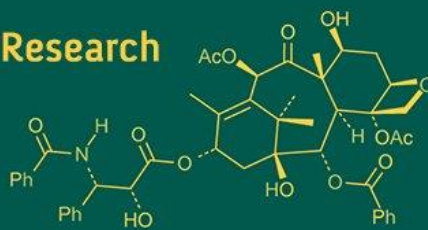


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Yield gap and resource use efficiency of chilli cultivation in Tapi district of Gujarat

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Abstract

Chilli (*Capiscum annum* L.) is one of the most important commercial crops of South Gujarat. The study was conducted in Tapi district of South Gujarat. Total 320 chilli growers were selected for the present study. This study analyzed the resource use efficiency and yield gap in chilli cultivation within the Tapi district of Gujarat, employing a multistage random sampling method. Cobb-Douglas production functions were utilized to analyze resource use efficiency, revealing significant findings on fertilizer application and labour utilization. The study highlights under application of Nitrogen and Potash, suggesting potential for enhanced fertilizer usage. Additionally, the yield gap analysis underscores substantial disparities between best and average farmers, emphasizing the importance of adopting best practices for maximizing yields. The findings suggest avenues for optimizing input usage and improving economic efficiency in chilli cultivation.

Keywords: Yield gap, resource use efficiency, cultivation

Introduction

Chilli is an essential commercial spice crop in South Gujarat, with the Tapi district recognized as a premier region for dry chilli cultivation within the state. The region is known for producing high-quality, pungent chillies that are in demand both locally and for regional trade. As a high-value crop, chilli holds considerable promise for augmenting farmers' incomes and bolstering the economic landscape of the area. However, the efficient utilization of resources in chilli cultivation remains a crucial aspect deserving thorough investigation to ensure sustainable productivity and profitability.

Against this backdrop, this research endeavors to comprehensively examine the resource use efficiency and yield gap prevalent in chilli cultivation within Tapi district, Gujarat. The primary objective is to quantitatively evaluate the effectiveness of resource allocation in chilli farming, discerning the inputs contributing significantly to productivity. By meticulously measuring resource use efficiency, the study aims to pinpoint areas for enhancement and formulate strategies to optimize resource allocation in chilli cultivation.

Additionally, the research seeks to assess the yield gap existing in chilli production within the Tapi district. Through a comparative analysis of actual yields against potential yields achievable under optimal conditions, the study endeavors to quantify the extent of productivity shortfall. Such an assessment not only illuminates the prevailing inefficiencies within chilli cultivation but also serves as a foundation for devising interventions aimed at narrowing the yield gap and enhancing overall agricultural performance.

By addressing these critical aspects, this research aspires to contribute significantly to the understanding of chilli cultivation dynamics in the Tapi district. Through actionable insights derived from the pursuit of its objectives, the study aims to support sustainable agricultural development and foster economic prosperity in the region.

Data & Methodology

For the present investigation, primary data were collected using multistage random sampling method from Tapi district of South Gujarat. Out of the 7 talukas of Tapi District, 4 talukas were selected. Then 4 villages per taluka were selected. Thus total 16 villages were selected. Then 20 farmers were randomly selected per village. Total 320 chilli growers were selected for the present study.

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Resource use efficiency

The use of different inputs in production of Okra crops on sample farms was studied. To analyse the resource use efficiency in Okra, Cobb-Douglas production functions was used. The production function used as under:

$$Y = aX_1^{b_1} X_2^{b_2} X_3^{b_3} X_4^{b_4} X_5^{b_5} X_6^{b_6} X_7^{b_7} X_8^{b_8} U_i$$

Different variables were used in the production function as under:

Where,

Y = Output in quintals per hectare

X1 = Quantity of seed (kgs) per hectare

X2 = Quantity of F.Y.M. (quintals) per hectare. X3 = Quantity of Nitrogen (kgs) per hectare X4 = Quantity of Phosphorus (kgs) per hectare X5 = Quantity of Potash (kgs) per hectare X6 = Human labour (man-days) used per hectare X7 = Number of irrigations per hectare

X8 = Number of sprays (PP chemicals) per hectare a = Constant

b1, b2.....b8 = Regression coefficients/elasticities of production U_i = Error term

Yield Gap

Sample farmers in the study area were classified into two categories based on their okra yield levels: best farmers and average farmers. The top five farmers who obtained the highest yields were categorized as best farmers, while the remaining farmers were considered average farmers. The farm-level yield gap was then estimated by comparing the mean yield of the best farmers with that of the average farmers.

Results and Discussion

To full fill the objectives of the study, four talukas from Tapi district viz. Vyara, Valod, Dolvan and Nozar were selected. A list of villages was prepared from the selected

talukas from the revenue records of the office of TDO. Four villages from every selected talukas were selected. Thus total sixteen villages were selected randomly from each selected taluka. The lists of villages are presented in Table-1.

Table 1: Farmers selected from different talukas of Tapi district.

Name of Taluka	Name of village	No. of farmers
Vyara	Balpur	20
	Karanjvel	20
	Unchamala	20
	Bhatpur	20
	Sub-total	80
Valod	Andhatri	20
	Dadariya	20
	Degama	20
	Butvada	20
	Sub-total	80
Dolvan	Pati	20
	Ghani	20
	Gadat	20
	Bardipada	20
	Sub-total	80
N Nizar	Lakshmi kheda	20
	Nizar	20
	Vanka	20
	Sarvale	20
	Sub-total	80
Grand Total		320

The lists of respondents were prepared from each village at the third stage. From this list, 20 farmers were selected from each village and finally 320 respondents were selected by random sampling technique. Data were collected using pre-tested and well-structured interview schedule.

Input utilization

Per hectare quantities of different inputs/resources are given in table-2.

Table 2: Per hectare Resource use pattern for chilli cultivation

Sr. No.	Input	Small	Medium	large	All
1	Seedlings	15580.75	17880.8	18180.85	16300
2	FYM (quintals)	59.28	74.4	83.92	66.30
3	Fertilizers				
	(a) Nitrogen (kg)	85.32	97.15	112.50	91.84
	(b) Phosphorus (kg)	43.54	58.45	63.00	49.77
	(c) Potash (kg)	45.55	52.50	60.00	49.18
4	No. of irrigation	13.15	13.50	14.05	13.37
5	No. of spray (PP chemicals)	11.50	12.15	12.50	11.79
6	Human labour (man-days)				
	(a) Family	223.33	104.47	65.41	172.88
	(b) Hired	156.63	321.14	361.30	244.65

The table presents the input utilization pattern of chilli cultivation across different farm-size groups, namely small, medium, large and overall farms. The analysis indicates considerable variation in the use of inputs among the different categories of farmers.

Among all the inputs, the use of seedlings was highest on large farms (18,180.85 seedlings), followed by medium farms (17,880.80 seedlings), while small farms used comparatively fewer seedlings (15,580.75 seedlings). The overall average use of seedlings was 16,300.

The application of FYM (Farm Yard Manure) also increased with farm size. Large farmers applied the highest quantity of FYM (83.92 quintals), followed by medium farmers (74.40 quintals) and small farmers (59.28 quintals). The overall average application was 66.30 quintals.

A similar trend was observed in fertilizer consumption. Large farms applied higher quantities of nitrogen (112.50 kg), phosphorus (63 kg) and potash (60 kg) compared to medium and small farms. Small farmers used the least amount of fertilizers, with nitrogen, phosphorus and potash

application recorded at 85.32 kg, 43.54 kg and 45.55 kg, respectively. The overall average fertilizer use was 91.84 kg of nitrogen, 49.77 kg of phosphorus and 49.18 kg of potash. The number of irrigations provided was slightly higher on large farms (14.05) than on medium (13.50) and small farms (13.15), with an overall average of 13.37 irrigations. Similarly, the number of plant protection chemical sprays was highest on large farms (12.50 sprays), followed by medium farms (12.15 sprays) and small farms (11.50 sprays).

Regarding labour utilization, small farms relied heavily on family labour, employing man-days, compared to 104.47 and 65.41 man-days on medium and large farms, respectively. In contrast, the use of hired labour increased with farm size. Large farms employed the highest hired labour (361.30 man-days), followed by medium farms (321.14 man-days) and small farms (156.63 man-days). The overall average use of family and hired labour was 172.88 and 244.65 man-days, respectively.

Overall, the table reveals that larger farms utilized higher quantities of most modern inputs such as fertilizers, FYM, irrigation and plant protection chemicals, whereas small farms depended more on family labour for cultivation activities.

Resource use efficiency

The regression analysis presented in Table 3 explains the effect of different production variables on the cultivation of okra. The estimated coefficients indicate the direction and magnitude of the influence of each input on okra yield, while the significance levels reveal whether the effects are statistically reliable.

The intercept value was estimated at 2.27986, indicating the baseline level of output when all explanatory variables are held constant. Among the variables included in the model, seedling quantity showed a positive and statistically significant effect at the 1 percent level, with a regression coefficient of 0.050. This implies that an increase in the number of seedlings used in cultivation contributed positively to okra production. The result highlights the importance of maintaining optimum plant population for achieving higher productivity.

Table 3: Regression coefficient of different production variables and their significance in cultivation of Chilli.

Variable	Coefficients	Standard Error
Intercept	2.27986	0.653
Seedling	0.050**	0.033
Farm Yard Manure	0.004	0.012
Nitrogen	0.061**	0.024
Phosphorus	-0.002	0.017
Potash	0.056**	0.016
Human labour	0.212*	0.109
Irrigations	0.037	0.050
Pesticides Spray	-0.059	0.050
Bullock Labour	-0.012	0.017

*and**Indicates significance at 5 percent and 1 percent level

Human labour had a positive coefficient of 0.212 and was significant at the 5 percent level. This finding indicates that labour-intensive operations such as interculturing, harvesting, irrigation management and plant protection practices contribute significantly to increased output in chilli cultivation.

On the other hand, farmyard manure (FYM), phosphorus, irrigations, pesticides spray and bullock labour was found to be statistically non-significant. Although FYM and irrigation had positive coefficients, their effects on yield was not statistically significant, indicating that variations in their use among farmers did not substantially influence output. Phosphorus, pesticides spray, and bullock labour exhibited negative coefficients, implying an inverse relationship with output; however, these effects were also statistically non-significant. The negative coefficient of pesticide spray may indicate excessive or inefficient use of chemicals, while the negative effect of bullock labour suggests the declining relevance of traditional labour inputs in modern chilli cultivation practices.

Overall, the regression results reveal that seedlings, nitrogen, potash and human labour was the major determinants significantly influencing chilli production in the study area. Efficient and balanced use of these inputs can help farmers improve productivity and achieve better economic returns from chilli cultivation.

Table 4: Resource use efficiency in Chilli production

Variable	Coefficients	MPP	MVP	MFC	MVP/MFC
Seed	0.05	3.33	290.50	147.38	1.97
Farm Yard Manure	0.00	0.01	0.33	1.20	0.27
Nitrogen	0.06	12.67	390.46	38.60	10.12
Phosphorus	0.00	-0.52	-15.99	52.17	-0.31
Potash	0.06	16.33	502.96	32.50	15.48
Human labour	0.22	7.09	218.50	125.87	1.74
Irrigations	0.03	26.60	819.34	475.29	1.72
Pesticides Spray	-0.06	-65.58	-2020.38	998.67	-2.02

PP = Marginal physical product, MVP = Marginal value product, MFC = Marginal factor cost

The resource use efficiency analysis in chilli production was carried out using the ratio of Marginal Value Product (MVP) to Marginal Factor Cost (MFC). The efficiency criterion suggests that:

- ✓ MVP/MFC = 1 → optimum use of resource
- ✓ MVP/MFC > 1 → underutilization of resource (scope for increasing use)
- ✓ MVP/MFC < 1 → overutilization of resource (resource should be reduced)
- ✓ Negative MVP → excessive use of input causing decline in output

The results presented in Table 4 indicate varying levels of efficiency among the production inputs used in chilli cultivation. The coefficient of seed was positive (0.05), with an MVP/MFC ratio of 1.97. This indicates that seed input was utilized in chilli production. An additional investment in quality seed could increase productivity and profitability. The positive marginal productivity further confirms that improved seed rate or better seed quality contributes positively to output. Nitrogen exhibited a positive coefficient (0.06) and a very high MVP/MFC ratio of 10.12. This clearly indicates substantial under utilization of nitrogen fertilizer. Since the marginal value product greatly exceeded the marginal factor cost, increasing nitrogen application within recommended limits could significantly enhance chilli yield and farm income. Potash had a positive coefficient (0.06) and the highest positive MVP/MFC ratio (15.48), indicating severe under utilization. The high

marginal returns suggest that additional application of potash could considerably improve chilli production and profitability. Potash is essential for fruit development, disease resistance and quality improvement in chilli crops. Farm Yard Manure showed a very low coefficient (0.00) and an MVP/MFC ratio of 0.27, indicating overutilization. The marginal returns from FYM was lower than its cost, suggesting that farmers were applying FYM beyond the economically optimal level. Rationalization in FYM application could help reduce production costs without adversely affecting output. The coefficient of phosphorus was nearly zero with a negative MPP and MVP, resulting in an MVP/MFC ratio of -0.31. This implies overuse of phosphorus fertilizer, which may have adversely affected crop productivity. Excess phosphorus application can create nutrient imbalance in soil and reduce efficiency of other nutrients. Therefore, phosphorus uses, should be reduced and balanced according to soil test recommendations. Pesticide spray showed a negative coefficient (-0.06), negative MPP and negative MVP, with an MVP/MFC ratio of -

2.02. This indicates excessive and uneconomic use of pesticides. Overapplication may not only increase production cost but also negatively affect crop growth, beneficial organisms and environmental quality. The result suggests the need for judicious pesticide use through Integrated Pest Management (IPM) practices.

Human labour recorded a positive coefficient (0.22) with an MVP/MFC ratio of 1.74, indicating underutilization. The results imply that additional labour use in operations such as weeding, harvesting, intercultural practices and plant protection could enhance output. Efficient labour management may therefore increase productivity. Irrigation had a positive coefficient (0.03) and an MVP/MFC ratio of 1.72, suggesting underutilization. Since chilli is sensitive to moisture stress, proper and timely irrigation could improve yield. The findings indicate that increasing irrigation frequency or improving irrigation management may enhance production efficiency.

Yield gap

As described in methodology, the present analysis has been attempted to estimate only farm level yield gap for chilli in the study area. For this the sample growers were classified into two categories viz., best and average farmer accordingly to the level of their chilli productivity. The highest yield of crop obtained by the best five sample farmers was considered as the potential yield of the chilli in the area. This was treated as a farm level potential yield which can be realized through proper inputs and management. This farm level potential yield was then compared with the average yield obtained by remaining farmers (average farmers). Therefore, the yield gap in the present study was calculated between the best and the average sample farmer. The result pertaining to yield levels and yield gap is presented in Table 5.

Table 5: Yield levels and yield gap in Chilli

Sr. No.	Particular	Yield (Qt/ha)
1	On farm average yield level	
	(a) Best farmers	177.56
	(b) Average farmers	158.66
2	a. Yield gap in absolute term	18.90
	b. Yield gap in percentage term	11.91

It can be observed from the Table 5 that the average yield of best farmers for chilli were considerably high (177.56 Qt/ha) than the average yield levels (158.66Qt/ha) of the average farmers. The results revealed that there was significant difference between the yield of the best farmer and average farmers, which was about 18.90 quintals per hectare absolute terms.

Table 5 presents the yield performance of chilli cultivation among best farmers and average farmers, along with the estimated yield gap. The analysis of yield gaps is important for understanding the extent to which existing technologies and management practices are being efficiently utilized by farmers.

The results revealed that the average yield obtained by best farmers was 177.56 quintals per hectare, whereas the average farmers obtained 158.66 quintals per hectare. The difference in productivity indicates the presence of variations in input management, adoption of recommended cultivation practices, resource use efficiency and managerial ability among farmers.

The yield gap in absolute terms was estimated at 18.90 quintals per hectare, while the yield gap in percentage terms was 11.91 percent. This indicates that average farmers produced nearly 12 percent lower yield compared to best-performing farmers. The existence of this gap suggests that substantial scope exists for increasing chilli productivity by improving production practices among average farmers.

Table 6: Resources used by best and average farmers

Resources used	Average farmers	Best farmers
Seedlings	15500.75	18280.85
FYM (quintals/ha)	58.8	85
Fertilizers		
(a) Nitrogen (kg/ha)	85.84	113.50
(b) Phosphorus (kg/ha)	48.38	54.1
(c) Potash (kg/ha)	46.03	55.3
No. of irrigation	13.91	14.25
No. of spray (PP chemicals)	11.75	12.35
Human labour (man-days)		
(a) Family	170.88	182.50
(b) Hired	370.30	344.20

Table 6 presents the comparative pattern of resource use between best farmers and average farmers in chilli cultivation. The analysis indicates noticeable differences in the quantity and combination of inputs used by the two groups, which may explain the variation in yield levels observed earlier.

It was observed from Table 6 that best farmers used more seedlings (18,280.85 seedlings/ha) compared to average farmers (15,500.75 seedlings/ha). The higher plant population maintained by best farmers may have contributed to better crop stand and higher yield realization. Proper spacing and optimum plant density are important factors influencing chilli productivity. Best farmers applied significantly higher quantities of Farm Yard Manure (85 q/ha) compared to average farmers (58.8 q/ha). Adequate application of FYM improves soil structure, moisture retention capacity, microbial activity, and nutrient availability, thereby enhancing crop growth and productivity. The higher use of organic manure by best farmers indicates better soil fertility management practices. The use of chemical fertilizers was also higher among best farmers than average farmers. Nitrogen: Best farmers applied 113.50 kg/ha, while average farmers applied 85.84

kg/ha. Phosphorus: Best farmers used 54.10 kg/ha compared to 48.38 kg/ha by average farmers. Potash: Best farmers applied 55.30 kg/ha against 46.03 kg/ha by average farmers. The number of pesticide sprays was also slightly higher among best farmers (12.35 sprays) compared to average farmers (11.75 sprays). This suggests that best farmers adopted more intensive plant protection measures to control pests and diseases. However, the effectiveness of pesticide use depends not only on the number of sprays but also on proper timing, dosage and chemical selection. The utilization of family labour and hired labour differed between the two categories of farmers. Family labour: Best farmers used more family labour (182.50 man-days) than average farmers (170.88 man-days). Hired labour: Average farmers used more hired labour (370.30 man-days) compared to best farmers (344.20 man-days). The greater use of family labour by best farmers may indicate closer supervision, timely farm operations and better management efficiency. In contrast, higher dependence on hired labour among average farmers could result in relatively less efficient labour utilization and increased production costs.

The findings clearly indicate that best farmers adopted relatively higher levels of critical inputs such as seedlings, FYM, fertilizers, irrigation and family labour compared to average farmers. These differences in resource use patterns likely contributed to the higher productivity achieved by best farmers.

The results suggest that improved management practices, balanced nutrient application, proper crop supervision and timely execution of farm operations are key factors influencing chilli productivity. The study further implies that average farmers can enhance their yield levels by adopting the input use pattern and management practices followed by best farmers.

Conclusion

The study revealed that the use of inputs per hectare in chilli cultivation tended to increase with the increase in farm size. Larger farmers was found to utilize relatively higher quantities of critical inputs such as seedlings, fertilizers, irrigation and labour compared to smaller farmers.

The resource use efficiency analysis indicated that the application of fertilizers, particularly nitrogen and potash, as well as the use of seedlings, was below the economically optimum level in the study area. Therefore, increasing the use of these inputs within the recommended limits could enhance chilli productivity and profitability.

The findings suggest that adoption of balanced nutrient management practices and optimum plant population would improve resource use efficiency and contribute to higher productivity and economic returns from chilli cultivation.

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