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Economic impact of improved Adsali sugarcane production technology in Maharashtra

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Abstract
Sugar is the largest agro based industry after textile. In Maharashtra, the proportionate share of sugarcane area is about 5 per cent of the gross cropped area. This paper highlights to assess the impact of sugarcane production technologies, resource use productivity and resource use efficiency, cost effectiveness and decomposition of productivity gain in Adsali sugarcane cultivation in different recovery zones of the Maharashtra State. This investigation is based on the primary data collected from 270 sample cultivators spread over three sugarcane recovery zones. A specially designed questionnaire was prepared for the year 2012-13 and sample farmers were personally interviewed.
The technologies *viz*; soil type, proper seed rate, management of irrigation, use of N, P and K were adopted more in all the recovery zones. And the technologies regarding preparatory tillage, use of manures, seed selection, use of micronutrients and seed treatment were used at low level in all the recovery zones. The nine resource variables included in the production function analysis have jointly explained 76, 74 and 73 percent of the total variation in the yield of low, medium and high technology adopters, respectively. The variables like use of human labour, manures and technology adoption index are positive and significant indicating these are the important inputs to which output was highly responsive. The ICBR ratio indicates that the high adopter farmers were in profit than medium and low adopters. The decomposition analysis inferred that the high adopters were not able to consolidate the technology gain.

Keywords: Economic, Adsali sugarcane, production technology

Introduction
The sugar industry has played a pivotal role in Maharashtra under the co-operative sector in upliftment of rural sector, in particular and development of state economy in general. Since sugarcane is the basic raw material for sugar and sugarcane based industries, the sickness of sugar industry is mainly due to inadequate supply of sugarcane to cater to the need of the factory. Establishment of new units and expansion in crushing capacity of existing units call for concentrated efforts on the part of policy makers, administrators, research workers as well as development workers for sustained sugarcane production. It is needless to say that sustained and in depth efforts are required to increase production and productivity of sugarcane in Maharashtra. At the state level, the proportionate share of sugarcane area is about five percent of the gross cropped area. The sugarcane yield and sugar content are affected as a consequence of climatic features and annual weather fluctuations in terms of temperature and rainfall variations. Efforts have been made to evolve and transfer of new production technology. Yet farmers have not adopted the technology in its entire. The major aspect of this study is to examine in detail the extent of technology adoption for adsali sugarcane and to measure the contribution of technology in yield gap.

Materials and methods

The state has nine agro-climatic zones and sugarcane is grown almost in all these zones. However, on the basis of productivity and sugar recovery, the state has been identified with three zones, *viz*: High, Medium and low recovery zones. The present investigation is based on the primary data collected from 270 sample cultivators from 18 villages spread over three sugarcane recovery zones. In order to assess the extent of technology adoption and cost effectiveness, a specially designed questionnaire was prepared for the year 2012-13 and sample farmers were personally interviewed.

1. Extent of adoption of technology

Actual level of adoption of each item of technology on farmers field was identified using recommended technologies developed by MPKV, Rahuri and MAU, Parbhani. Efficiency of each technology was calculated. All Efficiency score were scaled down from zero to one.

$$EA = \frac{\text{Actual adoption Score}}{\text{Recommended technology Score}}$$

Where, EA= Extent of adoption.

2. Development of composite index of technology

The components of technology recommended by the University for sugarcane crop in terms of adoption scores (X1,…, Xn) was utilized for developing composite index of technology adopted. A composite index is a single numerical value representing the net adoption of all components of technologies whose values lies in between 0 and 1.

The Principle Component Analysis (PCA) approach was used for developing composite index. PCA based on correlated matrix between K^{th} components of technology was computed. A set of K^{th} components explaining 100 per cent of total variation of all components of recommended technologies was considered. Correlation matrix where row represents variables and columns represents Eigen vectors from which weight (W_i) or coefficients of components of technology say Σ is determined as,

$$W_i = \frac{Mi}{\Sigma\, Mi}$$

Where

W_i = Weight or coefficient of component of technology

M_i= Maximum element in i^{th} row

Σ Mi = Sum of maximum element in i^{th} row

The required linear function for developing composite index is

$$S_i = W_1X_1 + W_2X_2 + \text{------------------} W_nX_n$$

Where

Si = composite index score.

Xi's = adoption scores for individual component of technology.

This provides adoption index (of all components of technologies) for each cultivator. The composite index obtained in the process lie in between 0 and 1.

The composite score of farmers was classified as low level adoption (0-60%) medium level (61-80%) and high level of adoption (above 80%).

3. Production function analysis

The Cobb-Douglas type of production function was used in the present investigation as it is an appropriate one for estimating the resource use productivities. The data was therefore, subjected to functional analysis by using the following form.

$$Y = aX_1^{b_1}X_2^{b_2}X_3^{b_3}X_4^{b_4} \dots\dots X_n^{b_n}e^u$$

In this functional form Y is dependent variable 'Xi's are the independent resource variables, 'a' is the constant and 'bi'^s are the regression coefficients. The regression coefficients obtained from these equations are also elasticities of production, which remain constant throughout the relevant changes in inputs. The sum of regression coefficients i.e. 'bi'^s indicates the nature of returns to scale.

4. Selection of input variables

It was conceptabilized that the output of sugarcane is largely depend on input factures such as total human labour, bullock labour, machine power, manures, nitrogen, phosphorus, potash, and micronutrients. One more input factor considered was technology adoption index. Separate analysis was done for each recovery zone. Thus, the model of production function took the form of

$$Y = a\, X_1^{b_1}\, X_2^{b_2}\, X_3^{b_3}\, X_4^{b_4}\, X_5^{b_5}\, X_6^{b_6}\, X_7^{b_7}\, X_8^{b_8}\, X_9^{b_9}\, e^u$$

Where

Y = Output (tons/ha)

X_1 = Total human labour(mandays/ha)

X_2 = Bullock power (pair days/ha)

X_3 = Machine power (hrs/ha)

X_4 = Manures (q/ha)

X_5= Nitrogen (kg/ha)

X_6 = Phosphorus (kg/ha)

X_7 = Potash (kg/ha)

X_8 = Micronutrients (Rs./ha)

X_9 = Technology Adoption Index (Per cent)

e^u = Error term

a = Intercept

The production functions for low, medium and high adopters of technology were estimated separately. The significance of each of the coefficient of the variable from the estimated function were tested with the help of 't' statistics and goodness of fit was judged on the basis of R^2.

5. Estimation of marginal value products (MVP)

In order to study the efficiencies of resources in sugarcane cultivation, the Marginal Value Products (MVPs) of the resources were estimated and compared with its unit price (MC).

The marginal value product (MVP) of individual input was worked out with the help of following equation.

$$MVP\ x_i = bi\, \frac{Y}{Xi}\, Py$$

Where

b_i = Elasticity of production of i^{th} input

Y = Geometric mean of output

X_i = Geometric mean of i^{th} input

P_y = Per unit price of output

The efficiency of resources was studied through the differences between MVP's of resource with their respective acquisition costs. The estimated results of planting types of sugarcane production with respect of magnitudes of regression coefficients were compared.

6. Decomposition Analysis

To measure the contribution of each component of technologies in the yield gap the data collected under study was used along with the adoption level of technologies and the yield gap was estimated in relation to the recommended yield. The yield gap is considered as a function of level of adoption and the contribution of each technology in yield gap were worked out by fitting linear regression between the level of adoption of each technologies and yield gap.

$$Zij = \frac{[Xij - Xj]}{Sj}$$

Where

$$Sj2 = \frac{\Sigma^{n}{}_{1} [Xij - Xj]^2}{N}$$

i= 1, 2, 3, …., n and j= 1, 2, 3, …, k
Z_{ij} denotes the matrix of standardized indicators.

Yield gap between standard yield and actual yield by the farmer is regressed on standardized value of indicators and best fit was obtained.
Contribution of each indicator in yield gap was studied to arrive concluding of yield gap and technological adoption gap.

Results and Discussion
Package of recommended technologies
In Maharashtra, there are in all four Agricultural Universities as per the different regions. Each university develops its own crop production technology and recommends to the farmers of the respective region. The selected sample districts lie in the jurisdiction of Mahatma Phule Krishi Vidyapeeth, (MPKV) Rahuri and Vasantrao Naik Marathwada Krishi Vidyapeeth, (VNMKV) Parbhani. Hence, the technologies developed by these agricultural universities were taken into consideration. These technologies made possible to improve the land productivity and higher level of profitability.

Extent of technology adoption
Adsali sugarcane plantation was mostly done near river basin or where ample of irrigation water is available. As the study area has three recovery zones, the recovery zone wise extent of technology adopted by adsali sugarcane cultivators were studied and presented in Table 1. It is revealed from the table that, the technologies *viz*; soil type, proper seed rate, management of irrigation, use of N, P and K were adopted more in all the recovery zones. However, the technologies regarding preparatory tillage, use of manures, seed selection, use of micronutrients and seed treatment were used at low level in all the recovery zones. It is mainly due to unavailability of manures and planting sets of recommended variety with its high cost in the study area. The extent of adoption of harvesting at proper stage for adsali sugarcane was found low in all the recovery zones because of delayed start of sugarcane crushing season. From the above discussion it is revealed that, the extent of use of technology adoption regarding application of manures, seed selection, seed treatment and use of micronutrients was low in all the recovery zones and in all the adoption groups.

Table 1: Extent of technology adoption for Adsali sugarcane (Per cent)

Sr. No.	Technology	Low Recovery Adopters			Medium Recovery Adopters			High Recovery Adopters		
		Low	Medium	High	Low	Medium	High	Low	Medium	High
1	Soil	100.00	81.25	75.00	76.67	80.56	100.00	62.50	76.79	100
2	Preparatory Tillage	50.00	63.02	65.63	60.00	71.53	66.67	66.67	78.57	67.50
3	Seed Selection	50.00	69.79	71.88	60.00	71.53	79.17	73.21	73.66	72.50
4	Seed rate	99.10	96.37	93.10	70.18	89.61	100	87.46	97.21	97.08
5	Seed treatment	0.00	25.00	37.50	3.33	11.11	33.33	8.57	3.57	20.00
6	Inter-culturing	45.24	64.88	71.43	66.67	76.19	80.95	83.33	88.78	82.86
7	Irrigation	70.00	80.83	90.00	76.00	85.56	93.33	77.78	98.57	92.00
8	Manures	25.00	72.49	68.92	58.96	66.80	65.11	41.67	60.71	68.00
9	N	86.64	81.54	95.37	53.32	83.15	66.10	80.73	87.45	93.00
10	P	81.28	76.34	97.79	81.93	92.77	83.24	58.46	76.65	80.00
11	K	73.57	69.51	83.66	63.22	89.21	87.62	92.61	85.86	65.00
12	Micro-nutrients	25.00	22.92	37.50	6.67	19.44	33.33	41.67	35.71	30.00
13	Harvesting	72.22	70.83	75.00	57.78	53.70	55.56	89.79	54.76	66.67

Resource use productivity
Table 2 is devoted to discuss the resource use productivities on the sugarcane producing farms having Adsali plantation in Maharashtra under different adoption levels. The Cobb-Douglas production function estimates are deployed to estimate resource use productivities.
The nine resource variables included in the production function analysis have jointly explained 76, 74 and 73 percent of the total variation in the yield of low, medium and high technology adopters, respectively. In low adopters the regression coefficient of the total human labour (X_1) was 0.42 and highly positively significant at 1 per cent level. It indicates that if we increase the total human labour by one per cent the output of Adsali sugarcane will increase by 0.42 per cent. Variable manures (X_4) and technology adoption index (X_9) are turned out to be positive and significant at 5 percent level. This indicates that these are the important inputs to which output was highly responsive.

Table 2: Results of Cobb-Douglas production function for Adsali Sugarcane in Maharashtra

Sr. No.	Items	Adopters		
		Low (N=27)	Medium (N= 70)	High (N=12)
1	Constant (a)	0.9165	1.3844	1.2720
2	Human Labour (Man days) X1	0.4158*** (0.1229)	0.3205*** (0.0637)	3.9619** (1.2090)
3	Bullock Labour (Pair days) X2	0.0023	0.0162**	0.1621***

		(0.0164)	(0.0074)	(0.0410)
4	Machinery (Hrs) X3	0.0064 (0.1106)	-0.0105 (0.0181)	0.0984 (0.0875)
5	Manure (q) X4	0.0041** (0.0018)	-0.0008 (0.0069)	0.4902** (0.1958)
6	Nitrogen (Kg) X5	0.0017 (0.0691)	-0.0242 (0.0719)	2.9867** (1.2341)
7	Phosphorous (Kg) X6	0.0269 (0.1909)	-0.0724 (0.0905)	0.3249* (0.0805)
8	Potash (Kg) X7	0.0798 (0.0903)	0.2178*** (0.0641)	1.9607** (0.8168)
9	Micronutrients (Rs)X8	0.0034 (0.0061)	-0.0059 (0.0034)	0.2032 (0.0527)
10	TAI (%) X9	0.8050** (0.3187)	0.3160** (0.1311)	0.2310* (0.1283)
11	R^2	0.76	0.74	0.73

(***, ** and * Significant at 1, 5 and 10 per cent, respectively)
(Figures in the parenthesis indicates standard error of respective coefficients.)

Among the medium technology adopters, the regression coefficients of the variables *viz*., total human labour (X_1) and potash fertilizer (X_7) are highly significant at 1 per cent level, indicating there by that the output is highly responsive to these important inputs. Similarly, bullock labour (X_2) and technology adoption index (X_9) are the important inputs as they are significant at 5 per cent level.
For high adopters, the regression coefficient of the bullock labour (X_2) input variables is positive and highly significant at 1per cent level. Also the regression coefficients of human labour (X_1), Manure (X_4) and potash (X_7) are turned out to be positive and significant at 5 per cent level. The regression coefficient of phosphorus (X_6) and technology adoption index (X_9) were positive and significant at 10 per cent level. These all significant regression coefficients indicates the economic importance of these inputs in the production of adsali sugarcane for high adopters.

Resource use efficiency

A resource or input is considered to be used more efficient if marginal value product just offsets its unit cost. Equality of marginal value product with factor cost is, therefore, the basic condition that must be satisfied to obtain efficient resource use. Hence, the marginal value of the resources so obtained from the estimated production function at the geometric mean level of their use in the production of adsali, suru and ratoon sugarcane crop on the sample farms are presented in Table 3.
Table 3 indicates that, the marginal value products of total human labour were greater than their respective unit acquisition cost. The marginal value products of bullock labour were greater than their respective unit acquisition cost in the case of medium and high adopters group indicating the under use of bullock labours. Among the different adoption groups of sugarcane cultivation marginal value products of machinery was found less than their marginal costs which indicated the need for effecting reduction in their use from the existing use levels. The marginal value products of manures for low and high adoption groups were greater than their respective marginal costs. This indicates under use of manures by these adoption groups. The marginal value products of Nitrogen in high adoption group was greater than their marginal cost which indicated the scope to increase sugarcane production through increased use of nitrogen.

Table 3: Comparison of Marginal Value Products of resources

Sr. No.	Particulars	MVP/ MC		
		Low	**Medium**	**High**
1	Human labour	1.4484	1.0970	1.1519
2	Bullock labour	0.2140	1.8668	3.3926
3	Machinery	0.1409	0.3266	0.4592
4	Manures	1.3613	0.2925	1.3167
5	N	0.0722	0.9046	1.1254
6	P	1.3187	3.0353	0.2123
7	K	8.8602	17.668	1.3622
8	Micro-nutrients	6.8047	4.9155	15.190

The marginal value products of micro nutrients is less than their respective marginal costs in all adoption groups of adsali plantation except in all adopters groups indicating that there is a need to reduce the use of micro nutrients. The findings confirms with the results of Singh (2013) and Rao (2013).

Adoption levelwise cost effectiveness and economic impact

To examine the additional cost and additional yield as per the level of adoption and its impact on returns is estimated and presented in Table 4.
It is revealed from the Table 4 that the per hectare yield is increasing as farmers adopt the higher level of adsali sugarcane technologies. The added yield was 11.15 and 14.30 tons per hectare over the low o medium and medium to high level of adoption. Thus for producing this extra yield, per hectare costs were also increased by Rs. 5939.94 to 5160.62 and accordingly, the added returns were also increased from Rs. 9663.78 to Rs. 10013.10.

Table 4: Cost effectiveness and economic impact of technology Adoption

Sr. No.	Particulars	Adoption Groups		
		Low	Medium	High
1	Yield (tons/ha)	80.28	91.43	105.73
2	Added yield(tons/ha)		11.15	14.30
3	% increase in Yield		13.89	15.64
4	Cost C (Rs.)	126703.8	132643.7	137804.4
5	Added Cost (Rs/ton)		5939.94	5160.62
	Cost (Rs/ton)	1578.27	1450.77	1303.36
	Unit cost reduction (Rs./ton)		127.51	147.41
	% reduction		8.08	10.16
6	Returns/ha	203242.8	212906.6	222919.7
	Added returns/ha		9663.78	10013.10
	ICBR Ratio		1.63	1.94

The ICBR ratio indicates that the high adopter farmers were in profit with 1.94 ICBR ratio and followed by medium adopters with ICBR ratio of 1.63. It clearly indicates that, the farmers may adopt the sugarcane cultivation technologies to the further extent for maximizing returns and minimizing per unit cost.

Decomposition of productivity gain

The results of the decomposition analysis for *adsali sugarcane* production are presented in Table 5.

The total gain in production due to the shift from 'low adopters' to 'high adopters' was found to be 28.95 per cent, which was mainly contributed due to the difference in the levels of input use. The contribution of technological change to the yield gain was 11.49 per cent, which implies that the output could not be increased with the same levels of inputs used by low adopters. Among the components of technological change, the contribution of neutral technological change in total productivity was estimated to be 168.79 per cent. The negative neutral technologies implied that, there was decrease in efficiency of inputs used by the low adopters, as the farmers were not able to adjust to the requirements of new methods for *adsali sugarcane* production. While, the contribution of non-neutral technologies to the yield gain was estimated to -157.30 per cent. This indicates that, high adopters in place of low adopters would bring an upward shift in the *adsali sugarcane* yield.

Table 7: Decomposition of productivity gain in *adsali sugarcane* production

Sr. No.	Sources of technical change	Percent contribution
A.	**Total observed productivity gain**	**30.62**
B.	**Productivity gain due to technological change**	
	a. Neutral technological change	168.79
	b. Non–neutral technological change	-157.3
	Total productivity gain due to technological change (1+2)	**11.49**
C.	**Productivity gain due to input use**	
	a. Human labour	6.28
	b. Bullock labour	2.90
	c. Machine labour	-5.05
	d. Manure	5.60
	e. Nitrogen	4.48
	f. Phosphorous	-11.39
	g. Potash	6.30
	h. Micronutrients	8.32
	Total productivity gain due to input use (1+2+3+4+5)	17.46
D.	**Total estimated productivity gain (B+C)**	**28.95**

With regard to the difference in the level of input use, micronutrients contributed to 8.32 per cent gain in the production of the total 17.46 per cent of gain due to input use. The increase in the quantities of micronutrients to the farm is the result of the productivity gain through the improvement of soil physical properties compared to chemical fertilizers with high nutrient content in the field. The contribution of potash fertilizer to the productivity gain was up to 6.30 per cent followed by human labour (6.28%) and manures (5.60%). The productivity gain from the use of machine labour was found to be negative (-5.05%), indicating the over use of this inputs. The total contribution of the differences in levels of input use to the productivity gain was 17.46 per cent, which indicated that, low adopters can increase the production to an extent of 17.46 per cent, if the input use levels by these adopters could be increased to the same level of input use levels by high adopters.

Thus it can be inferred that, from the decomposition analysis, that the high adopters were not able to consolidate the technology gain. The yield gain was mainly due to the adjustments made in the level of input used. Hence, the extension agencies should make efforts to train the farmers about the adoption of new production technologies. The decomposition analysis revealed that, the yield gain by the high adopters was mainly due to the application of micronutrients, potash and human labours in the field.

Conclusions

The technologies like soil type, proper seed rate, management of irrigation, use of N, P and K were adopted more in all the recovery zones. However, the technologies regarding preparatory tillage, use of manures, seed selection, use of micronutrients and seed treatment were used at low level in all the recovery zones. All significant regression coefficients indicates the economic importance of these inputs in the production of adsali sugarcane for high adopters. The ICBR ratio indicates that the high adopter farmers were in profit with 1.94 ICBR ratio and followed by medium adopters with ICBR ratio of 1.63. It clearly indicates that, the farmers may adopt the sugarcane cultivation technologies to the further extent for maximizing returns and minimizing per unit cost. The decomposition analysis revealed that, the yield gain by the high adopters was mainly due to the application of micronutrients, potash and human labours in the field.

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