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Research Paper

Production Dynamics of Groundnut and Green gram in Odisha

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ABSTRACT

Increased production of non-paddy crops especially pulses and groundnut assume multidimensional significance in a state like Odisha, where the rice-based cropping system is increasingly proven non-sustainable; economically and environmentally. Increased production and productivity achieved through high resource use efficiency makes farming of these crops remunerative and enhances food and nutritional security. However, the growth pattern of area, yield and production of both the crops over the decades is highly inconsistent and unstable both for Odisha and India as measured through CAGR and Cuddy-Della Valle index. Cobb-Douglas production function reported allocative inefficiency of several key inputs for both groundnut and green gram. Technical efficiency as assessed through Frontier production function amply showed high production inefficiency prevalence. To revamp the production and productivity of these two major non-paddy crops, a systematic and well-coherent measure to be promoted targeting consistent and decent growth in area and productivity. Diffusion of technical know-how and targeted capacity development program can complement the efforts to make the production cost effective and profitable.

HIGHLIGHTS

- The growth rate of groundnut, green gram in area, yield, and production over the last six decades in Odisha and India has been inconsistent and registered high instability.
- The pattern and trend of growth of green gram in area, yield, and production of Odisha are dissimilar to those of India.
- Most farmers operate in a low to medium regime of technical efficiency of the inputs and fail to achieve the maximum possible output from a given resource base.
- The technologies involving high-yielding varieties, hybrids, crop diversification to groundnut, and efficient crop management must be adopted to increase the production of groundnut and green gram.

Keywords: non-paddy, CAGR, Cuddy-Della Valle index, Cobb-Douglas production function

The agrarian economy of Odisha has made several strides in the last five decades to improve its position in food and nutritional security (Pathal *et al.* 2018). Even though the productivity of significant crops today falls below the national average, per capita availability has significantly improved. Agriculture as a sector makes up 20.61% of the state's total Gross Value Added in 2021-22 (Economic survey, 2021-22 AE) besides employing 62% of the total 17 million workforce of the state (Samrudhi, 2020). Moreover, 83% population lives in rural areas (Census, 2011), and crop production constitutes a significant share of their household income (NSS 77th round); thus, the economic significance of agriculture in Odisha is enormous. Paddy is the major crop covering 3.9 million hectares every year. The annual value of

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agriculture and allied produce is INR 75800 crore, and more than half comes from four crops—paddy, milk, meat, and brinjal. Paddy alone contributes 24.4% of the total value of the agricultural output (Samrudhi, 2020). The average monthly income of a farm household in the state is INR 5117, which is merely 50% of the national average.

Agriculture in the state is primarily paddy-centric in terms of its volume, acreage, and contribution to agriculture GDP (Das, 2012). Despite lower productivity, Odisha has come a long way to be pretty a rice surplus state (Acharya *et al.* 2012). During 2020-21, Odisha produced 11 million tons of paddy with a national share of 8.5% (Economic survey, 2021-22 AE). In 2019-20, about 60% of the total 97.55 lakh tons Government procured at MSP for the central pool needed a colossal transaction. Today, Odisha contributes around 10% of total rice procurement in the country. Rice, by nature, is a water-guzzling crop and preferably grown in stagnant water, thus demands assured irrigation, especially in the dry season. Besides, water stagnant rice field is a significant source of greenhouse gas emissions that adds to the climate challenges. The imprudent fertilizer usage in rice is also a challenge in maintaining balanced soil health for subsequent crops. Such manifestation essentially gives a clarion call to rationalize rice production and diversify the cropping system, emphasizing that non-paddy agricultural commodities have substantial shortages in the state. There is greater scope for crop diversification with the increased production of oilseeds and pulses.

Odisha, especially the rural parts of the state, continues to bear malnutrition due to low energy intake, protein, and fat (Nutrition in Odisha, 2020). In rural Odisha, 41% of people consume less than the recommended daily protein intake. The daily energy requirement sourced from food crops has consistently improved in recent decades. However, in 15 districts, the percentage of people consuming less than recommended per capita per day protein compared to the state-level average. Besides, the percentage of the population consuming less than the recommended fat level is as high as 63%.

Interestingly, improved availability and access to pulses and oilseeds can address this problem of nutritional insecurity. The rice-based cropping system in the state has not been able to meet its domestic requirements of pulses and oilseeds (Amutha, 2014). Annually the state needs about 12 lakh tons. The pulse productivity in Odisha is also stagnating at 550-600 kgs/ha, significantly less than the national average of 806kg/ha. There are 2 million hectares of identified rice fallow areas in several districts, where a growing pulse can be a sustainable option.

The state grows oilseeds in 6.02 lakh hectares of land in winter. Groundnut, sesame, and mustards are the major oilseed crops in Odisha. The state has an annual requirement of 23.12 lakh tons but produces only 5.23 lakh tons creating a shortfall of 17.89 lakh tons (Economic survey, 2021). It is, therefore, a massive challenge for the state government to meet the daily prerequisite of oilseeds.

The state's self-sufficiency in rice production, environmental crisis due to unsustainable rice cultivation, and production inadequacy of non-paddy crops like pulses and oilseeds are the major drivers for crop diversification and intensification. The state has a well-articulated policy that accelerates crop diversification efforts to meet domestic demands for non-cereal crops such as pulses and oilseeds.

It is, therefore, imperative to understand the structural pattern and trend of non-paddy crops, especially pulse and oil seed crops, over the years in the state. An in-depth analysis and contextual correlation of this subject matter will help build perspectives and insights about the state's status and the possibility of crop diversification (Asmatoddin *et al.* 2009). Furthermore, the findings will contribute to shaping policy frameworks for actionable measures in the state's interest in agricultural development. Since the state government is acting on the production boost of pulses and oilseeds, it is equally important to understand the current level of resource use efficiency of these non-paddy crops. Good insights on this aspect will help optimize the yield and production given a rice-based cropping system in Odisha.

In Odisha, Groundnut and Green gram are the two most critical non-paddy crops that need strategic attention and supportive measures for crop diversification and cropping intensity enhancement. The present study investigated these two crops' structural patterns, growth trends, and resource use efficiency. Area-wise, groundnut covers 34% of total oilseed areas while it is 42% for green gram.

ANALYTICAL FRAMEWORK

(A) Compound Annual Growth Rate (CAGR)

The compound annual growth rate was used to know the per annum growth rate of cost of cultivation, cost of production, various input costs, prices, profitability and physical quantities of inputs and outputs. The analysis was done exponential form of growth equation. The exponential form of growth equation can be represented as,

$$y_t = ab^t U_t \qquad \ldots\text{(i)}$$

Where,

y_t = Variable under consideration at time period t

t = Time element which takes the value 1, 2, 3……n

a and b are parameters to be estimated where b = (1+g), where g is the rate at which y grows every year with respect to its value in the preceding year

U_t = Disturbance term

After logarithmic transformation of equation (i) we get,

$$Log\ y_t = log\ a + t\ log\ b + log\ U_t \qquad \ldots\text{(ii)}$$

This could be expressed as,

$$y_t^* = a^* + tb^* + U_t^* \qquad \ldots\text{(iii)}$$

Where,

$y_t = log\ y_t;\ a^* = log\ a;\ b^* = log\ b\ and\ U_t^* = log\ U_t$

The estimate of compound growth rate can be written as,

$$g = (antilog\ b^* - 1)*100 \qquad \ldots\text{(iv)}$$

Significance of coefficients were tested by t-statistic and significance of the model was tested in terms of R^2 value.

1. Cuddy-Della Valle Instability Index

It is an enhancement over coefficient of variation (Mean/standard Deviation), as CV over-estimates instability measure in time-series data. The Cuddy-Della Valle instability index (1978) de-trends and shows the exact direction of instability.

$$CDVI = CV*(1 - Adjusted\ R2)0.5 \qquad \ldots\text{(v)}$$

Adjusted $R2$ is determined from the time series regression. It is the coefficient of multiple determinations adjusted for degrees of freedom.

The ranges for interpretation of CDVI are:

0-15 = Low Instability

>15-30 = Medium Instability

>30 = High Instability

(A) Resource use efficiency

Efficiency can be defined in terms of producing a maximum amount of output, given a set of inputs; or producing a given level of output using a minimum level of inputs; or a mixture of both. Efficient farms either use less input than others to produce a given quantity of output or for a given set of inputs they generate a greater output. For obtaining resource use efficiency at the farm level different production function forms were tried.

Finally, Cobb-Douglas production functions were selected on the basis of number of theoretically significant variables it is circumscribing, the coefficient of multiple determination R^2 and Mallow's Cp criteria. The models with maximum theoretically relevant variable, high R^2 and low Cp were selected for each crop. These procedures were done using SAS 9.3.

The general form of Cobb-Douglas equation used was,

$$Y = \beta_0 \times \prod_{i=1}^{n} X_i^{\beta_i} \times e^u \qquad \ldots\text{(i)}$$

Where,

Y = Output in q ha^{-1} or `ha^{-1}

X_i = vector of input

β_i = Estimated coefficient of i^{th} input

u = Error term

The variables defined in the model are as follows:

Y = Output in q ha^{-1} or ` ha^{-1}

$X1$ = Area under study crop in hectare

$X2$ = Total human labour in hours ha^{-1}

$X3$ = Casual labour in hours ha^{-1}

$X4$ = Family labour in hours ha^{-1}

$X5$ = Tractor use in hours ha^{-1}

$X6$ = Machine labour use in Hrs ha^{-1}

$X7$ = Seed in kg ha^{-1} (Cost of seedling in ` ha^{-1} in case of paddy)

$X8$ = NPK applied in kg-nutrients ha^{-1}

$X9$ = Nitrogen applied in kg-nutrients ha^{-1}

$X10$ = Phosphorus applied in kg-nutrients ha^{-1}

$X11$ = Potassium applied in kg-nutrients ha^{-1}

$D1$ = Regional dummy for zone 1

$D2$ = Regional dummy for zone 2

(B) Allocative efficiency

The allocative efficiency (AE) of each input was calculated from the β s obtained from multiple regression as following,

$$AE = MVP_{Xi} / MFC_{Xi}$$

$$MVP_{Xi} = \beta_i\left(\frac{\overline{Y}}{\overline{X}_i}\right)$$

Where,

$\overline{X}_i$(GM) = Geometric mean of i^{th} input

$\overline{Y}$(GM)= Geometric mean of output

β_i = Estimated coefficient or elasticity of i^{th} input

P_Y = Price of output

MVP_i = Marginal value productivity of i^{th} input

MFC_{Xi} = Marginal factor cost of the i^{th} input

(C) Technical Efficiency

The R Frontier package 1.0 by Tim Coelli and Arne Henningsen (2013) was used to estimate the maximum likelihood estimates as well as the technical efficiencies of individual farms.

The stochastic frontier production function of Cobb-Douglas form is given by,

$$Y = \beta_0 \times \prod_{i=1}^{n} X_i^{\beta_i} \times e^{(v-u)}$$

Where,

Y = Output in q ha^{-1} or ` ha^{-1}

X_i = Vector of inputs (same as equation (i)).

β_i = Estimated coefficient of i^{th} input

$v_i = v_i$ is a symmetrical random term and assumed to be normally distributed $\left[N\left(0,\sigma_v^2\right)\right]$

u_i = Farm-specific technical inefficiency assumed to follow a half normal distribution

A producer faces own stochastic production frontier $f(X_i, \beta)$ exp (v_i); a deterministic part $f(X_i, \beta)$ common to all producers and producer specific part exp (v_i). The farm specific technical efficiency can be given as,

$$TE_i = \frac{f\left(X_i,\beta\right)\exp\left(v_i - u_i\right)}{f\left(X_i,\beta\right)\exp\left(v_i\right)} = \exp\left(-u_i\right)$$

Where,

f = Cobb-Douglas form of the production function

TE = Technical efficiency of individual farm ($0 < TE_i \leq 1$)

The score of technical efficiency thus obtained was then converted into certain class intervals and distribution of farmers under each interval was studied along with their descriptive statistics.

(D) Likelihood ratio test

For establishing that maximum likelihood method is suitable a Likelihood Ratio test was conducted which shows the adequacy of maximum likelihood estimates over OLS estimates. The likelihood function for stochastic frontier production function with half normal distribution of farm specific inefficiency term is given by,

$$1n\ L = \sum_{i=1}^{n}\left\{\frac{1}{2}1n\left(\frac{2}{\pi}\right) - 1n\ \sigma S + 1n\ \Phi\left(-\frac{s\varepsilon_i\lambda}{\sigma S}\right) - \frac{\varepsilon_i^2}{2\sigma^2 S}\right. \ldots\text{(i)}$$

Where,

L is normal and standard density function in equation (i) ; L_{1j}= 0 (lower limit) and L_{2j} = 1 (upper limit) are normal and standard density functions

$$\sigma S = \left(\sigma_u^2 + \sigma_v^2\right)^{\frac{1}{2}}$$
$$\lambda = \sigma_u + \sigma_v$$
$$\gamma = \sigma_u^2 + \sigma_v^2$$
$$\varepsilon_i = y_i - X_i\beta$$

$\Phi =$ Cumulative distribution function of the standard normal distribution

s = 1 for production function and -1 for cost functions

To determine whether Cobb-Douglas or the OLS model provided the best fit for the data, the Likelihood Ratio test was used (Ahemed *et al.* 2002):

$$LR = n\ln\left[\frac{RRSS}{URSS}\right] \quad \ldots(ii)$$

Where,

RRSS = Residual sum of squares of *OLS*

URSS = Residual sum of square of Cobb-Douglas specification

Wald chi-square test is conducted upon this Likelihood Ratio for its significance.

The likelihood function for two-limit Tobit model can as specified by Maddala (1999) is given by,

$$L\left(\beta,\delta \mid y_i, X_j L_{1j}, L_{2j}\right) = \prod_{y_j - L_{1j}} \phi\left(\frac{L_{1j} - \beta X_j}{\delta}\right)$$
$$\prod_{y_j = y_j^*} \phi\left(\frac{y_{1j} - \beta X_j}{\delta}\right) \prod_{y_j - L_{2j}} \phi\left(\frac{L_{2j} - \beta X_j}{\delta}\right) \quad \ldots(iii)$$

(E) Data and its sources

For the analysis of compound growth rates of area, yield, and productivity, decadal data as available with Directorate of Agriculture and Food Production, Government of Odisha was used for temporal analysis and interpretation. To assess the resource use efficiency in the selected crops, primary data were collected from farmers in a multistage sampling framework.

The whole study can be divided into three major section:

(i) Compound growth rate in area, yield and production of groundnut and green gram crop in India and Odisha.
(ii) Production function analysis of groundnut crop in Odisha
(iii) Allocative efficiency in production of groundnut in Odisha
(iv) Technical efficiency in production of groundnut in Odisha

RESULTS AND DISCUSSION

1. Compound growth rate in Area, yield, and production and their instability in groundnut and Green gram

1.1 Groundnut

Growth rate in area, yield and production over the decades for Odisha and India was analysed both for Odisha and India. The results indicate the inconsistent growth rate in the area, yield, production and instability of groundnut in India and state of Odisha in the last six decades. In the country groundnut registered a negative growth rate of - 0.6 % for the whole period from 1960-2019 and it was significant at 1 % level of significance. In the corresponding period, India registered 1.3 % and 0.7 % positive and significant growth rates in yield and production, respectively. The decadal growth rate was very unstable for the crop. The area growth was positive but not significant from 1960-70, from 1980-90, it became negative but non-significant from 2090-2000. It again became negative and significant at a 1 percent level of significance. In the next two decades, there was negative, non-significant growth in the area of the crop. The growth rate in production and yield rate registered non- significant rate in different decades. However, the overall growth rate from 1960 -2019 for yield 1.3 percent and it is significant at 1 % level of significance. There was also positive growth of 0.7 % for production and significant at 1 % level of significance.

In Odisha groundnut registered 9.15 % and 8.51 % growth in area from 1960-70, 1970-80 respectively. During 1980-90 and 2000-2010, the area registered negative growth rate. There was no consistency in increase in productivity, and production of the crop in the state of Odisha. Given the increasing prices in recent times, state needs to maintain a consistency in yield as well as production. Since groundnut is the major oilseed crop in Odisha, suitable policy interventions need in this direction to ameliorate the situation. Notably, the decadal growth rates at national and state level in area, production, yield exhibited large variance and they did not always change in the same direction. On production front, Odisha has recorded higher and significant growth rate than the country as a whole, resulting a positive and significant growth rate in area in the state between 1960-80 and 1990-00. The yield at national level showed a positive but insignificant growth rate during all the decades, however, Odisha could register a positive yield growth rate only after 1990. At national level, growth rates in area, yield and production were found to be statically insignificant indicating a possibility stagnancy and status quo in the parameters. Such differences between state and country explains the differentiable status of the groundnut improvement in Odisha and India. The details are tabulated below (table 1).

The Cuddy Della-Valle index indicates the variability in growth rate, ranged from 2.34 to 7.25 % for area, 1.91 to 20.17 % for yield and 3.83 to 23.07% for production. This indicates very high level of instability in the growth rate of the crop in the country. Similarly, in the state of Odisha the Cuddy Della-Valle index ranged from 2.50 to 8.39 % for area, 1.51 to 12.95 % for yield rate and 2.05 to 23.03 % for production (Table 2). The index further strengthens the finding that there was very high level of instability in area, yield and production growth rate of groundnut in the country as well as in the state of Odisha and needs appropriate actionable measures at the state and central government levels to address the problem and to make the country self-sufficient in production of groundnut crop. The learnings from ambitious Technology Mission on Oilseeds should be used contextually to boost oilseeds production both in the state and country. This is more significant in view of country's high dependence on foreign countries to meet domestic edible oil requirement.

Table 1: Compound annual growth rate (%) of Groundnut area, yield and production: India and Odisha

	India			Odisha		
Decade	**Area**	**Yield**	**Production**	**Area**	**Yield**	**Production**
1960-70	0.34 NS	0.34 NS	0.69 NS	9.15 ***	-4.2 *	4.56 **
1970-80	-0.32 NS	0.93 NS	0.61 NS	8.51 ***	-0.58 NS	7.87 ***
1980-90	1.7 *	1.2 NS	2.92 NS	-5.07 ***	-1.93 NS	-6.89 ***
1990-00	-2.75 ***	0.56 NS	-2.21 NS	2.06 **	4.72 ***	6.88 ***
2000-10	-0.8 NS	2.76 NS	1.94 NS	-3.96 ***	0.74 **	-3.24 **
2010-19	-0.54 NS	2.96 NS	2.41 NS	1.4***	0.8***	2.2***
1960-2019	-0.6***	1.3***	0.7***			

Note:, ** and *** are significant at 10 percent, 5 percent and 1 percent level of significance respectively.*

Table 2: Cuddy-Della Valle Instability Index for Area, Yield and Production of Groundnut: Odisha in Comparison to India

Decade	India			Odisha		
	Area	**Yield**	**Production**	**Area**	**Yield**	**Production**
1960-70	3.47	12.45	12.15	NA	NA	NA
1970-80	2.81	12.09	13.6	NA	NA	NA
1980-90	7.25	12.84	18.47	8.39	7.63	9.6
1990-00	2.34	13.3	13.34	3.34	12.95	13.46
2000-10	6.19	20.17	23.03	7.02	7.6	12.72
2010-19	6.87	15.76	18.3	6.64	1.51	8.05
1960-2019	4.87	1.91	3.83	2.5	4.48	2.05

Table 3: Trend in Area, Yield and Production of Green Gram in India and Odisha

Decade	India			Odisha		
	Area	Yield	Production	Area	Yield	Production
1970 - 80	NA	NA	NA	7.83***	-2.61NS	5.02*
1980 - 90	1.71***	0.94NS	2.67**	0.41NS	1.89**	1.49NS
1990 - 00	-1.28NS	-1.76NS	-3.01**	-3.54**	-3.45**	-6.86**
2000 - 10	0.17NS	-1.72NS	-1.55NS	5.48***	3.56***	9.23***
2010 - 20	4.79***	0.88NS	5.71**	0.22NS	1.4**	1.61*
1980-2020	0.74***	0.44*	1.19***	1.39***	-0.41**	0.97***

Note:*, ** and *** are significant at 10 %, 5 % and 1 % level of significance respectively.*

Table 4: Instability in growth rate in area, yield and production of Green gram in India and Odisha

Decade	India			Odisha		
	Area	Yield	Production	Area	Yield	Production
1970 -80	NA	NA	NA	11.12	12.68	20.74
1980 -90	3.64	8.07	9.45	11.04	6.2	11.19
1990 -00	6.25	9.52	10.26	11.07	10.23	20
2000- 10	8.42	19.41	26.42	9.41	6.36	13.14
2010- 20	11.46	7.55	16.25	4.11	3.9	6.62

2. Green gram

Green gram is the largest produced pulse crop in Odisha followed by black gram and horsegram. At national level, the decadal compound growth rate in area, yield, production and instability of green gram are tabulated below (table 3) for Odisha and India. In the decade of 1980-90, the area registered a growth rate of only1.71% and it was significant at 1% level of significance. However, in the following next two decades there was no significant growth in area of the crop. In fact, during 1990-00, area growth for greengram was negative. However, there was 4.79 % growth rate from 2010 -2020 and significant at 10 % level of significance. Overall the growth rate in area during last four decades (1980-2020) at national was only 0.74 % at 1% level of significance. The growth rate in production recorded an increase of 2.67 % increase from 1980-1990 and -3.01, -1.55 and 5.71 for the period 1990-00, 2000-2010, and 2010-2020, respectively. The overall growth rate from 1980 -2020 was 1.19 % and found to be significant at 1% level of significance. There was no significant growth rate in the yield of the crop in different time periods. But during last forty years i.e. 1980-2020 there was only 0.44 % increase in yield rate with 10 % level of significance. Such statistics reveal to boost production, the area and yield under greengram have to be increased through feasible cropping system measures and best-bet agronomy.

The pattern and trend of growth in area, yield and production of Odisha is quite dissimilar to those of India. In Odisha green gram registered 7.83 and 5.48 % growth rate (significant at 1% level of significance) during 1970-1980, and 2000-2010. During the decades of 1980-90, 1990-00, 2010-2020 the growth rate was either negative or there was no significant growth in area of the crop. The overall growth rate was 1.39 and it was significant at 1% level. The growth rate in production of green gram indicates positive and significant increase in 1970-80 (5.02%), 2000-2010 (9.23%), 2010-2020 (1.61%), but in the time period 1980-90, 1990-2000 the growth rate was negative. The overall growth rate in production was 0.97%, less than the growth rate at national level. The growth in the yield was estimated to be negative in first three decades. The study found out the positive and significant growth rate (at different levels of significance) during 2000-20. However, the overall growth rate (between 1970-2020) in yield was -0.41 and significant at 5% level of significance. During the same period the yield growth rate in the country was positive (44%). Even if there has been increase in area and production of green gram in the state the yield rate has remain stagnant or decline in the last five decades. This needs to be addressed by the policy makers and Department of Agriculture.

Similar to groundnut, a higher degree of instability of area, yield and production in green gram was also observed suggesting suitable measures for a consistent positive growth. In the country, the index for area was in the range of 3.64 to 11.87 and it was 7.55 to 19.55 for yield and 9.45 to 26.42 for production (table 4). Such high index values again revealed an instability in the growth rate of the crop in the country as well as in the state. In the state, area instability is comparatively more than that at country level. However, towards the last two decades (2000-20), such instability in yield and production has shown a declining trend for both state and country.

The last decade (2010-20) has seen highest instability in area, yield and production at country level, whereas, instability during same period at state level was the least. At aggregate level for all decades, the high value of instability index both at state and country level, suggest to minimize the variability and enhance the production and yield through well planned and inclusive policy measures.

Mostly the green gram and black gram in India are grown in low fertility, problematic soils and unpredictable environmental conditions. More than 87% of the area under pulses is rainfed. Drought and heat stress may reduce seed yields by 50%, especially in arid and semi-arid regions. Another major problem is salinity and alkalinity of soils which is high both in semi-arid tropics and in the Indo-Gangetic plains. With recent changes in the global temperatures the grain yield is likely to be drastically affected by temperature extremities. Poor drainage/water logging during the rainy season causes heavy losses to green gram on account of low plant stand. Until recently the government also gave less importance to pulses compared to the staple cereals. In general farmers' access to inputs is limited, both because of low purchasing power and accessibility to markets to sell the excess produce of pulses. Because of this situation, the farmers give first priority to staple cereals. Enhancing the productivity and production of pulses in India as cash crops, better management and allocation of critical input is required but second priority given to pulses. As a result, pulses continue to be grown on poor soils with low inputs. In addition, there is lack of policy support and post-harvest innovations related to pulse crops. Availability of quality seed of improved varieties and other inputs is one of the major constraints in increasing the production. The potential strategies to improve pulse productivity and production in state can be cultivation of high yield and common disease resistant varieties and adoption of improved agronomic practices.

2. Production function analysis of Groundnut and Green gram in Odisha

2.1 Groundnut

The results of estimated Cobb-Douglas production function on data for groundnut are presented in table 5. The high value (0.6529) the coefficient of multiple determinations (R^2) of estimated production functions is indicative of model fitness with high explanatory power. The estimated results highlighted that the included explanatory variables in the production functions collectively explained about 65 % variation in the groundnut productivity.

Table 5: Cobb-Douglas production function for Groundnut and Green gram in Odisha

Parameters	Groundnut	Green gram
Intercept	-18.387*	0.909*
Area under Groundnut (ha.)	-0.110	0.051*
Casual labour (Man-hours/ha)	-0.003	-0.048*
Hired Animal labour (Pair-hours/ha)	0.001	0.022***
Owned Animal labour (Pair-hours/ha)	-0.008	0.001
Seed (kg. /ha.)	3.841*	0.026
Nitrogen Fertilizer (kg-nutrients/ha)	-0.094**	—
Phosphatic Fertilizer (kg-nutrients/ha)	0.063	—
Potassic Fertilizer (kg-nutrients/ha)	0.062	—
Total fertilizers/ha	—	0.026***
Irrigation	—	0.018**
Owned Machine labour (hours/ha)	0.013	—
Hired Machine labour (hours/ha)	0.054*	0.00
Dummy for Small farmers	0.280	-0.038
Dummy for Semi-medium Farmers	0.159	0.004
Dummy for Medium Farmers	0.105	0.032
Dummy for Large farmers	-0.147	0.042
Multiple R^2	0.6529	0.59
Adjusted R^2	0.4997***	0.14***
F- Statistic	4.263***	4.241***
Residual Standard Error	0.4034	0.52
Number of Observation	100	100

Note:**, ** and *** are significant at 10 %, 5 % and 1 % level of significance respectively.*

The estimated coefficients (elasticities in this case as the selected functions are Cobb-Douglas) of per hectare groundnut productivity with respect to and phosphatic fertilizer use , owned machine labour and hired machine labour were positive and significant at 10 % level for the year 2008-09. The negative values of the coefficients for seed, casual labour and, owned animal labour indicated that if these variables were increased by 1 %, the productivity of groundnut would decrease by 0.358, 0.012 and 0.048% respectively. The magnitude of coefficient of land area indicated that with one % increase in area, the proportionate increase in groundnut productivity would have been 0.095 %.

The estimated coefficients of per hectare groundnut productivity with respect to nitrogenous fertilizer use and hired machine labour were positive and significant at five % level for the year 2012-13. The negative values of the coefficients for casual labour, hired animal labour and owned animal labour and phosphatic fertilizer indicated that if these variables were increased by 1 %, the productivity of groundnut would decrease by 0.009, 0.006, 0.017 and 0.013 % respectively. The magnitude of coefficient of land area indicated that with one % increase in area, the proportionate increase in groundnut productivity would be 0.01 %.

The estimated coefficients of per hectare groundnut productivity with respect to seed and hired machine labour use were positive and significant at five % level for the year 2016-17. The negative values of the coefficients for casual labour, owned animal labour and nitrogenous fertilizer indicated that if these variables were increased by one %, the productivity of groundnut would decrease by 0.003, 0 008, and 0.094 % respectively. The magnitude of coefficient of land area indicated that with one % increase in area, the proportionate increase in groundnut productivity would be 0.011 %.

2.2 Green gram

For groundnut, the calculated value of coefficient of multiple determination (R^2) of the production functions is 59% and it is significant at 1% level of significance. The results revealed that the included explanatory variables in the production functions collectively explained about 59 % variation in the green gram productivity.

The estimated coefficients of per hectare green gram productivity in respect of hired labour and total fertilizer use and irrigation were positive and significant at one and five % level respectively. The negative value of the coefficient for family labour-0.048 indicated that if the use of family labour was increased by one %, the productivity of green gram would have been decreased by 0.048 %. The magnitude coefficient of land indicated that with one % increase land area, the proportionate increase in green gram productivity would have been 0.051 % and significant at 10 % level of significance.

3. Resource Use Efficiency and Technical Efficiency

1. Groundnut

Production function analysis was carried out to ascertain the functional relationship of various inputs used in production with the output. The basic functional relationship recognised by functional analysis relates to decision making. The marginal productivities or the elasticities obtained from the functional analyses can further be used to obtain the marginal rate of return, otherwise called as allocative efficiency. This allocative efficiency can be applicable to optimize the allocation of resources for profit maximisation. The elasticity of crop productivity with respect to different inputs was examined by fitting Cobb-Douglas type production function for each reference year of the study.

1.1 Allocative efficiency of major inputs used in production of Groundnut and Green gram in Odisha

Profit maximisation is the sole goal of a rational farmer for which it is necessary to allocate resources consistent with their marginal rate of return in monetary terms. The magnitude of this accomplishment is measured by allocative efficiency. The allocative efficiency of the resources was analyzed using the ratio of marginal value productivity (MVP) and marginal factor cost (MFC). The optimal resource use conditions for each input can be analyzed from it. If the marginal contribution of one unit of input is not significantly different from the price of the input or in other words the ratio of MVP to MFC is one then input is said to be being used optimally. However, MVP to MFC ratio with respect to specific input different from one (below or above one) indicates the inefficient use of the respective input, resulting in allocative inefficiency. A ratio greater than unity indicates that returns could be increased by using more of that resource and the ratio less than unity indicates the unprofitable use of that resource which should be reduced to increase the profits. A negative marginal rate of return would suggest excessive use of inputs and fixed resources are no longer responsive to variable-input applied. The allocative efficiency for various size-groups and the pooled sample has been discussed crop wise in this section.

Table 6: Resource use efficiency in Groundnut and Green gram in Odisha

Resources	Groundnut	Green gram
Seed	-0.048	0.2999
Nitrogenous Fertilizer	-0.005	
Phosphatic Fertilizer	0.025	
Owned Machine hours	0.254	
Hired Machine Hours	0.179	0.048
Family Labour Hours/Ha		-1.18
Hired Labour Hours/Ha		0.58
Hired Animal Labour Hours/Ha		1.25
Owned Animal Labour Hours/Ha		
Irrigation		2.48
Fertilizers use/Ha		0.04798

Note: *Only significant inputs have been included.*

The allocative efficiency for the groundnut and green gram for significant inputs is presented in Table 6. The tabulated data shows that the MVP to MFC ratios of resources in the pooled sample sub-optimal use of the inputs for both the crops. In case of groundnut, the ratio of MVP to MFC of phosphatic fertiliser and owned and hired machine labour were less than unity for the year 2008-09, thus confirming the overuse of these inputs in groundnut production. It is also suggestive of lower utilization of phosphatic fertilizer would result in realizing higher profit. Similar suggestions are also made for owned machine labour and hired machine labour whose magnitudes are less than one. The ratio of MVP to MFC for seed was -0.048 indicating that decreased utilization of seeds would result in gaining more profits.

The MVP to MFC ratio in case of nitrogenous fertilizer was -0.005 indicating that decreased utilization of the said input would result in realizing higher profits in groundnut farming.

In case of Green gram, only irrigation and Hired animal labour as inputs have the more than one MVP to MFC ratio, pointing out their underutilization, more return can be achieved with increased application of these inputs. The other inputs such as seed, hired machine labour, hired physical labour are excessively used, thus return can be enhanced through cutting down these resources.

1.2 Technical efficiency in production of Groundnut and Green gram in Odisha

Technical efficiency analyses the farm's ability to attain maximum possible output from a given resource base. This maximum attainable output is called the potential output. As Cobb-Douglas production function did not distinguish between technical and allocative efficiency and assumed that all techniques of production are same across farms, which is not always true, technical efficiency is analyzed by stochastic frontier production function which gives maximum likelihood estimates (Sampath, 1979). A technically efficient farm operates on production frontier and one that operates below frontier could operate on frontier either by increasing output with same input bundle or using less input to produce the same output. The closer a farm gets to the frontier, the more technically efficient it becomes. The technical efficiency scores predicted from the stochastic frontier production function are relative as each farmer is studied in relation to the best farmer in the sample. This section explains the estimates of stochastic production function and distribution of technical efficiency score for green gram and black gram.

As far as technical efficiency measurement goes, both groundnut and green gram exhibit similar findings. Since the technical efficiency scores in groundnut production was based on the stochastic production function, it is necessary to discuss the estimated parameters and their statistical properties in brief. The estimated value of variance parameters viz. σ_u^2 and σ_v^2 were found to be significantly different from zero which indicated that the inefficiency in both the crops. It was not due to chance alone but owing to individual inefficiency. Further, l(lambda)

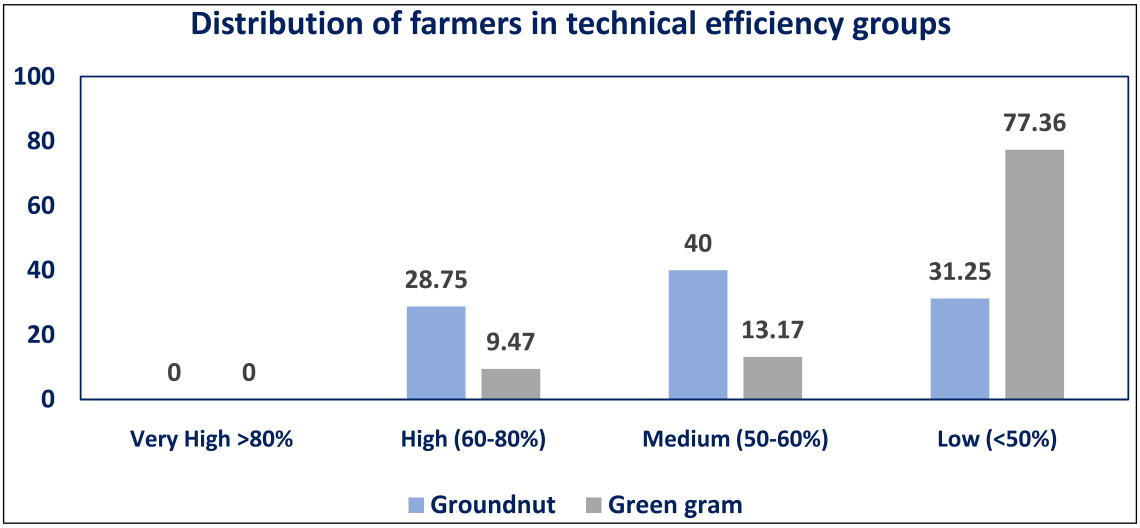

Fig. 1: Distribution of groundnut and green gram farmers in technical efficiency groups

which measures the degree of asymmetry in the distribution of the composite error term ($E_i = v_i - u_i$) was found to be more than one and significant at one % level of significance.

Thus, value of l points towards the presence of high degree of technical inefficiency and dominance of one-sided error component u_i in E_i along with the fact that inefficiency was not dominated by random factors or the statistical noise. For further confirmation of inefficiency, the parameter var(u) σ_v^2 was estimated and found to be greater than one. This parameter var(u) σ_v^2 suggested that variance of the observed output below the stochastic frontier. The relatively higher value of g(gamma), very close to one indicated the dominance of efficiency effect over random error. It was observed that most of the maximum likelihood estimates (MLE) with respect to various independent variables considered was having a similar sign as that of OLS estimates discussed. These significantly positive values indicated that there was scope for increasing the production of groundnut and green gram through increasing the level of all the inputs. The coefficient of the area under green gram and family labour use were significantly negative pointing towards over-use which needed to be reduced in order to optimise the use of these inputs.

The gamma(y) value was estimated to be 0.66 signifying high technical in-efficiencies of the farmers in the study year. It can be implied that 66% differences between observed yield and potential yield of the groundnut growers in the reference year is due to in-efficient use of resources, which is under the control of the farmers. The Log likelihood function of the corresponding year was 89.23 indicating that likelihood functions of the farmers in the year 2016-17 was large and conspicuously different from zero indicating a good fit and correctness of specific distribution assumption. The mean technical efficiency was found to be 0.722 in the year 2016-17. It reveals that 28 % increase in yield of the farmers in the study year can be obtained by increasing the technical efficiency, which can be achieved by adopting the technology used by the best performers.

The frequency distribution of technical efficiency of overall farmers in groundnut and green gram production along with mean level technical efficiency and variation has been presented in Fig. 1. For groundnut, the frequency distribution of groundnut farmers, based on technical efficiency revealed that only 28.75 % farmers operate in high (60-80 %) technical efficiency as compared to 40 % in medium (50 - 60 %) technical efficiency) and 31.25 % farmers operate in low(<50 %) technical efficiency.

With regard to green gram, the study has found that 36 % farmers were operating in technical efficiency below 50 level of technical efficiency in the state. Only 13.17 percent operate at 50 to 60 % and 9.47% 60 to 80 % level of technical efficiency. The low level of productivity of the crop over the decades with high instability in yield and production further strengthens these findings for both the study crops.

CONCLUSION

In order to achieve self-sufficiency in edible oil production and reduce dependence on imports of edible oils, the groundnut production in the country needs to be enhanced along with other oilseeds. There is a growing realization that the scope for increasing oilseeds production through area expansion is limited. Crop intensification in underutilized farming situations like rice fallows can contribute to an increase in area under oilseeds. These approaches will lead to crop intensification and without sacrificing the yield or area under other crops. The technologies involving high-yielding varieties, hybrids, crop diversification to groundnut and efficient crop management need to be adopted to increase the area under groundnut. The strategy to achieve diverse sources of productivity enhancement like use of improved agro-techniques and improvements in input–use efficiency may be adopted. Effective technology dissemination to the cultivators is crucial to the success of the strategy.

The availability of key physical inputs (seed, fertilizers, pesticides, irrigation water etc), financial (credit facilities, crop insurance) and technical inputs (technology dissemination, extension services) need to be ensured in major crop ecological zones for groundnut to enhance the resource use efficiency. Selective farm mechanization in oilseeds cultivation, especially in sowing, inter- cultural operations and groundnut digging may be adopted.

In case of green gram, the drastic decline in human labour use on account of increased mechanisation calls for policy initiatives to create employment opportunities outside agriculture sector to absorb the surplus agricultural labour in the state. Significant use of hired machinery even on larger farm size groups points towards the need of strengthening of custom hiring services of machinery. The government should develop Agro-Service Centres at PACS for such services and take steps like fixing the custom hiring rates and creating more awareness about the custom hiring of farm machinery. This would particularly be beneficial to the small farmers to cut down their cost of production and enhance their net farm income. The issue of irrational use (overuse and underuse) of some of the important resources in crop production as pointed by the study needs to be addressed seriously. This calls for the strengthening of existing extension services to educate the farmers to make the judicious use of vital resources and bring down the cost of cultivation.

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