Reference:
Training Manual on Sustainable Sugarcane Initiative: Improving Sugarcane Cultivation in India, An Initiative of ICRISAT-WWF Project, ICRISAT, Patancheru - 502 324, Andhra Pradesh, India. E-mail:info@agsri.com.

Sustainable Sugarcane Initiative

Introduction

Water is increasingly becoming a major limiting factor for agriculture, especially where irrigated crops and dry land agriculture are intermixed. Often in the same watershed, both irrigated crops such as rice and sugarcane exist with dry land crops such as sorghum and millets. In such circumstances, the impact of irrigated crops on dry land agriculture is significant, particularly in semi-arid regions, where irrigation is primarily based on ground water exploitation, leading to decline in soil moisture and seriously reducing the productivity. Further, the erratic trends in rainfall add to the growing complexity of the water issues. Thus, we need to explore every possible approach to reduce the water input to all crops, particularly those which excessively depend on scarce resources. Any water reduction to thirsty crops such as sugarcane will have a positive impact on the dry land agriculture in the same region. To improve productivity and protect the ecosystem, an integrated approach to agriculture involving all stakeholders is essential in tackling pressing issues such as the decline in productivity, ground water table, soil moisture and the uncertainty of monsoons, all of which are interlinked. On one hand, watershed management can improve the water resources in basins, but on the other hand, until and unless that water is used more productively, the investments will not yield results.

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, India will find it difficult to meet its growing demand for sugar.

Sugarcane is an important crop in India. There are 35 million farmers growing sugarcane and another 50 million depend on employment generated by the 571 sugar factories and other related industries using sugar. In Uttar Pradesh, Maharashtra and Tamil Nadu, sugarcane plays a major role in the state economy.

During the last 10 years, sugarcane production in India has been fluctuating between 233 million tonnes and 355 million tonnes. Similarly, the productivity at the farm level is as low as 40 t/ha. With such low yields and fluctuations in production, and India having the second

largest area under sugarcane cultivation in the world next to Brazil, the industry is in for big trouble.

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, India will find it difficult to meet its growing demand for sugar. Under such situation development of new technology involves less input to produce more will be the viable option.

Sugarcane in India is grown in two distinct agro-climatic regions – the Tropical (largely comprising Maharashtra, Karnataka, Gujarat and Tamil Nadu) and the Sub-tropical (Uttar Pradesh, Punjab, Haryana and Bihar).

Among the states, Uttar Pradesh occupies half (2.25 m.ha) of the total area followed by Maharashtra (1.04 m.ha). Though UP dominates in production with 134 MT followed by Maharashtra with 79 MT, in terms of productivity, Tamil Nadu leads with 105 t/ha followed by Karnataka (88 t/ha) and Andhra Pradesh (82 t/ha).

Yet despite its long tradition and large area in India, in terms of productivity, sugarcane yields are unimpressive, especially where the crop is irrigated. The average productivity of sugarcane is low with certain regions reporting yields as low as 40 t/ha only. Not only is the cane yield low, the sugar yield - typically at less than 10% of cane weight - is also less than satisfactory given that yields of 14% of cane weight at the time of cutting (and sometimes much higher) are possible. The Australian sugar industry for instance is regularly typifi ed by sugar yields of around 14%, while yields of up to 25 tonnes of sugar per hectare have been reported in Hawaii! Sugarcane cultivation and the sugar industry in India are facing serious challenges due to various internal and external factors.

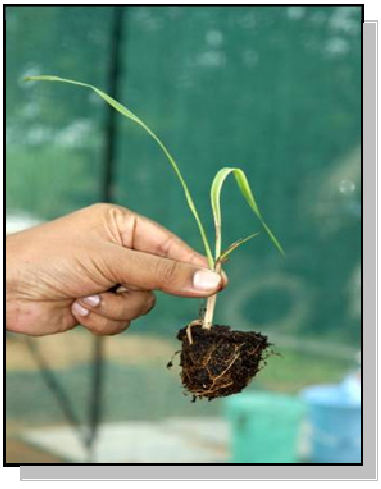
The reasons for such low productivity are:

- The improved varieties released by research organizations perform well in the initial years but lose their vigour and decline in yield in due course.
- Water availability is unpredictable. The concern is not only thequantity of water required, but also the lack of proper water management practices. Due to this, water is either wasted or sometimes not available at the right time.

- Unpredictable climatic aberrations, improper cultivation practices, negligence in plant protection measures, imbalanced nutrient management and other practices like mono cropping often result in low productivity, fetching low price in the market.

In addition, it is also very important to consider the enormous amount of water that goes into the sugarcane production. Approximately 25,000 kg of water is needed to produce 10 kg of sugarcane. But, the water table is depleting every year. Costs of production, moreover, are increasing not just for the small farmers but for the large industrial players as well. In future, these challenges will become even more complex with climate change inducing direct and indirect effects on crops, water, pests and diseases, and volatility in the international market.

A recent FAO report predicts sharp shortfall of sugar production in India in the year 2009. On one hand, there is the opportunity in terms of growing demand for sugar and other bi-products of sugarcane, and on the other hand, there is the decline in production and productivity due to various reasons. The rising cost of farm chemicals, along with the increasing social and environmental costs of water use by the agricultural sector and the pollution accruing to modern, input intensive production practices have begun to raise serious questions in the minds of policy makers, planners and farmers alike. Any problem affecting the sugar sector is a widespread problem, affecting a significant number of households and ecosystems. The desirability of a widely replicable solution is therefore equally obvious.



This question is already being addressed in the rice sector, with the System of Rice Intensification (popularly known as SRI). SRI is an integrated approach that greatly reduces irrigation water requirements while producing a range of benefits including higher yields, better quality rice, less chaff and resistance to lodging.

The Sustainable Sugarcane Initiative (SSI) is yet another practical approach to sugarcane production which is based on the principles of ‘more with less’ in agriculture like System of Rice Intensification (SRI). SSI improves the productivity of water, land and labour, all at the same time, while reducing the overall pressure on water resources.

Sustainable Sugarcane Initiative (SSI)

Sustainable Sugarcane Initiative is a method of sugarcane production which involves using less seeds, less water and optimum utilization of fertilizers and land to achieve more yields. Driven by farmers, SSI is an alternate to conventional seed, water and space intensive Sugarcane cultivation.

The major principles that govern SSI can be stated as below:

- Raising nursery using single budded chips
- Transplanting young seedlings (25-35 days old)
- Maintaining wide spacing (5X2 feet) in the main field
- Providing sufficient moisture through water saving efficient irrigation technologies viz., skip furrow, alternate furrow and subsurface drip irrigation

- Practicing intercropping with effective utilization of land

Water management

- Produce more per mm of water and all other inputs
- Raise cane crop even under marginal lands
- Raise crop in problem soils and water
- Minimum tillage

- Create micro catchments for water harvesting
- Multi-ratooning
- Produce higher cane yield with less water

Fertigation schedule for sugarcane

RDF - 275:63:115 NPK kg/ha Once in 10 days

Stage (Day After Planting)	(kg/ha)		
	N	P	K
0-30	39.4	0	0
31-60	48.6	26.25	9
61-90	51.4	20.50	13.5
91-120	55.2	16.25	14.6
121-180	57.8	0	40.5
181-210	10.5	0	35.0
Total	275.0	63.0	115.0

Overall benefits

- In conventional method, cost of setts occupies the major part of cost of cultivation
- By practicing SSI, this seed cost can be reduced up to 75%
- Reduction in the plant mortality rate
- Increases in the length and weight of each cane
- It is easy to transport the young seedlings for longer distance
- Intercultural operations can be carried out easily due to wider spacing

Opportunities offered by SSI

- Addresses the issue of late planting by raising seedlings and their transplantation later on which actually advances the entire process.
- Addresses the issue of narrow spacing as the technology is based on successful

exploitation of sunlight and air by following wider spacing in the main field.

- ❖ Addresses the problem of improper method of irrigation, namely, flooding.
- ❖ Significant reduction in seed requirement, as only the bud is used as seed material.

Comparison between Conventional and SSI methods of Sugarcane Cultivation

Particulars	Conventional method	SSI method
Seeds/Setts	48,000 buds (16,000 three budded setts)	5000 single budded chips (5,000 buds per acre)
Nursery preparation	No	Yes
Planting	Direct planting of setts in the main field	Transplanting of 25-35 days old young seedlings raised from bud chips
Spacing	1.5 to 2.5 ft between rows	5 ft between rows
Water requirement	More (flooding of field)	Less (maintenance of moisture in the furrows and adoption of drip irrigation)
Mortality rate among plants	High	Low
No. of tillers per plant	Less (10-15)	More (15-20)
Accessibility to air and sunlight	Low	High
Scope for intercrop	Less	More

Scope of SSI in Tamil Nadu

Tamil Nadu, being the number one state in sugarcane productivity (more than 100 t/ha), has a great potential in SSI. The following are some of the reasons to foresee the great impact of SSI in Tamil Nadu sugarcane sector.

- ❖ Farmers are very much innovative, eager to take up any new technologies with great enthusiasm and support.
- ❖ SSI will be a suitable option to solve the present problems of increasing seed cost,

labour cost and other soil fertility and productivity related issues.

- ❖ Due to wider spacing, intercultural operation becomes easy, thus reducing the drudgery among women labourers.
- ❖ The wider spacing suggested in SSI are ideal in case of introducing Mechanical harvester, an effort already in practice in some of the Mills areas in Tamil Nadu.

Conclusion

SSI involves use of less seeds, less water and optimum land utilization to achieve more yields. It is governed by some principles like using single budded chips, raising nursery, wider spacing, sufficient irrigation and intercropping. By practicing these measures, the following benefits can be realized:

- Better germination percentage
- High number of millable canes
- Reduction in the duration of crop to some extent
- 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 and
- Extra income from intercrops

On the whole, by practicing SSI farmers can very well increase their productivity by reducing the use of inputs like fertilizers and saving the vital resources like water simultaneously. Hence, it is very much possible for sugarcane farmers to reap greater economical benefits by maintaining ecological sustainability.

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Science with a human face

Sustainable Sugarcane Initiative

SSI

Improving Sugarcane Cultivation in India

Sustainable Sugarcane Initiative

Training Manual

An Initiative of
ICRISAT-WWF Project

Sustainable Sugarcane Initiative (SSI)
Improving Sugarcane Cultivation in India

Training Manual

March 2009

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Note:
The information in the manual has been produced after extensive research and verification by ICRISAT-WWF project team with support of highly acclaimed sugarcane farmers, experts, institutes, agencies and practical experiences. However we would appreciate critical comments or additional information concerning the contents of this manual.

Sustainable Sugarcane Initiative

Contents

Foreword

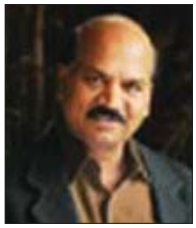
Water is increasingly becoming a major limiting factor for agriculture, especially where irrigated crops and dry land agriculture are intermixed. Often in the same watershed, both irrigated crops such as rice and sugarcane exist with dry land crops such as sorghum and millets. In such circumstances, the impact of irrigated crops on dry land agriculture is significant, particularly in semi-arid regions, where irrigation is primarily based on ground water exploitation, leading to decline in soil moisture and seriously reducing the productivity. Further, the erratic trends in rainfall add to the growing complexity of the water issues. Thus, we need to explore every possible approach to reduce the water input to all crops, particularly those which excessively depend on scarce resources. Any water reduction to thirsty crops such as sugarcane will have a positive impact on the dry land agriculture in the same region.

To improve productivity and protect the ecosystem, an integrated approach to agriculture involving all stakeholders is essential in tackling pressing issues such as the decline in productivity, ground water table, soil moisture and the uncertainty of monsoons, all of which are interlinked. On one hand, watershed management can improve the water resources in basins, but on the other hand, until and unless that water is used more productively, the investments will not yield results.

In order to understand and address the water issues in a holistic way, the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) entered into a partnership with the World Wide Fund for Nature (WWF). The joint project on 'Improving the water productivity of the agriculture' is researching non-traditional and out-of-the-box approaches wherein the resource inputs are low and yields are high. The Sustainable Sugarcane Initiative (SSI) is one such approach that could reduce the inputs - water, fertilizer, seed material - while improving sugarcane production significantly. This farm-based approach gives farmers options to grow intercrops such as pulses to improve their income, while effectively using the soil moisture to grow dry land crops. This manual describes, step-wise, how to put SSI in to practice. It has been developed following extensive consultations with farmers and is very user friendly. It will be translated soon into several Indian languages so that farmers can use and benefit from this new method.

I am delighted that the ICRISAT-WWF partnership is working on solutions to address the water crisis without compromising on agricultural production. The WWF, with its main mandate of protecting the ecosystems, is working with a vision that the methods like SSI will help in producing more while reducing the ecological foot print of agriculture. Similarly, ICRISAT is collaborating with WWF to understand and integrate the ecological concerns of agriculture. This partnership is unique and we are looking forward to many more practical results on the ground. This manual is one such attempt. I do hope farmers and researchers will be able to use it effectively to address the pressing issues of sugarcane production in general and the water crisis in particular.

William D. Dar
Director General
ICRISAT



Preface

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, India will find it difficult to meet its growing demand for sugar.

Sugarcane is an important crop in India. There are 35 million farmers growing sugarcane and another 50 million depend on employment generated by the 571 sugar factories and other related industries using sugar. In Uttar Pradesh, Maharashtra and Tamil Nadu, sugarcane plays a major role in the state economy.

During the last 10 years, sugarcane production in India has been fluctuating between 233 million tonnes and 355 million tonnes. Similarly, the productivity at the farm level is as low as 40 t/ha. With such low yields and fluctuations in production, and India having the second largest area under sugarcane cultivation in the world next to Brazil, the industry is in for big trouble.

The Sustainable Sugarcane Initiative (SSI) aims at providing practical options to farmers in improving the productivity of land, water and labour, all at the same time. In addition, it reduces crop duration and provides factories a much longer period of crushing season and hence increasing employment to a longer period of time. SSI is also expected to reduce the overall pressure on water resources and contribute to recovery of ecosystems.

It is important to mention here a few things about SSI and this manual. This is a farm based method and farmers have the option to use the variety of their choice. The SSI is a package of practices based on the principles of 'more with less' in agriculture. The inspiration for putting this package together is from the successful approach of SRI- System of Rice Intensification. SSI is another practical approach that originated from farmers and the civil society to improve productivity while reducing the pressure on natural resources. This will contribute to reducing the human footprint on planet earth.

This is a step-wise manual. The practices mentioned in the manual did exist here and there in a small way. Most of these practices were innovated and improvised by the farmers. Our contribution is to put all of them together after extensive consultation with farmers. By no means is this a comprehensive compilation of the farm based practices. There are many more, and we are in the process of collecting them, testing and improvising to suite the local conditions. This process will continue. So this manual is a first attempt and we do hope we will be coming together with more

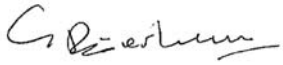
options to improve the sugarcane production in future. Our aim is to make sugarcane cultivation simple, affordable and profitable for both the small and big farmer and the industry.

We also hope the practices prescribed in this manual will be adopted based on the local agro-climatic conditions. We are aware of the difficulties in prescribing certain things. For example, we suggest to the farmers to totally adopt organic methods to improve the quality of sugarcane and the soil. While that is our recommended practice, farmers may opt for the more pragmatic approach - gradually reducing the inputs and building the soil fertility through various methods. Similarly, practicing SSI using drip irrigation will save water up to 80%, but that requires capital costs. So we expect financial institutions to play a role in providing the credit at affordable rates as part of improving the production and saving water in large quantities. Farmers need some incentives and support to switch to drip irrigation.

We estimate that by adopting SSI, a farmer will be able to produce at least 20% more sugarcane while reducing 30% of water input and 25% of chemical inputs. There is no other proven method available today which can do both - reducing water pressure while improving the productivity. In addition, SSI will also offer an opportunity for farmers to grow another short duration crop in between the rows to get additional income. Sugarcane millers will have the opportunity to use their machinery and human resources in a much more productive way to improve their profitability.

By the end of 2009, we will be revising this manual and producing it in many local languages with the help of partners. By then we will have a lot more data based on demonstration sites we are establishing using the SSI method. We will be incorporating the experiences to fine tune this method.

The current crisis in agriculture is great opportunity. As part of adapting to the climate-induced uncertainties, the agriculture sector needs to take advantage of the farm based methods to improve productivity. The SRI in rice and SSI in sugarcane have proved the potential of addressing the water crisis while improving the productivity and profitability. India needs to invest in these methods to upscale to see the full positive impact of such approaches at the national level. It is also time for civil society, government agencies to work together to support the farmers in adopting these methods in a big way.



Dr. Biksham Gujja
Team Leader ICRISAT-WWF project

In India, sugar is a Rs. 30,000 crore industry, the second largest in the country in the agro-processing sector, next only to Textiles, and represents the principle livelihood of 35 million farmers.

Background

Celebrations without sweets and cakes and a cup of coffee or tea without sugar are unthinkable. Sugar which adds sweetness to our life is extracted from the juice of the sugarcane. The thick stalks of canes store energy as sucrose in the sap. The cultivation of sugarcane dates back to the Vedic period. The most ancient reference to sugarcane is in `Athervaveda' which is 5000 years old, and the word 'sugar' is derived from the Sanskrit word *Sankkara*/*Sarkara*. In the 1400 - 1500 AD in India, cows belonging to the Sultan of Mandu were fed with sugarcane for weeks to make their milk sweet for use in puddings.

India ranks second in the world, after Brazil, in terms of area (4.1 m.ha) and sugarcane production (355 million tonnes in the year 2007).

Different species of sugarcane likely originated in different locations with *Saccharum barberi* originating in India and *S. edule* and *S. officinarum* coming from New Guinea. The first sugar mill in India was established in Bengal on the banks of river Hoogly in the year 1784. By 1994 - 1995, India had about 408 mills in operation with an average crushing capacity of 2452 tonnes (t) per day and a crushing duration of 161 days. By March 2005, the total number of sugar factories in India were 571.

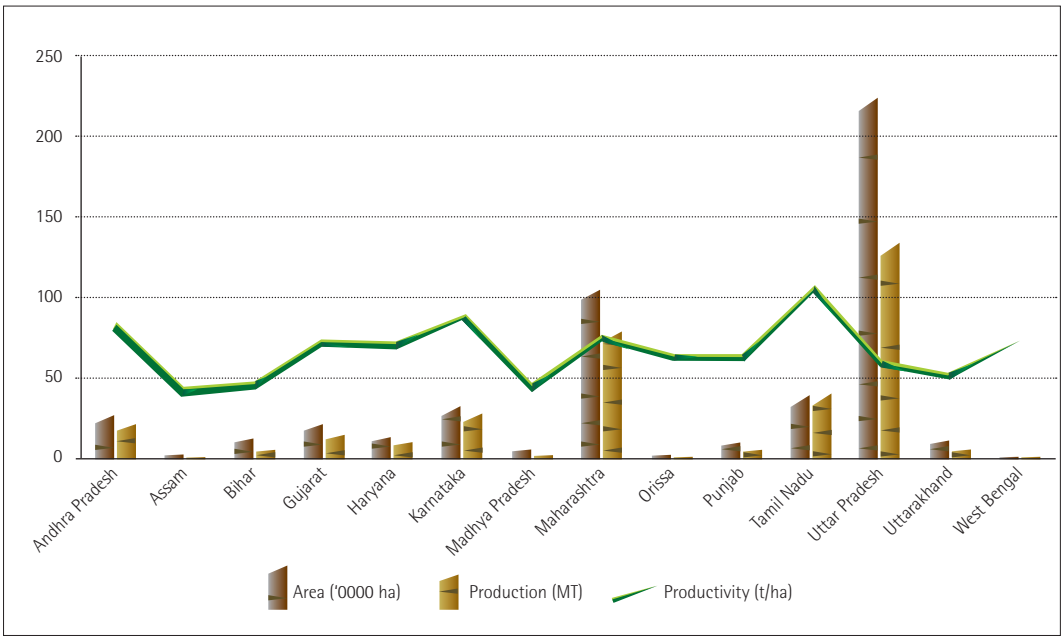
Today, India ranks second in the world, after Brazil, in terms of area (4.1 m.ha) and sugarcane production (355 million tonnes in the year 2007).

In India, sugar is a Rs. 30,000 crore industry, the second largest in the country in the agro-processing sector, next only to textiles, and represents the principle livelihood of 35 million farmers. Apart from this, sugarcane is in great demand for various other uses like fodder, paper production and most importantly bio-fuels. In a typical sugar mill, 100 t of sugarcane on an average produces 10 t of sugar, 4 t of molasses from which ethanol is produced, 3 t of press mud which is converted into bio-fertilizer, 30 t of bagasse used for cogeneration of power to yield 1,500 kw electricity and for manufacturing paper. Besides, about 30 t of cane tops and leaves are generally left in the field, which through recycling further adds to the economic value of the crop.

Crystal sugar

There is a growing demand for sugar in India as it is the largest sugar consuming country in the world (around 20 million tonnes in the year 2007-08).

State-wise Area, Production and Productivity of Sugarcane in India (2006-07)



Source: Directorate of Economics and Statistics, Ministry of Agriculture

Sugar factory

Despite long tradition and large area in India, the average productivity of sugarcane is low with certain regions reporting yields as low as 40 t/ha only.

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Traditional Jaggery making

Sugarcane dependent livelihoods

given that yields of 14% of cane weight at the time of cutting (and sometimes much higher) are possible. The Australian sugar industry for instance is regularly typified by sugar yields of around 14%, while yields of up to 25 tonnes of sugar per hectare have been reported in Hawaii!

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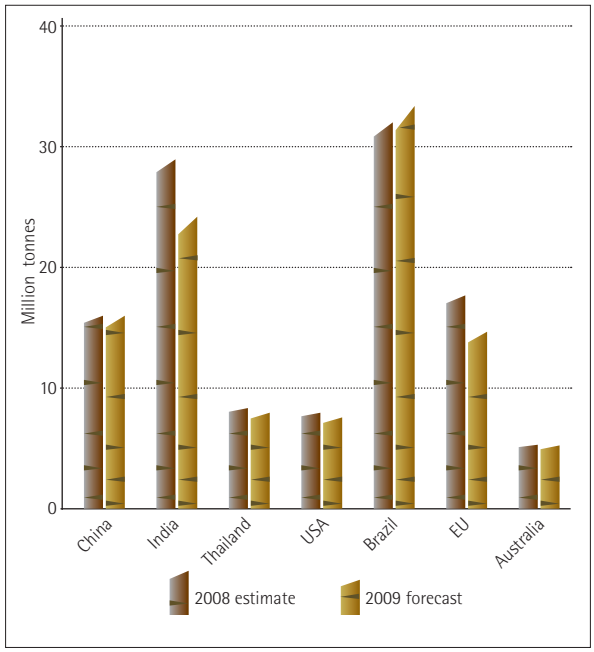
- Unpredictable climatic aberrations, improper cultivation practices, negligence in plant protection measures, imbalanced nutrient management and other practices like mono cropping often result in low productivity, fetching low price in the market.

World Sugar Production Forecast (2008-09)



Source: Food Outlook, Global Market Analysis, Nov. 2008

In addition, it is also very important to consider the enormous amount of water that goes into the sugarcane production. Approximately 25,000 kg of water is needed to produce 10 kg of sugarcane. But, the water table is depleting every year. Costs of production, moreover, are increasing not just for the small farmers but for the large industrial players as well. In future, these challenges will become even more complex with climate change inducing direct and indirect effects on crops, water, pests and diseases, and volatility in the international market.

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Sugarcane research field

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This question is already being addressed in the rice sector, with the System of Rice Intensification (popularly known as SRI). SRI is an integrated approach that greatly reduces irrigation water requirements while producing a range of benefits including higher yields, better quality rice, less chaff and resistance to lodging.

With this in mind, being very similar conceptually and philosophically, the ongoing ICRISAT - WWF project has designed the Sustainable Sugarcane Initiative, SSI in short. SSI is a combination of cane planting innovations and water saving practices that has great potential for not only meeting the growing demands of sugar sector players looking for increased revenues and profitability, but also for the bigger picture of improved natural resource management, reduced environmental footprints and improved livelihoods by means of technologies that are appropriate and effective at household farm level.

If India has to sustain its sugarcane production, it importantly needs to improve the productivity of the sugarcane per unit of land, water, labour and capital all at the same time while striking a balance between economy and ecology.

Crushing of canes

Sustainable Sugarcane Initiative (SSI): An Introduction

Sustainable Sugarcane Initiative is a method of sugarcane production that involves the use of less seeds, less water and optimum utilization of fertilizers and land to achieve more yields. Driven by farmers, SSI is an alternative to conventional seed, water and space intensive sugarcane cultivation.

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The major principles that govern SSI are:

- Raising nursery using single budded chips.
- Transplanting young seedlings (25-35 days old).
- Maintaining wide spacing (5X2 feet) in the main field.
- Providing sufficient moisture and avoiding inundation of water.
- Encouraging organic method of nutrient and plant protection measures.
- Practicing intercropping for effective utilization of land.

In SSI, single budded chips are used for raising nursery

Conventionally, 2-3 budded setts are used

Raising nursery using single budded chips

In the conventional method, 2-3 budded sugarcane setts are used for planting. In SSI, single budded chips, carefully removed from healthy canes are used for raising nursery. The selected buds are placed in trays filled with coco-pith (coconut coir waste) to raise the seedlings. By raising nursery, high percentage of germination can be achieved within a week depending on the agro climatic conditions.

Placing buds in the tray

Transplanting young seedlings

The young seedlings raised in the nursery are transplanted to the main field at the age of 25 – 35 days. It is important to note here that this one month growth of seedlings achieved under SSI method cannot be achieved even after two months in conventional method.

Young seedling sprouted from a bud chip


Wider spacing between rows

Wider spacing drastically reduces the seed requirement from 48,000 buds to 5,000 buds per acre.

Transplanting at wider spacing

In conventional methods, the distance between two rows is maintained at 45 to 75 cm (1.5-2.5 ft), and 16,000 three budded setts (48,000 buds) are directly planted in the soil to achieve normal population of 44,000 canes per acre. But unfortunately, only 25,000 millable canes are achieved at the end. On the other hand, in the SSI method of sugarcane cultivation, wide spacing of 5X2 feet maintained in the main field leads to 45,000 to 55,000 millable canes because of more tillering. So, wider spacing in SSI cultivation not only reduces the seed usage from 16,000 three budded setts to 4,000 to 5,000 single buds, but most importantly it also supports easy air and sunlight penetration in the crop canopy for better and healthy cane growth.

Gradual switching from inorganic to organic method will bring long term benefits to farmers.

Water management

In SSI water management is another crucial issue. It is always emphasized that sufficient moisture is provided rather than inundating the field with water as flooded condition will actually hinder the growth of the plant. Measures like raising of nursery, following furrow/alternate furrow irrigation, optimum application of water through drip irrigation should be followed. So, by giving only required quantity of water about 40% of water is saved.


Drip Irrigation

Organic method of cultivation

The SSI method discourages high application of chemical fertilizers and use of pesticides and weedicides. Farmers should incorporate more organic manures, bio-fertilizers and follow bio-control measures. The sudden switch over to organic cultivation is not advisable. Instead, a gradual reduction of inorganic and adoption of organic methods can be tried by framers for long term benefits.


Application of organic manure

Intercropping reduces the weed-growth (in the initial stage), and increases the farm income.

Intercropping with potato

Intercropping

SSI supports intercropping in sugarcane with crops like wheat, potato, cowpea, french bean, chickpea, water melon, brinjal etc. In addition to effective utilization of land, this practice will reduce the weed growth up to 60% and give extra income to farmers.

Overall benefits

- In conventional method, the cost of setts occupies a major part of the cost of cultivation. But by practicing SSI, the seed cost can be drastically reduced up to 75%.
- Reduction in plant mortality rate.
- Increase in the length and weight of individual canes.
- Easy to transport the young seedlings to longer distance.
- Easy intercultural operations because of wider spacing.

Table 1. Comparison between Conventional and SSI methods of Sugarcane Cultivation

Particulars	Conventional method	SSI method
Seeds/Setts	48,000 buds (16,000 three budded setts/ acre)	5000 buds (5000 single budded chips/acre)
Nursery preparation	No	Yes
Measures to maintain uniformity among plants	No Grading	Grading is done during nursery
Planting	Direct planting of setts in the main field	Transplanting of 25-35 days old young seed-lings raised in a nursery
Spacing	1.5 to 2.5 ft between rows	5 ft between rows
Water requirement	More (flooding of field)	Less (maintenance of moisture in the furrows)
Mortality rate among plants	High	Low
No. of tillers per plant	Less (10-15)	More (20-25)
No. of millable canes achieved per clump	4-5	9-10
Accessibility to air and sunlight	Low	High
Scope for intercrop	Less	More

1. Bud selection

In SSI method, single budded chips from the healthy mother canes are used for raising nursery. The procedure given below has to be followed for the selection of healthy buds:

- Select healthy canes of 7 to 9 months old which have good internode length (7 to 8 inches) and girth.
- Observe and avoid canes with disease infestation like fungus growth, spots etc.
- Cut the required quantity of canes (refer table 2). Farmers who are unable to go for immediate chipping of buds may keep the cut canes for about a week under shade.
- Remove buds from the selected canes using an implement called Bud Chipper (as shown in the picture). The Bud Chipper comprises a handle and a cutting blade fixed on a wooden plank.
- Keep the cane on the plank and adjust it in such a way that a single bud is placed exactly below the cutting blade. When the handle is pressed, single bud chip comes off the cane.
- Large number of buds (about 150/hr) can easily be chipped off in this way in a short period of time.
- Next, the chipped buds have to be treated with organic or chemical solutions.

While selecting buds, avoid taking buds from extreme top and 3-4 short internodes at bottom.

Take care to cut the chip with healthy bud placed at the center.

Damaged, split and sprouted buds are to be avoided while chipping.

Table 2. Details of canes required for 1 acre

Age of the cane	No. of potential buds per cane	No. of canes required
7-9 months	10-12	450-500


Bud Chipper


Cutting single budded chips


Bud chips

For 1 acre plot, 5000 buds, 100 trays (each with 50 cones) and 150 kg coco-pith are sufficient to raise nursery.

2. Treatment

It is important to treat the buds with various organic or chemical solutions before planting to avoid infestation. The bud treatment has to be done in the following way:

- Take a tub preferably made of aluminium or plastic.
- Pour 10 litres of water in the tub and dissolve the chemical or organic components as shown in table 3.

Bud treatment helps in 90% germination.

- Put the bud chips in a plastic or gunny bag and immerse the bag in the prepared solution for 10-15 minutes.
- After treatment, the bud chips have to be dried for 2 -3 hours under shade and then used for nursery plantation.

Take care to select healthy buds while:
a. Chipping,
b. Treatment and
c. Placing in trays.

Table 3. Treatment solutions for buds (1 acre)

Chemical	Organic
Malathion – 20 ml	Trichoderma or Pseudomonas – 500 g
Carbendazim – 5 g	Cow urine – 1 to 2 litres Lime – 100 g

3. Nursery

Young seedlings are raised in the nursery. It is better to establish a shade net shed for the purpose of nursery management. It is a fully covered structure meant to provide shade and create other favourable conditions like warm and wind free environment (See Annexure for dimension of Shade net shed).


Placing buds in half filled tray

- For raising the nursery, take-well decomposed coco-pith. Fill half of each cone in the tray with coco-pith.
- Place the buds flat or in a slightly slanting position in the cones of a tray. Do not press or push it hard. Ensure that the bud side faces up (as shown in the picture with caption - Placing buds in half filled tray).


Covering the buds with coco-pith

- Cover the bud chips in trays completely with coco-pith.
- After filling all the trays, place them one above the other and finally keep an empty tray upside down at the top. About 100 trays (4 sets, each consisting of 25 trays) are to be placed together and wrapped tightly with polythene sheets. Place small weights on the bundles and keep it for 5 to 8 days in the same position to create high temperature and humidity.
- Take measures to control termites around the trays by drenching the soil with Chlorpyriphos 50 EC (5ml/l)


Placing trays one above the other


Wrapping the trays with polythene sheet

and ensure that there are no weeds in and around the nursery area.

- Care should be taken to avoid water, air or sunlight entering into the trays by tightly covering and keeping the bundles in shade net or preferably inside a room. Create artificial warmth through electric bulbs if the climate is too cold. This is the most crucial phase of the nursery management. Under proper conditions (especially, warm temperature) within 3 – 5 days, white roots (primodia) will come out and shoots will also appear in next 2 to 3 days.


Germinated buds on 5th day

- Either on the 5th or 8th day (based on the climatic conditions), all the trays with sprouted buds are to be


Keeping the trays side by side on the ground


Grading of the plants in trays

If the coco-pith in the cone is dry, water can be applied. If it is sticky application of water can be delayed.

Excess water may lead to death of shoots. So, give less water even while using rose cans.


Tillage operation

Deep ploughing of 10 to 12 inches is essential to facilitate better aeration and infiltration of water into the soil.

removed from the polythene sheet and kept side by side in beds on the ground (see Annexure for the details on arrangement of trays) to facilitate watering and other nursery management practices.

- Based on the moisture content of coco-pith, watering to the trays (seedlings) has to be initiated in the evenings for the next 15 days using rose cans. Shoots will start growing strong and leaves will start sprouting. After appearance of two leaves, application of water can be increased gradually depending on moisture level in trays.

- During six leaf stage (about 20 days old seedling), grading of the plants has to be done. Stop giving water for a day to loosen the coco-pith in the trays, this enables easy lifting up of the young seedlings.

- Plants of similar age (height) can be lifted up and placed in one tray. This way grading of plants according to their height is achieved and damaged or dead plants can be removed.

4. Main field preparation

The main field preparation in SSI method is similar to that of conventional method. A good land preparation approach should involve the following essential steps.

4.1 Removal of residues

Main land preparation for sugarcane starts with clearing the preceding crop residues. Stubbles are to be collected and removed from the field. All residues can be incorporated into soil by a rotavator.

4.2 Tillage

Tillage operations through tractor drawn implements are most ideal and quick. After one or two initial ploughings, soil must be allowed to weather for a week or two before going for further tillage operations.

- Tillage operations can be carried out using harrows or rotavator. The operations are to be repeated to make the soil bed free from clods, weeds and crop residues.

- After tillage operation, the field should be deep ploughed using a tractor.

- If the field is uneven, leveling has to be done using a tractor operated leveler. While leveling, a gentle slope can be maintained to facilitate easy movement of irrigation water.


Application of organic manure

Organic manure can be added before the last ploughing.

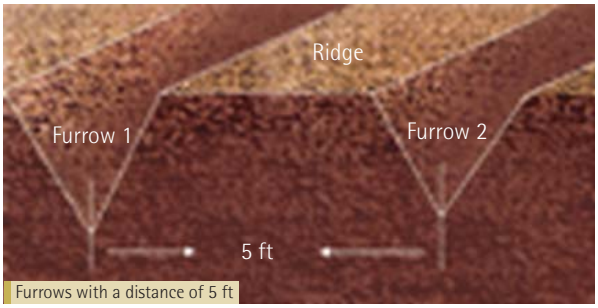
Green manure like daincha or sunhemp can also be raised in the field and ploughed *in situ* before planting.

4.3 Addition of organic manures

The SSI method encourages application of organic manure as it enhances the macro and micro nutrient content in the soil in an eco friendly way, helps in optimum utilization of some of the chemical fertilizers and protects the soil from degradation and other hazardous effects.

- Apply organic manure like FYM/compost/well-decomposed press mud (about 8-10 tonnes/acre).
- Quantity of organic manure could be adjusted in such a way as to supply 112 kg N/acre through one or more sources depending on their N content.
- Trichoderma and Pseudomonas (each 1 kg/acre) and Decomposing cultures can be mixed with the organic manures. This will improve the soil fertility to realize higher yields.

Furrows and ridges help in proper application of manure and optimum utilization of irrigated water.

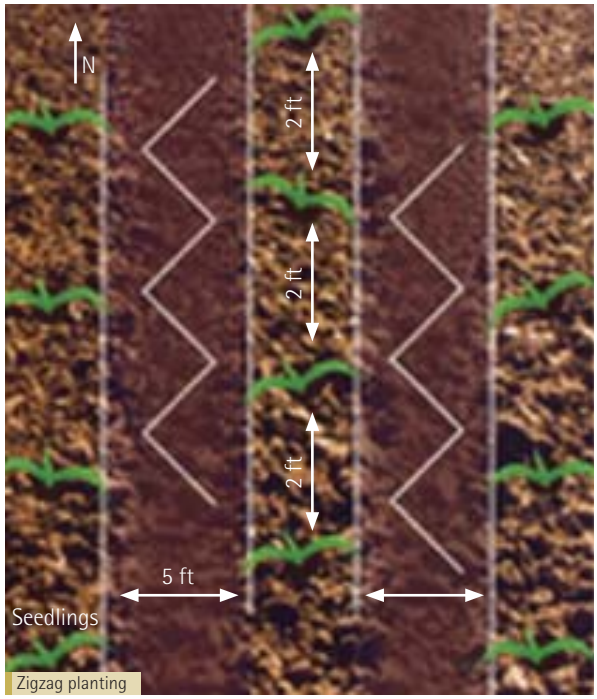


Furrows with a distance of 5 ft

4.4 Making furrows and ridges

- Make furrows with a distance of 5 ft in between (see the picture).
- Run a sub-soiler attached to the ridger/plough through the furrow to loosen the soil. This will support proper incorporation of the manure, deep plantation and prevention of lodging.

While planting care should be taken to avoid air gaps.



Zigzag planting

5. Transplanting

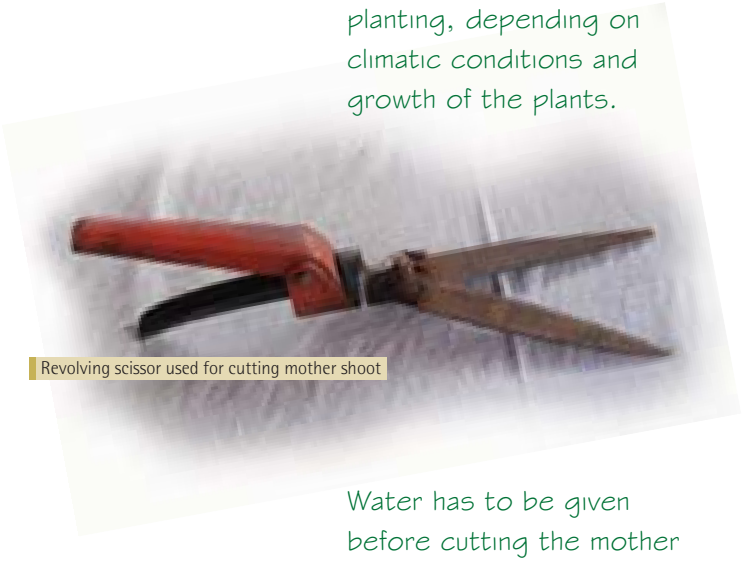
The ideal age for transplanting the young seedlings from nursery to the main field is 25 to 35 days.

- Stop giving water one day before transplanting. This will loosen the coco-pith in cones and help in easy lifting of seedlings for transplantation.
- While transplanting to the main field, zigzag method of planting (see picture) can be followed to utilize more space and achieve maximum tillers.

Flooding the field with excess water will damage the transplanted seedlings.

- Plant to plant distance of 2 ft has to be maintained for easy sunlight penetration and profuse tillering.
- For better access to sunlight, follow North-South direction of planting. However, slope of the field should also be taken into consideration.
- Seedlings are to be planted in the moistened soil with a gentle thrust.
- To moisten the soil, irrigate the field one or two days before transplanting. Similarly, irrigation should be given immediately after planting. The water will flow and fill the air gaps around the plant, if soil compaction is not proper.
- It is important to irrigate the field with minimum quantity of water instead of flooding.

The time of cutting the mother shoot may vary from 3 to 30 days after planting, depending on climatic conditions and growth of the plants.



Revolving scissor used for cutting mother shoot

- After the establishment of plants, the mother shoot may be cut to get even tillers. Plant should be cut just one inch above the ground with a revolving scissor (see picture). This will ensure more number of tillers and millable canes per plant. It is better to try this practice in a smaller area initially and extend further based on the success rate.

Water has to be given before cutting the mother shoot to prevent fungus infection.

6. Weeding

A weed-free environment is absolutely essential for efficient intake of nutrients. This can be achieved by:

- Deep ploughing and removal of perennial weeds.
- Hand weedings and mechanical weedings (30, 60 and 90 days after planting) are better for long term benefits.
- Appropriate other measures to control the weeds should be practiced to minimize the production loss.

Trash mulching

7. Mulching

Trash mulching is important in sugarcane cultivation as it helps in checking the weeds and providing needed moisture.

- Mulching will develop earthworms which in turn will improve the soil aeration and infiltration of water.
- Sugarcane trash can be applied @ 1.5 t/acre within 3 days of planting. Similarly, after detrashing the removed leaves can be applied in the interspaces as mulch.

Mulching is the best practice to control weeds.

8. Fertilizer application

Nutrient management in sugarcane cultivation is very essential for crop growth.

- It is always better to know the required quantity of nutrients through soil testing and enrich the soil accordingly. If there is no facility for that, then NPK can be applied at the rate of 112 kg, 25 kg and 48 kg per acre, respectively through inorganic or organic methods.

- Inorganic fertilizers like Urea, Super Phosphate, Muriate of Potash and Ammonium Sulphate are applied to achieve the above mentioned nutrient requirement.

- It is observed that by practicing appropriate cultivation practices like wider spacing, mulching and earthing up, the required quantity of NPK can be achieved by applying optimum or less quantity of these fertilizers.

- The recommended quantity of fertilizers can be applied in 2 to 3 split doses for the efficient utilization by plants.

- Further, by applying organic manures at the time of field preparation and incorporation of green manures into the soil, sufficient quantity of nutrients can be supplied for plant growth.In addition, application of bio-fertilizers like Azospirillum and Phosphobacteria, 2 kg each on 30th and 60th day after planting by mixing it with FYM (200 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.

Fertilizer application

It is essential to apply micronutrients like iron, zinc, manganese, copper, molybdenum and boron after considering their deficiency in the soil.

9.Water management

It is always better to provide sufficient quantity of water on time rather than flooding the field with enormous amount of water.

- In conventional flooding method water is always applied more than the biological demand of the crop which may affect the crop growth.

- After transplantation, the frequency of the irrigation may differ depending on the soil type, age of the crop, rainfall and moisture availability. For sandy soil, the frequency will be more and for clay soil it will be less.

- Give irrigation once in 10 days during tillering stage (36-100 days), once in 7 days during Grand Growth period (101-270 days) and once in 15 days during Maturity period (from 271 days till harvest).

Water requirement for sugarcane records an average of 1500 mm (i.e. 60 lakh litres/acre for full season) including rainfall, to produce 100 t millable canes. However, in conventional method of flood irrigation, 2000 mm (80 lakh litres/acre) of water is applied by irrigation alone.

Drip irrigation

Furrow and alternate furrow irrigation can be followed to save water up to 50%.

In drip system, irrigation efficiency improves up to 90%, water is saved up to 40-70% and consumption of electricity is also reduced.


Providing sufficient moisture

- Furrow irrigation helps in proper application and saving of water. Alternate furrow irrigation means irrigating the furrows of odd numbers initially followed by irrigating the furrows of even numbers after 7 to 15 days as per the moisture content and age of the crop. This will ensure saving of water up to 50%.

In SSI, about 5 irrigations can be saved as the Germination period (up to 35 days) is spent in nursery.

- Drip irrigation can be practiced effectively in SSI due to wider spacing and raising of single seedlings. Farmers who wish to adopt drip irrigation can contact the concerned firms and install them in their fields.

10. Earthing up

Earthing up means application of soil at the root zone to strengthen the crop stand.

- Normally two earthing up's (partial and full) are followed during a crop period.

- Partial earthing up is done after first top dressing essentially to cover the fertilizer and to provide anchorage to the freshly developed roots. In this case, little soil from either side of the

Earthing up helps in:
1. Sufficient anchorage,
2. Prevention of lodging,
3. Covering of applied fertilizers,
4. Better root development,
5. Checking further tillering and
6. Providing better aeration.


Earthing up

furrow is taken and placed over the fertilizer band. This can also be done by using a bullock drawn implement or a country plough.

- Full earthing up is done after second top dressing (coinciding with peak tillering). In this operation soil from the ridge is thrown on both the sides towards furrows and these furrows will become ridges and vice versa. The newly formed furrows will be later used for irrigation.

11. Detrashing

Detrashing means removal of excess and unproductive leaves from the plants.

- Sugarcane produces large number of leaves. A normal stalk, on an average, bears 30-35 leaves under good growing conditions. But, for effective photosynthesis, only the top 8-10 leaves are sufficient. Most of the bottom leaves would not participate in the process and eventually dry. But, they would compete for the nutrients which otherwise could be used for stalk growth. Therefore, it is important to remove the lower dry and green leaves during the 5th and 7th month, and applied as mulch in the interspaces.


Detrashing

Detrashing helps in:

1. Clean cultivation,
2. Easy movement of air into the crop canopy,
3. Reduction in pests,
4. Easy intercultural operations and,
5. Detrashed leaves can be used in mulching or compost preparation.

12. Propping

Propping means giving support to the canes to avoid lodging. Normally it is done by tying the canes with leaves.

- In conventional method, propping is done in the 7th month either by tying the canes in each row or by bringing the canes of two rows together and tying.

- In SSI, it is recommended to provide a fence like wooden structure at one side of the field in order to give support to the lodging crops. In this way, tying of adjacent middle leaves can be avoided and thus making those leaves effectively contribute to the crop growth and saving of labour.


Propping

13. Plant protection

Like every crop, sugarcane should also be protected from pests and diseases. Following are some of the major pests and diseases and their control measures:

Early Shoot borer:

- Trash mulching along with good water management and light earthing up at 35th day.

- Release of 50 fertilized Sturmiopsis parasite/acre when the crop is at the age of 45-60 days.


Symptom of Early shoot borer attack


Pheromone Trap

Bio-control measures and Pheromone traps help in control of specific pests and preservation of other friendly insects.

Internode borer:

- Distribution of cards pasted with eggs of *Trichogramma chilonis* @ 10 cards/acre, at 20 meters distance when the crop is 4-11 months old.
- Pheromone traps (@ 10/acre at 20 meters distance) in the 5 months old crop.
- Male moths can be trapped and killed.

Mulching, good water management and earthing up are good practices for controlling Early shoot borer.

Top borer:

- Release of parasite, *Isotima javensis Rohn* against 3rd or 4th broods of the pest.

White grubs:

- Handpicking and destruction.

Selection of resistant varieties and disease free bud chips are important to avoid diseases in later stages.

Red rot:

- Selection of resistant varieties and disease free bud chips.
- Destruction of affected clumps.

Wilt:

- Healthy buds, crop rotation and optimization of soil moisture.


Intercropping with bean

14. Intercropping

In sugarcane, intercrops like cowpea, chickpea, potato, green gram, water melon, wheat and many other crops can be tried, as there is a wide spacing between rows. Depending on the location specific factors, different intercrops may be tried.

- Intercrops control weeds up to 60% in the initial stage and provide extra income to farmers.
- They act as a live mulch and preserve moisture and reduce the pest attack by being alternate hosts in some cases. Green manures raised as intercrop improve the soil fertility on incorporation.

Intercropping helps in optimum utilization of land.

15. Harvesting

Harvesting in sugarcane is practiced in collaboration with the industry, in most of the cases, to suit the factory timings. Sucrose content in the plants will reach the desirable level on the 10th month of the one year crop duration, and they will be ready for harvest within the next two months.

Sucrose content in the plants will reach the desirable level on the 10th month of one year old crop

Pit System of Planting

Circular pits

In this method, the seedlings are planted in circular pits dug out with specific diameters and distances. The circular pits of 3 ft or 5 ft diameter are dug out to a depth of 1.5 to 2 ft. Row to row spacing is maintained at 7 ft and pit to pit spacing is maintained at 6 ft.

Lower layer of the soil gets good light and air.

- At these spacing's, about 1050 to 1150 (with 3 ft diameter) or 500 to 550 (with 5 ft diameter) pits can be made per acre. The pits are then filled with loose dug out soil, FYM or press mud leaving about 1 ft space at the top.

- Two to four seedlings per pit with 3 ft diameter and 6 to 8 seedlings per pit with 5 ft diameter can be planted close to the edge and covered with soil to a thickness of 5 cm. About 2000 to 4000 seedlings are sufficient per acre, saving the seed cost further for a farmer.

- All other crop management practices can be followed as practiced in normal method.

Pit with sprouted seedlings

Benefits:

- This method has given high yields in the subtropics and in the tropical part of India, about 25-50 % higher yields were obtained.

- Growth of the crop will be vigorous and the maturity will also be earlier compared to the normal method

Insects are exposed and eaten by birds.

All nutrients are placed in the root, thus better utilized.

- Sufficient and equal spacing between the clumps and rows allows sufficient light and air circulation improving the growth.
- In case of drip irrigation, nutrition supplied through drip fertigation will help in faster crop growth

Sufficient space between pits will make operations like spraying, dusting and propping easy.

- This method allows a farmer to pay individual attention to the crops or crop pits.
- It gives better ratoon crops and has also been found useful under saline soils and saline water irrigated conditions.
- All the shoots will be of the same age, so there is uniformity in growth and sugar accumulation in the canes.

Due to strong root growth, lodging is checked.

- The most important factor is that the seedlings are placed at a depth, which will be always moist, hence, in case of drought, or non-availability of water, the yields will not get affected.

Rows of pits with drip irrigation

Ratoon Management in Sugarcane

Ratooning is a method where the lower parts of the plants along with the roots are left uncut at the time of harvesting. It is the most commonly followed and important practice in sugarcane cultivation. In ratoon crops, there is a saving in cost of cultivation in terms of land preparation, seed canes, etc. If ratoons are well maintained, they give high yields. But, for a better ratoon crop, a better plant crop is necessary.

Within a week after harvesting the plant crop, ratoon management practices like stubble shaving, off baring, gap filling etc., should be initiated.

Avoid ratooning of pest and disease infected plant crops.

Stubble shaving

- The stubbles just above ground level should be cut using a very sharp blade.
- This helps the healthy underground buds to sprout and establish a deeper root system.
- The deeper root system thus obtained facilitates optimum utilization of the nutrients and moisture available in the lower soil layers and provides good support for growth of the ratoon crop.

Plant crops should be harvested when the weather conditions are conducive for stubble sprouting.

Off baring

- It is an operation wherein the ridges are broken or cut on either side using a plough.
- This will loosen the soil to develop better root system and thereby better absorption of nutrients and water.

Harvest of the plant crops should be done close to the ground level.

Ratoon management

Healthy ratoon crops

Gap filling

- If there are no cane clumps for a distance of more than 60 cms or so, it can be considered as a gap.
- Clumps with excess sprouting can be uprooted, cut into quarters and planted in the gaps.
- Gap filling can be done using the seedlings raised in the nursery.

Row thinning

In areas where close spaced plantings are followed, entire canes of alternate rows can be removed. This can be done by running a plough along the sides of the alternate ridges selected for removal of the cane rows. This will break or loosen the ridges and facilitate easy lifting and removal of the plants. While removing the canes, gap filling in the adjacent rows can be done. This practice of removing alternate rows of canes will increase the space between the rows and thus facilitate sprouting of more tillers because of optimum utilization of the available nutrients and sunlight.

Fertilizer application

- Entire dose of phosphorous, one-third each of nitrogen and potassium as recommended for plant crops can also be applied to ratoon crops. The suggested dose should be applied soon after stubble shaving and off barring, and covered with soil.
- The remaining dose of nitrogen and potassium can be top dressed in equal splits around 30th and 60th days.

Besides the above mentioned practices, all the other crop management practices like irrigation, weeding and earthing up should be continued and followed as done for plant crops. Ratoon crops mature one month prior to the plant crops. In the conventional method of sugarcane cultivation, ratoon crops are maintained for only a maximum of two seasons but farmers practicing SSI methods maybe able to achieve 5 to 6 ratoon crops.

Summary

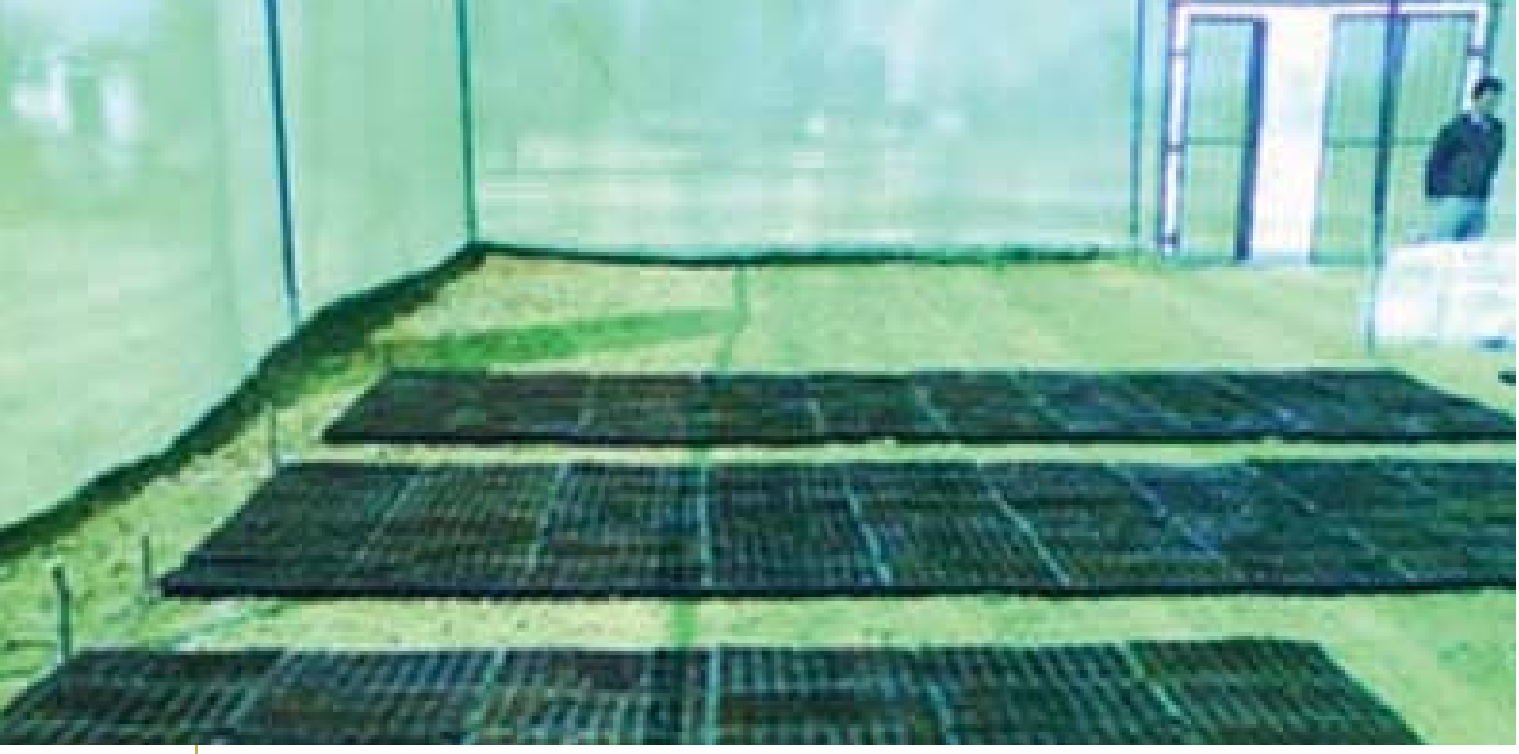
Sugarcane is one of the most important industry based crops in the world. India is the second largest sugarcane producer and the highest sugar consumer in the world. Apart from sugar, sugarcane is grown for many other uses like fodder, paper and bio-fuel. In spite of its growing demand, there are a number of problems which affect the sugarcane farmers in sustaining their production and increasing their profit. On the ecological front also sugarcane cultivation is becoming a difficult task, due to its water-guzzling nature and depleting water table. So, it's high time we amend our usual, high inputs intensive method of sugarcane cultivation and lookout for some innovative, resource concerned method of producing sugarcanes. Sustainable Sugarcane Initiative (SSI) is one such method of sugarcane cultivation which uses less inputs in a sustainable manner.

SSI involves use of less seeds, less water and optimum land utilization to achieve more yields. It is governed by some principles like using single budded chips, raising nursery, wider spacing, sufficient irrigation and intercropping. By practicing these measures, the following benefits can be realized:

- Better germination percentage
- High number of millable canes
- Reduction in the duration of crop to some extent
- 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 and
- Extra income from intercrops

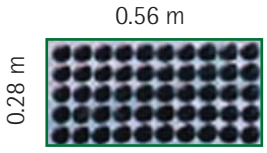
On the whole, by practicing SSI farmers can very well increase their productivity by reducing the use of inputs like fertilizers and saving the vital resources like water simultaneously. Hence, it is very much possible for sugarcane farmers to reap greater economical benefits by maintaining ecological sustainability.

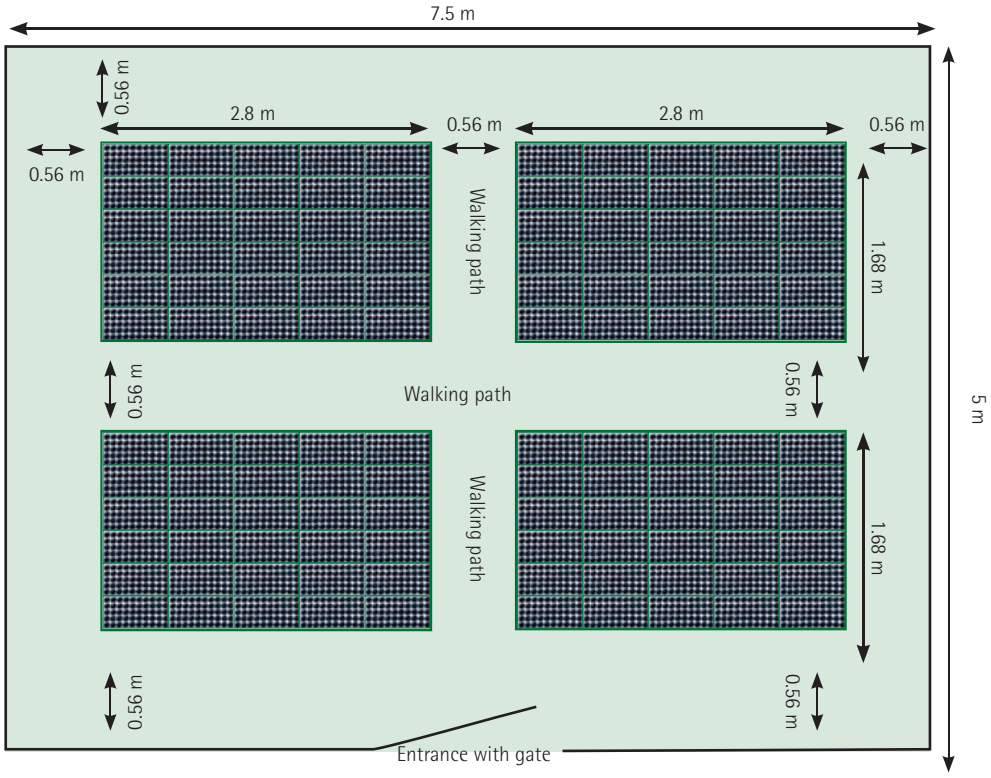
By practicing SSI farmers can very well increase their productivity by reducing the inputs and saving the water.



Size of Shade net shed required for nursery (1 acre)

Size of a tray (50 cones)





Total number of trays needed for nursery (1 acre): 100
Size of Shade net shed: Length: 7.5m, Width: 5 m, Height: 3 m, which can accommodate 120 trays.
The size of the Shade net shed can be extended as per the requirement.

Raising nursery through SSI method requires materials like plastic trays, coco- pith, shade nets, rose cans etc. The materials can be obtained from manufacturers or Horticulture and Forest nursery equipment suppliers locally. For information on materials contact ICRISAT-WWF Project office.

Trainings and field interventions on SSI methods by ICRISAT-WWF

SSI field training for staff from Triveni Sugars, Uttar Pradesh at Vikarabad in Andhra Pradesh

Farmers being trained on bud chipping at Khatauli in Uttar Pradesh

Transplanting of seedlings in the main field at Chandanpur in Uttar Pradesh

SSI training for farmers from Orissa at ICRISAT, Patancheru in Andhra Pradesh

Farmers from Punjab counting the tillers of mother shoot cut plant at a farmer's field in Andhra Pradesh

Field training for farmers on SSI methods at Nayagarh in Orissa

Farm labour gaining practical experience in transplantation of seedlings at Hathanur in Andhra Pradesh

Farmers and NGO staff from Karnataka interacting with SSI farmer at Basanthpur in Andhra Pradesh

The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) and World Wide Fund for Nature (WWF) have partnered together to explore options for 'Improving the water productivity in agriculture'. Currently working on rice with the System of Rice Intensification (SRI) and Sustainable Sugarcane Initiative (SSI) in sugarcane, the project is specifically looking at farm-based approaches based on principles of 'more with less' in agriculture. The highly successful methods and practices increase the profitability of the farmers significantly while reducing the inputs – water, fertilizer, seed material – and improving the productivity of water, land and labour.

This project is directly relevant to the broader goals of both the WWF and ICRISAT with respect to improving the lives and livelihoods of millions of farmers and reducing the ecological footprint on planet earth without compromising on the food security.

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