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Factors affecting the production of major pulse crops in Madhya Pradesh

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ABSTRACT

Pulses, commonly known as "poor man's meat" and "rich man's vegetable," are the primary source of protein. Pulses have historically been an important component of Indian dietary behaviours and farming systems. The goal of this study was to understand which factors influence pulse crop output in Madhya Pradesh. This study is based on secondary data collected from 2000-01 to 2018-19. Seed, fertiliser, manure, irrigation, bullock labour,human labour and plant protection measures were all evaluated using the Cobb-Douglas (CD) production function.The coefficient of multiple determinations (R^2) for chickpea, black gram, lentil, and pigeon pea was 0.68, 0.87, 0.46, and 0.48, respectively. In chickpea, the CD production function was significant; in black gram, fertiliser, human labour, animal labour and plant protection measures were significant; in lentil, human labour was significant; and in pigeon pea, plant protection and animal labour measures were significant.

***Keywords*:** factors, Madhya Pradesh, production function and pulses

Pulses are significant sources of protein, fatty and essential amino acids, minerals, fibres, high-quality carbohydrates, essential vitamins in the human diet for the impoverished, as well as a vegetarian way of life in the country (Bairwa *et al*., 2020, Verma *et al*., 2021a). Pulses are commonly referred to as "poor man's meat" and "rich man's vegetable" (Singh *et al*., 2015). As a result, the United Nations designated 2016 as the "International Year of Pulses" (IYP) to raise public awareness of pulses' nutritional benefits as part of a sustainable food production strategy targeted at food security and nutrition (Kumar *et al*., 2018). Pulses are a smart food because they are essential for food baskets, and they are a high-protein source (20-25%). Pulses are the principal source of protein in the diets of the great majority of Indians (Bairwa *et al*., 2020). Cereals provide a wonderful balance of vegetarian protein components with significant biological value when supplemented with them. Pulses are also a great cattle feed and fodder (Avinash and Patil, 2018). After cereals, pulses are the next essential agricultural group. During 2015-16, global pulses production amounted to 71 million tonnes from 79 million hectares, with an average yield of 910 kg ha^{-1}. India is the largest producer of pulses in the world, accounting for 25% of world production (Sengar *et al*., 2018), 27% in world consumption, and having 14% share as importer of pulses in the world (Singh *et al*., 2021). India account for 90% of red gram, 75% of Bengal gram, and 37% of lentil area globally. Under a variety of agro-climatic conditions, the country grows green gram, red gram, Bengal gram,dry peas, black gram, lentils, and other pulse crops.

Pulses have long been an important part of Indian farming systems and consumption habits (Mohanty and Satyasai, 2015). The area under pulses crops has been reduced in all the major states due to a reduced share of profit in the pulses compared to their competing crops (Singh *et al*., 2016). Whereas the minimum support price is ineffective for pulse crops, prevailing market prices should be considered while fixing the MSP to minimize the gap between production and consumption. The competing crops have a stable market price and have an assumed income from these crops. Over time, the cost of cultivation of various pulses has been increased many times. The primary challenge is to improve the output and minimizing the cost (Verma *et al*., 2021b). To boost production while lowering expenses, one must first analyse how well farmers are now using inputs,then detect inefficiently used inputs and make recommendations for how to make such inputs more efficient (Chand *et al*., 2007). Production function analysis is the best method for determining how efficiently inputs are used. The production function analysis shows how inputs are used and how outputs are affected. The production function analysis assesses the contribution of various inputs to the production margin by calculating their productivity levels. To figure out the input-output association among the farmers that were contacted for this study, Cobb-Douglas (CD) production function is used. Because of (1) its computational manageability in this linear equation and (2) the information regarding returns to scale that it gives, as well as its theoretical appropriateness to agriculture, the CD production function is employed in farm production economics (Tun and Kang, 2015). The

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CD production function was calculated using the least square regression approach (Douglas *et al*., 2002).

MATERIALS AND METHODS

The current study was based on the cost of cultivation of pulse crops in Madhya Pradesh. InMadhya Pradesh mainly four pulse crops were grown namely chickpea, black gram, lentil, and pigeon pea. The study has relied on secondary data. During the study, we explored the factors that caused production to fluctuate over time from 2000-01 to 2018-19. Seed (kg ha^{-1}), bullock labour (pair days ha^{-1}), human labour (man-days ha^{-1}), machine labour (man-days ha^{-1}), manure (t ha^{-1}), fertiliser (kg ha^{-1}), plant protection measures (Rs. ha^{-1}), and irrigation (Rs. ha^{-1}) were all included in the crop input data.

A CD production function represents the relationship between output and inputs (factors). It is used to determine input ratios for efficient production and to estimate technological change in production systems. The CD production function was used to estimate the temporal change in the production of pulse crops on various inputs such as seed,manure, fertiliser, human labour, bullock labour, plant protection and irrigation.In the study, the CD production function model shown below was used. (Chaudhary and Khan, 2009; Agarwal and Singh, 2015; Nazir *et al*., 2013; Verma *et al*., 2021a).

$$Y = \beta_0 X_1^{\beta_1} X_2^{\beta_2} X_3^{\beta_3} X_4^{\beta_4} X_5^{\beta_5} X_6^{\beta_6} X_7^{\beta_7} e^{u_i} \quad ....(1)$$

The CD function was estimated using the ordinary least square (OLS) approach after it was converted to log-linear form.

$$LnY = Ln\beta_0 + \beta_1 \ln x_1 + \beta_2 \ln x_2 + \beta_3 \ln x_3 + \beta_4 \ln x_4 + \beta_5 \ln x_5 + \beta_6 \ln x_6 + \beta_7 \ln x_7 + u_i \quad ...(2)$$

Where,

Y = Production (kg ha^{-1}),

β_0 = Scale parameter,

β_1-β_7 = Production elasticity,

X_1 = Seed (kg ha^{-1}),

X_2= Fertilizer (kg ha^{-1}),

X_3= Manure (kg ha^{-1}),

X_4= Human labour (man hours ha^{-1}),

X_5= Bullock labour (Pair hours ha^{-1}),

X_6= Irrigation (Rs.ha^{-1}),

X_7= Plant protection measures (Rs.ha^{-1}),

ui = error term.

The purpose of this research is to figure out what factors influence production and how important they are in increasing output. As a result, we should expect an increase in agricultural output and performance, based on scientific studies. The overall goal of the research is to quantify agricultural yield, determine production elasticity, and evaluate the impact of various production parameters (Sekhar *et al.,* 2016).

RESULTS AND DISCUSSION

Present status of major pulses in Madhya Pradesh

The present status of major pulses in Madhya Pradesh is given in Table 1. India is producing 297.50 million tonnes of pulses from 126.99 million hectares in 2019-20. India is the biggest producer of pulses. However, to meet domestic consumption needs, over 2-3 million tonnes of pulses are imported each year, accounting for 21.50 % of total food imports.

Madhya Pradesh contributes 11.3 % in total pulse production and 12 % in the total cultivated area under pulses in India. Production-wise contribution was highest by chickpea (2729 thousand hectares) followed by the black gram, lentil and pigeon pea, respectively. A similar pattern was followed in the area under pulses grown in Madhya Pradesh. Table 1 shows that Madhya Pradesh surpassed the national average in terms of yield in chickpea and pigeon pea. However, in the case of black gram and lentil, state performance fell short of the national average due to reduction in productivity. As a result, more interventions are needed to boost the productivity of pulses in the country, resulting in increased pulse production (Rai *et al.,* 2018; Srilatha and Srilatha, 2020).

Production function estimates for chickpea

Chickpea is consumed in the form of 'dal' and could be prepared in several ways, such as salad, snack, humus/paste, and baked products. It could combine with vegetables such as buridibud, soup (Belino *et al.,* 2015). Chickpea (grams) is India's most important pulse crop, accounting for over half of the country's total production. Madhya Pradesh is the highest producer of chickpea, contributing for roughly 25% of the national output, followed by Rajasthan and Maharashtra in 2019-20.

To determine the elasticities of major variables contributing to chickpea output in Madhya Pradesh, the CDproduction function was fitted to the observations (Table 2). The CD production function was used to evaluate the effects of different inputs like as seed, fertiliser, manure, plant protection measures, irrigation, bullock labour and human labour on the production of significant crops over time. The value of the chickpea crop's coefficient of multiple determination (R^2) was 0.68, suggesting that the seven resources included in the production function jointly explained as 68% of the total variation in chickpea production in Madhya Pradesh state. The study further revealed that manure was positively significant in the chickpea crop in Madhya Pradesh state. Chickpea production was reported to be influenced by manure in a positive and significant effect.The variable seed was negatively

Table 1: Present status of major pulses in Madhya Pradesh in 2019-20

Crops	Madhya Pradesh			India		
	Area (000 ha)	Production (000 Tonnes)	Productivity (kg ha^{-1})	Area (000 ha)	Production (000 Tonnes)	Productivity (kg ha^{-1})
Chickpea	1926 (19.9)	2729 (24.6)	1417	9699	11079	1142
Black gram	1794 (39.6)	503 (24.2)	280	4533	2081	459
Lentil	379 (29.1)	294 (26.7)	776	1303	1103	847
Pigeon pea	249 (5.5)	275 (7.1)	1104	4532	3892	859
Total Pulses	15246 (12.0)	33523 (11.3)	2199	126995	297504	2343

Notes: Figures in the parenthesis indicates % share of respective crop production from total production of India.

Table 2: Estimates of the CD production function for chickpea

Particular	Regression coefficient	Value of coefficient	Standard error
Intercept	b_0	-0.02	
Seed (X_1)	b_1	-0.36	0.55
Fertilizer (X_2)	b_2	0.69	0.68
Manure (X_3)	b_3	0.04*	0.01
Human labour (X_4)	b_4	0.03	0.29
Animal labour (X_5)	b_5	0.09	0.11
Plant protection measures (X_6)	b_6	0.05	0.07
Irrigation (X_7)	b_7	0.14**	0.10
R^2		0.68	

, at 5 and 10% level of significance, respectively.*

Table 3: Estimates of the CD production function for black gram

Particular	Regression coefficient	Value of coefficient	Standard error
Intercept	b_0	-8.82	
Seed (X_1)	b_1	0.08	0.41
Fertilizer (X_2)	b_2	0.06**	0.04
Manure (X_3)	b_3	-0.06	0.09
Human labour (X_4)	b_4	1.86**	1.05
Animal labour (X_5)	b_5	-0.27**	0.14
Plant protection measures (X_6)	b_6	0.05*	0.02
Irrigation (X_7)	b_7	0.01	0.01
R^2		0.87	

, at 5 and 10% level of significance, respectively.*

affected gram production. The negative sign of seed signals that this input has been overutilized in chickpea crop cultivation. The coefficients of fertilizer and irrigation charges were 0.69 and 0.14, respectively. According to these relationships, a 1% rise in fertiliser and irrigation costs would result in 0.69% and 0.14% increases in chickpea production, respectively. In contrast, 1% increase in plant protection measures was led to a 0.05% increase in chickpea production. Human and animal labour were shown to be both positive and non-significant contributors to chickpea crop production. Tithi and Barmon (2018) in Bangladesh, Vinayaka (2013) in India, and Sayili *et al.* (2008) in Turkey all confirmed similar results in chickpea.

Table 4: Estimates of the CD production function for lentil

Particular	Regression coefficient	Value of coefficient	Standard error
Intercept	b_0	-7.61	
Seed (X_1)	b_1	-0.41	0.88
Fertilizer (X_2)	b_2	0.17	0.32
Manure (X_3)	b_3	0.01	0.0
Human labour (X_4)	b_4	2.03**	1.47
Animal labour (X_5)	b_5	-0.10	0.12
Plant protection measures (X_6)	b_6	0.01	0.08
Irrigation (X_7)	b_7	-0.02	0.11
R^2		0.46	

**, ** at 5 and 10% level of significance, respectively.*

Table 5: Estimates of the CD production function for pigeon pea

Particular	Regression coefficient	Value of coefficient	Standard error
Intercept	b_0	0.89	
Seed (X_1)	b_1	-0.36	0.52
Fertilizer (X_2)	b_2	0.00	0.12
Manure (X_3)	b_3	0.07	0.09
Human labour (X_4)	b_4	0.02	0.07
Animal labour (X_5)	b_5	0.22**	0.13
Plant protection measures (X_6)	b_6	0.20*	0.10
Irrigation (X_7)	b_7	0.01	0.03
R^2		0.48	

**, ** at 5 and 10% level of significance, respectively.*

Production function estimates for black gram

One of the most important pulse crops farmed in India is black gram (urad). It's eaten as a split or whole pulse, and it's a great way to add variety to your cereal diet. It's eaten in the shape of 'dal.' The typical Indian diet includes a mix of dal-chawal or dal-roti (Prakash *et al.,* 2019). It is used in various way from north to south in the making of popular dishes such as dosa, idli, vada,umrati and, halwa as well as other food grains. It is primarily utilised as a green manuring crop and nutritional fodder for milch cattle (Kumar *et al.,* 2017a). The primary producers are Madhya Pradesh, TamilNadu and Maharashtra. During the rainy season, it is primarily grown in Rajasthan,Madhya Pradesh, Tamil Nadu, Maharashtra, Uttar Pradesh and Gujarat, whereas in the winter (*rabi*) season, it is primarily grown in West Bengal and Andhra Pradesh (Ram *et al.,* 2010). In 2019-20, Madhya Pradesh accounted for 24.2% of India's total black gram production.

The CD production function was used to evaluate the elasticity of major black gram production variables in Madhya Pradesh, (Table 3). The black gram crop's coefficient of multiple determinations (R^2) value was 0.87, suggesting that the seven resources included in the production function jointly explained as high as 87% of the total variation in black gram production in Madhya Pradesh state. The variables such as fertilizer, human labour, animal labour and plant protection measures were positive except for animal labour and significantly affected black gram production. This input indicates that the more use of fertilizer, human labour, animal labour and plant protection measures, the higher the black gram production. The negative sign of animal labour and manure signals that these inputs have been overutilized in black gram production. Seed and irrigation have coefficients of 0.08 and 0.01, respectively. According to the coefficients, a 1% increase in seed and 0.01% increase in irrigation water would result in 0.08% and 0.01% increases in black gram yield, respectively. Whereas1% increase in human labour would lead to a 1.86% increase in black gram production. Seed and irrigation costs were shown to be positive and non-significant influences in black gram production. Bullock labour was determined to be a detrimental but negligible contributing factor. It is in line with Shyamsundar *et al.*(2019), Amarnath (2018), Kumar *et al.*(2017b) and Subhashrao (2004).

Production function estimates for lentil

Lentils are consumed worldwide as whole grain or as decorticated and split kernels. Bread, cakes, noodles, and infant formula are all made with lentil flour mixture with cereal (Farooq and Boye, 2011; Rathod and Annapure, 2017; Turfani *et al.,* 2017). On the other hand, lentil vegetative parts can be used as green manure. In Madhya Pradesh, lentil was cultivated in 392 thousand hectares with 295 thousand tonnes production, which was 24.2% of the total lentil production of India in 2019-20.

To analyse the elasticity of important variables contributing to lentil production in Madhya Pradesh, the CD production function was fitted (Table 4).The coefficient of multiple determination (R^2) of the lentil crop in Madhya Pradesh was 0.46, suggesting that the independent variables in the equation explained 46% of the variation in the logarithmic value of output. At the same time, factors that had not been examined explained the remaining difference in productivity. Human labour, manure, fertilizer, and plant protection measures were shown to be favourable and might boost production by increasing the use of various inputs in the production of the lentil crop in Madhya Pradesh.The variables seed, animal labour and irrigation were negatively affecting lentil production. The negative sign of seed, animal labour and irrigation signals that these inputs have been overutilized in lentil crop cultivation. The coefficients of fertilizer, manure, human labour, and plant protection measures were 0.17, 0.01, 2.03 and 0.01, respectively. These coefficients can be interpreted that 1% increase in fertilizer, manure, human labour, and plant protection measures would lead to 0.17%, 0.01%, 2.03% and 0.01% increase in lentil production, respectively. All the variables that contributed to the lentil crop's output were non-significant (*i.e*., these variables or resources had no effect on a crop's yield level). So, more research and extension activities were required to make aware farmers to earn higher efficiency through the judicious use of scare resources. Miah *et al.*(2021) and Matin *et al.*(2018) also reported that human labour was significant in lentil production.

Production function estimates for pigeon pea

After chickpea, pigeon pea is the country's second most important pulse crop (Sekhon and Singh, 2019). The most important products come from seed, and dominant among these products is dal made by dehulling the dry seed and green seeds (Sarika *et al.,* 2011). Their seed husks and leaves are utilized to feed animals (Verma *et al.,* 2015). It is also utilized as green manure. Pigeon peas are produced in Thailand as a host for scale insects that manufacture lac, a key element in shellac. Pigeon peas are an important green manure crop in some locations, producing nitrogen up to 90 kg ha^{-1}. Pigeon peas' woody stems can also be used as firewood, fencing, and thatch (Emfiene *et al.,* 2014).

To determine the elasticities of major variables contributing to the production of pigeon pea in Madhya Pradesh, the CD production function was fitted to the observation (Table 5).The coefficient of multiple determination (R^2) indicates that 48% of the variation in yield could be explained by the variables for the pigeon pea crop. All the variables considered in the model have positive coefficients except for seed. The plant protection measures (0.2) turned out to be positively significant, indicating their importance in pigeon pea production in Madhya Pradesh. The negative sign of seed (-0.36) signal that this input has been overutilized in pigeon pea production. The variables such as fertilizer, manure, human labour, animal labour and irrigation were found to have positive and non-significant effects on pigeon pea production. Further results indicate that these inputs were productive and underutilised by the farmers. This crop's production and returns were too high and fruitful compared to other cereals and oilseed crops (Verma *et al.,* 2015).

To evaluate elasticities of major variables contributing to the production of chickpea, black gram, lentil, and pigeon pea in Madhya Pradesh, the CD production function was fitted.The coefficient of multiple determinations (R^2) for the chickpea crop, 0.87 for the black gram crop, 0.46 for the lentil crop, and 0.48 for the pigeon pea crop, respectively, was 0.68, 0.87, 0.46, and 0.48 for the pigeon pea crop.The CD production function was significant and positive for manure and irrigation in chickpea production. The variables such as fertilizer, human labour and plant protection measures were found positive and significant, while animal labour was negative and significant in black gram production. The production function resulted positive for human labour having significant affect in lentil production; while in case of pigeon pea, animal labour and plant protection measures were having positive affect on its production.It was suggested to strengthen the extension services to manage and proper use of expensive farm inputs. Fertilizers and pesticides used wisely not only assist in keeping production costs low but also help to safeguard soil health and productivity.

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