."

Dhakkan Lal Sharma
Manpur Village, Bulandshahar District, Uttar Pradesh

"SSI is the best ever among all the methods I have ever seen and experienced. If things are in my control, I would only like to see SSI plantation in the area".

Md Ali
Mulawan Village, Muradabad District, Uttar Pradesh

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SSI PLANS BY TNAU AND TAMIL NADU GOVERNMENT

B. J. PANDIAN
Professor of Agronomy and Head, IAMWARM Cell, Water Technology Centre, TNAU

Sugarcane, one of the most important commercial crops is being grown in an area of around 3.06 lakhs hectare in Tamil Nadu with a productivity of106 Mt ha^{-1}. Farmers cultivating sugarcane are facing multiple problems. Water is one of the major constraints and it is affecting the productivity and profitability of sugarcane growers and millers. The problem is going to further deteriorate due to variability of rainfall influenced by climate change. So, unless sugarcane farmers are provided with options of high yields with much less water, they will find it difficult to meet its growing demand for sugar.

Tamil Nadu Agricultural University (TNAU) has played a pioneering role in promoting various water saving technologies to increase the yield per unit of water. System of Rice Intensification (SRI) in paddy cultivation is one such example. SRI's proven principles and practices have been extensively and successfully implemented in the farmers' fields across Tamil Nadu. The Sustainable Sugarcane Initiative (SSI) is yet another practical approach to increase sugarcane production which is based on the principles of 'more with less' in agriculture. Sustainable Sugarcane Initiative improves the productivity of water, land and labour, all at the same time, while reducing the overall pressure on water resources.

Major principles of Sustainable Sugarcane Initiative

- Raising nursery using single budded chips.
- Transplanting young seedlings of 25 – 35 days old.
- Maintaining wide spacing of 5 x 2 feet in the main field.
- Drip Fertigation (sub or sub surface).
- Practicing intercropping with effective utilization of land.

SSI implementation through farmers' participatory approach

- TNAU initiated SSI demonstrations under World Bank funded IAMWARM Project to cover SSI in 100 ha in 2011-12
- Identification of entrepreneurship for seedling growing in each factory area
- Capacity building to factory officials and farmers on SSI

Research

- Standardization of pro-tray medium
- Optimizing plant population and spacing
- Identification of suitable intercrops
- Developing ratoon management practices to get maximum yield

Tamil Nadu Government Policy

- SSI to be adopted in 10,000 ha of area in 2011-12 (Co-operative sugar mills areas 4000 ha and private sugar mills 6000 ha)
- SSI to be promoted in 1.0 lakh ha in 12th five year plan

Expected outcome of the Sustainable Sugarcane Initiative

From farmers point of view	From factory point of view	From Government point of view
• Saving in seed (setts). • Higher cane yield with net return. • Bringing additional area under cane. • More crops in unit area and time. • Saving on water, labour and electricity. • Raising cane crop with poor quality water. • Cultivation cane in marginal and problem soils. • Timely and need based fertilizer application.	• Higher cane recovery. • Increase in crushing day. • Reduction in production cost. • Potential for co-generation. • Additional ethanol production.	• Employment generation in rural areas. • Electricity saved can be used for some other purposes. • Ground water exploitation can be reduced. • Higher returns to government through tax collection from sugarcane industries.

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Sustainable Sugarcane Intensification, SSI in Odisha - An Initiation by NIRMAN

PRASANT MOHANTY
General Secretary, NIRMAN, Nayagarh, Odisha

Sustainable Sugarcane Initiative (SSI): 'More with Less' principles

Marginal land holding, poor soil fertility, more dependency on farming which is overloaded with water scarcity in the era of 'climatic variation' has been putting the debt bound farmers' into never ending economic crisis. In the midst of destabilized system of farming, sugarcane cultivation in the state is at stake. Farmers, who produce sugarcane, other than by ratooning, spend a huge amount for seeds, chemical fertilizers, pesticides, and intensive labour, as well as for water. The practices followed lead to inadvertent detrimental effects on soil fertility, with less biomass and overall pressure on water sources and ecosystems. Because sugarcane is a long-duration crop (with more than 9 months for a crop cycle), it faces one or another of the vagaries of nature that adversely affect cane and sucrose productivity.

In the district, farmers spend anywhere from Rs. 33,000 to 38,000 per acre ($720-830/ha) to produce 28 to 35 tons per acre (70-87 t/ha). Marginal, small and landless farmers can neither get any loans from the banks nor receive any subsidies, incentives or compensation from the Government. Thus, a huge investment in the crop is involved with greater socio-economic risk. A minimum variation in yield put the farmers' in economically-vulnerable conditions; find themselves either in a never-ending debt trap, or they are led to lease out or sell their piece of land.

Sustainable Sugarcane Initiative (SSI) based on the principles and practices of System of Rice Intensification (SRI) has been introduced in the region among farmers as a solution to the above. Extending or extrapolating the ideas and methods of SRI to sugarcane, SSI involves practices including: bud (seed) treatment (with lime and cow urine), seedling bed preparation on plastic cavity-trays, single bud transplantation, transplantation of young seedlings (25-35 days), wider spacing (2 ft x 4 ft), and organic manure application. These practices improve the productivity of land and water, producing more healthy canes with less seeds and with more economic benefits to the farmers, with environmental benefits additionally. The mulching of dried sugarcane leaves in the inter-row spaces of sugarcane sets conserves surface moisture and controls weeds, reducing the water loss due to them.

NIRMAN, with the support from AGSRI, intensively started promoting SSI in 3rd year (2011) of implementation. It started SSI promotion in 2009 over 4 acres with only 20 farmers from 4 villages of Nayagarh district with the help of WWF-ICRISAT. In the 2nd year (2010), the propagation has touched 56 farmers over 29.73 acres coverage. The technology has been transferred to nearly three times more number of farmers' and that of area expansion in 2011 (Table-1). In addition to area expansion in native district Nayagarh, NIRMAN has spread the technology in Ganjam and Bargarh. Farmers' and like organizations from Koraput, Cuttack and Khurda have been supported for SSI adoption. Besides other districts, Bargarh is a drought prone district located in western most Orissa. NIRMAN has tried to revive the sugarcane cultivation in the district; joined hand with 27 marginalized farmers and cultivated over 10 acres on pilot basis. NABARD representative from the district has already recognized and planned to adopt SSI over reasonable number of acres.

Table-1: Horizontal expansion of SSI

	2009	2010	2011 ahead	2011 (Pit method)
District	1	3	**3**	**1**
Block	1	5	**7**	**2**
Panchayat	2	6	**22**	**7**
Village	7	17	**30**	**15**
Farmers	20	56	**159**	**25**
Acre(s)	4	29.73	**108.5**	**20**

Till date, NIRMAN has targeted more than 58 percent marginal & small farmers along with 27 percent landless and 56 percent share croppers increasing their economic level through 'SSI' intervention.

Type of Farmers covered in Intervention					
Farmer Category	Medium farmers	Small farmers	Marginal Farmers	Landless Farmers	Share croppers
% in 2010	3.57	7.14	64.29	25	58
% in 2011	**10**	**9.0**	**52**	**29**	**55**

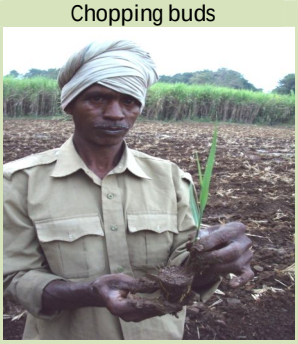
NIRMAN's working with the sugarcane growers of the district for the last two years has helped to clarify our understanding about costs of cultivation (Table-2), as well as of processing and marketing strategies for dealing with their food security.


Chopping buds


Seed treatment


Seedling bed


Seedling Nursery


Single seedling


SSI field


More number of tillers


Intercropping

The reduction in production costs is found to be beneficial to debt-bound farmers. It is estimated that by adopting SSI methods, a farmer will be able to produce at least 60% more sugarcane while reducing his water inputs by 3 times (or more).

Table-2: Conventional vs. SSI Management		
Particulars	**Conventional**	**SSI**
Seed (per acre)	76,800 nodes	5,600-6,500 buds
	Rs 14,400/- ($ 315)	Rs 1,300/- ($ 29)
Water	24 hrs/day for 4 days: 8 times in a crop cycle (768 hrs)	8 hrs/day for 3 days: 4 times in a crop cycle (96 hrs)
Labour (including irrigation)	1,190 person-days OR 1,776 hrs in a crop cycle	136 person-days OR 648 hrs in a crop cycle
Cost per acre	Rs 21,244/- ($ 464)	Rs 7,200/- ($ 157)
Intercropping	Nil	Possible – as a bonus for farmers
Fuel	Nil	Sufficient for a year for five member family

SSI is based on the principle of getting "more with less." Only 5,000 seedlings are required, weighing only 25-30 kg instead of the 5-6 tons of sugarcane required under the conventional method. Moreover, the farmer can crush the cane from which the buds were removed (after they are removed with a bud chipper) for making jaggery so this is an added economic benefit of SSI.

With conventional methods, the farmer must spend up to Rs. 16,000/- (nearly $ 350) just for seed. As with SRI, there is about a 90% reduction in seed costs when SSI is adopted. We see that with lower investment, a farmer can get more yields. This is true also for water. As there is irregular/deficient rainfall in the Nayagarh district and as sugarcane is the thirstiest crop- after paddy, SSI is a good solution to address the water-scarcity problems mentioned above as water is a growing constraint for sugarcane production. The savings in labor are also a major benefit for farmers. Reducing costs by two-thirds is an unprecedented attraction.

Experiences of SSI adoption:

Spacing in cultivation: Initially, all farmers refused to adopt the 5 feet spacing between rows. Whatever is the size of their piece of land, they didn't want to waste any space. Our gradual discussion made then agree to 4 feet spacing, and later a few farmers experimented with different spacing, e.g. 6 feet (in case of demonstration with drip irrigation), 4 feet, 3 feet, and 2 feet as well (Table-3).

Keeping all other factors such as variety of sugarcane, land type, soil type, water input, nutrient input, weeding and earthing up, etc. constant, they arrived at the following findings, which encouraged an increase in spacing at least to 4 feet:

Table-3: Experiments with different spacing

Spacing	No. of tillers	Length of internodes	Height	Girth (in cm)			Weight
				B	M	T	
6 ft	6	15 cm	315 cm	8	7.5	7	1.7 kg
4 ft	8	10 cm	373 cm	7.5	7.1	6.3	2.1 kg
3 ft	8	7.5 cm	357 cm	7.2	6	5.2	1.9 kg
2 ft	6	5.5 cm	330 cm	6.7	6	4.9	1.7 kg
B-bottom; M-middle; T-top							

More economic in-flow: It was found from farmers that selling of self-produced jaggery benefits them by three times more than supplying cane to the sugar factory. This further encouraged farmers to run their own processing units for jaggery, rather than to sell to the factory.

Fulfils fire wood requirements: Besides, the total bagasse from an acre's production (the biomass remaining after cane is crushed to extract the juice) is estimated to replace one year's firewood requirement for a five-member family. The family's dependence on fire wood is ended, saving as much as Rs. 18,000/- (almost $400), which further strengthens the household economic position.

Small scale agro-entrepreneurship: A few farmers later began to start producing and selling buds as a sideline business. They have taken on this activity as a way of income generation. The sugarcane bagasse can also be well powdered and mixed with other nutrient supplements to be made into a cattle feed. This aspect can be adopted for further economic development as it contributes to better animal health and production while generating additional income for households that produce feed.

Consumes less water, but assures irrigation source is indeed: Sustainable Sugarcane Initiative is a practice that requires 50% less water, but some minimum of water is of course needed. Some farmers are unable to provide irrigation during the water-short months of April and May. In the absence of an assured source of irrigation, it is found that SSI fields can face up to 40 percent crop damage for lack of water. Finding ways to assure supplementary irrigation as needed remains a constraint for SSI, as of course, it is (even more) for conventional sugarcane growth.

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Innovative Sugarcane Cultivation: Exciting Farmer Experiences on Sustainable Sugarcane Initiative, SSI in Medak, Andhra Pradesh, India

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Introduction

Enhancing sugarcane productivity is important both for the farmers and also the sugar industry. The critical steps to achieve this process are planting good quality seed material for establishing healthy and good plant stand in the field and good agronomic and crop management practices for higher yields. Given the conventional methods of planting cane setts, there is lot of wastage of cane and there is variability in the vigour and growth of plants in the sugarcane fields resulting in lesser yields and productivity. The situation therefore calls for innovative methodologies that can be adopted by farmers to address the issue of enhancing productivity and thereby higher income to farmers. *Sustainable Sugarcane Initiative* (SSI) methodology appropriately fits the requirement.

The WWF –international based at ICRISAT since 2004, among several projects had been working on increasing agricultural productivity with lesser use of inputs and environmentally sustainable mode- popularly called *more with less*. In 2008, the team put forward the Sustainable Sugarcane Initiative- SSI methodology, the principles which are set of good practices to address on sugarcane productivity with *more with less* approach. Studies were conducted in different locations in India through the WWF- International –ICRISAT project on the SSI field experimentation. Among the locations, the SSI methodology was tried in different locations in Medak district, Andhra Pradesh, India in 2009 and 2010. Since the inception of AgSri in 2010, the team continues to provide technical support on SSI methodology. In the context, the present paper discusses on the farmers' experiences on SSI methodology and cost comparison of SSI to conventional methods of cane planting of the mentioned locations in Medak district, Andhra Pradesh, India.

Background

Zaheerabad, located in Medak district Andhra Pradesh, India is one of the important sugarcane growing areas in the district; and the district has about 78 per cent people engaged in agriculture and allied activities. The average annual rainfall in the region is 873 mm (ranging from 635mm to 1036mm). The other sources of water for the farmers in the region include open wells, tanks and bore well facilities. In the region, both black and red soils can be seen where sugarcane is grown. Soil fertility is low to moderate and farmers apply organic and chemical fertilizers for the crops. In Zaheerabad mandal where sugarcane is grown, the farmers mostly sell the cane produce to Rajshree Sugar mills (then Trident Sugars) that is in the range of about 15 km and farmers with lands closer to Sangareddy mandal supply to Ganapathi sugars in the district.

Sugarcane cultivation- conventional method

In the district, since several years conventional method of cane cultivation has been in practice that involved planting large quantities of cane setts material, using high quantities of inputs such as water, fertilizers, chemicals; and these practices have been unsustainable. Higher costs of cultivation were incurred and the returns were medium to marginal. The average yields by the conventional method in the region have been in the range of 30 to 40 tons per acre. With decreasing water tables, low rainfall, increasing costs of fertilizers and chemicals, huge requirement of cane setts for planting, and non-availability and high labour costs, sugarcane cultivation was becoming difficult for the farmers.

Sustainable Sugarcane Initiative –SSI methodology

In 2009, as a farmers' need based sustainable approach for higher yields and better income with lesser inputs, the SSI was being promoted by WWF-International ICRISAT project in the sugarcane growing area. The key principles of SSI viz., raising nursery from single bud chips, transplanting young seedlings at wider spacing, maintaining optimal soil moisture conditions, fertilizer application in split doses, use of organics to provide for plant nutrient and for plant protection, and intercropping were to be adopted by the farmers.

Methodology

Thirty farmers from 4 mandals of Medak district viz., Zaheerabad, Nyalkal, Jharasangam and Raikode had adopted the new approach- the SSI methodology in the year 2010. The villages covered were Pastapur, Basantpur, Huggelly, Mogudampally, Metlakunta, Madgi, Shekapur, Pecharghad, Hothi-K, Hothi-B, Govindpur, Kuppanagar and Siroor. Farmers' in the study region have land holding in the range of 2 acres (small) to 5 acres (medium), in few cases 15 acres to 20 acres and the holding was also dependent on the family size. The farmers' who adopted SSI were in the age group of 25 to 50 years whose education ranged from high school to graduates; they have been practicing farming since 10 to 30 years.

The farmers interested in the approach were encouraged by the team to adopt SSI methodology in one acre of their land as a trial and follow the conventional method for the remaining sugarcane area. Initial training on SSI methodology was given to the farmers; however, since it was a new approach, the farmers required support for which guidance and regular monitoring was provided by the team. Nearly 1,50,000 seedlings nursery of varieties predominantly Co-86032 and, Co-62175 and Co-8014 varieties to some extent were raised by women self help groups supported by the project and distributed to 30 farmers. About 5000 cane seedlings-nursery were provided to each farmer to plant in one acre of land at the recommended spacing of 5' X 2'. The WWF-Intl. Team provided support on SSI methodology know-how, technical guidance on the steps such as the nursery, transplanting, agronomic and crop management practices during the preparatory and cropping period (years 2009 to 2010). Nursery transplanting was done in January and February 2010. Practices such as drip irrigation (80% of the farmers had adopted), optimal fertilizer application, and reduced chemical use were adopted in the SSI practiced fields. To study the effect of SSI approach on the sugarcane crop growth, yields, income and overall benefits, supporting data was collected at regular intervals during the crop period. For comparative assessment data was also collected from the conventional (farmers' practice) fields. Data on growth parameters such as number of tillers, and plant vigour; and water usage were periodically recorded. Yield attributes viz., number of millable canes per clump, individual cane weight and its height, and cane yield were recorded at the time of harvest. The cost of cultivation data and gross incomes was also documented to know the income benefits of SSI method.

Farmers' experiences and benefits of adopting SSI methodology

Farmers' field experiences on SSI methodology in the study region and how farmers were benefitted are presented hereunder. The farmers' experience sharing is supported with the data that was recorded during the crop season and harvest period.

Farmers were initially hesitant to adopt SSI approach due to the wider distance planting aspect. They assumed that with the recommended planting distance the overall plant stand would be less, and would affect the cane population and thereby the yields. However, they were satisfied when they harvested the crop and got higher yields.

The overall benefits of the SSI methodology were well reflected in the cane yields, gross income and profits that they made over the conventional approach. In general, the farmers were excited and happy about SSI method as there was lot of seed saving, it was easy method of cultivation, less water was needed, cost of cultivation was less, and they got more millable canes and higher yields compared to conventional method.

Though farmers initially felt that SSI planted fields may not perform better as the conventional fields looked good in the initial few days; with advancement of the crop stages and at the end of the season, SSI approach gave more millable canes and yields compared to the conventional practice.

For few farmers in SSI approach, the benefits were specially because seed rate was less where they used only about 5000 seedlings per acre in comparison to 48,000 buds planted derived from 16,000 three budded setts in conventional fields. It was easy to do the transplanting and operate in the field; and cultivation cost was much less than conventional method.

Ease of operations in SSI practice was also reflected while the farmers' were sharing their experiences. Many farmers were happy to have known about SSI methodology due to the overall ease of cultivation over the conventional method. They mentioned that it was easy watering with drip irrigation set up and saved on water. Farmers gave about 20 irrigations by drip method in SSI approach whereas more number of irrigations and higher costs were incurred by conventional irrigation methods. By this method farmers felt that the SSI method of cultivation was comparatively very easy over the conventional method. Intercultural operations such as weeding, earthing up and propping were much easier and required less labour compared to the conventional method.

Effect of time of planting was also found on the growth and yield in SSI adopted fields. Late planting effects were clearly seen in a case where the farmer took up planting in April 2010. Though relatively better yields were obtained in his SSI field compared to the conventional practice, when compared to other SSI adopted fields the yields were significantly lower. Due to very late planting, less number of tillers and lower cane girth was observed compared to other SSI fields which the farmer himself observed. As ideal planting time for the region is December and from their experiences farmers found that SSI planting could be done up to February.

The benefit of wider spacing (5' X 2') was also mentioned by farmers as they could do earthing up operation with the help of tractor because of wider planting. Another important benefit was due to wider inter row spacing, the farmers had opportunity to grow intercrops that would give them additional income.

Yield attributes

As SSI method advocates wider spaced cane cultivation, it provides more light and helps in better growth, with more number of tillers and millable canes contributing to higher yields. Similar trend was observed in farmer's fields.

Tiller number and millable canes per clump: In the SSI practice, good tillering and growth was seen compared to conventional practice. The minimum tiller number was about 8 per clump, and where there was good growth, the number went as high as 16 to 18 tillers per clump in SSI practice; the average number of tillers was about 10 per clump in SSI fields. While in conventional practice, the number of tillers was comparatively much lower and in the range of 5 to 8 tillers per clump with an average of 6 tillers per clump.

The millable canes that contribute to the final yields were also proportionate in SSI adopted fields with range of 6 to 14 millable canes and an average of 9 millable canes per clump. While in conventional practice only 4 to 6 millable canes were found with an average of 5 canes per clump. The millable canes in SSI plots were almost double the conventional practice. When farmers found high

tiller number (18) per clump, they believed that they would definitely get high yields with SSI methodology.

Individual cane weight: Higher cane girth, good height up to 12 feet in few cases was observed in the SSI fields. The individual cane weight in SSI practice was significantly higher compared to the conventional practice. With good cane growth, individual cane weight ranged from 1.5 kg to 2.6 kg in SSI practice, each cane on an average weighing about 1.9 kg (Table 1). In few SSI fields where the individual cane weight was higher in the range of 2.26 kg to 2.46 kg, higher cane yields were also recorded accordingly. In conventional practice, the individual cane weight was much lower and in the range of 1.2 to 1.6 kg with an average of 1.4 kg and this factor affected the cane yields in conventional practice.

Yields

In SSI adopted fields, impressive cane yields were recorded over the conventional practice. The harvest data showed that in SSI practice, yields recorded were in the range of 48 to 68 tons per acre with average of 57.5 tons per acre. In SSI practice where higher individual cane weights were recorded, cane yields were in the range of 65 to 68 tons per acre. Yields recorded in SSI practice in the range of 48 tons per acre were observed in farmer's fields who took up late transplanting and in few cases might have been also due to other factors such as poor soil fertility conditions. In conventional planting, farmers got comparatively lower yields that ranged from 35 tons per acre to 45 tons per acre with an average of 40 tons per acre. The farmers by adopting SSI practice got an additional yield in the range of about 8 tons to 24 tons per acre with an average of 16.2 tons per acre that gave them greater profits (Table 1.).

Table 1. Cane growth and yield in SSI practice and conventional practice

Parameter	SSI practice		Conventional practice	
	Range	Average	Range	Average
Tillers per clump	8 - 18	10	5 - 8	6
Millable canes per clump	6 - 14	9	4 - 6	5
Individual cane weight (kg)	1.5 – 2.6	1.9	1.2 – 1.6	1.4
Yields (t/acre)	46 - 68	57.5	35 - 45	40.1

Comparative Cost of Cultivation

Seed material, land preparation and transplanting: When the cultivation costs were assessed, farmers mentioned that they were largely benefitted by saving on seed material cost, with difference in the range of Rs. 1000 to Rs. 1500. A marginal reduction of Rs. 500 to Rs. 1,000 was found in the land preparation cost by adopting SSI practice. A benefit of about Rs. 400 to Rs. 600 was seen per acre in case of SSI method of transplanting over the conventional sett planting.

Irrigation and intercultivation: With reduced irrigations a difference of Rs. 1500 to Rs. 2000 was found in the irrigation costs by SSI approach. There was a significant reduction in the costs of intercultivation in SSI practice adding a benefit of Rs. 1000 to Rs. 3400 per acre.

Fertilizers, chemicals and harvest: Fertilizer costs incurred were lesser by Rs. 800 to Rs. 1000 per acre in SSI practice over the conventional practice. There was reduced use of plant protection chemicals adding a benefit of up to Rs. 800 in SSI practice. In contrast harvesting cost was higher in SSI compared to the conventional method ranging from Rs. 4500 up to Rs. 8000 per acre.

When overall cost of cultivation was calculated, in SSI approach the cultivation costs on average per acre (Rs. 44500) were lesser compared to conventional method (Rs. 46000), with an average difference of Rs. 1500. However in few cases in SSI practice, the farmers spent significantly lesser amounts by about Rs. 10,000 in comparison to conventional methods.

Though the SSI methodology advocated lesser use of inputs, most of the farmers tended to add more inputs to their fields, hence a relatively smaller difference in the cost of cultivation was seen between SSI and conventional practice.

Profits

Significant increases in gross returns were found in SSI adopted fields. The net income of farmers in SSI approach was in the range of Rs. 57,000 to Rs. 86,000 per acre with an average net income of Rs. 72,000. While in conventional practice, the net income of the farmers was in range of Rs. 26,000 to Rs. 46,000 with an average net income of Rs. 38,000. When the additional profits of SSI over conventional practice were compared, it was found that farmers got an extra profit in the range of Rs. 19,000 to Rs. 48,500 per acre, with an average of Rs. 34,000 with SSI practice. In few cases farmers very proudly mentioned that they got a profit almost double (about Rs.45,000) from SSI practice to what they generally got in conventional method. Interestingly even with late planting farmers got an additional benefit of Rs.26,000 with SSI method over the conventional method. And in few cases where farmers got a profit more than double, they ensured that they will continue and grow more area adopting SSI practice.

Looking at the profits and ease of operations, farmers plan to continue with SSI methodology, increase the area under SSI practice and if support is available, many of them want to shift their sugarcane growing area completely under SSI methodology. Some of the farmers want to be model farmers of SSI methodology in their locations.

Spill over effects and Micro-enterprise

Learning from the SSI experiences, farmers started adopting possible components of the SSI principles to other crops also. It has in a way helped them think of innovative and effective approaches in their farming as a whole. Further, to meet the requirements for SSI method of cane cultivation, organic usage components, vermicompost, panchakavya preparation activities have emerged. With this micro-enterprises such as mechanised bud chipping activities and SSI nursery material supply units, vermicompost or organic fertilizer making units have been set up. Nursery raising activities have become part time income generating activity for women, self help groups and farmers, and also during off season.

From the farmers

As the adoption of SSI methodology has been a farmer participatory approach, based on the field experiences of the farmers, following are few aspects that farmers are looking at:

1. To have a year long sugarcane nursery; to support this more number of farmers to raise sugarcane nursery to make it available all through the year.
2. Nursery raising activity may be taken up in every village or villages nearby to the farms for easy availability of the nursery that would also avoid hurdles of transportation.
3. Alternately since transportation of seedlings to the field at times is difficult, the farmers want this responsibility to be taken up either by the factory or the nursery sellers.
4. Every year factory units could also supply seedlings to farmers and overall factory units to follow up.

5. More number of varieties and improved varieties must be used in nursery raising centres.
6. Nursery raisers should ensure supply of good quality sugarcane seedlings of good varieties.
7. Continued support on SSI is the key requirement and the farmers wanted SSI experts to guide them on the practices, and trained persons to regularly visit the fields for good success.

By addressing above aspects such as providing timely and good quality seedlings along with guidance on SSI practices, it would help establish SSI methodology more successfully in sugarcane growing regions.

Opportunities and way forward

Based on the field experiences, there is a need to capacitate the farmers and provide them with hand holding support on the SSI methodology. As increasing cane productivity is important both for farmers and the factory units, focus on processes that support adoption of SSI methodology in the fields is required. Some of the suggested approaches that may be considered are:

- For greater SSI adoption, process to ensure availability of seedling nursery during the main sugarcane planting season.
- Factory units could tie up with nursery sellers to provide timely seedlings to the farmers' in their regions.
- Setup processes that would decrease the cost of the nursery.
- Suitable varieties to be made available for the region and provide good quality cane seedlings nursery.
- Setting up of SSI supporting microenterprises that would create additional rural employment opportunities.

Research organisations, factory units, and SSI promoting teams as AgSri, along with the farmers need to form a consortium and work towards achieving the common goal. Teams like AgSri who have expertise on SSI methodology could act as connecting link between the farmers and sugar industry to support on training and providing technical guidance for larger scaling up of the SSI methodology under the sugarcane growing area. This would immensely help the beneficiaries' viz., farmers and industry and the association would be mutually rewarding with greater sustainability.

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Studies on Physiological Aspects of Growth, Quality and Yield of Bud Chip Technology in Sugarcane

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Abstract

A field experiment was conducted at Agricultural Research Station, Basanthpur-Mamidigi to study the growth behavior, yield and quality of bud chip in comparison with traditional system by using eight different varieties of sugarcane during 2009-10 and 2010-11. The results revealed that propagation bud chip method had recorded higher cane yield (148.56 t/ha) compared to traditional method (139.3 t/ha). The stool weight (22.37 kg), leaf area index (6.82 cm2), cane height (340 cm), cane girth (3.36 cm) and single cane wt (2.36 kg) were higher in the bud chip method compared to traditional method.

Introduction

Sugarcane is an industrial crop; its area in A.P. shows a declining trend in recent years due to increased cost of cultivation. To prevent this decreasing trend in area it is necessary to bring some changes in cultivation aspects which will improve the profitability. Sugarcane as a C_4 plant, is considered as one of the most efficient converters of solar energy (N.V Naidu 2003), thus having potential to produce huge amount of biomass. The plant also can grow very quickly and is more efficient at using CO_2 and is resistant to drought and high temperature. With these advantages it is possible to increase the productivity of the crop by adopting SSI practices.

Water is also increasingly becoming a major limiting factor in r agriculture and any practice that will give scope for reducing water input is to be encouraged. Bud chip method coupled with drip irrigation in sugarcane could give higher cane yield.

The major soils in the areas of Zaheerabad division of Medak district are medium to light type viz., laterite to chalka soils. Sugarcane is best suited crop for this particular belt. Bud chip system is an improved method of sugarcane planting and requires only 800 kgs of seed material for planting one acre. Even these canes where buds are chipped out can be used for juice extraction or in production of jaggery or sugar.

Keeping these in view, the Agricultural Research Station, Basanthpur- Mamidigi has conducted an experiment on sustainability of sugarcane by using bud chip system to study the growth, yield and quality of bud chip in comparison with traditional system by using eight different varieties of sugarcane during 2009-10 and 2010-11. The trial was designed with 150 cm spacing between the rows and 45 cm within the row under surface method of drip irrigation. The data on percent germination, tiller count, number of malleable canes, leaf area index, cane girth, dry matter production were collected.

Results & Discussions

The results revealed that the propagation through bud chip method recorded better expression of growth attributes (Table 1) viz., cane girth, tiller number, NMC, photosynthetic rate and dry matter production. However there were some variations noticed among the varieties. Co 86032 has recorded higher production of tillers (89.50) and number of millable canes (83.05) in the bud chip method of planting and this variety seems to be significantly superior. The crop performance in terms of photosynthetic rate recorded higher for bud chip method of planting especially in Co 99006 and Co 86032, 22.9 and 21.2 (µ mol/Co2/m2/sec) respectively. There were some varieties having shy tillered

nature, these varieties were poor in harvesting net radiation under wider spaced system. 83 A 30 an early maturing sugarcane variety occupies a major area in southern parts of Medak district, This variety recorded the highest length of cane (340 cm) in sett method of planting, but at the expense of better tillering. The cane girth and dry matter production at 120, 150 and 180 DAP (0.44 kg/plant) were better for 97 R 401 (3.36 cm) in bud chip method as compared traditional method of planting.

Table 1 Growth attributing factors of sugarcane varieties

	Tiller (000/ha)		NMC (000/ha)		Plant Ht (Cm)		Photosynthetic rate (µ mol/Co2/m2/sec)		Dry matter 180 DAP (kg/plant)	
Varieties	**Sett**	**Bud chip**	**Sett**	**Bud chip**	**Sett**	**Bud chip**	**Sett**	**Bud chip**	**Sett**	**Bud chip**
Co 86032	87.7	89.5	78.1	83.1	315.0	328.0	20.3	21.2	0.3	0.3
Co 8014	69.7	72.7	66.2	68.2	285.0	291.3	18.6	18.9	0.3	0.3
Co 99004	63.2	66.2	61.2	43.4	308.0	316.7	19.6	19.6	0.3	0.2
Co 99006	73.4	76.9	68.1	70.0	300.6	298.7	22.6	22.9	0.3	0.3
Co 94008	72.4	76.2	65.6	71.0	301.0	303.3	18.6	17.8	0.3	0.3
97 R 401	63.6	64.2	52.9	55.7	304.3	323.0	21.4	22.8	0.4	0.4
97 R 129	72.4	78.9	60.6	63.0	289.3	294.7	19.4	18.8	0.4	0.4
83 A 30	76.3	78.2	64.8	70.7	340.7	334.2	18.6	19.4	0.3	0.3
Mean	72.3	75.4	64.7	65.6	305.5	311.2	19.9	20.2	0.3	0.3
CV (%)	4.07		4.22		7.86		8.02		5.26	
CD(0.05) Planting	2.33		2.141		5.44		0.32		0.002	
CD(0.05) Varieties	4.66		4.282		10.89		0.24		0.038	
Planting x Varieties	NS		NS		NS		NS		NS	

Among the different yield attributing factors (Table 2), the crop from bud chip seedlings gave higher levels of expression. The single cane weight was the highest in 83 A 30 (2.36 kg) and the clump weight (22.37 kg) and cane yield in Co 86032 (148.52 t/ha). Sucrose percent was the highest in Co 86032 but there are no varietal differences for sucrose percent.

Table 2 Yield attributing factors of sugarcane varieties

	Cane girth (cm)		Single cane wt (kg)		Clump wt (kg/clump)		Sucrose (%)		Yield (t/ha)	
Varieties	**Sett**	**Bud chip**	**Sett**	**Bud chip**	**Sett**	**Bud chip**	**Sett**	**Bud chip**	**Sett**	**Bud chip**
Co 86032	3.1	3.1	2.3	2.3	21.2	22.4	19.4	19.4	139.3	148.6
Co 8014	2.8	2.9	1.7	1.7	16.1	17.3	18.9	19.0	127.3	134.8
Co 99004	2.9	2.9	2.0	2.0	9.2	14.5	19.3	19.1	125.0	121.7
Co 99006	3.1	3.1	1.7	1.8	10.8	16.4	18.9	18.8	129.3	138.7
Co 94008	3.1	3.2	1.9	2.0	13.4	16.2	19.0	19.2	124.3	127.0
97 R 401	3.3	3.4	2.3	2.3	19.1	21.7	18.6	18.6	130.0	129.3
97 R 129	3.0	3.0	1.9	2.0	15.3	16.8	18.6	18.7	117.0	133.0
83 A 30	3.1	3.1	2.3	2.4	19.3	23.5	18.9	18.8	130.0	138.0
Mean	3.0	3.1	2.0	2.1	15.6	18.6	19.0	19.0	127.8	133.9
CV (%)	9.62		7.05		5.75		1.62		3.89	
CD(0.05) Planting	1.633		0.097		0.026		NS		2.99	
CD(0.05) Varieties	3.26		0.195		0.056		0.36		5.99	
Planting x Varieties	NS		NS		NS		NS		NS	

Since Co 86032 has a very good potential to produce more number of tillers, adoption of bud chip methodology to reduce input cost and can make it viable for sugarcane cultivation. Any other variety suitable for the area can also be cultivated under bud chip method to realise higher returns.

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Progress of Sustainable Sugarcane Initiative

GOPINATH
PONNI SUGARS (ERODE) LTD, Tamil Nadu

In order to overcome constraints in Sugarcane cultivation and maintain sustainability in production, our focus should be

- To reduce Cost of production of cane - for better income
- To improve Yield & Quality of cane - for sustainability
- To mechanize cultivation of cane - to overcome labour problem

We, at Ponni Sugars (Erode) Ltd with the above in mind, we now work with SSI to overcome the hurdles as this has the capacity to:-.

- Produce more with less
- Increase water and Fertilizer use efficiency
- Encourage mechanization coupled with Drip and Wider row planting.

Our Objectives and Priorities

- To meet out Primary nursery seed material requirement
- Drip irrigated wider row spaced plant crop fields
- For gap filling in both plant and ratoon Fields

Facilities at Factory

- State of art facility SSI nursery at Factory site in an area of 3000 sq.feet, have the capacity of producing 50,000 quality seedlings/ month, proposed to go up to 1.5 lakh seedlings / month in the days to come.
- Use mini poly tunnels of 2mx1m for uniform and early germination of buds
- Arrange for transport of seedlings from Factory to Farmers fields
- Seedlings to Farmers at subsidized cost and recovery from the crop cane proceeds (after one year).
- Arrange frequent trainings at nursery as well as Fields and visit to farmers fields.

Steps to produce quality seedlings

- Use healthy single bud instead of Chip bud or healthy single bud from Tissue culture derivatives
- Organic forms of N PK through Biofertilizers form apart from VAM are incorporated in the Coco-Pith medium for sturdy, vigorous seedlings for better Field establishment.
- Maintaining the trays under 50% shade for 10 days, do grading and foliar spray i.e. NPK and micronutrients.
- Keeping in partial shade for 7 to 10 days to attain required growth and effect dispatch to needy farmers.

By adopting the above, we hope to improve productivity, quality and thereby sustenance in sugarcane production in the days to come.

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