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Economic Analysis of Sugarcane Cultivation in Andhra Pradesh, India

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ABSTRACT: The area under sugarcane in India decreased from 5.06 Million hectares (Mha) to 4.57 Mha and during 2018-19 to 2019-20. Scenario was much worse in Andhra Pradesh state, where the area dwindled down (38%) from 1.39 Lakh Hectares (Lha) to 0.86 Lha in a span of five years (from 2014-15 to 2019-20). The present study was an attempt to estimate the factors affecting the sugarcane cultivation in Andhra Pradesh for the period 2019-20. The data on various aspects of costs and returns involved in crop collected from farmers based on multistage sampling. Budgeting techniques, Cost Concepts, Benefit Cost Ratio (BCR) and Bisliah model of Yield gap Analysis were employed for achieving objectives. The results revealed that, in plant crop, Benefit Cost Ratio (BCR on Operational Cost) was higher in rainfed (0.96) than irrigated (0.94). There was a 65.55 % yield gap between irrigated and rainfed, in which input usage (37.23%) had higher effect than cultural practices (28.32%). So, irrigated sugarcane method is a more remunerative, yields can be sustainable if irrigation is assured with proper package of practices.

Keywords: Sugarcane, Yield gap analysis, Irrigation, Srikakulam, Vizianagaram, Visakhapatnam, North Coastal Zone Andhra Pradesh.

I. INTRODUCTION

During 2020, the area under sugarcane in world was 26.47 million hectares (mha) with production of 1869.72 million tonnes (mt) recorded yield was 70.64 tons per hectare (t/ha). Brazil stands first place in area and production of 10.01 mha and 757.12 mt with yield 75.6 t/ha [1].

In India, sugarcane contributes about five per cent to the total value of output from agriculture and accounts for about 2.6 per cent of gross cropped area. The area under sugarcane in India had steadily increased from 2.21 Mha in 1931 to 3.28 Mha in 1987-88 and to 5.06 Mha in 2018-19 and then it decreased to 4.57 Mha during 2019-20 contributing 355.7 Mt of production [2]. Total sugarcane production in the country during 2019-20 is estimated at 399.83 Mt [3]. The production of sugarcane during 2019-20 is higher by 39.40 Mt than the average sugarcane production of 360.43 Mt. Uttar Pradesh ranked first in terms of area under sugarcane with 2.15 Mha (44.39%) with a production of 173.816 Mt (46.10%) [4].

In Andhra Pradesh, the average area under sugarcane was 1.22 Lakh Hectares (Lha) in 2015-16 and it was decreased to 0.86 Lha in 2019-20 [5]. In North Coastal Districts of Andhra Pradesh, the area under sugarcane is about 0.75 Lha during the year 2006-07 and it was decreased to 0.45 Lha during the year 2019-20 [6].

Among the six Agro-Climatic Zones (ACZs) in Andhra Pradesh, North Coastal Zone (NCZ) is the major sugarcane growing Zone (nearly 50% of the area). The yields of sugarcane in North Coastal Zone is stagnant since last two decades (hovering between 75 to 80 tonnes per hectare). This was mainly because of the more area under rainfed condition (Nearly 40%) where average yield is 40 to 45 t/ha. To know the impact of irrigation on yield -gap, present study was taken up with following objectives.

(i) To work out costs and returns in different methods of cultivation

(ii) To assess the most important factors effecting the production in in different methods of cultivation

(iii) To assess the impact of irrigation in yield gap between irrigated and rainfed method of cultivation

II. MATERIALS AND METHODS

The study was conducted during 2019-20. Multistage sampling technique was adopted in selecting the sampling units at various levels. Sugarcane cultivation was classified as irrigated and rain-fed. In irrigated condition the water source is assured through irrigation, whereas in rain-fed condition crop is totally depend on rainfall. Sugarcane is cultivated as plant crop and ratoon also. Andhra Pradesh comprises of six Agro-Climatic Zones (ACZs). North Coastal Zone (NCZ) was selected based on highest area criteria. NCZ comprises of three districts *Viz*., Srikakulam, Vizianagaram and Visakhapatnam. From each district two mandals (one each for irrigated and rainfed) and from each mandal two villages (one each for irrigated and rainfed) were selected based on highest area criteria. Fifteen farmers were selected at random from each village. Sampling design was one state, three district, six mandals, 12 villages and 180 farmers (90 each for irrigated and rainfed conditions).

Analytical tools:

Apart from budgeting techniques and cost concepts following were employed;

1) Benefit Cost Ratio (BCR): It is calculated as Gross returns accrued divide by total cost incurred on i^{th} enterprise by j^{th} farmers as given below:

$$BCR_{ij} = \frac{\sum GR_{ij}}{\sum TC_{ij}}$$

2) Decomposition of sources of yield gaps: The following Cobb-Douglas type of production function was fitted to identify the most important factors effecting the production in both Irrigated and Rain fed method of cultivation;

$$Y = a_o H^{a1} M^{a2} N^{a3} P^{a4} S^{a5} e^u$$

Where,

Y= Out put of main produce (quintals) per hectare

a_o = Intercept

H = Human labour (man-days) per hectare

M = Manure (quintals) per hectare

N = Nitrogen (kg) per hectare

P = Phosphorous (kg) per hectare

K = Potassium (kg) per hectare

S = Seed rate (kg) per hectare

e^u = Error term

a_1 to a_5 are the elasticities of production

Then, to examine the structural break in production relations in irrigated and Rainfed sugarcane the above equation was estimated by the Ordinary Least Square (OLS) technique as follows;

$$\text{Log } Y_1 = \text{Log } a_o + a_1 \text{ Log } H_1 + a_2 \text{ Log } M_1 + a_3 \text{ Log } N_1 + a_4 \text{ Log } P_1 + a_5 \text{ Log } S_1 + a_6 \text{ Log } I_1 + U_1 \quad \ldots(1)$$

$$\text{Log } Y_2 = \text{Log } b_o + b_1 \text{ Log } H_2 + b_2 \text{ Log } M_2 + b_3 \text{ Log } N_2 + b_4 \text{ Log } P_2 + b_5 \text{ Log } S_2 + b_6 \text{ Log } I_2 + U_2 \quad \ldots(2)$$

Where, Y_1 and Y_2 are yield levels on rainfed and irrigated method plots respectively. The inputs have the symbols as stated above along with associated coefficients. The combination of different resources to yield gap was estimated with the Decomposition model [7]. The following functional forms specified as Eq. (1) and (2) above mentioned were used.

$$\text{Log } (Y_2/Y_1) = [\text{ Log } (b_o/a_o)] + [(b_1-a_1) \text{ Log } H_1 + (b_2 - a_2) \text{ Log } M_1 + (b_3 - a_3) \text{ Log } N_1 + (b_4 - a_4) \text{ Log } P_1 + (b_5 - a_5) \text{ Log } S_1 + (b_6 - a_6) \text{ Log } I_1] + [b_1 \text{ Log } (H_2/ H_1) + b_2 \text{ Log } (M_2/M_1) + b_3 \text{ Log } (N_2/N_1) + b_4 \text{ Log } (P2/P_1) + b_5 \text{ Log } (S_2/S_1) + b_6 \text{ Log } (I_2/I_1)] + [U_2-U_1]$$

This equation involves decomposing the yield gap. The summation of 1st and 2nd bold bracketed term on the right hand side of equation represents the yield gap, attributable to the difference in the cultural practices. The 3rd term represents the yield gap attributable to the difference in the input use (input gaps) between irrigated method and rainfed method. The last term takes care of the random disturbance.

III. RESULTS AND DISCUSSION

I) Comparative Costs and returns in cultivation of Irrigated and Rain fed Sugarcane:

Total cost of cultivation (₹/ha) in irrigated conditions; in plant crop was ₹2,72,381 with working cost was ₹1,84,406 (67.7% of total cost), in ratoon crop was ₹ 2,10,173 with working cost was ₹1,35,188 (64.3% of total cost) (Table 1). Under rainfed condition; in plant crop, cost of cultivation was ₹1,92,567 with working cost ₹ 1,35,563 (70.4 % of total cost), in ratoon crop, cost of cultivation was ₹ 1,34,726 with working cost ₹ 88,563 (65.7 % of total cost). In terms of percentages working cost is higher in rainfed sugarcane. Out of the total operational cost, under irrigated conditions, 76% (₹1,55,565) was incurred on labour charges and 24% (₹49,126) was spent on materials in plant crop, where as, in rainfed condition 71% (₹136,723) was incurred on labour charges and 29% (₹55, 844) was spent on materials. This shows the labour-intensive nature of sugarcane under irrigated conditions. Among the working costs, in irrigated plant crop, harvesting and transport charges was highest ₹ 63,594 (34.5%), followed by seed material and planting ₹ 28,344 (15.4%), TT Propping ₹ 26,750(14.6%) *etc*. Trend was noticed similar in all other methods of cultivation. Higher costs were incurred on labour related activities than material related, whatever may be the method of cultivation. This implies that sugarcane cultivation is labour intensive in nature.

During 2008-09, operational cost of cultivation (per ha) of sugarcane in Visakhapatnam district was ₹ 90,939 [8]. In present study operational cost of cultivation (per ha) of sugarcane in NCZ (Visakhapatnam district is part of that) was ₹ 1,84,406. Thus, there was increase of ₹ 93,467 per hectare *i.e.,* 103 per cent in 11 years. Labour wages are the major contributor for this increase. Between these 11 years, labour wages (on an average) increased three times i.e., ₹120/- to 360 /-.

2) Comparative resource use pattern in cultivation of irrigated and rainfed Sugarcane:

The per hectare productivity (t/ha^{-1}) under irrigated and rainfed condition was 7.5 and 5.0 (Table 2). There was 66.25 % higher yield in under irrigated than rainfed condition. Except potassium, all the resources use was higher in irrigated condition than rainfed condition. This was reflected in the cost of cultivation of sugarcane. Usage of potassium higher in rainfed condition is because of potassium gives the crop resistance to drought condition.

Table 1: Comparative cost of cultivation (per Ha) of irrigated and rainfed Sugarcane in 2019-20.

Particulars	Irrigated		Rainfed	
	Plant	Ratoon	Plant	Ratoon
Land preparation/Stubble Shaving	9,563	4,688	9,563	2,925
Furrow preparation	4,500		4,500	
Seed material/ Gap filling	22,344	3,438	17,188	3,562.5
Cutting and Transplanting cost	6,000		4,500	
Manures and fertilizers Application	22,000	24,375	17,813	16,250
Weeding &Plant protection	18,281	16,125	11,250	9,375
Irrigation	9,375	3,750	1,875	1,875
TT propping (3 times)	28,750	25,000	22,625	15,500
Harvesting & transportation	63,594	57,813	46,250	39,313
Working cost	**1,84,406**	**1,35,188**	**1,35,563**	**88,563**
Interest on working capital	20,285	7,745	7,767	5,074
Operational cost	**2,04,691**	**1,42,933**	**1,43,329**	**93,636**
Depreciation	**4,688**	3,125	2,213	1,813
Land cess	**750**	750	500	500
Rental value of Own land	55,000	48,125	41,250	34,375
Interest on fixed capital	7,253	6,240	5276	4,403
Fixed costs	**67,690**	**58,240**	**49,238**	**41,090**
Total cost of cultivation	**2,72,381**	**2,01,173**	**1,92,567**	**1,34,726**
Gross Returns	**1,92,500**	**1,71,875**	**1,37,500**	**1,16,875**
BCR on OC	**0.94**	**1.27**	**0.96**	**1.25**
BCR on TC	**0.71**	**0.85**	**0.71**	**0.87**

Table 2: Comparative resource use between irrigated and rainfed Sugarcane (per Ha)

Sr. No.	Resource Particulars	Units	Irrigated		Rainfed	
			Plant	Ratoon	Plant	Ratoon
1	**Human Labour**	Mandays	453	249	231	129
2	**Manure**	Quintals	100	5.0	45	2.5
3	**Nitrogen**	Kilograms	165	245	140	210
4	**Phosphorus**	Kilograms	165	55	139	46
5	**Potassium**	Kilograms	55	30	80	50
6	**Seed Rate**	Kilograms	8,750	500	7,500	429
7	**Productivity**	Quintals/ hectare	700	625	500	425

3) Production function estimates in cultivation of irrigated and rainfed Sugarcane:

The Cobb-Douglas type of production function was fitted to the observations for the estimation of elasticities of important variables contributing to the yield of sugarcane plant crop in both irrigated and rainfed conditions. A perusal of Table 3, reveal that, the analysis of variance in respect of the production function showed significant variance indicating the overall significance of estimated production function.

The value of coefficient of multiple determinations (R^2) in irrigated condition was 0.86, which suggest that the six resources included in the production function had jointly explained as high as 86% of total variation. R^2 was 0.77, in rainfed method, which suggests that the six resources included in the production function had jointly explained as high as 77% of total variation. That shows the variables taken into consideration were crucial factors in irrigated than in rainfed conditions, owing to irrigated sugarcane is being in more under controlled conditions than rainfed.

Except, seed rate under rainfed condition all other variables found significant. Negatively significant was noticed in Phosphorous in rainfed condition and Potassium in irrigated condition. Coefficients of all variables are higher in irrigated than rainfed except Human Labour and Potassium. That shows the more response of rainfed sugarcane for Potassium than other nutrients in comparison with irrigated conditions.

4) Sources of yield gap between Irrigated and Rain fed Sugarcane:

The 65.55 % of the potential farm yield of sugarcane left untapped owing to rainfed method of cultivation (Table 4). Among the different sources of yield gap, input usage (37.23%) turns out to be major contributor than cultural practices (28.32%). This shows that irrigation is an important factor in the sugarcane cultivation. In input usage manure turns out to be very crucial factor. In the raw data also wherever manure was applied more than 15 t/ha^{-1}, the yield was more than 90 t/ha^{-1}. The next important factors are potassium and labour. But, Nitrogen (-2.55) and Phosphorous (- 3.52) contributed negatively to the usage shows that there was higher usage of these nutrients than requirement. Thus, increase in dose of Nitrogen and Phosphorous automatically results in input usage negative effect and results in decrease in yields. Through appropriate usage of inputs can reduce the yield gap between rainfed and irrigated method to the tune of 37.23 per cent.

Using the Bislaih (1977) model of decomposition, [8] estimated that yield gap between irrigated and rainfed method of sugarcane was 67.79 %, in which input usage (41.86%) had higher role than cultural practices (25.93%). Similar trend was noticed in the present study; with less magnitude, where yield gap was 65,55%, in which input usage (37.23%) had higher role than cultural practices (28.32%).

Table 3: Cobb-Douglas production function estimate for Irrigated and Rain fed Sugarcane (plant crop)

Sr. No.	Particulars	Method of Cultivation	
		Irrigated	Rainfed
1.	Human Labour (X_1)	0.67**	1.25**
2.	Seed Rate (X_2)	0.44**	-0.16
3.	Manure (X_3)	0.56**	0.33**
4.	Nitrogen (X_4)	0.39**	0.23**
5.	Phosphorus (X_5)	0.20**	-0.01**
6.	Potassium (X_6)	-0.10*	0.16 **
7.	Intercept	-2.52**	-2.61**
	R^2	**0.86**	**0.77**
	F Value	**13.0****	**33.8****

Note: 1) * and ** indicates significance at 5 and 1 per cent respectively
2) Figures in parenthesis are standard errors for the respective regression coefficients

Table 4: Decomposition of yield gap between Irrigated and Rain fed sugarcane (plant)

Sr. No.	Sources of Difference	%
A.	**Total**	**65.55**
1.	**Cultural Practices**	**28.32**
2.	**Input Usage**	**37.23**
a.	**Human Labour (X_1)**	2.75
b.	**Seed Rate (X_2)**	24.85
c.	**Manure (X_3)**	13.72
d.	**Nitrogen (X_4)**	- 2.55
e.	**Phosphorus (X_5)**	- 3.52
f.	**Potassium (X_6)**	1.98

IV. CONCLUSIONS

(i) Return on Investment was Higher in ratoon crop than plant crop

(ii) Human labour was the most important factor under both rainfed and irrigation conditions

(iii) In-put use difference (37.23%) was major contributor than cultural practices (28.32%) in yield gap (65.55%) between irrigated and rainfed sugarcane.

V. POLICY IMPLICATIONS

(i) Farmers are going for ratooning continuously and average yields are decreasing, owing to higher BCR for ratoon crop. Seed material should be supplied at subsidized rate to encourage for fresh plantings after one or two ratoons.

(ii) Proper use of irrigation water and inputs the yields in rainfed sugarcane can be increased by another 65.55%,

(iii) Labour shortage was major constraint in sugarcane cultivation, necessitates the urgency of mechanization in sugarcane.

VI. FUTURE SCOPE

Identification of factorial contribution in the yield-gap.

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