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Original Research Paper

Production function analysis for vegetable cultivation in Kullu valley of Himachal Pradesh: Application of Cobb-Douglas production model

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ABSTRACT

Vegetable cultivation plays a vital role in the agricultural economy of India. Agriculture is the main occupation of the people of Himachal Pradesh. Vegetable cultivation is facing challenges in profitability and economical use of resources. But a limited research has been done on resource use efficiency and elasticity of production in tomato, cauliflower and peas which are the major vegetable crops grown in Kullu. The present study was carried out in Kullu valley in the year 2019-2020 and multi-stage random sampling technique was used to select sixty farmers from different panchayats and villages on the basis of area they had under these crops. The elasticity of inputs used in the production of vegetables was worked out by fitting Cobb-Douglas production function. The sum of elasticity coefficients in case of tomato (Σb_i = 1.22), cauliflower (Σb_i = 1.56) and pea (Σb_i = 1.31) were greater than unity which is statistically significant and shows increasing returns to scale. The ratio of marginal value product (MVP) to marginal factor cost (MFC) represented by value of r, was greater than unity in tomato for plant protection (8.38) and labour (1.05) which indicated their under-utilization. Value of plant protection (0.30) on the other hand was less than unity in cauliflower, which shows its over-utilization. In case of peas, values for fertilizer (-1.09), seed (-2.44) and FYM (0.87) showed these were over utilized. It is suggested that the farmers should be trained for judicious use of resources.

Keywords : Cobb-douglas, elasticity, panchayats, resource use efficiency

INTRODUCTION

India has been blessed with a wide range of climate and geographical conditions and is most suitable for growing various kinds of vegetable crops. Vegetables are important constituents of Indian agriculture and are grown in an area of 10353 thousand hectares with an annual production of 191769 thousand MT (National Horticulture Board, 2020). Vegetables with shorter duration and higher productivity have resulted in greater economic returns to farmers over the last two decades. Agriculture is the main occupation of the people of Himachal Pradesh. The total area under vegetable cultivation in the state was 8861 thousand hectares with a total production of 1776.02 thousand MT in the year 2019-2020 (National Horticulture Board, 2020). The major vegetables grown in the state are potato, tomato, pea, ginger, capsicum, cauliflower, french beans, radish, cabbage, okra, carrot, chilli, and spinach.

There are a number of problems associated with the vegetable production. Productivity of vegetable crops is unable to reach its optimum level. Low productivity may be attributed to poor infrastructure, poor irrigation, small and fragmented land holdings, and low investment capacity of the farmers, fragile ecosystem and inaccessibility to technology (GC and Hall, 2020). The perishable nature of the vegetables also results in inability on the part of producers to manage supply in assembling markets. Vegetable cultivation is also facing the challenge of profitability and economical use of resources. These parameters need to be validated time to time for policy making and for the farmers to take judicious farm decisions (National Commission on Farmers, 2006). Production function analysis expresses the relationship between the quantities of productive factors (such as labour and capital) used and the amount of product obtained (Britannica, 2022).

It can also be used to determine the cheapest combination of productive factors that can be used to produce a given output. Keeping in view the above facts, the study was conducted to study about the production function analysis for vegetable cultivation in Kullu valley of Himachal Pradesh.

MATERIALS AND METHODS

The study was conducted in Kullu valley of Himachal Pradesh, India. Multi-stage random sampling technique was used to select the respondents. At the first stage, two development blocks *viz.,* Kullu and Naggar were selected. At the second stage, five panchayats from each block were selected randomly. The panchayats selected from the Kullu block were Bajaura, Hatt, Jia, Mohal and Shamshi and the panchayats selected from the Naggar block were Badagran, Brann, Hallan-I, Hallan-II and Katrain. At the third stage, a list of farmers growing vegetables was prepared from the selected panchayats and a sample of six vegetable growers was taken assigning random number using simple random technique from each panchayat, thus, comprising a sample of 60 vegetable growers in total for final survey. Primary data was collected on a pre-tested and well-structured schedule by personal interview method from the selected respondents during the year 2019-2020 and were studied at Department of Social Sciences (Agricultural Economics), College of Forestry, Dr. Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh, India. The Cobb-Douglas production function was used for studying the relationship between output of vegetables and the various inputs of each vegetable (Cobb and Douglas, 1928; Lokapur *et al.,* 2014).

$$Y = aX_1^{b_1}X_2^{b_2}X_3^{b_3}\ldots X_n^{b_n}e_u$$

or

$$\text{Log}Y = \text{Log } a + b_1\text{Log}X_1 + b_2\text{Log}X_2 + b_3\text{Log}X_3 \ldots\ldots + b_n\text{Log}X_n + U$$

Where, Y = Gross return (quintal); X_1 = Expenditure on human labour (manday); X_2 = Expenditure on FYM (quintal); X_3 = Expenditure on Plant protection (kg); X_4 = Expenditure on fertilizers (kg); X_5 = Expenditure on seed (kg); a = intercept and b_1 to b_5 are the elasticity coefficients and u = error term.

Adjusted R^2 is the modified version of R that has been adjusted for the number of predictors in the model. Adjusted R is the statistic based on the number of 30 independent variables in the model which is the desired property of a goodness of fit statistic. The adjusted value of R^2 is calculated as follow:

$$\bar{R}^2 = 1\text{-}(1\text{-} R^2)\ \frac{n-1}{n-k}$$

Where, R^2 = Coefficient of multiple determination; n = Number of sample observation; k = number of parameters estimated and R^2 = Adjusted R^2

'F' test was used to test the overall significance of explanatory variables to check if they affected the dependent variable or not. The expression for the test is as under:

$$F\ (k\text{-}1,\ n\text{–}k)\ df = \frac{R^2}{1-R^2}\frac{n-k-1}{k}$$

Where, k= Number of parameters; n = Number of observations in the sample and R^2 = Coefficient of multiple determination.

Estimation of resource use efficiency

The marginal value product of a particular resource represents the expected addition to the gross returns caused by an additional unit of a resource, while other inputs are kept constant (Kireeti and Guleria, 2015). The marginal value product (MVP) of the resources employed in vegetable production was calculated by multiplying the marginal physical product (MPP) by the unit price of the output(P_y), as given below:

$$MVP_{xi} = MPP_{xi}.P_y$$

Where, MVP_{xi} = Marginal value product of i^{th} input; MPP_{xi} = Marginal physical product of the i^{th} input and P_y = Price of unit output.

The estimation of MVP-Factor Cost Ratio was done using the formula given below:

$$r = MVP_{xi}/MFC$$

Where, r = Efficiency ratio; MVP_{xi} = Marginal value product; MFC = Marginal factor cost; If r = 1 resource is efficiently used; r > 1 resource is under-utilized and r\ < 1 resource is over utilized

The elasticity of production was calculated as:

$$e_p = MPP_{xi}/\ APP_{xi}$$

where , e_p= elasticity of production; MPP_{xi} = Marginal physical product and APP_{xi} = Average physical product

RESULTS AND DISCUSSION

One of the main objectives of a production unit is to co-ordinate and utilize resources or factors of production in such a manner that together they yield the maximum net returns. The cost and return analysis does not put sufficient light on the efficiency of resource allocation. It just depicts the general idea about the different factors of production or inputs used in the cultivation and production. In order to explain the contribution of individual input in the total output, production function analysis is helpful to evaluate the efficiency of various inputs used by the farmers. The elasticity of inputs used in the production of vegetables has been worked out by fitting Cobb-Douglas production function (Goni *et al.,* 2013). The analysis was carried out at overall basis as there was no significant difference was observed among various categories of farm.

Cobb - Douglas production function in tomato, cauliflower and peas

The estimated Cobb-Douglas production function for tomato is presented in Table 1. The production function analysis shows that in case of tomato, 88 % of variation in output was explained by the variables under study. The sum of elasticity coefficients in case of tomato was greater than unity (Σb_i = 1.22) which was statistically significant and showed increasing returns to scale which meant that the output increased in a greater proportion than the increase in input. The plant protection and labour were found statistically significant at 1 and 5 % respectively.

Cobb-Douglas production function for cauliflower is represented in Table 1. The sum of elasticity coefficients in case of cauliflower was greater than unity (Σb_i = 1.56) which was statistically significant and showed increasing returns to scale which meant that the output increased in a greater proportion than the increase in input. Seed, FYM, fertilizer and labour were found to be statistically significant at 1 % level of significance.

In case of peas (Table 1), the sum of elasticity coefficients in case of pea was greater than unity (Σb_i = 1.31) , which was statistically significant and showed increasing returns to scale which meant that the output increased in a greater proportion than the increase in input. FYM and labour were found to be

Table 1 : Estimated Cob-Douglas production function in tomato, cauliflower and pea

Function	Tomato			Cauliflower			Pea		
	Coefficient	Standard Error	P-value	Coefficient	Standard Error	P-value	Coefficient	Standard Error	P-value
Intercept	54.95	-0.49	0.00	120.00	-0.07	0.25	4.27	-1.42	0.66
Seed	0.03	-0.06	0.61	0.11*	-0.04	0.01	-0.07	-0.13	0.61
FYM	-0.04	-0.1	0.67	0.10*	-0.04	0.01	0.02*	-0.01	0.00
Labour	0.29**	-0.12	0.02	1.11*	-0.05	0.00	0.90*	-0.36	0.01
Fertilizer	-0.02	-0.11	0.00	0.24*	-0.07	0.00	-0.07	-0.13	0.61
Plant Protection	0.93*	-0.10	0.87	0.03	-0.03	0.26	0.39**	-0.18	0.04
Σb_i	1.22**	R^2	0.88	1.56*	R^2	0.99	1.31*	R^2	0.81
F	80.62	Adjusted R^2	0.87	1332.99*	Adjusted R^2	0.99	11.46*	Adjusted R^2	0.77

* and ** significant at 1 and 5 % level respectively

Table 2 : Estimated resource use efficiency and elasticity of production in tomato, cauliflower and pea

Crop	Function	Coefficient	APP	MPP	Py	MVP	MFC	r
Tomato	Seed	0.03	1.70	0.06	1000.00	55.72	275.00	0.2
	FYM	-0.04	1.61	-0.07	1000.00	-71.63	150.00	-0.48
	Labour	0.29	1.26	0.37	1000.00	368.22	350.00	1.05
	Plant Protection	0.93	2.26	2.10	1000.00	2095.52	250.00	8.38
	Fertilizer	-0.02	1.88	-0.03	1000.00	-30.83	525.15	-0.06
Cauliflower	Seed	0.11	1.68	0.18	1200.00	215.20	200.00	1.08
	FYM	0.10	1.65	0.16	1200.00	190.85	150.00	1.27
	Labour	1.11	1.56	1.73	1200.00	2072.81	350.00	5.92
	Fertilizer	0.24	1.82	0.44	1200.00	528.17	525.15	1.01
	Plant Protection	0.03	1.96	0.06	1200.00	75.01	250.00	0.30
Pea	Seed	-0.07	1.5	-0.10	4885.26	-488.54	200.00	-2.44
	FYM	0.02	1.53	0.03	4885.26	129.89	150.00	0.87
	Labour	0.90	1.19	1.07	4885.26	5245.21	350.00	14.99
	Fertilizer	-0.07	1.75	-0.12	4885.26	-572.25	525.15	-1.09
	Plant Protection	0.39	2.10	0.82	4885.26	4017.05	250.00	16.07

significant at 1% level whereas, plant protection was found to be significant at 5 % level.

Resource use efficiency and elasticity of production in tomato, cauliflower and peas

Resource use efficiency indicates whether a particular input is used efficiently or not as dictated by its economically optimum level. If a particular input is used up to that level where its marginal factor cost equal to the value of associated marginal products, then the resource use is said to be efficient. If the efficiency ratio is less than one it indicates that the resource is being over utilized and if ratio is more than one, the resource is being under-utilized.

For tomato, it was observed that the ratio of MVP to MFC represented by value of r in case of plant protection and labour wasgreater than unity which meant these were under-utilized and an increase in their usage would increase the production. Values of fertilizer, seed and FYM were less than unity, which meant these were over utilized and a reduction in their usage would lead to the maximization of profits in the sampled households.

In case of cauliflower, the ratio of MVP to MFC represented by value of r in case of seed, FYM, fertilizers and labour was greater than unity which showed under-utilization of these inputs and increasing their use would increase the production. Value of plant protection on the other hand was less than unity which showed its over-utilization and a reduction in their use would lead to maximization of profits.

In case of pea, the ratio of MVP to MFC represented by value of r in case of plant protection chemicals and labour was greater than unity which means these were under-utilized and an increase in the use of these would increase the production. Values for fertilizer, seed and FYM were less than unity, which meant these were over utilized and a reduction in their use would lead to the maximization of profits in the sampled households.

CONCLUSION

The Cobb-Douglas production function analysis indicated that the labour and plant protection had significant impact on output of tomato, whereas seed, labour, FYM and fertilizer significantly contributed towards cauliflower production. In case of pea, role of FYM, human labour and plant protection played a significant role in increasing the production. The efficiency ratios for the significant variables indicated that the farmers were not using the resources judiciously. The reason for this may be lack of awareness and knowledge. Therefore, it is suggested that the farmers should be trained for judicious use of resources.

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