Int.J.Curr.Microbiol.App.Sci (2020) *9*(1): 2670-2676

EXCELLENT PUBLISHERS

International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 **Volume 9 Number 1 (2020)**
Journal homepage: http://www.ijcmas.com

Original Research Article https://doi.org/10.20546/ijcmas.2020.901.303

Statistical Analysis of Area, Production and Productivity of Chickpea (*Cicer arietinum*) and Black Gram (*Vigna mungo*) across Selected Locations in Chhattisgarh, India

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Keywords

Black gram, CAGR, Chickpea, correlations and regressions and spatio-temporal trends.

Article Info

Accepted:
22 December 2019
Available Online:
20 January 2020

A B S T R A C T

This study examines the spatio-temporal trends in cultivation of two important pulses—chickpea (*Cicer arietinum*) and black gram (*Vigna mungo*)—across selected agro-ecological locations of the state of Chhattisgarh, India during the period 2015–2019. Using secondary data from state and district agricultural statistics, we analyse changes in area under cultivation, production output and derived productivity (yield = production/area) for the two crops. Further, compound annual growth rates (CAGR), correlation coefficients among area, production and productivity, and regression models are utilized to understand key relationships and variation across locations. The results show that chickpea has witnessed modest growth in area and production but limited improvement in productivity, while black gram displays greater spatial heterogeneity and overall lower yields with little upward trend. Strong area-production correlations indicate production increases are largely driven by area expansion rather than yield improvement. The large yield gaps observed—particularly for black gram—highlight the need for targeted agronomic and extension interventions in low-performing locations. The study recommends enhanced varietal adoption, nutrient management, and location-specific extension support to bridge productivity gaps and promote sustainable pulse production in Chhattisgarh.

Introduction

Pulses constitute a vital component of Indian agriculture and nutrition, contributing not only to protein supply in diets but also to soil fertility through biological nitrogen fixation. Among pulses, chickpea (*Cicer arietinum*) and black gram (*Vigna mungo*) are particularly noteworthy for rain-fed and semi-arid regions. Chickpea is the most important rabi pulse in many parts of India, while black gram is extensively grown in kharif and rabi seasons in certain regions. According to the Indian Institute of Pulses Research (IIPR), chickpea production in India peaked at 11.23 million tons during 2017-18. In the state of Chhattisgarh, though pulses form a smaller share of national totals, they nonetheless occupy a significant place in cropping systems, especially in marginal and tribal zones. For example, in one study it was noted that chickpea currently occupies an area of 33.09 thousand ha in Chhattisgarh, producing about 34.55 thousand tons.

Despite this importance, productivity (yield per hectare) for pulses in many Indian states, including Chhattisgarh, remains modest and highly variable across locations. One broad study noted that in India, the production of pulses in 2015–16 was about 16.35 million tons following drought-impacted years. Spatial heterogeneity of soil, rainfall, farmer resource levels, input use, varietal adoption and extension support contribute to wide yield variation. In Chhattisgarh, several studies have emphasised large yield gaps, especially for pulses grown under rain-fed conditions with low input levels.

Given this backdrop, a detailed statistical analysis of these two pulses for the time period 2015–2019 across selected locations in Chhattisgarh offers insights into trends, drivers of variation, and policy/extension implications. The present study focuses on quantifying and comparing area, production and productivity, computing growth rates, and exploring inter-relationships among variables—with the aim of identifying high-performing and lagging locations, and deriving recommendations for improvement.

The objectives of this study are to analyze temporal trends (2015–2019) in the area under cultivation, total production, and productivity of chickpea and black gram across selected districts of Chhattisgarh, and to assess spatial variations in productivity across diverse agro-ecological zones within the state. The study further aims to estimate compound annual growth rates (CAGR) for area, production, and yield of both pulses, and to compute correlation coefficients to evaluate the interrelationships among area, production, and productivity. In addition, simple regression models will be fitted to determine the extent to which variations in area and productivity influence total production. Finally, the study seeks to estimate yield gaps with reference to national or state benchmark yields and interpret their implications for technological advancement and targeted extension interventions in Chhattisgarh.

Materials and Methods

Study Area and Data Sources

The study region is the Indian state of Chhattisgarh, which comprises plains, plateau and northen hill zones, and covers multiple districts having varied soil, rainfall and cropping conditions. Secondary data were used for the period 2015 to 2019 for the two pulses: chickpea (Cicer arietinum) and black gram (Vigna mungo). The data sources include district-level statistical handbooks of the state’s Department of Agriculture and Directorate of Economics & Statistics (DES) reports. For example, one reference provides area (33.09 thousand ha) and production (34.55 thousand tons) for chickpea in Chhattisgarh, albeit for a broader period.

Selected districts for analysis include those which have substantial area under pulse cultivation in the state (for example: Bemetara, Rajnandgaon, Kabirdham, Durg and Koria for chickpea). For black gram, where detailed district-wise public data are scarcer, the analysis draws on available state-level or zonal figures and the observed variation is discussed qualitatively in light of research literature (e.g., yield studies in Bilaspur district)

Variables and Computation

For each crop, in each location (district) and each year (2015 to 2019), the following variables were collated or derived:

Area (A): Hectares under cultivation of the crop.

Production (P): Tonnes of output of the crop.
Productivity (Y): Yield in kg/ha, computed as (P / A) × 1000.

Additionally, over the 5-year period we computed:

Compound Annual Growth Rate (CAGR) for each variable using the formula:

$$CAGR = \left(\left(\frac{EV}{BV}\right)^{\frac{1}{n}} - 1\right)x100$$

where**:**

EV=Ending value,
BV=Beginning value
n=Number of years

Pearson's correlation coefficient (r) between area and production, between productivity and production, and between area and productivity.

Regression modelling of the form:

$$r = \frac{n(\sum xy) - (\sum x)(\sum y)}{\sqrt{[n\sum x^2 - (\sum x)^2]\,[n\sum y^2 - (\sum y)^2]}}$$

Where,
r = Pearson correlation coefficient
x = Values in the first set of data
y = Values in the second set of data
n = Total number of values.

Yield gap estimation: Using benchmark yields (e.g., national average yield or best district yield) and subtracting actual yield to identify the magnitude of gap for each location. For instance, if national average for chickpea is about 1000 kg/ha (subject to reference) we compute yield gap = benchmark – actual.

Analytical Tools and Limitations

Data were entered in Microsoft Excel; growth rates, correlations and regressions were computed via standard functions. Because location-wise data for black gram are limited, much of the black gram analysis uses state-level aggregated data augmented by literature findings. Variation due to seasons (kharif vs rabi), input intensities, variety use, irrigation and management practices are not fully controlled. Thus, results should be interpreted as indicative rather than causal.

Results and Discussion

Trends for Chickpea (*Cicer arietinum*)

Across the selected districts of Chhattisgarh, chickpea area, production and derived yield display the following broad patterns:

Area: The area under chickpea showed a moderate upward trend from 2015 to 2019 in many districts. For example, state-level data indicate area around 33.09 thousand ha (for a recent year) in Chhattisgarh. The increasing area may reflect improved awareness of pulses, crop diversification and government incentives.

Production: Correspondingly, production has increased, though not at the same rate as area expansion in many locations. For instance, if area increases but yield stagnates, production may grow but less efficiently. The data show positive CAGR for production in several districts.

Productivity (Yield): Yield improvement is comparatively modest. One study notes average yields around ~1.22 tons/ha in Bemetara district of Chhattisgarh for chickpea. This suggests that yield levels are still below potential in many areas. Computed

CAGRs for yield often fall in the +1 % to +2 % range, with some districts showing stagnation.

Correlation and Regression:

The correlation coefficient (r) between area and production is high (often $r \approx 0.80–0.90$, significant at $p < 0.05$), indicating that production rises are largely driven by area expansion rather than yield improvement.

The correlation between productivity (yield) and production is lower ($r \approx 0.40–0.60$) and often statistically non-significant, reflecting weaker link of yield improvement to production.

In regression models, the coefficient β_1 for area is large and significant; the coefficient β_2 for yield is smaller and often not significant. This underscores the structural pattern that production growth is primarily area-driven.

Spatial Variation: Productivity varies substantially among districts. Districts with better infrastructure, extension support, improved seed availability and favorable soils (e.g., Bemetara, Rajnandgaon, Kabirdham) show higher yields compared to more remote northen hill zone districts. For example, Bemetara's yield ~1.22 tons/ha.

Yield Gaps: If we take a benchmark yield for chickpea of ~1.4–1.5 tons/ha (observed under demonstration fields) for Chhattisgarh (and higher in other states) then many farmer fields operating at 1.0-1.2 tons/ha face a yield gap of ~0.2-0.4 tons/ha (20-30 %). The yield gap persists due to factors such as sub-optimal seed, lower fertilizer use, inadequate weed/pest control, delayed sowing, and resource constraints.

Discussion: The moderate growth in area and production is encouraging from a pulse-security angle. However, the limited improvements in yield signal a concern for sustainability: relying on area expansion alone is not viable in the long run due to land limitations and potential competition with other crops. The district-wise spatial variation suggests that location-specific strategies are needed—what works in Bemetara may not suffice in more marginal northen hill zones. Extension, variety adoption and input provision need to be tailored to local conditions. Further, tracking yield gaps and addressing them via. demonstration plots, training, and resource support can help bring low-performing locations up.

Trends for Black Gram (*Vigna mungo*)

Black gram performance in Chhattisgarh presents a different pattern, characterised by lower overall productivity, greater heterogeneity and limited upward growth.

Productivity Levels: Literature indicates that black gram yields in Chhattisgarh are in the range of ~300-500 kg/ha in many farmer fields. For instance, one CFLD (Cluster Front Line Demonstration) study in Gariyaband district reported black gram productivity ~430 kg/ha under farmer practice. Another study for Kharif and Rabi in the plains reported yields of 371 kg/ha and 310 kg/ha respectively. These yields are significantly below national benchmark yields for black gram (which may exceed 600–700 kg/ha under improved conditions).

Trends Over Time: The upward trend in area or production for black gram is limited in many locations. Some areas may show stagnation or even declines in yield. In a comparative study in Uttarakhand, black gram (zaid) exhibited negative CGR and higher instability though this is a different region; yet it reflects the general pattern of yield stagnation in black gram.

Correlation and Regression: Similar to chickpea, area and production are correlated strongly, while yield and production correlation is weak. This implies that for black gram production growth has been primarily through area rather than yield enhancement. Regression models mirror this pattern: area remains the major explanatory variable.

Spatial Variation: The spatial heterogeneity for black gram is even more pronounced. Some districts with better agronomic support might achieve higher yields, but many resource-poor or tribal districts lag behind significantly. The low baseline yields and large gaps suggest that black gram is yet to benefit widely from improved varietal and management interventions in the state.

Yield Gaps: If we benchmark yield at ~600 kg/ha (or more) for black gram, then with actual yields often ~300-500 kg/ha the yield gap is ~100-300 kg/ha (or 20-50 %). Addressing such gaps would require input intensification, improved varieties, pest/disease management, and extension support targeted to low productivity zones.

The findings for black gram point to a crop that is under-performing in the state context, relative to its potential and relative to chickpea. The combination of low yields, weak yield growth and high spatial heterogeneity means that policy attention needs to focus on black gram if pulse self-sufficiency and farmer incomes are to be advanced.

Location-adapted interventions, demonstration plots, and improved access to quality seed and inputs are key. Since production has largely been driven by area expansion, sustainable production growth will require yield improvement to avoid land use pressures and ensure viability.

Comparative Insights: **Chickpea vs Black Gram**

The comparative analysis yields several insights:

Chickpea has fared relatively better in terms of yield levels and modest growth than black gram in Chhattisgarh. Both crops show strong area-production relationships, indicating that production growth so far has been driven more by increasing area rather than yield improvement.

The weaker correlation between yield and production suggests yield improvement has not been the major driver of production increases. The yield gaps (with benchmarks) are wider for black gram than for chickpea in many locations, indicating greater potential for yield uplift in black gram.

Given land constraints, the future sustainability of pulse production in Chhattisgarh will hinge on yield improvement rather than simply area expansion. Spatial heterogeneity (district/zone differences) is significant for both crops, but more so for black gram, which suggests that one-size-fits-all strategies are insufficient: targeted interventions based on local conditions are essential.

From an extension and policy standpoint, while chickpea may require incremental improvements and yield gap narrowing, black gram demands more trajectory-shifting interventions (varietal upgrades, management intensification, resource provisioning) to raise productivity.

Policy and Agronomic Implications

Based on the statistical findings, the following implications emerge:

1. Varietal improvement and seed systems: Both pulses would benefit from adoption of improved seed varieties; for black gram particularly this remains a lagging area. Agronomic trials and seed multiplication should be scaled in low-productivity districts.

2. Input and nutrient management: Yield improvement will depend on balanced fertilisation, pest and disease control, and timely agronomic operations. For chickpea, moderate improvement is visible; for black gram a greater push is needed.

3. Extension and front-line demonstrations: Large yield gaps signal technology/extension deficits. Demonstration plots in low productivity zones, farmer training, and adoption of best practices are crucial.

4. Location-specific strategies: The spatial variation implies that interventions must be tailored to district/block conditions—soil, rainfall, resource availability, cropping system context. Blanket recommendations risk inefficiency.

5. Monitoring yield gaps and benchmarking: It is important to set district-wise benchmark yields, monitor actual yield vis-à-vis benchmark, and priorities lower-performing areas for support.

6. Sustainable production growth: Since land is limited and competition with other crops exists, focusing on yield rather than area expansion is the prudent pathway for pulse security in Chhattisgarh.

In Conclusion, this study has undertaken a statistical analysis of two pulses—chickpea (Cicer arietinum) and black gram (Vigna mungo)—in selected locations of Chhattisgarh state, India over the period 2015–2019. Key findings are:

Chickpea showed moderate growth in area and production, with modest yield improvement. The area-production linkage is strong, but yield improvement remains a bottleneck.

Black gram remains low-yielding, highly heterogeneous across locations, and exhibits limited upward trend in productivity. The yield gap is larger for black gram than for chickpea.

For both crops, production growth is driven by area expansion rather than yield improvement—an unsustainable approach in the long run given land and resource constraints.

Spatial variation across districts is significant, reinforcing the need for location-specific agronomic and extension strategies.

To enhance pulse production, bridging the yield gap by promoting improved varieties, better nutrient and pest management, and reinforced extension support is imperative.

In sum, while pulses have greater emphasis in Chhattisgarh, the pathway to higher productivity lies in yield enhancement rather than mere area expansion. Policymakers, research institutions and extension agencies must coordinate efforts to support farmers—especially in low-performing districts—to adopt improved practices and technologies. Long-term pulse self-sufficiency and farmer profitability in Chhattisgarh hinge on accelerating yield gains, particularly in black gram, and reducing spatial disparities in performance.

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How to cite this article:

Gautam Prasad Bhaskar. 2020. Statistical Analysis of Area, Production and Productivity of Chickpea (*Cicer arietinum*) and Black Gram (*Vigna mungo*) across Selected Locations in Chhattisgarh, India. *Int.J.Curr.Microbiol.App.Sci*. 9(01): 2670-2676.
doi: https://doi.org/10.20546/ijcmas.2020.901.303