Agricultural Economics Research Review
Vol. 29 (No.1) January-June 2016 pp 117-126
DOI: 10.5958/0974-0279.2016.00024.0

Is Sustainable Sugarcane Initiative (SSI) Technology More Profitable than Conventional Method for Sugarcane Production? — An Economic Analysis[§]

Arthi K., V. Saravanakumar* and R. Balasubramanian

Department of Agricultural Economics, Tamil Nadu Agricultural University, Coimbatore-641 003, Tamil Nadu

Abstract

The study has examined profitability, sources of productivity improvement and determinants of a new technology – Sustainable Sugarcane Initiative (SSI) —adoption in sugarcane cultivation in Tamil Nadu by collecting primary data from 120 sugarcane farms during 2014-15. Although the cost of cultivation has been found higher in SSI method vis-a-vis conventional method, the cost of production is lower due to 26 per cent more cane yield. The cost and return analysis has indicated that sugarcane cultivation is more profitable under SSI method than under the conventional method. The decomposition analysis has shown that the inputs, viz. fertilizers, micro-nutrients and deployment of labour are the major sources of productivity enhancement in the SSI method. The estimates of logit model have indicated that farmers' educational level and experience are the major determinants for adoption of SSI method in sugarcane cultivation. The major policy options suggested to improve production and profitability of sugarcane include provision of drip irrigation with subsidy, ensuring timely availability of critical inputs and imparting periodical trainings to farmers on SSI method such as fertigation, wide row spacing, etc.

Key words: Sugarcane cultivation, technology impact, sustainable sugarcane initiative, economic analysis, productivity enhancing sources, Tamil Nadu

JEL Classification: Q1, Q01, Q16, E23, O32

Introduction

In India, the sugar industry is the second largest industry next to the textile industry in playing a vital role in the socio-economic transformation of country (Wagh, 2015). The sugar industry being an important agro-based industry, provides livelihoods to about 6 million sugarcane farmers and around 7 lakh workers who are employed in the sugar mills. India ranked second in sugarcane production in the world, after Brazil, with an area of 5.31 million hectares and production of 366.8 million tonnes with productivity of 69.1 tonnes/ha during 2014-15 (ISMA, 2015). The major sugarcane-growing states in India are Uttar Pradesh, Maharashtra, Tamil Nadu, Karnataka, Andhra Pradesh, Gujarat, Bihar, Haryana, Punjab and Madhya Pradesh and among these states, Tamil Nadu occupied fifth position in area (after Uttar Pradesh, Maharashtra, Karnataka and Bihar), fourth rank in production and third in productivity in 2014-15. The area and production of sugarcane in Tamil Nadu during 2014-15 was 2.55 lakh ha and 22.3 Mt, respectively and the productivity was 104 t/ha in the year 2013-14 (Government of Tamil Nadu, 2015). The sugar industry provides direct employment to a large number of persons, apart from providing indirect employment to thousands of persons in the rural areas who are involved in cultivation, harvesting and transportation of cane and other related services. At present, Tamil Nadu has

* Author for correspondence
Email: E-mail: sharanu2k@gmail.com

§ This paper is part of the master's study of first author supervised by second author.

43 sugar mills, of which 16 are owned by the co-operative sector and 27 by the private sector.

The demand for sugar and by-products of sugar industry is raising, whereas production is declining due to reasons such as decrease in cultivable lands, climate change effect, escalating cost of inputs such as fertilizers and human labour and fluctuating and insufficient cane price. The sugar industry also faces 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, inadequate availability of planting material at the time of onset of season leading to inadequate coverage of targeted area (NABARD, 2012).

Besides, irrigation water is emerging as one of the major constraints affecting productivity and profitability of both farmers and millers. The excessive ground water exploitation and wide variability in rainfall due to climate change are debilitating the sugarcane farmers in the country (Goud, 2011). Further, less use of farm mechanization due to closer spacing in the conventional method of sugarcane production increases drudgery of human labour and its production cost. In Tamil Nadu, the sugarcane area increased from 3.15 lakh ha in 2001-02 to 3.48 lakh ha in 2012-13, but it was minimal during the years 2003-04, 2004-05, 2005-06 and 2009-10 due to poor monsoon and its aftermath. This is the major reason for deceleration of growth rate of sugarcane area during the recent years. These crises call for development of alternate options and technologies for sugarcane cultivation to make it viable and remunerative to both farmers as well as sugar mills.

The sustainable Sugarcane Initiative (SSI) is a new method which improves the productivity of sugarcane by using less resource and thereby, reduces the input cost also. The SSI is a better method of sugarcane cultivation than the conventional methods which are seed - water - space-intensive. By adopting SSI method, the productivity of cane can be enhanced by practising drip irrigation with fertigation, maintaining optimum plant spacing of 5ft × 2ft for easy penetration of sunlight, and profuse tillering and after the establishment of 2 or 3 tillers, the mother shoot may be removed just one inch above the ground to facilitate more number of tillers. The benefits of SSI method vary depending on how efficiently farmers use these practices. The farmers work in a synergistic way to save inputs and achieve higher yields per unit area. This method has been recommended by the Tamil Nadu Agricultural University (TNAU) for wide adoption by farmers. However, its adoption rate by the farmers is comparatively low, ranging from 15 to 20 per cent (Kiruthika, 2014). Due to efficient utilization of water by fertigation method, growing of intercrops and getting higher outputs, it was believed that SSI method would be profitable (Loganandhan *et al.*, 2013; Shanthy and Ramanjaneyulu, 2014). However, there are no holistic studies to assess the profitability of SSI, sources of productivity changes in SSI and determinants of SSI adoption. Therefore, this paper has studied profitability and adoption level of SSI with the following objectives: (i) to work out the economics of sugarcane production under conventional and SSI methods, (ii) to examine the sources of productivity improvement in SSI, and (iii) to analyse the factors determining the adoption of SSI method.

Data and Methodology

The present study was conducted in Tamil Nadu because of significant production and consumption of sugarcane in the state. The multistage random sampling technique was followed to select 120 sample households from the districts of Villupuram and Trichy. The Villupuram district falls under the high productivity (110 t/ha) area, whereas Trichy falls under low productivity (71 t/ha) area. The primary data were collected during the year 2014-15 through a well-structured interview schedule.

Economic Analysis

(a) Estimation of Cost and Returns

To estimate cost and returns of sugarcane under conventional and SSI methods, the standard method developed by the Commission on Agricultural Costs and Prices (CACP) was followed (Raju and Rao, 1990; Narayanamoorthy, 2013).

(b) Sources of Change in Sugarcane Productivity

To measure the sources of change in sugarcane productivity, Cobb-Douglas production function was used as given by Equation (1):

$$YLD_i = \beta_0 \, NITRO_{i1}^{\beta i1} \, PHOS_{i2}^{\beta i2} \, POTAS_{i3}^{\beta i3} \, MNM_{i4}^{\beta i4} \, HLAB_{i5}^{\beta i5} \, MLAB_{i6}^{\beta i} \, u_i \quad \ldots(1)$$

where,

Subscript i = 1 indicates conventional method; i = 2 indicates SSI method

YLD = Sugarcane yield (t/ha)

$NITRO_{i1}$ = Quantity of nitrogenous fertilizers used (N) (kg/ha)

$PHOS_{i2}$ = Quantity of phosphatic fertilizers used (P) (kg/ha)

$POTAS_{i3}$ = Quantity of potassic fertilizers used (K) (kg/ha)

MNM_{i4} = Micronutrients applied (kg/ha)

$HLAB_{i5}$ = Human labour (person days/ha)

$MLAB_{i6}$ = Machine labour (hours/ha)

β_0 = Intercept-term (scale parameter)

u_i = Error-term independently distributed with zero mean and constant variance.

β_{i1}, β_{i2}, β_{i3}, β_{i4}, β_{i5} and β_{i6} are the regression coefficients of nitrogenous, phosphatic and potassic fertilizers, micronutrients, human labour and machine labour, respectively. The family labour was imputed and evaluated at the prevailing wage rates of hired labour at the village level.

Chow's test (Gujarati and Porter, 2014) was employed to identify whether the parameters governing the production relations were different in the "conventional method" and "SSI method" and it was used to compute the 'F' ratio. The computed 'F' value was compared with 'F' critical value 'p' and (n+m-2p) degrees of freedom at appropriate level of significance; where, 'n' refers to the number of observations and 'm' refers to the number of variables. The non-significant 'F' value indicated no structural difference between conventional and SSI methods.

In this study, the output decomposition model developed by Bisaliah (1977) and Balasaheb (2013) was used to examine the productivity difference between conventional and SSI methods due to technological change and input use.

c. Factors Influencing the Adoption of SSI Technology

The logistic regression models are used to predict the probability of occurrence of binary events to predictor variables by assuming that an individual decision-maker makes rational choices in maximizing his/her utility (Rahm and Hufman, 1984). In the present study, the producer's preference to adopt SSI and conventional methods are represented by '1' and '0', respectively. The logistic regression (LR) model specified in the study (Tefera *et al.*, 2010; Loganandhan *et al.*, 2013; Kiruthika, 2014) is given in Equation (2):

$$\log (P_i) = \ln(p_i / 1-p_i) = \beta_0 + \beta_1 AGE_{1i} + \beta_2 SQAGE_{1i} + \beta_3 EDU_{3i} + \beta_4 HHSIZE_{4i} + \beta_5 FARMSIZE_{5i} + \beta_6 INCOME_{6i} \quad \ldots(2)$$

where,

P_i = 1 indicates willingness and 0, non-willingness to adoption of SSI method

β_i = Coefficients to be estimated

AGE = Age of household-head (in years)

SQAGE = Age squared

EDU = Education level of household-head (in index)

HHSIZE = Household size (No.)

FARMSIZE = Total land area owned (acres)

INCOME = Annual income (in Rupees)

The effect of each independent variable on technology adoption was determined by the β coefficients and the sign of any coefficient represented the positive and negative effect of the variable on adoption of SSI technology. To quantify the effect of each variable, odds-ratio is determined. It quantifies the probability of adoption of a new technology such as SSI and is represented algebraically by Equation (3):

$$\text{Probability of adoption of technology, } P = (\text{odds ratio of } X_i - 1) * 100 \quad \ldots(3)$$

where, X_i is the independent variable and i = 1,2,...,6.

Results and Discussion

Economics of Sugarcane Cultivation

The economics of sugarcane cultivation under conventional and SSI methods are presented in Table 1.

The overall total cost of sugarcane cultivation was worked out to be ₹ 179008/ha under conventional

Table 1. Economics of sugarcane cultivation under conventional and SSI methods

(₹/ha)

Particulars	Villupuram district		Trichy district		Overall	
	Conventional	SSI	Conventional	SSI	Conventional	SSI
			Fixed cost			
Depreciation	5605	13040	5666	11931	5635	12486
	(3.12)	(6.25)	(3.18)	(5.80)	(3.15)	(6.03)
Interest on fixed assets	4228	9837	4274	9001	4251	9419
	(2.35)	(4.71)	(2.40)	(4.38)	(2.37)	(4.55)
Rental value of owned land	20540	21034	20742	21271	20641	21153
	(11.43)	(10.08)	(11.63)	(10.34)	(11.53)	(10.21)
Total fixed cost	30373	43911	30682	42203	30528	43057
	(16.90)	(21.04)	(17.21)	(20.52)	(17.05)	(20.78)
			Variable cost			
Setts cost	19385	18935	20086	23053	19736	20994
	(10.79)	(9.07)	(11.27)	(11.21)	(11.02)	(10.13)
Fertilizer cost	18793	21568	17894	20044	18344	20806
	(10.46)	(10.34)	(10.04)	(9.75)	(10.25)	(10.04)
Plant protection chemicals cost	2793	2540	3037	2259	2915	2400
	(1.55)	(1.22)	(1.70)	(1.10)	(1.63)	(1.16)
Human labour cost	93225	106726	91228	102954	92227	104840
	(51.87)	(51.14)	(51.17)	(50.06)	(51.52)	(50.61)
Machine labour cost	15160	15008	15359	15136	15260	15072
	(8.43)	(7.19)	(8.61)	(7.36)	(8.52)	(7.28)
Total variable cost	149356	164777	147604	163446	148480	164112
	(83.10)	(78.96)	(82.79)	(79.48)	(82.95)	(79.22)
Overall total cost	179729	208688	178286	205649	179008	207169

Note: Figures within the parentheses indicate percentage to the total

method and ₹ 207169/ha under SSI method. In this cost, the share of total fixed cost ranged from 17 to 21 per cent and the remaining 79 to 83 per cent was accounted by the total variable cost. The total fixed cost component (depreciation and interest) incurred in SSI method was more due to additional expenditure on establishment of drip irrigation infrastructure and its maintenance.

Among the variable cost components, the cost on human labour was highest (50 %). The major share of labour cost was accounted for by the harvesting operation, which ranged from 34 to 37 per cent, under both conventional and SSI methods. The share of wages for harvesting was higher in the SSI method due to harvesting higher cane yield as compared to in the conventional method. The expenditure on fertilizers was the second major variable cost, which accounted for approximately 10 per cent of total costs in both the methods. This cost included expenditure on farmyard manure, fertilizers such as nitrogenous (urea), phosphatic (di-ammonium phosphate, single super phosphate) and potassic (muriate of potash); and micro-nutrients including humic acid, and bio-fertilizers. It was also observed that the cost of humic acid was higher in the SSI method (₹ 1098) than conventional method (₹ 862). Use of humic acid is the prevalent practice in sugarcane cultivation and it increases the fertilizer-use efficiency (Bohme and Thi Lua, 1997).

The liquid bio-fertilizers like AzoGro, PhoSol and PotaVit were used by the farmers that are also supplied by the sugar factories. The cost on bio-fertilizer was higher in SSI method (₹ 970) than in conventional

Table 2. Estimation of different cost and returns measures

Particulars	Villupuram district		Trichy district		Overall	
	Conventionl	SSI	Conventionl	SSI	Conventionl	SSI
Cost A_1 (₹/ha)	147736	171592	146256	168817	146996	170205
Cost B_1 (₹/ha)	151964	181429	150530	177818	151247	179624
Cost B_2 (₹/ha)	172504	202463	171272	199089	171888	200776
Cost C_1(₹/ha)	159189	187654	157544	184378	158367	186016
Cost C_2 (Total cost)	179729	208688	178286	205649	179008	207169
Yield (t/ha)	104	132	101	125	102.5	128.5
Price (₹/tonne)	2300	2300	2275	2275	2288	2288
Cost of production (₹/tonne)	1421	1300	1448	1351	1434	1325
Gross returns (₹/ha)*	239200	303600	229775	284375	234469	293944
Net returns (₹/ha)	91464	132008	83519	115558	87473	123739
Farm business income (₹/ha)	91464	132008	83519	115558	87473	123739
Farm investment income (₹/ha)	84239	125783	76505	108998	80353	117347
Family labour income (₹/ha)	66696	101137	58503	85286	62581	93168
Benefit-cost ratio	1.62	1.77	1.57	1.68	1.60	1.73

*In the study area, 70 per cent farmers cultivated pulses (black gram, green gram and cow pea) as intercrops and SSI farmers would additionally generate the gross income of ₹ 16200 /ha/annum.

method (₹ 859). The cost of plant protection chemicals (PPC) was higher in the conventional (₹ 2915) than under SSI (₹ 2400) method. The expenditure incurred on planting materials was less (₹ 19736) (for setts) in conventional than SSI (₹ 20994) (for seedlings) method. The planting materials were selected from the sugarcane varieties such as Co 86032, CoV 94102 and SI 309. However, the majority of farmers (95 %) used planting materials from Co 86032 variety under both the methods. The farm machineries were widely used for ploughing and ridge formation activities to reduce human drudgery. The share of machine labour in the total cost was 8.52 per cent and 7.28 per cent under conventional and SSI methods, respectively.

The SSI is referred as "More with less" technology, but the present study has found inputs cost higher under SSI than under conventional method. The reasons for this higher cost of inputs are: (i) although the quantity of planting materials used is less in the SSI method, the cost of producing single-budded chips is more. That is why the cost of planting material in SSI method is at par with or marginally higher than the conventional method, (ii) under SSI technology, there is water saving of 40-70 per cent and therefore consumption of electricity is also reduced. But electricity is available free for agriculture in the state, therefore, it is very hard to measure the economics of water saving, (iii) it is observed that farmers applied same qunatity of fertilizers in SSI as well as conventional system, (iv) human labour cost (i.e. wages) was higher in the SSI method due to higher yield. Mohanty *et al*. (2015) have also shown that the cost of inputs in SSI method is at par with the conventional method.

The different cost components for sugarcane cultivation (Cost A_1, Cost B_1, Cost B_2, Cost C_1 and Cost C_2) were worked out and are presented in Table 2.

A perusal of Table 2 revealed that all cost components, viz. Cost A_1, Cost B_1, Cost B_2, Cost C_1 and Cost C_2 were higher in SSI than in conventional method. The average yield obtained from SSI method was 128.5 t/ha, i.e. 26 per cent more than the yield from conventional method (102.5 t/ha). Therefore, the overall cost of production of was lower in SSI (₹ 1325/t) than conventional (₹ 1434/t) method. The net returns realized from sugarcane were lower under conventional method (₹ 87473/ha) than under SSI method (₹ 123739/ ha)**.** The farm business income represents the financial return on the shareholders' capital invested in the farm business. It is used while assessing the impact of new policies or regulations on the individual farm business.

The overall farm business income under conventional method (₹ 87473/ha) was lower than under SSI method (₹ 123739/ha). It indicates that in the wake of capital losses the SSI farmers can better withstand the uncertainties as compared to the conventional sugarcane growers. The overall family labour income (₹ 93168/ha) was also more in the SSI method. Farm investment income represents the return on all capital invested in the farm business including borrowed capital; it also incorporates returns to risk and entrepreneurship. The overall farm investment income was lower for conventional method (₹ 80353/ha) than the SSI method (₹ 117047/ha). It is a general measure of profitability of farming and it has indicated that SSI method is more profitable than the conventional method. The overall benefit-cost ratio was 1.60 under conventional and 1.73 under SSI method.

Summing-up, the sugarcane cultivation under SSI method is more profitable than the conventional method in the study areas. However, the escalating input-costs, fluctuating output-prices, and delayed payments by sugar mills are the major factors limiting productivity and profitability of sugarcane cultivation.

Production Function Estimates for Sugarcane Cultivation

To analyse the efficiency of resources used in sugarcane production, Cobb-Douglas production function was fitted separately for both conventional and SSI methods, including important inputs, viz NPK, micronutrients and human labour and machine labour as explanatory variable. Table 3 presents the production function estimates for conventional and SSI methods of sugarcane cultivation.

Table 3. Production function estimates for sugarcane cultivation

Variable code	Regression coefficient	
	Conventional method	SSI method
CONSTANT	-5.0139***	-2.4928***
	(0.6248)	(0.6970)
NITRO	0.5943***	0.3519***
	(0.1004)	(0.1236)
PHOS	0.0045	0.1424**
	(0.0184)	(0.0505)
POTAS	-0.0012	0.2386***
	(0.0387)	(0.0460)
MNM	0.0371**	-0.0650
	(0.0103)	(0.04419)
HLAB	0.9881***	0.5763***
	(0.1206)	(0.0971)
MLAB	-0.0159	-0.0175
	(0.0105)	(0.0268)
R square	0.94	0.85
F – value	150.821***	51.520***

Note: ***(P<0.01), **(P<0.05), *(P<0.1).
Figures within the parentheses are standard errors of estimates.

Table 3 reveals that variations in sugarcane yield could be explained up to 94 per cent in the conventional method and 85 per cent in SSI method by the independent variables included in the model. The F–value of conventional and SSI methods (150.821 and 51.520, respectively) was found statistically significant which indicated the overall significance of the model. In both conventional and SSI methods, the elasticity coefficients for nitrogenous fertilizer (0.5943) and human labour (0.9881) were found positive and significant at one per cent level. The coefficient for potassic fertilizer was found significant at one per cent level in the SSI method. Since, sugarcane crop is a luxurious consumer of potassic fertilizers, it was observed that farmers apply potassic fertilizers more than the recommended level.

Decomposition Analysis

Chow test was used to test the shift from conventional to SSI method. The calculated value of Chow test (which follows 'F' distribution) was 7.71 which was more than the critical value of F (7,106), viz. 2.79. Hence, the null hypothesis was rejected which implied that there was a significant difference between SSI and conventional methods. Therefore, decomposition analysis was performed to identify the different sources of productivity improvement under the SSI method. The sources of output gain in the SSI method were decomposed using production function parameters (given in Table 3) and geometric mean level of input (see Annexure I). The results of decomposition analysis are given in Table 4.

The total gain in sugarcane production due to shift from conventional method to SSI method was found

Table 4. Sources of productivity gain in SSI method of sugarcane production

Sl. No.	Source of productivity difference	Contribution (%)
A.	Total observed productivity gain	24.41
B.	Productivity gain due to technology change, i.e. neutral technology and non-neutral technology change	2.16
C.	Total productivity gain due to input-use (1+2+3+4+5+6)	20.49
1.	Nitrogenous fertilizers (kg/ha)	5.68
2.	Phosphatic fertilizers (kg/ha)	0.48
3.	Potassic fertilizers (kg/ha)	2.46
4.	Micronutrients (kg/ha)	3.53
5.	Human labours (persondays/ha)	7.77
6.	Machine labours (hours/ha)	0.54
D.	Total estimated productivity gain (B + C)	22.65
E.	Residual factors	1.76

to be 22.65 per cent, which was mainly contributed by the difference in the levels of input-use in these methods. The total contribution of difference in input-use levels to productivity gain was 20.49 per cent, which indicated that the productivity of conventional practices can be increased by 20.49 per cent, if the input-use levels on these farms could be increased to the levels of SSI method. In the total productivity gain due to input-use, the contribution was highest of human labour (7.77%), followed by nitrogenous fertilizers (5.68%), micronutrients (3.53%), potassic fertilizers (2.46%), machine labour (0.54 %) and phosphatic fertilizers (0.48 %). Among the components of technological change, the contribution of neutral technological change in total productivity was estimated as 2.16 per cent.

Thus, it can be inferred from the decomposition analysis, that the 'SSI method' was not able to consolidate the gains due to introduction of a new technology. The yield gain was largely due to the raise in input levels in the SSI method. Hence, the extension agencies should provide training to the farmers on the adoption of SSI method of sugarcane production very effectively. Besides, the yield of sugarcane is also influenced by drip irrigation and fertigation. Hence, these factors should be exposed and demonstrated to the farmers for more adoption of SSI method and hence for realizing more yield and economic returns.

Table 5. Parameter estimates of logit model

Variables	Coefficient	Odds ratio
CONSTANT	7.8051	-
AGE	-0.3091	0.6708
SQAGE	0.00298*	1.0028
EDU	2.5036***	12.2265
HHSIZE	-1.3429**	0.2610
FARMSIZE	-0.3370*	0.7138
INCOME	0.0001**	1.0001

Note: ***(P<0.01), **(P<0.05), *(P<0.1).
Descriptive statistics of the variables are given in Annexure-II.

Factors Influencing Adoption of SSI Method

To identify the factors that influence adoption of SSI method in sugarcane cultivation, the estimated parameters used from the logit model were age, education, household size, total area and annual income. The parameter estimates of logit regression are given in Table 5. A perusal of Table 5 revealed that the educational level of farmers was positive and significant at one per cent level with coefficient value as 2.50, depicting a positive influence on willingness to adopt SSI technology in sugarcane cultivation. The household size showed a negative value for coefficient (-1.34) and significance at five per cent level. The annual income was positive and significant at five per cent level.

A comparison of odds ratio showed that if age, household size and total area increase by one unit, the probability of SSI adoption would be reduced by -32.9 per cent, -73.90 per cent and -28.62 per cent, respectively. The coefficients of age square, education and annual income have shown that with increase of one unit, the probability of being an SSI adopter would increase by 0.28 per cent, and was 1122.65 per cent i.e. 0.01 per cent, respectively. It was concluded that education is a major factor influencing the adoption of SSI method at one per cent significant level. Similar studies conducted by Kiruthika (2014) and Tripp and Ali (2001) have also reported that education has a positive impact on the adoption level of technology.

Conclusions and Policy Recommendations

In India, the sugar industry is facing the problem of cane supply, which is due to reduction in area under sugarcane, labour scarcity, timely availability of planting material, less use of farm mechanization and escalation in input costs. This warrants adoption of new and improved methods in sugarcane cultivation so as to make it viable and remunerative and to increase the supply. Therefore, this study has evaluated the profitability of sugarcane production under conventional method and a new method, viz., Sustainable Sugarcane Initiative (SSI). It has also identified the factors that influence the adoption of SSI method and constraints faced by the farmers in SSI adoption.

Although the total cost of cultivation has been found higher in SSI method than conventional method, the yield obtained from the SSI method was more and therefore, overall gross returns and net returns were higher in the SSI method. The study has concluded that sugarcane cultivation is more profitable under SSI than conventional method. The increase in productivity under SSI over conventional method has been found 24.41 per cent. The study has found the contribution of productivity gain by input-use as 20.49 per cent and technological change as 2.16 per cent. It has concluded that SSI is "more with less" technology in terms of water and seed and it is a positive technological change (implying more output with same inputs) in term of human labour, fertilizer and machine labour.

The logit regression analysis has revealed education and experience to be most influential factors for willingness on adoption of SSI method in sugarcane cultivation. Therefore, efforts should be made to increase the educational level and knowledge status of farmers about the latest technologies such as SSI, fertigation, intercropping, bio-fertilizers, etc. Development of necessary infrastructural facilities, ensuring timely availability of critical inputs (thereby input outlets) and quality planting materials, periodical trainings on SSI method and effective policy for deploying labour from MGNREGA are the major policy options suggested to improve sugarcane production and farm profitability.

Acknowledgements

The authors thank the anonymous referee for his helpful suggestions.

References

Balasaheb, T.D. (2013) *Quantification of Yield Gaps in Different Planting Types of Sugarcane in Maharashtra.* Indira Gandhi Institute of Development Research, Mumbai.

Bisaliah, S. (1977) Decomposition analysis of output change under new production technology in wheat farming: Some implications to returns on investment. *Indian Journal of Agricultural Economics*, **32**(3): 193-201.

Bohme, M. and Thi Lua, H. (1997) Influence of mineral and organic treatments in the Rhizosphere on the growth of tomato plants. *Acta Horticulturae*, **450**: 161- 168.

Chouhan, S. Singh, S.R.K, Pande, A.K. and Gautam, U.S. (2013) Adoption dynamics of improved sugarcane cultivation in Madhya Pradesh. *Indian Research Journal of Extension Education,* **13**(2): 26-30.

Ganesh Kumar, B. (2003) A study to measure the technological change in dairy farming in Tamil Nadu. *Productivity*, **44** (1): 97-104.

Goud, Vinod (2011) *First National Seminar on Sustainable Sugarcane Initiative (SSI)*, A Methodology to Improve Cane Productivity. Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu. 24- 25 August.

GoTN (Government of Tamil Nadu) (2015) *Seasonal and Crop Report, Tamil Nadu - 2013-14*. Department of Economics and Statistics, Chennai.

Gujarati, D.N. and Porter, D.C. (2014) *Basic Econometrics*. Fifth Edition. McGraw Hill. pp.1-915.

ISMA (Indian Sugar Mills Association) (2015) *Indian Sugar: Statistical Abstract-Advanced Estimates*. New Delhi.

Kiruthika, N. (2014) Determinants of adoption of drip irrigation in sugarcane cultivation in Tamil Nadu. *American International Journal of Research in Humanities, Arts and Social Sciences*, **5**(2): 143-146.

Loganandhan, N., Gujja, Biksham, Goud, Vinod and Natarajan, U.S. (2013) Sustainable sugarcane initiative (SSI): A methodology of more with less. *Sugar Technology*, **15**(1): 98-102.

Mohanty, M., Das, P. P. and Nanda S.S. (2015) Technology for enhanced cane production and economic returns in real farming situations under East Coast climatic conditions of India. *Sugar Technology,* **17**(2). (DOI: 10.1007/s12355-014-0311-8)

Murthy, S.R.S. (2010) *Economics of Sugarcane Production and Processing*. National Bank for Agriculture and Rural Development. Mumbai.

NABARD (National Bank for Agriculture and Rural Development) (2012) *AgriSri SSI- Sustainable*

Sugarcane Initiative. Natural Resource Management Centre, Kolkata.

Narayanamoorthy, A. (2013) Profitability in crops cultivation in India: Some evidence from cost of cultivation survey data. *Indian Journal of Agricultural Economics*, **68**(1): 104-121.

Pusappa, K.N. (2013) *Economics of Sugarcane Cultivation in Andhra Pradesh*. Department of Economics, Andhra University,Visakhapatnam. pp. 1-13.

Rahm, R.M. and Hufman, W.E. (1984) The adoption of reduced tillage: The role of human capital and other variables. *American Journal of Agricultural Economics*, **66**: 405-413.

Raju, V.T. and Rao, D.V.S. (1990) *Economics of Farm Production and Management*. Oxford and IBH Pulishing Co. Pvt. Ltd, New Delhi. 185 p.

Rao, R. (2012) Efficiency, yield gap and constraints analysis in irrigated vis-à-vis rainfed sugarcane in North Coastal Zone of Andhra Pradesh. *Agricultural Economics Research Review,* **25**(1): 167-171.

Rao, R. (2014) Input use and cost of cultivation of sugarcane – A study in Telangana region of Andhra Pradesh. IOSR *Journal of Economics and Finance*, **5**(5): 67-74.

Shanthy, R.T. and Ramanjaneyulu, S. (2014) Socio-economic performance analysis of sugarcane cultivation under sustainable sugarcane initiative method. *Indian Research Journal of Extension Education*, **14**(3): 93-98.

Tefera, T. and Melesse Giorgis, W. (2010) Determinants of coffee husk manure adoption: A case study from southern Ethiopia. *Indian Journal of Agricultural Economics*, **65**(1): 159-172.

Thennarasu, R. and Banumathy, V. (2011) Economics of sugarcane production using ecofriendly technology in Cuddalore district, Tamil Nadu. *Indian Journal of Agricultural Economics,* **66**(1): 88-96.

Tripp, R. and Ali, A. (2001) *Farmer Access to Natural Pest Control Products: Experience from an IPM Project in India*, Overseas Development Institute, Agricultural Research and Extension Network, Paper No.113, London, U.K.

Wagh, A.D (2015) Investment in Indian sugar industry: A perspective. *Journal of Contemporary Research*, **3**(1): 111-117.

Received: December, 2015; Accepted: May, 2016

Annexure I: Geometric mean levels of inputs used in SSI method

Variable	Conventional method	SSI method	Per cent change in input use/Output
Yield (t/ha)	101.90	127.38	25.00
N fertilizer (kg/ha)	539.59	605.70	12.25
P fertilizer (kg/ha)	137.49	141.19	2.69
K fertilizer (kg/ha)	219.56	238.45	8.60
Micronutrients (kg/ha)	52.14	88.54	69.81
Human labour (person days/ha)	361.10	413.29	14.45
Machine labour(hours/ha)	8.58	10.47	22.02

Annexure II: Descriptive statistics for the factors affecting adoption of SSI method

Factor	Mean value	Minimum value	Maximum value	Standard deviation (±)
Age (years)	47.41	28	71	11.39
Age square	2377.05	784	5041	1116.67
Education (index*)	4.46	1	6	1.60
Household size (No.)	4.75	3	9	1.51
Total area (acres)	8.46	1.25	32	5.29
Annual income (₹)	312350	137281	826048	174831

Note : * Weighted average of formal education received by the household members (illiterate = 0, primary = 1, middle = 2, secondary = 3, higher secondary = 4, graduate = 5 and post-graduate = 6).