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Resource Use Efficiency of Cucumber (*Cucumis sativus* L.) in Sultanpur District of Uttar Pradesh, India

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ABSTRACT

This study was designed to measure the profitability and resource use efficiency of cucumber production during agricultural year 2021-22 in Sultanpur district of Uttar Pradesh. The study utilized a multistage stratified purposive cum random sampling technique to select districts, blocks, villages, and respondents. Using a pre-tested questionnaire, primary data and information were collected from 100 cucumber producing farmers, categorized in 66 marginal, 23 small and 11 medium farmers were chosen from the five villages in the Dubeypur block of the Sultanpur district. For functional analysis, Cobb - Douglas production function was employed for estimating resource use efficiency. The t-test for testing the significance of factor elasticities and the F-test for testing the significance of R^2 were used. The study revealed that return to scale was found to be increasing in cucumber production and Marginal Value Product was more than one in all the cases except few, which indicate the further chance of investment on variable inputs to get the optimum income. Through comprehensive analysis of financial efficiency measures, it has been revealed that marginal farms exhibit greater profitability in terms of farm business income compared to small and medium-sized farms.

Keywords Cobb-Douglas, Cucumber production, MVP, Resource use efficiency, Return to scale.

INTRODUCTION

Agriculture plays a significant role in the process of economic development of any country, particularly in countries where per capita real income is low. Agriculture and its allied sectors have been the backbone of the Indian economy. Its contribution to GDP has decreased from 54.19% in 1950-51 to 20.2% in 2020-21 (Mishra *et al.* 2023a and NSO 2021). This is due to globalization, natural resource depletion, climate change, rapid industrialization, population growth and changing consumer behaviors. Agriculture and allied sectors are experiencing a period of transition all around the world. Now, Indian agriculture must reorganize itself by extending its scope beyond just primary agriculture. As a result, there is a need to reform the farming sector, invest extensively in infrastructure development, enhance access to formal credit, and adopt agriculture policies that

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are in step with ground reality (Kumar *et al*. 2023).

The demand for vegetables in developing countries has been on the rise due to the simultaneous growth in population and income levels (Arsanti *et al.* 2007). India is the second largest producer of vegetables and fruits after China and is popularly known as Fruits and Vegetable Basket of the world (Nabi and Bagalkoti 2017). In the last few decades, this sector has gained prominence by contributing a growing share in Gross Value Addition of the Agriculture and allied sectors. Under the changing agriculture scenario, it has been realized that the horticulture sector is important to the Indian economy (contributes 30.4% to GDP and 33% to GVA of agriculture) (Schenau *et al.* 2022). Because it is more productive than agriculture, the horticulture sector has emerged as one of the primary drivers of growth (food grains mainly). Horticulture production in India has risen dramatically in recent years. In the past ten years, horticulture has experienced a steady growth rate of 2.6% per year in the cultivated area, and the annual production has seen a notable increase of 4.8% (Mishra *et al.* 2023b and Kumar and Singh 2020). Apart from ensuring the nation's nutritional security, it also creates new jobs, diversification of farm activities, provides raw materials to various food processing industries and increases farm profitability through increased productivity and foreign exchange earnings.

Vegetables contain water soluble vitamins like vitamin B and vitamin C, fat-soluble vitamins including vitamin A and vitamin D, and also contain carbohydrates and minerals and fiber (Settaluri *et al.* 2012). Though they contain less than 3% protein, these proteins are of high biological value. In addition, vegetables possess medicinal properties also. For example, juices of carrot, cucumber, bitter gourd, cabbage, lettuce, spinach (Wavdhane *et al.* 2016 and Singh *et al.* 2022). Fruit vegetables such as cucumbers (*Cucumis sativus* L.) are a valuable source of conventional antioxidant nutrients including vitamin C, beta-carotene, and manganese. They contain approximately 95% water, making them a highly recommended natural diuretic and beneficial for bodybuilding purposes (Elum *et al.* 2016, Maurya *et al.* 2019).

Cucumber (*Cucumis sativus* L.) (2n=14) belongs to the family of Cucurbitaceae, a member of the Cucumis genus. The cucumber is known to be originated from Southern Asia, but today grown in most countries (Grumet *et al.* 2021, Yang and Sagar 2022). Asia accounts for over 50% of the world's cucumber production, with Turkey, Iran, Uzbekistan, Japan and Iraq being recognized as the primary contributors to this significant output within the continent (Khan *et al.* 2015). Since its pivotal moment over 4000 years ago, Cucumber has transcended Indian borders, journeying through Ancient Greece, Rome, Europe, the New World, and China, to ultimately establish itself as the world's fourth most widely cultivated vegetable (Lutfa *et al.* 2019).

Cucumber goes by numerous names, such as pepino, cetriolo, gherkin, gurke, krastavac, concombre, hunggua, kiukaba, khira, kiukamupa and kukamba. It's a summer season (temperature between 18 and 24°C) short duration (90-100 days) crop that matures quickly. It is used as a cooling food in summer (Khan *et al.* 2015, Xanthopoulou *et al.* 2022). Cucumber grows best on light, heavy, well-drained soil with an abundance of organic matter. Cucumber plants are naturally monoecious, which means they have separate male and female flowers (Swamy 2017). The specific objectives of this research were assessing the profitability of cucumber. However, the specific objectives were spelled out to workout resource use efficiency of various resources used in production process of cucumber.

MATERIALS AND METHODS

Cucumber farmers' data for the agricultural year 2021-22 were gathered using a multistage purposive cum random sampling technique. The study was conducted at Sultanpur district based on intensity of cucumber cultivation. The Dubeypur block was purposefully chosen due to the popularity of cucumber cultivation in the region. A comprehensive list of all the villages in the block was created, along with the specific area dedicated to growing this selected crop. From this list, five villages were randomly selected for further analysis. Ultimately, 100 respondents (i.e., 66 marginal, 23 small and 11 medium) were selected randomly through proportionate allocation to the population. Necessary data were collected through survey method. Mostly descriptive statistics like average, percentage were used to achieve the objectives of the study.

Functional analysis

Cobb-Douglas production function

The Cobb-Douglas production model was useful for the estimation of resource use efficiency due to econometric and statistical advantages like sign and size of coefficients, t-test, f-test and R^2 (Ashfaq *et al.* 2012). The method found application in multiple research studies, including those conducted by Mishra *et al.* (2023b), Abid *et al.* (2011), Mohammed *et al.* (2014), and Ibitoye *et al.* (2015). Abid *et al*. (2011), Ashfaq *et al.* (2012), Dlamini and Kongolo (2014), and Ibitoye *et al.*(2015), also incorporated socio-economic variables into the Cobb-Douglas model.

The mathematical form of Cobb-Douglas production function is :

$$Y = a\, x_1^{b1} x_2^{b2} x_3^{b3} x_4^{b4} x_5^{b5} x_6^{b6} \ldots\ldots x_n^{bn} e^{\mu} \qquad \ldots\ldots\ldots\ldots\ldots (1)$$

Where,

Y = Per hectare output (Rs/ha)
xi = i^{th} independent variable (Rs/ha)
x_1 = Human labor (Rs/ha)
x_2 = Machinery charges (Rs/ha)
x_3 = Seed (Rs/ha)
x_4 = Manure and fertilizers (Rs/ha)
x_5 = Irrigation (Rs/ha)
x_6 = Plant protection
a = Constant
b_i (i = 1, 2, 3, 4, 5, 6) = Production elasticity with respect to X_i
e = Error term or disturbance term
μ = Random variables

The values of the constant (a) and coefficient (bi) in respect of independent variables in the function have been estimated by using the method of least squares (Bakhsh *et al.* 2007, Kshirsagar *et al.* 2016).

Log form of Cobb-Douglas production function is :

$$\log Y = \log a + b_1 \log x_1 + b_2 \log x_2 + b_3 \log x_3 + b_4 \log x_4 + b_5 \log x_5 + b_6 \log x_6 \ldots\ldots\ldots\ldots\ldots b_n \log x_n + \mu \log e. \ldots\ldots\ldots\ldots\ldots (2)$$

This form was used for estimating the parameters of the function based on sample data.

Marginal value productivity (MVP)

The marginal value product of input was estimated by taking partial derivatives of returns with respect to the input concerned, at the geometric mean level of inputs (Maurya *et al*. 2018, Maurya *et al*. 2021). The marginal value product of inputs was estimated by the following formula :

$$MVP\,(X_j) = \frac{bj\,\bar{Y}}{\bar{X}j} \qquad \ldots\ldots\ldots\ldots\ldots (3)$$

Where,

MVP = Marginal value product

b_j = Production elasticity with respect to X_j

$\bar{Y}$ = Geometric mean of the dependent variable (Y)

$\bar{X}_j$ = Geometric mean value of X_j independent variable

MVP_j = Marginal value production j^{th} input

j = 1, 2, 3, 4, 5 variables included in the study

Significance tests of the sample regression coefficients

After estimating the elasticity coefficient, reliability of these estimates was worked out. The widely employed "*t*" test was utilized to determine the statistical significance of the sample production elasticity coefficient, bj, at a specific probability level, indicating whether it differs significantly from zero or not.

$$\text{'}t\text{' calculated} = \frac{bj}{SE\ of\ bj} \qquad \ldots\ldots\ldots\ldots\ldots (4)$$

Where,

b_j = Production elasticity of Xj

SE = Standard error

If calculated 't' value is greater than the table value of 't' at specified probability level and 'n-k-1' degree of freedom, bj is said to be significantly different from zero 'K' is number of independent factors and 'n' is sampled size (Maurya *et al*. 2018, Choudhri and Singh 2019, Kant and Singh 2020).

$$F = \frac{\text{Regression mean square}}{\text{Error mean square}} = \frac{RSS/K}{\sum e^2 /\text{n-k-1}} \quad \text{...............} (5)$$

Where,
RSS = Regression sum of square

e^2 = Error sum of square

Return to scale

The returns to scale can be easily estimated from this type of production function.

Thus,

Returns to scale = $a_1 + a_2 + ... + a_n$ .... (6)

$= \sum_i a_i = 1, 2, ..., n$

Therefore, the summation of the powers of all the input variables provided us directly with a ready estimate of the returns to scale as also the degree of homogeneity of the production function. The returns to scale are decreasing, constant or increasing, depending on whether a, is less than, equal to or greater than one (Rede *et al.* 2013, Mishra 2022).

RESULTS AND DISCUSSION

The purpose of the production function analysis was to assess the effectiveness of key resources in cucumber production. These prime resources included human labor, machinery charge, seed, manure, fertilizer, irrigation, and plant protection. These variables were utilized to explain the efficiency and productivity of cucumber cultivation. The Cobb-Douglas production function as best fit was explored and respective results are summarized in this section.

Elasticity of production

The value of elasticity of production, standard error, coefficient of multiple determination (R^2) and returns to scale of cucumber production by different size group of farms have been worked out and presented in Table 1 and as well as Fig. 1.

Coefficient of multiple determinations

Table 1 reveals that the coefficient of multiple determinations (R^2) on marginal, small and medium size group of farms accounted for 0.8604, 0.8740 and 0.8946, respectively and indicating that all the explanatory variables viz., human labor, machinery charges, seed, manure and fertilizer, irrigation and plant protection together contributed 86.04, 87.40 and 89.46%, respectively.

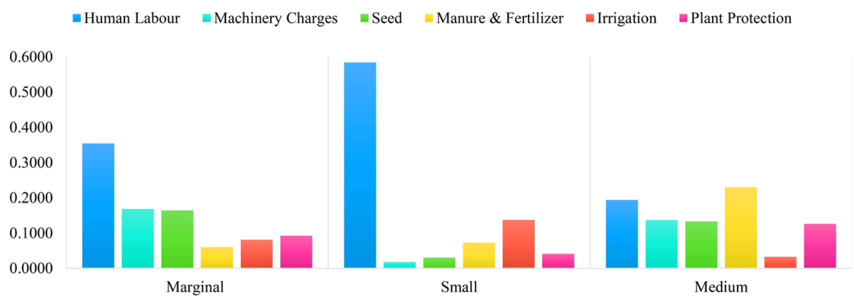

Fig. 1. Production elasticity of cucumber crop group on different size group of farms.

Table 1. Production elasticity of cucumber crop on different size group of farms. *Significant at 1% level of probability, **Significant at 5% level of probability.

Size group of farms	Production elasticity							
	Human labor (X_1)	Machinery charges (X_2)	Seed (X_3)	Manure and fertilizer (X_4)	Irrigation (X_5)	Plant protection (X_6)	Return to scale	R^2
Marginal	**0.35**** (0.14)	**0.16**** (0.12)	**0.16**** (0.10)	**0.06** (0.11)	**0.08** (0.11)	**0.09** (0.07)	**0.92**	**0.86**
Small	**0.58*** (0.15)	**0.01** (0.09)	**0.03** (0.14)	**0.07** (0.13)	**0.13**** (0.10)	**0.04** (0.07)	**0.88**	**0.87**
Medium	**0.19**** (0.67)	**0.13** (0.36)	**0.13** (0.39)	**0.22*** (0.37)	**0.03** (0.29)	**0.12** (0.30)	**0.85**	**0.89**

Significance of factor of production

It is observed from Table 1 that on marginal farms, the elasticity of production with respect to human labor and machinery charges was statistically significant at 5% level of significance that these input factors contributed to the output significantly. In the case of small farms, the elasticity of production with respect to human labor and irrigation was found significant at 5% and 1% level of significance, respectively. For medium farms, the study revealed a notable significance in the elasticity of production concerning human labor and seed, with a significance level of 5%. Similarly, manure and fertilizer exhibited a significant impact on production elasticity at a higher level of significance, specifically 1%. Rest factors of production included in the production process were found statistically non-significant. It can be inferred that there was no further scope for the application of these inputs in the production of cucumber.

Returns to scale

Returns to scale pertained to marginal, small and medium farms were analyzed and estimated 0.9225, 0.8848 and 0.8533, respectively, which was found to be less than unity. Less than unity value of returns to scale indicates that the nature of the functional analysis is of diminishing return to scale. Consequently, it can be deduced that a simultaneous one percent increase in all factors yields a return increase of less than one percent in each farm situation.

Where,
X_1, X_2, X_3, X_4, X_5 and X_6 stand for human labor, machinery charges, seed, manure and fertilizers, irrigation and plant protection (Rs.), respectively.

Marginal value productivity (MVP) of cucumber

It is evident from Fig. 2 that the variable showed in marginal, small and medium farms was greater than

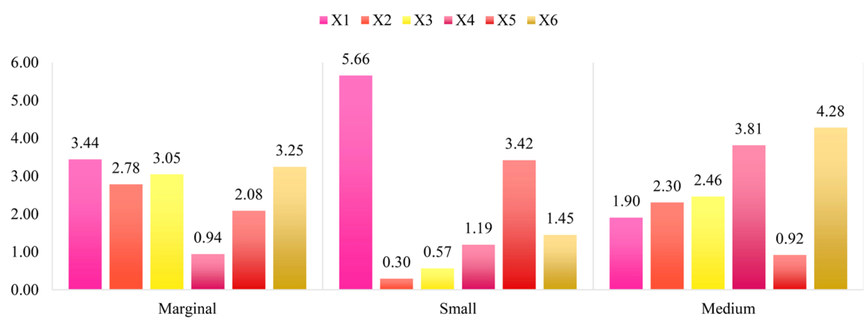

Fig. 2. MVP of included factors in the production process of cucumber cultivation.

unity revealed that these variables can be used in future for making more profit but except for the variable which was less than unity i.e., marginal and medium farms in manure and fertilizer, as well as small farms in machinery charges and seed, means the excess use of this variable hence, there needed to decrease it, for increasing profitability of farms.

In marginal farms, the MVP of human labor was 3.44, machinery charges were 2.78, seed was 3.05, manure and fertilizer were 0.94, irrigation was 2.08 and plant protection was 3.25 this shows that for the production of one additional quintal of cucumber the additional cost incurred for different is equal to the respected MVP. In small farms, the MVP of human labor was 5.66, machinery charges were 0.30, seed was 0.57, manure and fertilizer were 1.19, irrigation was 3.42 and plant protection was 1.45 this shows that for the production of one additional quintal of cucumber the additional cost incurred for different is equal to the respected MVP. In medium farms, the MVP of human labor was 1.90, machinery charges were 2.30, seed was 2.46, manure and fertilizer were 3.81, irrigation was 0.92 and plant protection was 4.28 this shows that for the production of one additional quintal of cucumber the additional cost incurred for different is equal to the respected MVP.

CONCLUSION

The primary objective of this research was to examine the profitability and resource use efficiency of cucumber production in Sultanpur district of Uttar Pradesh. The findings indicate that for marginal farms, there is a statistically significant correlation between the elasticity of production and factors such as human labor, machinery charges, and seed. Statistically significant findings emerged regarding the elasticity of production of human labor and irrigation under small farms, while under medium farms, the significance was observed in human labor, manure and fertilizer. Returns to scale on marginal, small and medium size of sample farms were characterized by decreasing returns to scale. Out of total variation in the dependent variable explained by independent variables i.e., human labor, machinery charges, seed, total, manure and fertilizers, irrigation and plant protection which were found significant at 5% level and 1% level of significance. R^2 was found to be 0.8604, 0.8740 and 0.8946 which means that 86.04%, 87.40% and 89.46% marginal, small and medium farms of the variation in yield were explained by independent variables which reflect a higher magnitude of resource use efficiency. The sum of elasticities indicates decreasing returns to scale. Marginal value productivity in marginal, small and medium farms was greater than unity revealed that these variables can be used in future for making more profit but except for the variable which was less than unity i.e., marginal and medium farms in manure and fertilizer, as well as small farms in machinery charges and seed, means the excess use of this variable hence, there was the need to decrease it, for increasing profitability of farms.

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