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ECONOMIC IMPACT EVALUATION AND FACTORS AFFECTING THE DECISION OF FARMERS FOR ADOPTION OF GAR-13 VARIETY OF RICE

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ABSTRACT

The study highlighted the economic impact of technology of GAR-13 variety and local variety of rice grown by the farmers in the study area. The analysis was carried out by collecting the primary data on the various economic aspects considering 60 GAR-13 respondents and 60 local variety respondents. The results evident that per hectare higher gross and net income earned by the farmers of GAR-13 as compared to the farmers cultivated local variety of rice. Moreover, the yield and price obtained from GAR-13 was significantly higher as compared to the local variety. Further, the contribution of technology was about 15.87 per cent and the difference due to input use level was about 4.71 per cent which together contributed to the total productivity difference of about 19.57 per cent. Probability of the farmer's decision in adoption of GAR-13 was positive and significantly influenced by education level, farm size, credit facility and income.

Keywords: *rice, GAR-13, local variety, economic impact, decomposition analysis, logistic regression*

INTRODUCTION

Rice was originally cultivated in tropical Asia, the oldest record dating 5000 years BC, but then extended also to the temperate regions. Further, sativa rice varieties are commonly grouped into three sub-species *viz.,* indica, japonica and javanica. The species grown in India belongs to the indica. Rice is grown under many different conditions and production systems, but submerged method of rice cultivation is the most common method used worldwide. Rice and Jal brahmi can be grown under varying soil and climatic conditions (Saran and Patel, 2019; Okuta et al., 2023). Both plants perform well in poorly drained soils and waterlogged conditions (Saran *et al*., 2022). Rice is a supreme commodity and major food staple to mankind (Churpal *et al.,* 2015), because it is truly life, culture, tradition and means of livelihood to millions. It provides about 60-70 per cent calories intake to the consumers. The United Nations General Assembly, in a resolution declared the year 2004 as an "International Year of Rice", which has tremendous significance to food security. It very eloquently upheld the need to heighten awareness for the role of rice in alleviating poverty and malnutrition. It having vital role in achieving food and nutritional security (Devi and Bhoi, 2022a). Hence, authorized institutes, policy makers and regulated bodies are turning to new solution for improving the economic situation and to reap the benefits of small and marginal producers by grouping of farmers (Padaliya *et al.,* 2022).

Rice accounts nearly 40.50 per cent of total food grain production and occupies around one quarter of the total cropped area in the country (FAO). India ranks 2nd in the world's rice producing countries (Agarwal *et al.,* 2018). During the year 2018-19 the estimated area of rice in India was 44.15 million ha with production 116.47 million tons which is 3.69 million tons higher as compared to 112.75 million tons. The main rice-growing states are West Bengal, Uttar Pradesh, Punjab, Andhra Pradesh, Odisha, Telangana, Chattisgarh, Bihar, Tamil Nadu and Assam. These states contributed about 78.37 per cent share in total production of country. West Bengal produced the largest volume of rice in the year 2018-19 across India. This amounted to nearly 16.24 million tons. Uttar Pradesh followed by Punjab ranking second and third, respectively. In terms of productivity the leading states are Punjab accounted about 4165.33 kg per hectare followed by Andhra Pradesh (3685.67 kg/ha), Telangana (3239.67 kg/ha), Haryana (3171.67 kg/ha) during the triennium ending 2018-19 (Anonymous, 2020[a]).

Gujarat produces about 1930099 MT from the area of 847283 hectares during triennium ending (TE) 2018-19. The middle Gujarat region constituted about 65.32 per cent area and 60.50 per cent rice production during the year 2018-19 (Anonymous, 2020[b]).

The rice variety developed by Anand Agriculture University (AAU) giving a major boost to rice production in Gujarat namely GAR-13. It was released during the year 2009 with special characteristics of mid early, medium slender and fine grain type, multiple resistant to pests and diseases, good cooking quality *etc.* It has recorded yield of about 6000-6500 kg per hectare which is generally higher than other rice

varieties in Gujarat. The maturity duration is about 130-135 days, alike any other normal rice variety. As such, it does not require any extra irrigation or hamper the sowing cycle of the next crop. The percentage of milling of this variety is also better with lower wastage and breakage as compared to other existing rice varieties. Keeping the above views in mind the present study was under taken for comparative economic impact with local variety.

OBJECTIVES

(1) To study the impact of technology of GAR-13 rice variety with local variety

(2) To study the factors affecting the decision of farmers for adoption of GAR-13 variety

METHODOLOGY

The primary data were used in present study for the year 2020. In Middle Gujarat, Kheda district was selected purposively on the basis of concentration of area under GAR-13 variety of rice and from Kheda district, two talukas namely Matar and Kheda was selected purposively on the basis of concentration of area under the variety. From each selected taluka, 30 respondents were selected randomly those who were cultivated GAR-13 variety of rice release by AAU and 30 respondents who cultivate other local or dominant variety of rice. Thus, total 120 (2x60) which comprises 60 respondents of GAR-13 and 60 respondents of local variety were selected to achieve the stipulated objectives of the study.

Decomposition analysis

To see the impact of technology, decomposition model given by Bisaliah (1977) was employed which previously developed by Solow (1957) to know the contribution of technology and resource use difference to the total yield difference between the varieties. The Cobb-Douglas production function was used and the general form of production function fitted was as follows.

$$Y = a\, X_1^{b1}\, X_2^{b2} X_3^{b3} X_4^{b4}\, X_5^{b5} X_6^{b6} e^{u} \quad \text{_____(1)}$$

Where, Y = Output (Rs/ha), X_1 = Human labour (Rs/ha), X_2 = Tractor (Rs/ha), X_3 = Seed (Rs/ha), X_4 = Manure (Rs/ha), X_5 = Chemical fertilizer (Rs/ha), X_6 = Irrigation (Rs/ha) and u = Error term.

The following functional form of decomposition model was used by using the subscripts‘g’ and‘l’ respectively, to represent production functions for GAR-13 and local variety of rice. The difference in the natural logarithms of output of both the varieties are given as follows.

$$[\ln Y_g - \ln Y_l] = [\ln A_g - \ln A_l] + b_{gi}\ln X_{gi} - b_{li}\ln X_{li} \quad \text{_____(2)}$$

Equation two can be rewrite by adding and subtracting $b_{gi}\ln X_{li}$] and rearranging the terms, yields the following decomposition model.

$$[\ln Y_g - \ln Y_l] = [\ln A_g - \ln A_l] + b_{gi} - b_{li}]\ \ln X_{li} + b_{li}\,[\ln X_{gi} - \ln X_{li}] \quad \text{____(3)}$$

Output Difference	Netural Technology	Non-Netural Technology	Input difference

This model decomposed the logarithm difference of output per hectare of GAR-13 and local variety of rice. This is approximately a measure of percentage change in per hectare output between both the varieties. The summation of neutral and non-neutral technology represents the technology change between the varieties, which is attributable to the differences in the input use by the respondents.

Logistic regression model

The Logistic Regression model was employed to study the determinants or factors that affect the decision level of the farmers to adopt the improved variety. A logistic regression model quantify the relative influence of various factors in the decision of the respondents to adopt improved variety. It was assumed that the probability of a farmer adopting GAR-13 (Li) depends on the attributes like age of the respondent (years), education level (years), family size, farm size, income *etc*., The index variable Zi indicates whether a farmer is adopting GAR-13 or not has been expressed as a linear function of the independent variables.

Thus, the logit regression model was specified as following Equation:

$$\beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + U_i$$

Where,

P_i = probability of being an adopter of GAR-13 ranges from 0 to 1, Z_i = Function of “n” explanatory variables (x), L_i = log of the odds ratio, X_1 = Age (years), X_2 = Education (years), X_3 = Family size (No), X_4 = Credit facility (1 if yes, otherwise 0), X_5 = Farm size (ha), X_6 = Income (Rs), B_0 = Constant and U_i = Error-term

The index variable Zi is a dichotomous variable, *i.e*. it takes the value of one if a respondent is adopting GAR-13 (Zi=1) and takes the value zero otherwise (Zi=0).

RESULTS AND DISCUSSION

Level of input use

Data furnished in Table 1 shows that on an average per hectare use of total human labour in GAR-13 variety of

rice were about 103.51 man-days and about 92.45 man-days in local variety of rice, respectively. Moreover, the results exposed that all most all the inputs are used in higher amount in GAR-13 as compared to local. The difference among the categories may be due to that GAR-13 is mid early maturing variety therefore, requirement of labour and other input were more. Similar kind of study also conducted by Devi and Bhoi (2022b) to compare the input use level and economic parameters of turmeric production.

Table 1: Level of input use by the respondents (Per hectare) (n=120)

Sr. No.	Particulars	GAR-13 (n=60)	Local (n=60)	Difference	%	t-value
1	**Family labour (man days/ha)**	17.66	16.19	1.47	9.08	0.749
2	**Hired labour (man days/ha)**	85.85	76.26	9.59	12.58	3.263**
3	**Total human labour (man days/ha)**	103.51	92.45	11.06	11.96	3.839**
4	**Tractor (hrs/ha)**	12.42	12.33	0.09	0.73	0.583
5	**Seed (kg/ha)**	17.63	15.22	2.41	15.83	3.426**
6	**Manure (q/ha)**	409.47	397.93	11.54	2.90	0.371
7.	**Fertilizer (kg/ha) N**	220.50	253.50	-33	-13.02	2.570*
	P	95.80	88.00	7.8	8.86	1.274
	K	26.73	38.00	-11.27	-29.66	1.124
	Zinc	9.98	12.32	-2.34	-18.99	1.135
8	**Plant protection (kg/ha)**	1.73	1.49	0.24	16.11	3.614**
9	**Herbicide (kg/ha)**	2.28	1.68	0.6	35.71	9.720**
10	**Irrigation (No./ha)**	5.10	4.17	0.93	22.30	7.584**

Source: Field survey

Note: ** and * indicate significant at 1 & 5 per cent level of probability, respectively

It could be seen from the Table 2 that per hectare average yield of GAR-13 was significantly higher (61.76 q/ha) as compared to local (53.23 q/ha). Higher level of yield could be attributed due to the technology advancement and better management practices. The per quintal average price received by farmers for GAR-13 was also significantly higher due to their fine quality grain attributes (₹ 1578.42) as compared to local (₹ 1394.58). This clearly indicated the significant gap between the yield and price realized and directly it was made the significant difference between the net return realized by the farmers those who were cultivated GAR-13 variety of rice. Although, the prices were ruined due to the covid-19 situation about ₹ 100-200 per quintal. Devi, (2020) reported that major constraints being faced by farmers related to production and marketing were labour, planting material, inputs cost, transportation cost, prices are not remunerative *etc.*

Table 2: Comparative cost and return profile of GAR-13 and local variety of rice (₹/ha) (n=120)

Sr. No.	Particulars	GAR-13 (n=60)	Local (n=60)	Difference	%	t-value
1	**Total cost of cultivation**	81387	76304	5083	6.66	4.054**
2	**Yield of main product (q/ha)**	61.76	53.23	8.53	16.02	8.074**
3	**Average price of main product (Rs/q)**	1578.42	1394.58	183.84	13.18	19.417**
4	**Income from main product**	97483	74234	23249	31.32	13.703**
5	**Income from by-product**	17040	16731	309	1.85	1.285
6	**Gross return (main product + by-product)**	114523	90965	23558	25.90	13.080**
7	**Net return**	**33136**	**14661**	18475	126.02	11.284**
8	**B-C ratio**	**1.41**	**1.19**	0.22	18.49	-
9	**Cost of production (₹/q)**	1318	1433	-115	-8.07	4.215**

Source: Field survey

Note: ** indicate significant at 1 per cent level of probability

Production function estimates

The estimates of production function analysis were furnished in Table 3. The results put forth that the value of coefficient of multiple determinations (R^2) was 0.723 and 0.698 which indicates that 72.3 and 69.8 per cent variations in the gross income from GAR-13 and local variety was influenced by explanatory variables included in the model, respectively. The regression coefficients for human labour, seed, manure and irrigation were found positive and significant in GAR-13, whereas, the regression coefficients of human labour, tractor and manures were found positive and statistically significant in local variety. This indicated a visible and favourable impact of these inputs on the returns. Hence, increase in the use of inputs such as human labour, seed, manures and irrigation would increase the returns on the farms.

Tables 3: Estimates of production function for GAR-13 and local variety of rice

Sr. No.	Explanatory variables	Parameters	GAR-13		Local	
			Coefficients	p-value	Coefficients	p-value
	Intercept	A	0.351 (0.703)	0.819	0.678 (0.478)	0.256
1	**Human labour (X_1)**	b_1	0.917** (0.298)	0.001	0.575** (0.169)	0.001
2	**Tractor charges (X_2)**	b_2	0.587 (0.392)	0.061	0.048** (0.011)	0.002
3	**Seed (X_3)**	b_3	0.519** (0.141)	0.003	-0.282 (0.188)	0.983
4	**Manures (X_4)**	b_4	0.378** (0.099)	0.000	0.213* (0.093)	0.031
5	**Chemical fertilizers (X_5)**	b_5	-0.083 (0.069)	0.657	0.015 (0.070)	0.745
6	**Irrigation (X_6)**	b_6	0.996** (0.272)	0.001	0.069 (0.051)	0.072
Coefficient of multiple determinations (R^2)			0.723		0.698	
F- value			17.21**		13.89**	
n			60		60	

Note: Figures in the parentheses denote standard error

Note: ** and * indicate significant at 1 & 5 per cent level of probability, respectively

Decomposition analysis

The decomposition model was employed to know the productivity difference between the varieties by decomposed into different sources. It was noticed from the Table 4 that total observed difference in output was 19.57 and the estimated difference was 20.58 which implying that there was not much divergence between the observed difference and the estimated difference in the productivity of GAR-13 and local variety of rice. Moreover, the contribution of technology was about 15.87 per cent and the difference due to input use level was about 4.71 per cent which together contributed to the total productivity difference of about 19.57 per cent. This indicated that if farmers grow GAR-13 variety results into 15.87 per cent more productivity due to technology only as compared to local variety. Further, it could be seen from the table that the higher amount of human labour and fertilizer used in local variety results to increase yield of paddy by 14.05 per cent and 21.66 per cent, respectively. Correspondingly higher amount of tractor, seed, manure and irrigation used in GAR-13 variety helps in increase the yield of rice by 19.01, 8.70, 5.29 and 7.42 per cent, respectively. This clearly indicated that the farmers, those who were cultivate GAR-13 variety of rice can obtained higher income by using the more amount of tractor, seed, manure and irrigation, whereas, by using the less amount of human labour and fertilizer. Similar type of study is also conducted by Basavaraja *et. al.,* (2008) for a comparative analysis of traditional and SRI methods of rice cultivation, Mondal *et. al.,* (2015) for watershed management intervention and Rai *et. al.,* (2020) studied Impact of frontline demonstration on mustard through improved production technology under renfed condition.

Table 4: Contribution of resources to the yield difference between the GAR-13 and local variety of rice

Sr. No.	Source of output difference	% Contribution
A	**Total observed difference in output**	**19.57**
B	**Change due to technology**	**15.87**
1	Neutral	54.10
2	Non-neutral	-38.23
(i)	Human labour	-27.09
(ii)	Tractor	-22.09
(iii)	Seed	-2.08
(iv)	Manures	6.84
(v)	Fertilizer	-29.48
(vi)	Irrigation	35.67
C	**Due to difference in input use level**	**4.71**
(a)	Human labour	-14.05
(b)	Tractor charges	19.01
(c)	Seed	8.70
(d)	Manures	5.29
(e)	Fertilizer	-21.66
(f)	Irrigation	7.42
D	**Total estimated difference in output**	**20.58**

Source: Field Survey

Logistic Regression Analysis

The estimated results of the logistic regression analysis revealed that probability of the farmer's decision in adoption of GAR-13 was positive and significantly influenced by education, farm size, credit facility and income. Whereas, the probability of the farmer's decision in adoption of GAR-13 was negative and significantly influenced by the age of farmer, since younger farmers are usually more willing to take risk as compared to older farmer. This indicated that if the age of farmers increased the adoption of GAR-13 was decreased. Increase in age of farmer decrease the odd ratio of the farmer's decision in the adoption versus the decisions of the farmers not to adopt by the factor of 1.004. In case of education and farm size the rate of adoption increases by 1.086 and 0.953 times, as a unit increase in education and farm size, respectively (Table 5). According to the study carried out by khan *et al.*, (2017) and Neupanea, *et al.*, (2002) the age of farmer had significant negative effects on the tree planting on farms.

Credit facility is playing the important role in adoption of GAR-13. The accessibility of loan and credit facility increases the tendency of the farmers to induce a decision in adopting a new technology. The odd ratio value is 4.67, which indicated that a unit increase in this variable the rate of adoption was increases by 4.67 times. Lerra & Tefera (2016) also indicated that loan and credit facility is a critical issue in eucalyptus tree plantation. Family income is also one of the important factor for determining the farmer's decision in adoption of improved technologies. Income was positive and significant with odd ratio 0.912 which implied that unit increase in income leads the rate of adoption of GAR-13 by 0.912 times. This study also parallels with the studies of Changela (2019), Ashraf, *et al*., (2015) and khan *et al.*, (2017) reported that the monthly income of the farmers is significant and positive for adoption of trees. Also Patil (2020) studied the factors affecting farm mechanization in rainfed area of western Maharashtra in India.

Table 5: Estimation of logistic parameter for adoption of GAR-13 variety of rice (n=120)

Sr. No.	Particulars	Bi	Standard Error	Significance	Expectations β
1	**Age (years)**	-0.459*	0.218	0.035	1.004
2	**Education (years)**	0.081**	0.023	0.001	1.086
3	**Family size (No.)**	-0.007	0.067	0.911	1.008
4	**Farm size (ha)**	0.052**	0.014	0.011	0.953
5	**Credit facilities**	1.540**	0.456	0.000	4.678
6	**Income (₹)**	0.473*	0.232	0.033	0.912
7	**Constant**	-1.420	1.310	0.275	0.239
-2Log Likelihood		151.64			
Percentage Correct		76.35			
Chi square ($\chi 2$)		86.12**			
Count R^2		0.77			
No. of observations		120			

Source: Field survey

Note: ** and * indicate significant at 1 & 5 per cent level of probability, respectively

CONCLUSION

It was observed from the present study that the per hectare higher net income earned by GAR-13 growers as compared to local variety growers with benefit cost ratio of about 1.41 and 1.19 respectively. Moreover, the yield and price obtained from GAR-13 was also significantly higher, which results into the higher net income realized by the farmers.

The results of decomposition analysis revealed that, the contribution of technology was about 15.87 per cent and the difference due to input use level was about 4.71 per cent which together contributed to the total productivity difference of about 19.57 per cent. This implied that GAR-13 variety results into 15.87 per cent more productivity due to technology only.

Logistic regression analysis exposed that probability of the farmer's decision in adoption of GAR-13 were positive and significantly influenced by education level, farm size, credit facility and income. Whereas, negative and significantly influenced by the age of farmer.

POLICY IMPLICATION

It was found that the rice variety 'GAR-13' having the potential for getting higher net return due to higher productivity and price with more benefit cost ratio as compared to local rice variety in the study area. Therefore, need to create more awareness among the farmers for more adoption of GAR-13 variety of rice.

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CONFLICT OF INTEREST

No conflict of interest among researchers.

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