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An Economic Analysis of Sugarcane Cultivation and its Productivity in Major Sugar Producing States of Uttar Pradesh and Maharashtra

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ABSTRACT

An effort has been made in this study to examine the trends in area, production, productivity, costs, returns and profitability of sugarcane and to determine the factors which are contributing toward productivity of sugarcane in major sugar producing states of Uttar Pradesh and Maharashtra. It has been observed that area expansion has significantly contributed towards increased production of sugarcane but productivity has remained stagnant. Cost of cultivation of sugarcane also witnessed increasing trend and due to much higher use of inputs, it was found to be higher for Maharashtra than Uttar Pradesh. However growth of value of output has outpaced the growth of cost of cultivation and thus rising trend of profitability was observed and was higher for Uttar Pradesh as compared to that of Maharashtra. The study found the positive and significant contribution of human labour, machine, fertilizers, insecticides and size of plot towards productivity of sugarcane and thus efficient management of these inputs can certainly led to increasing the productivity of sugarcane in India.

Keywords: Sugarcane, area, production, productivity, cost of cultivation, profitability

In India, sugarcane is the most important commercial crop which is grown over 2.57% of its gross cropped area. Globally India is the second largest producer of sugarcane after Brazil and accounts for about 25% of the world's production. It has engaged around 7.5% of the country's rural population in sugarcane farming and contributed to 10% of the agricultural GDP in 2010-11 (Solomon, 2016). The sugar industry of India is the second largest agro-based industry after textiles and it has successfully contributed towards providing employment and economic development of country (Ahmed and Rahman, 2014). The sugar industry as a whole has supported 6 million farmers and their families (Verma, 2015). Sugarcane is considered as the crop for the future because of its contribution to production of sugar, jaggery, khandsari and many by products like molasses, bagasses and press mud and also certain renewable sources of green energy in the form of bioethanol and many bio-based products. In India, the agro-climatic regions of sugarcane cultivation can be divided into two: tropical and sub-tropical. The sub-tropical region constitutes the northern states of Uttar Pradesh, Bihar, Uttarakhand, Punjab, Haryana comprises of 55% of total area under sugarcane and contributes 47% of country's sugarcane production. The tropical region constitutes mainly the southern states of Maharashtra, Karnataka, Tamil Nadu and Andhra Pradesh. Despite having lesser area i.e. 42% of the total area under sugarcane, the tropical region contributes higher i.e. 51% of country's sugarcane production as the longer duration crop and favorable climatic condition causes higher productivity and better sugar recovery (GOI, 2016).

In this era of globalization and when almost everything is decontrolled, sugar industry continues to be tightly regulated. The different regulations in the form of cane reservation area, regulated release mechanism for the produced sugar, levy sugar obligation and dual pricing of sugarcane

(centrally determined fair and remunerative price (FRP) and state determined state advised price (SAP)) has adversely affected the competitiveness and growth performance of mills and therefore led to delayed payment to sugarcane farmers (Shroff, 2014). However after the deregulation of 2013, sugar sales and prices are freed but sugarcane quantity and prices are still controlled (Sawhney, 2016). Sugarcane crop requires much higher amount of inputs because of its longer duration nature and the cost of sugarcane production has shown an increasing trend over the years (Murthy, 2010). Out of various factors of production of sugarcane, labour and land accounted for 32 % each in the total C2 cost of production in TE 2013-14. The prices of farm inputs including farm wages have shown an increasing trend over the years (GOI, 2016).The productivity and sugar recovery from sugarcane has remained stagnant over the years which are major challenges for Indian sugar sector.

With this background, the study has analyzed trend in area, production and productivity of sugarcane in major sugar producing states of Uttar Pradesh and Maharashtra and India as a whole. The pattern of costs, return and profitability of sugarcane cultivation over the years has been analyzed here. The various factors determining sugarcane productivity have also been estimated in the present study.

Data and methodology

The data on area, production, productivity and cost of cultivation of sugarcane was collected from Directorate of Economics and Statistics (DES), Ministry of Agriculture, GOI. The data on deflators of various inputs like irrigation, pesticides, tractors and output i.e. sugarcane was obtained from the Office of the Economic Adviser, Ministry of Commerce and Industry, GOI. Besides that, the plot level summary data under the cost of cultivation scheme for Uttar Pradesh and Maharashtra was collected from DES, Ministry of Agriculture, GOI for examining the factors contributing to the sugarcane productivity.

To estimate the relationship between productivity of sugarcane and various inputs including farm size, linear as well as Cobb-Douglas production function was fitted between output and all the selected inputs. Human labour (hrs./ha), animal labour (hrs./ha), machine labour (hrs./ha), fertilizers (Kg/ha), insecticides (₹/ha), irrigation charges (₹/ ha) were selected as independent variables and yield (q/ha) as a dependent variable. Separate dummies for states (Uttar Pradesh and Maharashtra) and planting material (planted and ratoon) were also incorporated as explanatory variables. For ascertaining the effect of farm size on yield, a dummy for farm size was taken as an independent variable. A separate production function having actual plot size as an explanatory variable in place of dummy for farm size was also attempted. Linear as well as Cobb-Douglas production function both were tried and based on R square and significance of the estimated coefficients, Cobb-Douglas production function was finally chosen. The following two production functions were fitted among the chosen variables:

$$y = \alpha_0 \Pi x_i^{\beta_i} e_j^{\gamma_j D_j} e^u \quad \ldots(1)$$

Where, y = yield,

i = 1,2….6, j = 1,2,3

$x_1, x_2, \ldots x_6$ = human labour, animal labour, machine, fertilizer, insecticide and irrigation charges

D_1 = 1 if state is Uttar Pradesh

= 0 otherwise

D_2 = 1 if crop is planted

= 0 otherwise

D_3 = 1 if farm size is small and marginal

= 0 otherwise

α_0 = intercept

$\beta_1, \beta_2 \ldots..\beta_6, \gamma_1, \gamma_2, \gamma_3$ = regression coefficients

u = error or residual.

$$y = \alpha_0 \Pi x_i^{\beta_i} e_j^{\gamma_j D_j} e^u \quad \ldots(2)$$

Where, y = yield,

i = 1,2….7, j = 1,2

$x_1, x_2, \ldots x_7$ = human labour, animal labour, machine, fertilizer, insecticide, irrigation charges and plot area

D1 = 1 if state is Uttar Pradesh

= 0 otherwise

D2 = 1 if crop is planted

= 0 otherwise

α_0 = intercept

β_1, β_2 …..β_7, γ_1, γ_2 = regression coefficients

u = error or residual.

After taking natural logarithm of eq. (1) and (2), these were converted into linearized Cobb-Douglas production function and then with the help of ordinary least square (OLS), the production functions were estimated.

RESULTS AND DISCUSSION

Trends in area, production and productivity of sugarcane

In India the area as well as production of sugarcane has followed a cyclical trend from the past one decade, however from the few years back it has shown a dampening nature (Fig. 1).

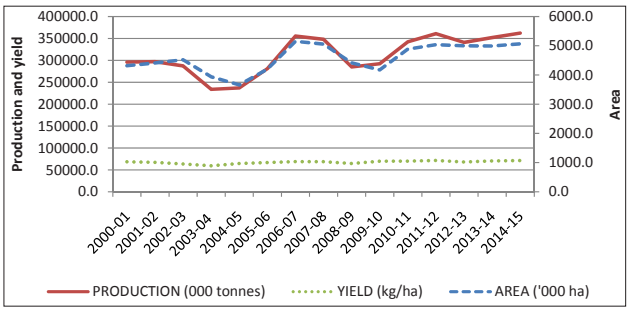

Fig. 1: Area, production and yield of sugarcane

Note: *Compiled from DES, GOI.*

The year of surplus sugar production causes glut leading to crash in the domestic prices. This creates crises for both millers as well as farmers, leading to reduced cane and sugar production in the subsequent years. Then the year of reduced production causes shortages leading to increased prices which again motivate the farmers to expand the area under crop. This causes induced cyclical nature of sugar as well as sugarcane production. The production of sugarcane decreased from 296 million tonnes in 2000-01 to 234 million tonnes in 2003-04 then it increased to 355.5 million tonnes in 2006-07, again decreased to 285 million tonnes in 2008-09. Now it has reached to 362 million tonnes in 2014-15. Similarly, area has also followed the same cyclical trend and it occupies 5 million ha area in 2014-15. Over this period the sugarcane area and production has registered a significant growth rate of 1.45% and 2.16%, respectively. The yield of sugarcane has shown a quiet stagnant trend and it has witnessed a significant growth of 0.69% over the period with national average yield of 71.5 kg/ha in 2014-15. The trend clearly suggests that growth rate of area has been significantly higher than that of yield and thereby contributing more to the increased production of sugarcane. Among all the states, Uttar Pradesh has the highest area (44% of total sugarcane area) followed by Maharashtra (19%), Karnataka (8%), Tamil Nadu (7%), Bihar (5%), Andhra Pradesh (4%) and Gujarat (4%). Uttar Pradesh also ranks first in terms of production (38% of total sugarcane production) followed by Maharashtra (22%), Karnataka (11%), Tamil Nadu (10%), Andhra Pradesh (5%), Gujarat (4%) and Bihar (4%).

The productivity pattern shows that West Bengal, Tamil Nadu and Kerala come under high productivity range because of longer duration crop and favorable climatic conditions. Karnataka, Maharashtra, Andhra Pradesh, Punjab, Haryana and Gujarat are in medium productivity category. While Uttar Pradesh comes under low productivity range along with the states of Rajasthan, Jharkhand, Orissa, Uttarakhand, Bihar, Madhya Pradesh, Chhattisgarh and some north eastern states. Uttar Pradesh and Maharashtra being the largest contributors in sugarcane area and production, this study focuses on these two states only.

In Uttar Pradesh, area and production of sugarcane has increased at a significant annual growth rate of 0.59% and 1.1% respectively over the period 2000-15 which is quiet less than that of Maharashtra where it registered a growth rate of 6.01% and 7.09% respectively.

However, yield of sugarcane has not witnessed a significant growth rate in any of the two states. The major factors behind this stagnant productivity of sugarcane are varietal deterioration, biotic and a biotic stresses, decline in soil productivity, low technology adoption and climatic vagaries. Thus this study highlights that the increased production has been mainly contributed by the area expansion in major sugar producing states of Uttar Pradesh and Maharashtra and in country as a whole. The low and stagnant productivity of sugarcane over the years is a major challenge for the country's sugar economy.

Table 1: Area, production and yield of sugarcane in Uttar Pradesh and Maharashtra

	Uttar Pradesh			Maharashtra		
	Area (lakh ha)	Production (million tonnes)	Yield (tonnes/ ha)	Area (lakh ha)	Production (million tonnes)	Yield (tonnes/ ha)
2000-01	19.38	106.07	54.72	5.95	49.59	83.35
2004-05	19.55	118.71	60.73	3.24	20.47	63.19
2009-10	19.77	117.14	59.25	7.56	64.16	84.87
2014-15	21.41	133.06	62.15	10.3	84.70	82.23
CAGR (2000-2015) %	0.59**	1.1**	0.51	6.01*	7.09**	1.03

Note: ** Significant at 1% level of significance, ** Significant at 5% level of significance;* ***Source:*** *Compiled from DES, GOI.*

Cost of cultivation of sugarcane: The general trend

The sugarcane crop is characterized by requiring a higher amount of inputs i.e. labour, fertilizers, irrigation and machinery etc., thereby making necessary to analyze the trends in cost of cultivation over the years. The case of Uttar Pradesh and Maharashtra can be generalized to all over India since these top sugar producing states contribute 60% of total sugarcane and sugar production of India. The trends in nominal cost of cultivation of sugarcane of two major sugar producing states of Uttar Pradesh and Maharashtra shows their positive movement over time witnessing an compound annual growth rate (CAGR) of 8.5% and 10% respectively (Fig. 2).

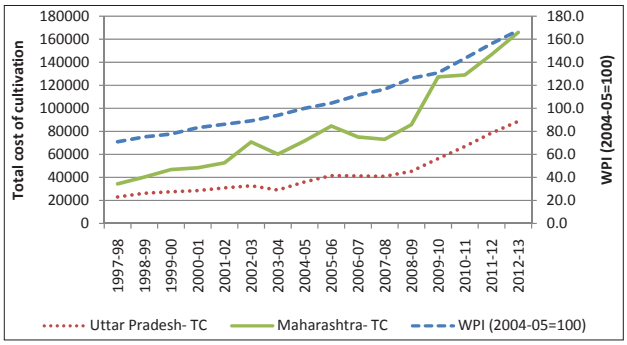

Fig. 2: Trends in nominal cost of cultivation of sugarcane in major sugar producing states and WPI

Source: *Compiled from DES and Office of Economic Advisor, GOI.*

The wholesale price index (WPI) for all commodities registered a CAGR of 5.7% over the same period. Thus it becomes necessary to separate out the effect of inflation from the nominal cost of cultivation and analyze the pattern of real cost of cultivation of sugarcane over the years.

Trends in real cost of cultivation, cost of production and gross value of output

To track the changes in pattern of real cost of cultivation and gross value of output over the years, the various components of costs (both fixed and operational cost) and output has been deflated by the respective price indices and a comparison has been made to know the real changes in use of inputs and resulting output. The operational cost which constitutes cost of human labour, animal labour, machine labour, planting material, fertilizer & manure, insecticides, irrigation charges, interest on working capital and other miscellaneous cost has of course increased over the years but didn't register a significant growth rate in Uttar Pradesh as well as in Maharashtra (Table 2). Fixed cost which constitutes rental value of owned land, rent paid for leased-in-land, land revenue, depreciation on implements and farm buildings and interest on fixed capital has also shown an increasing trend at a significant growth rate of 2.46% and 5.2% per annum respectively in Uttar Pradesh and Maharashtra. Total cost of cultivation which is sum of operational cost and fixed cost has also shown an increasing trend at a significant annual growth rate of 1.79% and 2.59% in Uttar Pradesh and Maharashtra respectively. Cost of production of sugarcane i.e. the cost of producing a unit quantity of output has grown a little in both the states. However, results clearly showed that gross value of output has shown a significant and impressive growth of 4.83% and 7.3% per annum in Uttar Pradesh and Maharashtra respectively.

Thus, growth in value of output was observed to have grown much rapidly than that of cost in both the states indicating the rising trend in profitability

Table 2: Trends in real cost of cultivation, cost of production and gross value of output in Uttar Pradesh and Maharashtra

	Operational cost		Fixed cost		Total cost of cultivation		Cost of production		Gross value of output	
	₹/ ha		₹ / ha		₹ / ha		₹ / quintal		₹ / ha	
Unit	UP	Maha	UP	Maha	UP	Maha	UP	Maha	UP	Maha
TE 1999-00	17558	39539	14389	16498	31947	56037	67	70	43214	56867
TE 2004-05	17303	50876	15717	18917	33020	69793	65	82	52558	82208
TE 2009-10	18484	47003	16931	25405	35415	72408	72	82	67299	99275
TE 2012-13	20986	52619	17022	25000	38008	77619	72	77	73236	121480
CAGR (%)	1.31	1.44	2.46*	5.20*	1.79*	2.59*	0.87	0.31	4.83*	7.3*

Note: *Values are at constant price of 2004-05; *Significant at 5% level of significance;* ***Source:*** *Computed from DES, GOI.*

of sugarcane cultivation over the period. However, farmers have spent more on acquiring fixed assets rather than the operational ones. The cost of cultivation was found almost double in Maharashtra than that of Uttar Pradesh. This may be because of using much more amount of fertilizers, human labour, machine labour and irrigation. Gross value of output was also higher in Maharashtra because of higher yield.

Trends in different components of operational cost

The study showed that among different components of operational cost, wages constituted highest share 54.7% and 46.7% in Uttar Pradesh and Maharashtra respectively in TE 2012-13 (Fig. 3).

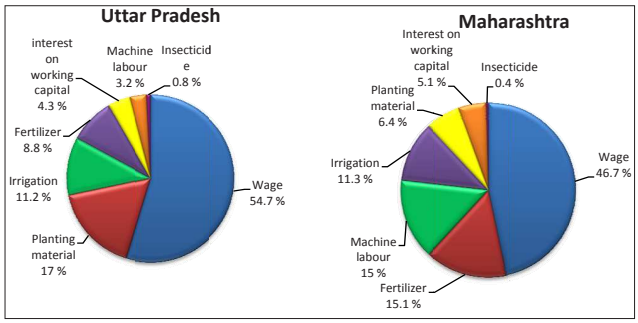

Fig. 3: Share of different inputs in real operational cost of sugarcane cultivation in major sugar producing states of Uttar Pradesh and Maharashtra (TE 2012-13)

Source: *Computed from DES, GOI.*

Wages were followed by cost of planting material (17%), irrigation (11.2%) and fertilizer (8.8%) in Uttar Pradesh while in Maharashtra; wages were followed by expenditure on fertilizer (15.1%), machine labour (15%) and irrigation (11.3%) in total operational cost. It is also significant to note here that sugarcane cultivators of Maharashtra were found to be using much higher amount of machine labour and fertilizer as compared to that of Uttar Pradesh.

The break-up of total operational cost into different components show that total wage cost has almost remain stagnant over the years (Table 3). Human labour has increased and animal labour has decreased thus almost balancing each other. Expenditure on fertilizer has increased significantly in both the states with much higher rate of increase (4.07%) in Maharashtra as compared to that of Uttar Pradesh (1.4%). Total machine labour cost has also witnessed a significant growth rate of 3.6% and 7.05% in Uttar Pradesh and Maharashtra respectively. Cost of irrigation also registered significant growth rate in both the states. Cost of planting material showed significant growth rate only in Uttar Pradesh.

Thus among the major components of operational cost only fertilizers, machine labour and irrigation cost registered significant increment over the period in both the states. It is also significant to note here that Maharashtra has been characterized by using much higher amount of inputs as compared to Uttar Pradesh mainly because of longer duration of crop.

Profitability of sugarcane cultivation

Profitability of sugarcane was estimated in terms of net return over cost A2 + family labour (which is the return over paid-out cost and imputed value of family labour) as well as net return over C2 cost of cultivation (which is return over total cost of cultivation including of fixed as well as paid out cost). From profitability analysis, the study found

Table 3: Trends in different components of operational cost (₹/ha)

	Total wage cost		Expenditure on fertilizer		Total machine labour cost		Irrigation cost		Cost of planting material	
	UP	Maha	UP	Maha	UP	Maha	UP	Maha	UP	Maha
TE 1999-00	9560	18250	2060	4865	604	3446	2191	6784	1831	3326
TE 2004-05	9074	21411	2101	6805	742	7522	2382	7321	1901	3781
TE 2009-10	9612	18499	2347	7261	820	5792	2119	8224	2457	3388
TE 2012-13	9663	18061	2457	8389	1014	11026	3339	7829	2785	2943
CAGR (%)	0.2	-0.05	1.4*	4.07*	3.6*	7.05*	2.2*	1.39*	3.3*	-0.08

Note: *Values are at constant price of 2004-05; *Significant at 5% level of significance;* ***Source:*** *Computed from DES, GOI.*

Table 4: Trends in profitability of sugarcane cultivation in major sugar producing states of Uttar Pradesh and Maharashtra

Years	Net return (on cost A2+FL basis) (₹ / ha)		Net return (on cost C2 basis) (₹ / ha)		NR as % of cost A2+FL		NR as % of cost C2	
	UP	Maha	UP	Maha	UP	Maha	UP	Maha
2004-05	37953	53740	20212	32090	204	107	56	45
2009-10	60037	76630	35877	34009	301	138	81	35
2012-13	51508	70372	25765	35527	190	109	49	36
2014-15	61549	32061	32659	-1006	243	43	60	-1

Note: *values are at constant 2004-05 price;* ***Source:*** *Computed from DES, GOI.*

that net return over cost A2+FL as well as net return over cost C2 has shown variations over the years (Table 4). However, net return as a percent of cost A2+FL and as a percent of cost C2 both have decreased over the period in Maharashtra but in Uttar Pradesh, it decreased upto 2012-13 and after that in 2014-15, it has shown upturn. The farmers of Uttar Pradesh and Maharashtra were earning 49% net return and 36% net return, respectively over total cost of cultivation C2 in 2012-13 and 60% and -1%, respectively in 2014-15. This implies that sugarcane farmers were getting ₹ 60 out of cost of ₹ 100 in Uttar Pradesh and in Maharashtra, farmers were getting loss of ₹ 1 out of cost of ₹ 100. This profitability ehas been always higher for sugarcane cultivators of Uttar Pradesh as compared to Maharashtra. This can be concluded that although sugarcane productivity was higher in Maharashtra but profitability was higher in Uttar Pradesh because of relatively higher cost of cultivation in Maharashtra.

Factors determining sugarcane productivity in Uttar Pradesh and Maharashtra

For estimating the contribution of different factors including inputs to sugarcane productivity, two types of Cobb-Douglas production function model has been fitted on plot level data pertaining to one year 2012-13. In first model, human labour (0.382), machine hrs. (0.012), fertilizers (0.055) and insecticides (0.005) got positive and significant coefficient which is indicating that one percent increase in these inputs will increase sugarcane productivity by 0.382, 0.012, 0.055 and 0.005 percent respectively (Table 5). The coefficient of animal labour (-0.01) was significant but negative thus indicating that one percent increase in animal labour will decrease sugarcane productivity by 0.01 percent. Among all incorporated dummies, only dummy for states got a significant coefficient (-0.349) indicating that in comparison to Maharashtra, sugarcane productivity in Uttar Pradesh is lower by 0.349 percent. Coefficients of rest of the variables

Table 5: Estimated values of coefficients of Cobb-Douglas production function model

	Model 1	Model 2
Intercept	3.631 (0.24)*	3.456 (0.026)*
Labour	0.382 (0.03)*	0.405 (0.03)*
Animal labour	-0.010 (0.003)*	-0.010 (0.003)*
Machine	0.012 (0.004)*	0.011 (0.004)*
Fertilizer	0.055 (0.01)*	0.054 (0.01)*
Insecticide	0.005 (0.002)*	0.005 (0.002)*
Irrigation	-0.007 (0.01)	-0.007 (0.01)
Plot area	—	0.073 (0.03)*
Dummy states (UP=1, Maharashtra=0)	-0.349 (0.04)*	-0.345 (0.04)*
Dummy planting material (planted=1, ratoon=0)	-0.021 (0.03)	-0.018 (0.03)
Dummy farm size (small & marginal=0, others=1)	0.035 (0.03)	—

Note: **Significant at 5% level of significance, values in the parentheses are the corresponding standard errors;* ***Source:*** *Computed from DES, GOI.*

like irrigation, dummy for planting material and dummy for farm size were not found significant.

In the second model, actual plot area of sugarcane was taken in place of dummy for farm size as an independent variable along with other inputs. Here also coefficients of human labour (0.405), machine hrs. (0.011), fertilizers (0.054), insecticides (0.005) and plot area (0.073) were positive and significant and thus indicating that one percent increase in these inputs will increase sugarcane productivity by 0.405, 0.011, 0.054, 0.005 and 0.073 percent respectively. Coefficient of animal labour (-0.01) was significant but negative. Coefficient of dummy for states (0.345) was also significant; indicating that as compared to Maharashtra sugarcane productivity of Uttar Pradesh is lower by 0.345 percent. Rest of the variables like irrigation and dummy for planting material did not turn out significant.

The regression analysis did not confirm any definite relationship between farm size and sugarcane productivity. It may be inferred from the study that more use of human labour, machine, fertilizers, insecticides and increasing the size of plot will definitely improve productivity of sugarcane cultivation.

CONCLUSION

This study has analysed the trends in area, production, productivity, costs, returns and profitability of sugarcane cultivation and determined the factors contributing to productivity of sugarcane. It revealed from the study that yield of sugarcane has shown a stagnant trend because of varietal deterioration, biotic and a biotic stresses, decline in soil productivity, low technology adoption and climatic vagaries. Thus increased production of sugarcane is mainly led by the area expansion over the years. The costs and returns analysis showed that value of output has grownmuch rapidly than that of cost in both the states indicating the rising trend in profitability of sugarcane cultivation over the years. The cost of cultivation was found almost double in Maharashtra than that of Uttar Pradesh may be because of longer duration crop and thus using much more amount of fertilizers, human labour, machine labour and irrigation.

The study found relatively less mechanization and fertilizer use in Uttar Pradesh as compared to Maharashtra. Among all of the major components of operational cost only fertilizers, machine labour and irrigation cost witnessed significant increment over the period in both the states. Although productivity of sugarcane was found higher in Maharashtra but profitability of sugarcane was estimated to be higher in Uttar Pradesh because of relatively higher cost of cultivation in Maharashtra. The study revealed that productivity of sugarcane can be increased by more and efficient use of human labour, machine, fertilizers, insecticides and increasing the size of plot. Thus the present study suggests a way towards increasing the currently stagnant productivity of sugarcane.

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