



Economics of Apple Production in Different Farm Size: A Comparative Study of Jubbhal and Kotkhai Tehsil of District Shimla

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ABSTRACT

Background: The process of production involves converting the raw material resources into the finished product and these resources possess the cost, which needs to be optimised with the better utilization and allocation of the resources. Farms with the best resource utilisation have more chances to gain the economics of scale therefore it is necessary to study the allocative and productive efficiency of the different farm sizes in the study area.

Methods: The field survey was conducted at Tehsil Jubbhal and Kotkhai of Shimla district where data from 200 Apple-producing farming households of different farm sizes was collected with the help of a questionnaire. The collected data was analysed with the use of the Cobb-Douglas production function to analyze the resource use efficiency of different farm sizes.

Result: The study indicates that in the case of marginal farms in Kotkhai Tehsil, land, labour and manures and fertilizers were found to be statistically significant at the 5% and 10% probability levels. However, for marginal farms in Jubbhal Tehsil, the production elasticity of factor inputs such as land and manures and fertilizers is positive, while labour and seeds show a negative elasticity, although these results are not statistically significant. The MVP (Marginal Value Product) of land, labour, seeds and other inputs is statistically less than unity for small, marginal and medium farms in both Kotkhai and Jubbhal Tehsils. This suggests that farmers are utilizing these resources beyond their optimal capacity. Additionally, the MVP of manures and fertilizers is negative for small and medium farms in both Tehsils, indicating that reducing their usage would lead to higher returns.

Key words: Allocative efficiency, Marginal value product, Optimal capacity, Productive efficiency, Resource optimization.

INTRODUCTION

The Agro-climatic conditions of Himachal Pradesh make it ideal for cultivating temperate to sub-tropical fruits. As a result, there has been a shift in cultivation patterns from Agriculture to Horticulture crops over the past few decades. The area devoted to fruit cultivation in Himachal Pradesh has grown significantly, from 792 hectares in 1950-51, yielding 1,200 tonnes, to 2,33,300 hectares in 2019-20, with total production reaching 8.45 lakh tonnes. Apple remains the most significant fruit crop contributing around 85% of total fruit production with 49% of the total area under fruit crop in the region. There has been a significant rise in area under apple cultivation from 400 hectares in 1950-51 to 3,025 hectares in 1960-61 and reached 1,14,144 hectares by 2019-20. The shift towards fruit cultivation especially Apple due to the commercialization of the same in Himachal Pradesh requires proper study to find out whether the farmers are making the best use of the resources. (Economic Survey Report 2018-19).

Several studies were conducted by Bhat and Dhar (1989); Singh and Vashist (1994); Haque (2006); Kumar and Sharma (2011); Kireeti (2013); Singh (2013); Ravi *et al.* (2017); Kumari *et al.* (2018); Venkatraman *et al.* (2019); Bey *et al.* (2022); Sindhu *et al.* (2023); Chotaliya *et al.* (2024); Adaik *et al.* (2024) and Ishita *et al.* (2025) to understand the input-output relationship in agriculture production and

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all the given studies identify that factor inputs like fertilizers, human labour, manures etc. influence the agriculture production but misuse of the same can make the crop production inefficient therefore considering this aspect, a study was conducted at two different Tehsils (Kotkhai and Jubbhal) of District Shimla of Himachal Pradesh to understand the resource and allocative efficiency on Apple crop production of different farm sizes and to find whether the farmers are making the best utilisation of resources or if there are possibilities for improvement.

Jubbhal and Kotkhai play a significant role in apple cultivation in the Shimla district, with most of the local population dependent on this activity for their livelihood.

Therefore, this study contributes to understanding the key factors influencing apple production and highlights the issue of resource overutilization. By identifying these factors, the study can help farmers minimise resource wastage through better allocation, ultimately enhancing resource efficiency and profitability across all farm sizes in apple cultivation.

MATERIALS AND METHODS

The present study was conducted in the Jubbal and Kotkhai Tehsils of the district Shimla, where the field survey was conducted on 200 farming households of different farm sizes with the help of a questionnaire. The stratified random sampling method has been used, where the study area was divided into 10 different panchayats, with an equal distribution across both Tehsils. From each panchayat, two villages were selected and 10 farming households from each village-representing different categories (marginal, small and medium)-were randomly chosen. The Study primarily relies on primary data, collected through personal interviews, face-to-face interactions with farmer respondents and observational methods to gather relevant information.

Resource use efficiency

Land, labour, manure and other resources are vital in agricultural production. To assess resource use efficiency, it is essential to understand the marginal productivity of each factor, which can only be determined if the full technical relationship between output and input is known. Therefore, in this study, the Cobb-Douglas production function has been employed to analyse resource use efficiency across marginal, medium and small farms. The specification of the model for apple production in marginal, small and medium farms is given as:

$$Y = Ax_1^{b_1} x_2^{b_2} x_3^{b_3} x_4^{b_4} x_5^{b_5} e^u$$

Where

Dependent variable, Y = Gross returns (Rs/farm).

Independent variables,

X_1 = Land (hectares/farm).

X_2 = Human labour (Mandays/farm).

X_3 = Manures and fertilisers (Rs/farm).

X_4 = Seed (Rs/farm).

X_5 = Others (Rs/farm).

a = Constant (Intercept term).

u = Random variable.

b_1 to b_5 = Regression coefficient of respective inputs and implicitly represent the elasticities of the production of factor inputs.

A positive elasticity of less than one indicates decreasing marginal productivity of factor inputs. The larger the elasticity of factor input, the larger the increase in output in response to a given proportionate increase in that factor input, with other inputs held constant. Negative production elasticities of factors indicate their inefficient and excessive use.

Such a type of function can be transformed into the logarithmic form so that it can be solved by the methods of least squares.

$$\log Y = \log A + b_1 \log X_1 + b_2 \log X_2 + b_3 \log X_3 + b_4 \log X_4 + b_5 \log X_5$$

The statistical significance levels of regression coefficients were worked out to determine the goodness of fit. It was carried out by calculating the 't' statistics by following the formula for regression coefficients.

$$t = \frac{b_i}{\sqrt{\text{var}(b_i)}} \quad \text{with } (n-k-1) \text{ degree of freedom}$$

The sum of these production elasticities indicates returns to scale, which indicates the proportionate increase in output when all the inputs are increased by the same proportion. If this sum is less than, equal to or greater than unity, it indicates decreasing, constant or increasing returns to scale, respectively.

The resources are said to be efficiently allocated if their MVP is equal to its acquisition unit price therefore for efficient resource utilisation in crop production, the marginal value product (MVP) must be equal to the marginal factor cost (MFC). It was calculated by using the formula shown below:

$$AE = \frac{MVP}{MFC}$$

The marginal value productivity of inputs is calculated as:

$$MVP_i = \beta_i \frac{\bar{y}}{\bar{X}_i}$$

Where,

MVP = Marginal value productivity of i^{th} input.

β_i = Regression coefficient associated with i^{th} input.

$\bar{y}$ = Geometric mean of output.

$\bar{X}_i$ = Geometric mean of i^{th} input.

Where,

AE = Allocative efficiency.

MVP = Marginal value product.

MFC = Marginal factor cost.

AE = 1, it indicates efficient use of resources.

AE < 1 indicates a particular resource is over-utilised, i.e., the profit level can be increased by decreasing the quantity of a particular input used.

AE > 1 indicates a particular resource is being under-utilised, i.e., the profit level can be increased by increasing the quantity/rate of input particular used.

RESULTS AND DISCUSSION

Production involves the process where resources are used to produce some product therefore farmers also make use of various resources such as human labour, bullock power, mechanical power, water for irrigation, seeds, manures and fertilizers, insecticides and pesticides to produce the different crop but the output of the crop depends upon the productive and allocative efficiency of the resources.

Table 1.1: Resource utilisation in apple cultivation (value in Rs.).

Items	Marginal farmers (Kotkhai) N (20)	Marginal farmers (Jubbāl) N (20)
Input utilization		
Area (Hect)	1.06	1.16
Average area (Hect)	0.0532	0.0582
Average labour input per hectare (Mandays)	3105	3206
Average fertilisers and manures used per hectare (Rs.)	368311	342879
Average seeds used per hectare (Rs.)	6613	5625
Average other inputs used per hectare (Rs.)	359932	334205
Output efficiency		
Gross output (Rs.)	5464491	7717364
Gross output per hectare (Rs.)	5155181	6652900
Gross output per manday (Rs.)	1660	2074
Gross output per rupee of fertilizers and manures (Rs.)	13.99	19.4
Gross output per rupee of seeds (Rs.)	779	1182
Gross output per rupee of other inputs (Rs.)	14.3	19.9

Table 1.2: Coefficients of production function for marginal farms (≤ 1 hectares).

Items	Tehsil	
	Kotkhai	Jubbāl
Constants (Log a)	5.853 (3.246)	18.106 (6.489)****
Land in hectares (X1)	0.869 (0.375)****	1.804 (0.750)
Human labour in mandays (X2)	0.785 (0.311)****	-0.355 (0.621)
Manures and fertilizer in Rs. (X3)	0.521 (0.209)****	0.219 (0.419)
Seeds in Rs. (X4)	-0.425 (0.177)****	-0.595 (0.355)
Others in Rs. (X5)	0.250 (0.400)	0.304 (0.800)
Sum of elasticity coefficient ($\sum b_i$)	1.999	1.378
R ²	0.81	0.36
N (Number of observations)	20	20

Note (i) Figures in the parentheses are standard error.

(ii) *Significant at a 1 per cent probability level.

(iii) **Significant at 5 per cent probability level.

(iv) ***Significant at 10 per cent probability level.

(v) R² coefficient of multiple determination.

(vi) Number of observations.

The Cobb-Douglas production function shows the relationship between various inputs and crop yield of different farm sizes of different Tehsils and therefore reveals the efficiency.

Resource utilization and efficiency of marginal farms in Jubbāl and Kotkhai Tehsil

In apple production, critical resources include land, labour, fertilisers, seeds and other inputs. Table 1.1 highlights the comparative analysis of two tehsils marginal farmers

resource utilisation patterns. The Tehsil Kotkhai farmers use on average: Labour: 3,105 mandays/ha, Fertilizer: `368,311/ha, Seeds: `6,613/ha, other inputs: `359,932/ha and Tehsil Jubbāl farmers use: Labour: 3,206 mandays/ha, Fertilizer: `342,879/ha, Seeds: `5,625/ha, other inputs: `334,205/ha. In terms of gross output, Kotkhai yields `5,155,181 per hectare and `1,660 per manday of labour and Jubbāl yields `6,652,900 per hectare and `2,074 per manday of labour. As far as evaluating productivity per rupee invested in inputs, Kotkhai achieves: `13.99 per `1 of fertilizer, `7.79 per `1 of seeds, `14.30 per `1 of other inputs however Jubbāl achieves: `19.40 per `1 of fertilizer, `11.82 per `1 of seeds and `19.90 per `1 of other inputs. The analysis reveals that Jubbāl farmers utilise slightly more labour per hectare than Kotkhai farmers, whereas Kotkhai incurs higher costs in fertilizer, seeds and other inputs. However, Jubbāl outperforms Kotkhai in output efficiency across all these input categories, resulting in higher returns both per hectare and per unit of input.

However, to reveal more understanding about the Input-Output, we have to go with more statistical analysis, which will explain the relative picture of resource efficiency. Table 1.2 presents the regression coefficients for Apple crop production. The regression model includes several independent variables: land, human labour, manures and fertilizers, seeds and other inputs. For marginal farms in Kotkhai Tehsil, the variables land, labour and manures and fertilizers are statistically significant at the 5% and 10% levels. This indicates that a 1% increase in the use of land, labour and manures and fertilizers results in an average increase in gross output of 0.86%, 0.78% and 0.52% respectively, demonstrating a positive relationship between these inputs and apple production. In contrast, the elasticity coefficient for seeds is -0.42%, which is statistically significant and suggests a negative impact on output. For marginal farms in Jubbāl Tehsil, land and

manures and fertilizers show positive elasticity coefficients, while labour and seeds have negative coefficients; however, these are not statistically significant. The coefficient of multiple determination (R^2) is relatively high for Kotkhai Tehsil at 0.81, indicating that the independent variables explain a substantial portion of the variation in apple output. In comparison, the R^2 value for Jubbhal Tehsil marginal farms is lower, at 0.316, suggesting a weaker explanatory power of the model in that region.

The sum of the regression coefficients, or output elasticities, derived from the Cobb-Douglas production function for Marginal farmers in Kotkhai Tehsil was 1.99, while for Marginal farms in Jubbhal Tehsil, it was 1.37. This indicates that if all factors of production were to increase simultaneously by 1.00 per cent, the output would increase by 1.99 per cent in Kotkhai Tehsil and by 1.37 per cent in Jubbhal Tehsil's marginal farms.

Allocative efficiency of marginal farms in Jubbhal and Kotkhai Tehsil

Determining resource use efficiency involves estimating the marginal value products (MVP) of various resources. The MVP of each input is then compared to its corresponding

factor price or marginal factor cost (MFC). This comparison provides a valid assessment of the efficiency with which inputs are allocated in the production process. Table 1.3 reveals the resource allocation picture for the Kotkhai and Jubbhal tehsil marginal farms. In Kotkhai Tehsil, the marginal farms show the following ratios for the marginal value product (MVP): Land (0.00), Labour (0.00), Manures and Fertilizers (0.66) and Others (0.16). All of these are statistically less than unity, indicating that farmers are using these resources in excess. Additionally, the significantly low MVP ratio for Seeds (X_4) at -0.91 suggests that their usage should be reduced to achieve higher returns.

In Jubbhal Tehsil, the marginal farms exhibit MVP ratios of Land (0.00), Labour (0.00), Manures and Fertilizers (0.28) and Others (0.39), all of which are also less than unity, pointing to the overutilization of these resources. Furthermore, the MVP ratio for Seeds at -1.33 indicates their overuse, suggesting that reducing seed usage would lead to higher returns.

Resource utilisation and efficiency of small farms in Jubbhal and Kotkhai Tehsil

Resource utilisation and allocation give us understanding about the farm's performance; therefore, in the current

Table 1.3: Marginal value productivities of marginal farmers for apple crop and its ratio with factor cost at Jubbhal and Kotkhai tehsil.

Variables	Kotkhai			Jubbhal		
	Marginal farmers			Marginal farmers		
	MVP	MFC	Ratio	MVP	MFC	Ratio
Land under crop in hectares (X_1)	1.192	153929	0.00	-8.03	198730	0.00
Human labour in mandays (X_2)	0.885	370	0.00	-0.87	370	0.00
Manures and fertilizer in Rs. (X_3)	0.658	1	0.66	0.28	1	0.28
Seeds in Rs. (X_4)		1			1	
	-0.914	1	-0.91	-1.33	1	-1.33
Others in Rs. (X_5)		1	0.31	0.39	1	
	0.314	1				0.39

Table 2.1: Resource utilisation in apple cultivation (value in Rs.).

Items	Small farmers (Kotkhai)	Small farmers (Jubbhal)
	N (30)	N (30)
Input utilization		
Area (Hect)	3.65	3.78
Average area (Hect)	0.121	0.126
Average labour input per hectare (Mandays)	3252	2892
Average fertilizers and manures used per hectare (Rs.)	419296	297484
Average seeds used per hectare (Rs.)	6672	4788
Average other inputs used per hectare (Rs.)	404959	324356
Output efficiency		
Gross output (Rs.)	27077031	29815753
Gross output per hectare (Rs.)	7418365	7887765
Gross output per manday (Rs.)	2281	2727
Gross output per rupee of fertilizers and manures (Rs.)	18	27
Gross output per rupee of seeds (Rs.)	1112	1647
Gross output per rupee of other inputs (Rs.)	18	24

study, we have taken Land, Labour, fertilizers, seeds and other Inputs as the key resources in Apple cultivation. Table 2.1 reveals the utilisation pattern of different inputs for small farmers concerning the land (per hectare) and Gross Output (Rs). From the study, it is noticed that the Average labour Mandays, Fertilizers, seeds and other Inputs for Tehsil Kotkhai farmers are 3252 (Mandays per hectare), Rs 419296 (per hectare), Rs. 6672 (per hectare) and Rs. 404959 (per hectare) respectively in comparison to the Tehsil Jubbāl farmers 2892 Mandays (per hectare), Rs. 297484 (per hectare), Rs. 4788 (per hectare) and Rs. 324346 (per hectare). As far as Gross output is concerned, for Land and Labour it is estimated to be Rs. 5155181(per hectare), Rs. 1660 (per man day) for Tehsil Kotkhai farmers and Rs. 6652900 (per hectare), Rs. 2074 (per man day) for Tehsil Jubbāl farmers. However, Gross output per Rs. of Fertilizers, seeds and other inputs is concern,

it is estimated to be Rs. 18, Rs 1112 and Rs. 148 for Tehsil Kotkhai farmers and Rs. 27, Rs. 1647 and Rs. 24 for Tehsil Jubbāl farmers.

The study reveals that the per-hectare use of all the input resources for Kotkhai Farmers is more than compared of the Jubbāl farmers. When one looks towards the Gross output, it looks that Jubbāl has more Per Hectare Output in all the Inputs as compared to the Kotkhai farmers.

However, to reveal more understanding about the input-output, we have to go with more statistical analysis, which will explain the relative picture of resource efficiency.

Table 2.2 presents the regression coefficients for apple crop production on small farms in Jubbāl and Kotkhai Tehsils. The independent variables in the regression model include Land, Human Labour, Manures and Fertilizers, Seeds and other inputs. Labour emerged as a statistically significant factor at both the 5% and 10% probability levels in both the Tehsils. Notably, the labour coefficient is higher for small farms in Jubbāl Tehsil (1.38%) than in Kotkhai Tehsil (1.23%), indicating that a 1% increase in labour input would lead to a 1.38% and 1.23% increase in total returns, respectively. The coefficient for land is positive but not statistically significant in either Tehsils. Similarly, the coefficients for manures and fertilizers are negative and non-significant in both regions. In terms of seed input, the coefficient is positive (0.08%) for small farms in Jubbāl Tehsil and negative (-0.22%) for those in Kotkhai Tehsil, though neither is statistically significant. The "Others" variable (X_5) shows a positive but non-significant coefficient in Kotkhai and a negative, non-significant coefficient in Jubbāl. The coefficient of multiple determination (R^2) is relatively high-82.00% for small farms in Jubbāl and 57.00% for those in Kotkhai-indicating that the included variables explain a substantial portion of the variation in output, with minimal influence from unaccounted factors.

The sum of the regression coefficients or output elasticities, derived from the Cobb-Douglas production function for small farmers in Kotkhai Tehsil was 1.03, while for small farms in Jubbāl Tehsil, it was 1.19. This suggests that a simultaneous 1.00% increase in all factors of production would result in a 1.03% increase in output in Kotkhai Tehsil's small farms and a 1.19% increase in output in Jubbāl Tehsil's small farms.

Table 2.2: Coefficients of production function for small farms (1-2 hectares).

Items	Tehsil	
	Kotkhai	Jubbāl
Constants (Log a)	8.843 (4.098)	14.625 (3.560)
Land in hectares (X_1)	0.106 (0.512)	0.527 (0.360)
Human labour in mandays (X_2)	1.232 (0.319)*****	1.381 (0.209)*****
Manures and fertilizer in Rs. (X_3)	-0.153 (0.262)	-0.473 (0.172)
Seeds in Rs. (X_4)	-0.227 (0.171)	0.088 (0.086)
Others in Rs. (X_5)	0.075 (0.428)	-0.328 (0.271)
Sum of elasticity coefficient ($\sum b_i$)	1.033	1.194
R^2	0.57	0.82
N (Number of observations)	30	30

Note (i) Figures in the parentheses are standard error.

(ii) *Significant at a 1 per cent probability level.

(iii) ** Significant at 5 per cent probability level.

(iv) *** Significant at 10 per cent probability level.

(v) R^2 coefficient of multiple determination.

(vi) Number of observations.

Table 2.3: Marginal value productivities of small farmers for the apple crop and its ratio with factor cost at Jubbāl and Kotkhai Tehsil.

Variables	Kotkhai			Jubbāl		
	Small farmers			Small farmers		
	MVP	MFC	Ratio	MVP	MFC	Ratio
Land under crop in hectares (X_1)	0.141	222642	0.00	-3.46	236570	0.00
Human labour in mandays (X_2)	1.414	370	0.00	3.24	370	0.00
Manures and fertilizer in Rs. (X_3)	-0.193	1	-0.19	-0.62	1	-0.62
Seeds in Rs. (X_4)	-0.468	1	-0.47	0.19	1	0.19
Others in Rs. (X_5)	0.095	1	0.10	-0.42	1	-0.42

Table 3.1: Resource utilisation in apple cultivation (value in Rs.).

Items	Medium farmers (Kotkhai)	Medium farmers (Jubbal)
	N (50)	N (50)
Input utilization		
Area (Hect)	15.52	15.38
Average area (Hect)	0.310	0.307
Average labour input per hectare (Mandays)	3217	3163
Average fertilizers and manures used per hectare (Rs.)	349706	260012
Average seeds used per hectare (Rs.)	6036	4585
Average other inputs used per hectare (Rs.)	358699	349213
Output efficiency		
Gross output (Rs.)	104992393	124069931
Gross output per hectare (Rs.)	6764974	8066966
Gross output Per manday (Rs.)	2103	2551
Gross output per rupee of fertilizers and manures (Rs.)	19	31
Gross output per rupee of seeds (Rs.)	1121	1760
Gross output per rupee of other inputs (Rs.)	19	23

Table 3.2: Coefficients of production function for medium farms (above 2 hectares).

Items	Tehsil	
	Kotkhai	Jubbal
Constants (Log a)	3.844 (2.577)	7.561 (2.498)
Land in hectares (X1)	-0.036 (0.208)	-0.176 (0.190)
Human labour in mandays (X2)	0.654 (0.191)****	1.035 (0.116)****
Manures and fertilizer in Rs. (X3)	-0.017 (0.115)	-0.045 (0.119)
Seeds in Rs. (X4)	0.020 (0.118)	0.007 (0.079)
Others in Rs. (X5)	0.531 (0.243)****	0.026 (0.218)
Sum of elasticity coefficient ($\sum b_i$)	1.151	0.846
R ²	0.63	0.90
N (Number of observations)	50	50

Note (i) Figures in the parentheses are standard error.

(ii) *Significant at a 1 per cent probability level.

(iii) ** Significant at 5 per cent probability level.

(iv) *** Significant at 10 per cent probability level.

(v) R² Coefficient of multiple determination.

(vi) n number of observations.

Allocative efficiency of small farms in Jubbal and Kotkhai Tehsil

Small farms resource allocation picture for Kotkhai and Jubbal tehsil had been revealed in Table 2.3. In Kotkhai Tehsil, the MVP ratios for Small farms in Land (0.00), Labour (0.00) and Others (0.10) are all statistically less than unity, indicating that these resources are being used in excess. Additionally, the significantly low MVP ratios for Seeds (X4)

and Manures and Fertilizers, at -0.47 and -0.19, suggest that their usage should be reduced to achieve higher returns.

In Jubbal Tehsil, the MVP ratios for Small farms in Land (0.00), Labour (0.00) and Seeds (0.19) are also statistically less than unity, signalling overutilization of these resources. Furthermore, the negative MVP ratios for Seeds (-0.42) and Manures and Fertilizers (-0.62) indicate their overuse, suggesting that reducing their usage would lead to higher returns.

Resource utilization and efficiency of Medium Farms in Jubbal and Kotkhai Tehsil

Land, Labour, fertilizers, seeds and other Inputs are the key resources in Apple cultivation; therefore, Table 3.1 reveals the utilisation pattern of medium farmers for different inputs. Medium-scale apple farmers in Tehsil/ Kotkhai apply more inputs per hectare-3,217 labour mandays, `349,706 on fertilizer, `6,036 on seeds and `358,699 on other inputs-compared to those in Tehsil/Jubbal, who use 3,163 mandays, `260,012 on fertilizer, `4,585 on seeds and `349,213 on other inputs. Despite their lower input usage, Jubbal farmers outperform Kotkhai farmers in gross output per hectare- `8,066,966 versus `6,764,974-and deliver higher returns per unit of input: `2,551 per labour manday (vs. `2,103), `31 per rupee of fertilizer (vs. `19), `1,760 per rupee of seed (vs. `1,121) and `23 per rupee of other inputs (vs. `19).

However, to reveal more understanding about the Input-Output, we have to go with more statistical analysis, which will explain the relative picture of resource efficiency.

Table 3.2 presents the regression coefficients for apple crop production, incorporating the independent variables: Land, human labour, manures and fertilizers, seeds and others. The labour input was found to be statistically significant at the 5% and 10% probability levels on small farms in both Jubbal and Kotkhai Tehsils. Notably, the

Table 3.3: Marginal value productivities of medium farmers for apple crop and its ratio with factor cost at Jubbhal and Kotkhai Tehsil.

Variables	Kotkhai			Jubbhal		
	Medium farmers			Medium farmers		
	MVP	MFC	Ratio	MVP	MFC	Ratio
Land under crop in hectares (X_1)	-0.047	202818	0.00	2.03	242008	0.00
Human labour in mandays (X_2)	0.741	370	0.00	2.25	370	0.00
Manures and fertilizer in Rs. (X_3)	-0.022	1	-0.02	-0.06	1	-0.06
Seeds in Rs. (X_4)	0.039	1	0.04	0.01	1	0.01
Others in Rs. (X_5)	0.662	1	0.66	0.03	1	0.03

regression coefficient for labour is higher on medium-sized farms in Jubbhal Tehsil (1.03%) compared to Kotkhai Tehsil (0.65%), indicating that a 1% increase in labour input would lead to an increase in total returns of 1.03% and 0.65%, respectively. For the “Others” category of inputs, the coefficient on medium farms in Kotkhai Tehsil is both positive and statistically significant at the 5% and 10% levels, with a value of 0.53. This suggests that a 1% increase in these inputs would increase total returns by 0.53%. The coefficient for seeds (X_4) on medium farms in both Tehsils is positive but not statistically significant. Inputs such as Manures and Fertilizers and Land show negative coefficients on medium farms in both Jubbhal and Kotkhai Tehsils, though these relationships are not statistically significant. The coefficient of multiple determination (R^2) is 0.90 for medium farms in Jubbhal Tehsil and 0.63 for those in Kotkhai Tehsil, indicating that the model explains a substantial portion of the variation in output, particularly in Jubbhal Tehsil.

The sum of regression coefficients is derived from the Cobb-Douglas production function. The sum of regression coefficients, i.e., output elasticities of Medium farmers of Kotkhai Tehsil was 1.15 and Tehsil Jubbhal Medium farms was 0.84. It implies that if all the factors of production increased simultaneously by 1.00 per cent, then it will increase output by 1.15 and 0.84 per cent in medium farms.

Allocative efficiency of medium farms in Jubbhal and Kotkhai Tehsil

Table 3.3 indicates the medium farms resource allocation for Kotkhai and Jubbhal tehsil. In Kotkhai Tehsil, the MVP ratios for Small farms in Land (0.00), Labour (0.00), Seeds (0.04) and Others (0.66) are all statistically less than unity, indicating that these resources are being used in excess. Additionally, the significantly low MVP ratio for Manures and Fertilizers (-0.02) suggests that their usage should be reduced to achieve higher returns.

In Jubbhal Tehsil, the MVP ratios for Small farms in Land (0.00), Labour (0.00), Seeds (0.01) and Others (0.03) are also statistically less than unity, signalling overutilization of these resources. Furthermore, the negative MVP ratio for Manures and Fertilizers (-0.06) indicates their overuse, suggesting that reducing their usage would lead to higher returns.

CONCLUSION

The study found that, in Kotkhai Tehsil, the elasticity of marginal farm production with respect to land, labor and manure and fertilizers was statistically significant at the 5% and 10% levels. In contrast, in Jubbhal Tehsil, while land and manure and fertilizers had positive elasticities for marginal farms, the elasticities for labor and seeds were negative-though these were not statistically significant. Moreover, the labor coefficient for small farms in Jubbhal (1.38%) exceeded that in Kotkhai (1.23%), indicating that a 1% increase in labor yields a 1.38% increase in output in Jubbhal, compared to 1.23% in Kotkhai. For medium-sized farms, the labor coefficient in Jubbhal (1.03%) was also higher and statistically significant, compared to 0.65% in Kotkhai-suggesting that a 1% increase in labor input results in a 1.03% return increase in Jubbhal and just 0.65% in Kotkhai.

In terms of allocative efficiency, the MVPs of Land, Labour, Seeds and Others are statistically less than unity for small, marginal and medium farms in both Kotkhai and Jubbhal Tehsils. This indicates that farmers are using these resources in excess. Additionally, the MVP of Manures and Fertilizers is negative for small and medium farms in both tehsils, suggesting that their usage should be reduced to achieve higher returns.

Disclaimers

The views and conclusions expressed in this article are solely those of the authors and do not necessarily represent the views of their affiliated institutions. The authors are responsible for the accuracy and completeness of the information provided but do not accept any liability for any direct or indirect losses resulting from the use of this content.

Informed consent

All animal procedures for experiments were approved by the Committee of Experimental Animal Care and handling techniques were approved by the University of Animal Care Committee.

Conflict of interest

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