Factor Effecting the Production and Resource use Efficiency of Cucumber Crop under Protected Cultivation: A Case Study of Hamirpur District

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Abstract

The present study has been conducted in Hamirpur district of Himachal Pradesh on the primary data collected from the 150 sample polyhouse farmers to access the factor effecting the production of cucumber crop and resource use efficiency of cucumber crop. The polyhouse were classified into three categories, i.e. small (i.e.40 m^2), medium (i.e.250 m^2) and large (i.e.500 m^2). Further each size of polyhouse has been divided into three crops, i.e. tomato, cucumber and cucumber. Cucumber grown under 8.00m^2, 52.86 m^2 and 90.00 m^2 under the small, medium and large of polyhouses, respectively. Among all sample size of farms it has been worked out 45.33 m^2. In order to analyse factor effecting the production, Cobb- Douglas production function has been fitted to the data of total production as dependent variable (Y) and human labour (X_1), expenditure on fertilizers (X_2), expenditure on plant protection (X_3), fixed capital (X_4), expenditure on seeds (X_5) and management index (X_6) as explanatory variables. The effect of these explanatory variables has been analysed on the total production of selected crop. The estimates of the fitted production function was to study the effect of different variables on total production, production elasticity, resource use efficiency, marginal value of productivity of the different inputs and the returns to scale. The more than 98 per cent of the variation in total productions of the cucumber has been explained by the explanatory variables on different sizes of polyhouses. The resource use efficiency in production of different vegetables has been studied by comparing the Marginal Value Productivity (MVPs) with the Marginal Factor Costs (MFPs) of explanatory variables taken for Cobb-Douglas production function.

KEYWORDS: total production, production elasticity, resource use efficiency, marginal value of productivity and marginal factor cost.

Introduction:

The economy of Himachal Pradesh is third fastest growing economy in India. Agriculture contributes nearly 45 per cent to the net state domestic product. It is the main source of income as well as employment in Himachal. About 93 per cent of the state population depends directly upon agriculture. To achieve faster and more inclusive growth in the Eleventh Five Year Plan, the Department of Agriculture, Himachal Pradesh has prepared a project on production of cash crops by adoption of precision farming practices through polyhouse cultivation.[1] The most significant in this regard is 'Pandit Deen Dayal Kisan Baagwaan Samridhi Yojana,' a flagship programme for the upliftment of farmers in the state. The project provides for 80 percent subsidy to farmers for land up to 1000 square meters for developing polyhouses and to establish sprinklers and drip irrigation systems, the remaining 20 per cent is to be borne by the farmer himself. The scheme has been launched with the assistance of NABARD RIDF-IV Tranche. This project has been implemented in all the twelve districts of the state with an outlay of Rs. 353.01 crores. This project

comprises of two parts, production of cash crops through adoption of precision farming practices through polyhouse cultivation for Rs. 154.92 crores and project on diversification of agriculture through micro-irrigation and other related infrastructure for Rs. 198.08 crores. The project has been launched in January 2009 for four years. Over the period of four years an area of about 2.59 lakh sq. meters is intended to be covered under the polyhouse cultivation. It envisages construction of 16500 polyhouses and bringing 20,000 hectare area under micro irrigation. Though the subsidy provided is 80 percent for BPL families, constructing polyhouses, the state government has decided to reduce the beneficiary share from 20 percent to 10 percent. Thus, such families will get a ninety percent subsidy. According to the information as provided by the department of agriculture, polyhouses have been constructed in 55.02 hectares of land in 2009-10 as against the targeted 48.88 hectares. For this an assistance of Rs. 24.24 crores was released to the farmer on account of construction of 4,796 polyhouses. [2]

A several studies on this theme has been conducted by Sing and Pandey[3], Singh and Patel[4], Gupta et al [5] on the resource use efficiency and they concluded that they were not using their limited resources rationally. The improved seeds, organic manures and fertilizers were found to be highly responsive as compared to the human and bullock labour. Hanumantha Rao[6] has used production function, i.e. Cobb-Douglas Function to analyse agricultural data. He also applied regression separately for farmers in different size-groups and also for three natural regions of the Hyderabad State. The study revealed that the production elasticity of labour to be higher than that of land in two relatively less fertile regions and a reverse situation in the track of Marathwada. Mathur and Balishter[7] studied the impact of HYV's of crops on farm labour use. An attempt has been made to know the extent of labour utilization across different size of farms under various types of HYV"s in a sub-region of Agra district of Utter Pradesh. It is pointed out that average labour use per hectare in high-yielding varieties is higher than that of other type of varieties. Venkatesam, Naidu and Venkateswarlu[8] have discussed the resource use efficiency on maize farms in Karimnagar district of Andhra Pradesh. They applied the Cobb-Douglas production function to study the resource use efficiency of sample farms. They identified in the case of maize production, contribution of family labour and total cost of cultivation decreases with the increase in farm size. Small farmers used more manures and less fertilizers, whereas medium and large farmers used more fertilizers and less manures. It is also observed that the average yield of hybrid maize was more on small farms and decreased as the farm size increased. Cost of production was the lowest in small farms.

1. Material and Methods:

The pattern of input use provides important insights into the extent of adoption of technology in protected farming. Productivity level of any agricultural crop largely depends on the quality and quantity of critical inputs applied in the cultivation of the crop. As we know under the protected cultivation, off-seasonal crops are grown. In order to grow off-seasonal crops different type of costly and high quality inputs are used so it is very necessary to analyse the economic efficiency of inputs used for crops grown under protected farming.

1.1.Objectives:

Thepresent study has been undertaken to achieve the following objectives: i) to study the socio-economic profile of the sample farms ii) to study the factors

effecting the production of cucumber crop; and iii) to study resource use efficiency of different input factors under different farms size for the production of cucumber crop.

1.2.Methodology:

The present study has been conducted in Hamirpur District of Himachal Pradesh. A sample of 150 polyhouse farmers involved in cucumber cultivation under protected farming has been selected on purposive random sampling technique. The polyhouse growers were classified into three categories viz. small (40 m^2), Medium (250^2) and large (500 m^2) with the sample size of 50, 70 and 30 from the each size of polyhouse respectively. The collection of information is based on a structured questionnaire designed to collect relevant information on family size, land holding, cropping pattern, production, factors for production and factor cost etc. In the present paper, the factor effecting the production of cucumber crop and resource use efficiency of different inputs under protected cultivation has been worked out with the help of following formulas' i.e. Cobb-Douglas production function, Returns to scales and marginal value product and MVP- Factor cost ratio.

PRODUCTION FUNCTION:-

To examine the allocative efficiency of resources under polyhouse cultivation, the Cobb-Douglas production function has been used.The algebraic form of the function is[9]:-

$$\mathbf{Y= a\, x_1^{b1}\, x_2^{b2}\, x_3^{b3}\, x_4^{b4}\, x_5^{b5}\, x_6^{b6}}$$

Where

Y= Output
a = Constant term (coefficient)
x_1= Land (Hectares)
x_2= Seeds (Quintals)
x_3= Human labour(Days)
x_4= Fertilizer (Quintals)
x_5= Capital (Rupees)
x_6= Management Index
and b_1, b_2, b_3, b_4, b_5 and b_6 are the elasticity coefficient of the respective explanatory variables.

The log linear transformation of the Cobb Douglas function is as follows:

$$\mathbf{Log\ Y= Log\ a + b_1 \log x_1 + b_2 \log x_2 + b_3 \log x_3 + b_4 \log x_4 + b_5 \log x_5 + b_6 \log x_6}$$

Theadjusted coefficients of multiple correlation ($\overline{R}$) were estimated and tested for their significance by calculating F-value as follows:

$$F\ (k\text{-}1)\ (n-k)\ d.f. = \frac{R2/(k-1)}{(1-R2)/(n-k)}$$

The seriousness of multicollinearity among independent variables was also tested using zero order correlation. The significance of estimates of production functions was tested by using't' test.

Returns to scales[10]**:**

$$\mathbf{F\ (1,\ n-k)\ d.f.} = \frac{(\sum \mathbf{bi} - \mathbf{1})\mathbf{2}\ (\mathbf{n} - \mathbf{k})}{\sum \mathbf{v}\ (\mathbf{bi})}$$

Where,

n= number of observations
k= total member of parameter estimated
∑bi= sum of elasticity coefficients

Marginal value product and MVP-Factor Cost Ratio[11]:

$$\mathbf{MVP}_{\mathbf{xi}} = \mathbf{bi}\ \frac{\overline{y}}{\overline{xi}}\ \mathbf{(PY)}$$

Where,

$\overline{y}$ = Geometric mean of output

$\overline{xi}$ = Geometric mean of ith input

bi = regression coefficients

i= 1- - - - n

PY = Price of output per unit (Rs.)

To test the significance of difference between ratio of marginal value of productivity to factor cost and unity the variance of ratio of the marginal value of productivity to the factor cost of input xi (i.e. $bi\ \frac{\overline{y}}{\overline{xi}}\frac{Py}{Pxi}$) has been estimated by the following formulas[12]:

$$\mathbf{Var.}\left(\mathbf{bi}\frac{\overline{y}}{\overline{xi}} \cdot \frac{\mathbf{Py}}{\mathbf{Pxi}}\right) = \left(\frac{\mathbf{Py}}{\overline{xi}} \cdot \frac{\overline{y}}{\mathbf{Pxi}}\right)^2 \mathbf{v\ (bi)}$$

PY and Pxi = Price of output Y and xi respectively

$\overline{y}$ and $\overline{xi}$ = Geometric means

The value of 't' to test the significance of the difference between the ratio of marginal value productivity to the factor cost and unity is given by:

$$t = \frac{\left(bi\ \frac{\overline{y}}{\overline{xi}} \cdot \frac{Py}{Pxi}\right) - 1}{\sqrt{var\left(bi\ \frac{\overline{y}}{\overline{xi}} \cdot \frac{Py}{Pxi}\right)}}$$

In order to know how much of a particular input could be used profitability by vegetables growers, the marginal value productivity of each input for individual crop was compared with its factor.

2. Results and Discussion:

2.1. Average Family Size, Percentage of Family Work Force, and Percentage of Dependents among the Sample Farms:

The average size of family, percentage of labour force and the percentage of dependents among the sample farms has been presented in table I. The average size of family has been worked out, 6.88, 6.84 and 9.33 per cent on the small, medium and large size of farms respectively. The average size of family among all the sample farms together came out 7.35 as compared to the average size of family at the State level as a whole i.e. 4.66 according to 2011 census. Thus, as the farm size increases, almost the average size of family also increases. It shows that as the economic status of a household improves they become more social.The percentage of labour force has been worked out 68.90, 63.67.08 and 61.30 per cent on the small, medium and large size of farms group respectively. Among all the farms together, this percentage came out 64.88 per cent. The percentage of dependents is the highest on the medium size of farms group (i.e. 36.32 per cent) as compared to the other class of farms. Among all the holding groups together, this percentage of dependents came out 35.12.Thus, the percentage ratio of labour force shows almost a decreasing tendency with an increase in the size of farms whereas, contrary to it, the percentage of dependents shows an increasing tendency with an increase in the size of farms. The lowest percentage of the dependent is on the small size of farms group mainly due to higher percentage of work force as compared to the medium and large size of farms.

3.2. Production Function:

The impact of various factors of production like labour, seed, fertilizers, plant protection materials etc. on production of selected crop i.e. cucumber under protected conditions has been analysed with help of Cobb Douglas production. The Cobb-Douglas production function has been fitted to the data of total production as dependent variable (Y) and human labour (X_1), expenditure on fertilizers (X_2), expenditure on plant protection (X_3), fixed capital (X_4), expenditure on seeds (X_5) and management index (X_6) as explanatory variables. The effect of these explanatory variables has been analysed on the total production of cucumber crop. The regression coefficients based on the estimated Cobb-Douglas production function, their standard errors and the value of adjusted coefficient of multiple determination and returns to scale have been estimated for the cucumber.

The regression coefficients, their standard error and value of adjusted coefficient of multiple determination in case of cucumber obtained from the Cobb-Douglas production function for different categories of polyhouses, i.e. the small, medium and large size are depicted in table 2. The table reveals that more than 98 per cent of the variation in total production of the cucumber has been explained by the explanatory variables on different sizes of polyhouses. On overall farm situation human labour (X_1), fertilizers and manures (X_2), plant protection (X_3) and management index (X_6) were positively related with the total production (Y). The elasticity of production of this significant explanatory variable was found to be 0.39, 0.47, 0.44 and 0.79, respectively. This implies with 1 per cent increase in human labour (X_1), fertilizers (X_2), plant protection(X_3) , fixed capital (X_4), and management index (X_6), result a increase the production of cucumber by be 0.39, 0.47, 0.44 and 0.79 per cent, respectively. In case of small size of polyhouses, five explanatory variables i.e. human labour (X_1) , fertilizers (X_2), plant protection (X_3), fixed capital (X_4) and

management index (X_6), turned out to be significant out of the six explanatory variables. On an average 1 per cent increase in expenditure on human labour (X_1), fertilizers (X_2), plant protection(X_3), fixed capital (X_4) and management index(X_4)resulted in a 0.01, 0.35, 0.74, 1.40 and 0.95 per cent increase in total productions of cucumber, respectively. Others variable like seeds (X_5) was negatively related with production but was statistically non-significant.

The table further reveals that in case of the medium sized polyhouses all the explanatory variables were found to have positive relationship and were statistically significant except fixed capital (X_4) and seeds (X_5). The production elasticity coefficients of Human labour (X_1), fertilizer (X_2), fixed capital (X_4) and management index (X_6) were estimated at 0.28, 1.09, 0.22 and 0.33 ,respectively which means that with 1 per cent increase in these variables the production of cucumber will increase by 0.28, 1.09, 0.22 and 0.33 per cent, respectively. On the large sized polyhouses elasticities of co-efficient were 0.68, 0.51, 0.03 and 1.09 for use of human labour(X_1), fertilizers (X_2), fixed capital (X_4), and management index (X_6) were found to be significant. This indicates that there are scope of increasing total productions of cucumber by increasing level of human labour (X_2), fertilizers (X_2), plant protection(X_3), and improvement in management index(X_6).

The table further indicates there has been increasing return to scale in the production of cucumber on different categories of polyhouses. This indicates that if all the factors of production are increased simultaneously by 1 per cent, then the production of cucumber will increase by 3.53, 1.64 and 2.09 per cent in case of the small, medium and large polyhouses, respectively. Whereas, in case of overall farm situation, the production will increase by 1.97 per cent with 1 per cent increase in all the factors of production under consideration.

3.3. Resource use efficiency in the production of Cucumber Crop:

The resource use efficiency in the production of cucumber crop has been presented in table 3. The resource use efficiency in production of cucumber crop has been studied by comparing the Marginal Value Productivity (MVPs) with the Marginal Factor Costs (MFPs) of explanatory variables taken for Cobb-Douglas production function. The resource use efficiency has been studied only in case of those explanatory variables (X_is) which showed statistically significant effect on dependent variable i.e. total production of cucumber. In the regression analysis, among the different explanatory variables, the human labour (X_1) has been measured in mandays, while other explanatory variables i.e. fertilizers (X_2), plant protection (X_3), fixed capital (X_4), seeds (X_5) etc. has been used in monetary terms. In order to judge the efficient use of resources, the Marginal Value Productivities (MVP_{xi}) of different significant variables has been compared with their respective Marginal Factor Costs (MFC_{xi}). If the $MVP_{xi} = MFC_{xi,}$ then there resources has been efficiently used otherwise there was inefficient use of resources in the production of vegetables in polyhouse conditions. If $MVP_{xi}>MFC_{xi}$, then the resources has been under-used and the total productions can be increased by increasing the level of resource use. On the other hand if $MVP_{xi}<MFC_{xi}$ then there was excess use of resources, and gross income can be increased by decreasing the level of resources in production. In our case as the inputs were measured in monetary terms except human labour (X_1), hence the MVPs were compared with Rs 1 in case of all explanatory variables except human labour where it has been compared with Rs 150, the wage rate

of human labour/day. The MVPs of the significant explanatory variables in case of cucumber.

The careful examination of table revealed that the marginal value productivities of human labour was Rs.257 and Rs.619 in case of cucumber on the medium size and large size polyhouses. This indicates that the marginal value productivities of human labour (X_1) in cucumber crop were more the MFC, i.e. Rs 150 only on medium and large size of polyhouses. Hence, it can be concluded that there are scope of increasing the total productions from the selected crop by increasing the human labour on the medium and large size polyhouses in case of cucumber until the MVPs reaches the value of MFC of labour (i.e. Rs 150).

The plant nutrients required for the growth and development of plants are supplemented through the use of different fertilizers brands available in the market. It can be observed from the table that the use of fertilizers was found to be significant in different sizes of the polyhouses in selected vegetable crop. The MVPs of fertilizer varied between Rs 5.33 to Rs 19.43 on the all size ofpolyhouses. This indicates that the value of MVPs of fertilizers in different category of polyhouses were quite high compared to MFC of fertilizer (i.e. Rs 1), therefore, in order to increase the total productions of the crops, the use of fertilizers should be increased until MVPs of fertilizer use decreases to Rs 1. The vegetable growers of the study area has also been found using of the plant protection materials for the management of insect pest and diseases. The use of plant protection material (X_3) has been found to be significant in case of cucumber on the small and medium farms. The value of MVPs of plant protection materials use was more than one and positive on the small and medium size of polyhouses i.e. Rs. 18.64 and Rs 9.23, respectively.This implies the use of plant protection materials should be increased to increase the total productions of vegetables until the MVPs of plant protection materials (X_3) is decreased to Rs 1.

Similarly, the tables further reveals that the MVPs of use of fixed capital on the small and medium size polyhouses has been positive in selected vegetable but more than Rs 1, this indicates that the investment in fixed capital (X_4) should be increase until it reaches optimum level, i.e. MVP (X_4) =Rs 1. So there is need to increase the investment on fixed capital (X_4) on small and medium size polyhouses under cucumber. The table further indicates that among the various factors of production, the marginal value productivity of management index was quite high on all the sizes of polyhouses except the small size of farms, i.e. 31.11, 58.51 and 268.98 in case of small, medium and large size of farms respectively. Since the management is a composite index which indicates the adoption of technical guidelines for the production of cucumber crop. So, it is suggested that farmers may be guided to adopt the recommended package for the production of cucumber through proper trainings and technical know-how to vegetable cultivation.

3. **Conclusion:** it can be concluded from the present study that more than 98 per cent of the variation in total productions of the cucumber has been explained by the explanatory variables on different sizes of polyhouses. On overall farm situation human labour (X_1), fertilizers (X_2), plant protection(X_3) and management index (X_6) were positively related with the total productions (Y). The elasticity of production of these significant explanatory variable were found to be 0.3899, 0.4735, 0.4359 and 0.7875s, respectively. It can further be concluded that there has been increasing return to scale in the production of cucumber on different categories of polyhouses. This indicates that if all the

factors of production are increased simultaneously by 1 per cent, then the production of cucumber will increase by 3.52, 1.64 and 2.09 per cent in case of the small, medium and large polyhouses, respectively. Whereas, in case of overall farm situation, the production will increase by 1.97 per cent with 1 per cent increase in all the factors of production under consideration. The marginal value of productivity of human labour and fixed capital under small and large size of polyhouses were underutilised, respectively.The marginal value of productivity of seeds under different size of polyhouses was underutilised, so in order to increase the production, sample farms should increase the use of these inputs.

Table I: Average Family Size, Percentage of Family Work Force, and percentage of Dependents among the Sample Farms

Sr. No.	Particulars	Among the Sample Farms			
		Small	Medium	Large	All farms
1	Total Numbers of Sample Farms	50	70	30	150
2	Total Number of Family	344	479	279	1102
3	Average Size of Family	6.88	6.84	9.3	7.35
4	**Percentage of Family Work Force**				
a)	Male	109 (66.06)	165 (70.21)	111 (68.52)	385 (68.51)
b)	Female	130 (72.63)	140 (57.38)	60 (51.29)	330 (61.11)
c)	Total	239 (68.90)	305 (63.67)	171 (61.30)	715 (64.88)
5	**Percentage of Dependents**				
a)	Males	56 (33.93)	70 (29.78)	51 (31.48)	186 (33.09)
b)	Females	49 (27.37)	104 (42.62)	57 (48.71)	210 (38.88)
c)	Total	105 (30.52)	174 (36.32)	108 (38.70)	387 (35.12)
6	**Literacy Percentage**				
a)	Male	165 (94.50)	235 (96.20)	162 (98.80)	572 (96.70)
b)	Female	179 (82.60)	244 (86.10)	117 (90.60)	542 (86.40)

c)	Total	344 (88.80)	479 (91.00)	279 (95.3)	1102 (91.60)

Note: Figure in parenthesis indicates percentage to total family members of each category.

Table II: Estimated Regression Coefficients of Different Factors of Production Influencing Cucumber Production in Different Sizes of Polyhouses

S.N.	Particulars		Small Farms	Medium Farms	Large Farms	All Farms
1.	Intercept	a	-9.0493	-2.4601	-2.9268	-3.1191
		S.E (a)	1.8666	0.6461	0.7436	0.4884
2.	Human Labour (X_1)	b_1	0.0959	0.2804*	0.6786**	0.3899**
		S.E ($b_{1)}$	0.2942	0.1938	0.2594	0.0974
3.	Manures and Fertilizers (x_2)	b_2	0.3543**	1.0931**	0.5089**	0.4735**
		S.E ($b_{2)}$	0.1597	0.3	0.2429	0.0291
4.	Plant protection (X_3)	b_3	0.7435**	0.2242**	-0.1279	0.4359**
		S.E (b_3)	0.358	0.1119	0.2394	0.1135
5.	Fixed capital (X_4)	b_4	1.3959**	-0.253	0.0289	-0.0293
		S.E (b_4)	0.5007	0.087	0.201	0.0723
6.	Seeds (X_5)	b_5	-0.0116	-0.0384	-0.0937	-0.0909
		S.E (b_5)	0.0623	0.027	0.1338	0.0368
7.	Management index (X_6)	b_6	0.9507*	0.3318**	1.0985**	0.7875**
		S.E (b_6)	0.7831	0.1349	0.3656	0.223
8.	R^2		0.9099	0.9698	0.9662	0.9787
9.	Adjusted R^2		0.8973	0.9669	0.9574	0.9778
10	Returns to scale		3.5286	1.638	2.0934	1.9666

Note: Figures in parentheses denote standard error
** Significant at 1 per cent level of probability
* Significant at 5 per cent level of probability

Marginal Value Productivities of Factors of Production Used in Production of Cucumber on Different Sizes of Polyhouses

Sr.No.	Particulars		Small Farms	Medium Farms	Large Farms	All Farms
1.	Human Labour (X_1)	MVP (Rs)		257.7626	619.7525	362.3536
		S.E. (MVP)		178.1369	236.8659	90.5445
2.	Manures and Fertilizers (x_2)	MVP (Rs)	5.3332	19.4333	14.2367	9.5045
		S.E. (MVP)	2.4044	5.3338	6.7963	0.5846
3.	Plant Protection (X_3)	MVP (Rs)	18.6388	9.3236	-3.9843	15.4972
		S.E. (MVP)	28.1215	13.0943		20.386

4.	Fixed capital(X_4)	MVP (Rs)	13.5424	6.5393		5.3078
		S.E. (MVP)				
5.	Seeds (X_5)	MVP (Rs)				
		S.E. (MVP)				
6.	Management index (X_6)	MVP (Rs)	32.1124	58.5169	268.9791	112.5054
		S.E. (MVP)	26.4518	23.7891	89.511	31.854

Note: S.E stands for Standard Error.

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