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Analyzing Growth Patterns and Key Factors Influencing Pigeon Pea Surplus in Morena, Madhya Pradesh

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Abstract

This research analyzes long-term trends in pigeon pea cultivation in the Morena district, focusing on changes in area, output, and yield over the period from 2000-01 to 2017-18. The study also evaluates the extent of marketable and marketed surpluses and investigates the socio-economic factors influencing these surpluses, such as family demographics, land ownership, commodity pricing, consumption needs, and production levels. Results indicate a positive trajectory in both production and productivity, reflecting a dynamic shift in local agricultural practices. Among all crops studied, Pigeon Pea demonstrated the highest marketable surplus, followed by mustard. Additionally, the study explores how farmers allocate their produce for domestic use, seed reserves, animal feed, labor payments, and other non-commercial purposes. Gaining insights into these retention behaviors is vital for effective planning and management within the agricultural sector.

Keywords: Compound Growth Rate, Marketed Surplus, Marketable Surplus, Infrastructure

Introduction

Pigeon pea (*Cajanus cajan*) is one of India's most important pulse crops, recognized for its nutritional, agronomic, and economic significance. As a vital source of plant-based protein and a dietary staple, pigeon pea contributes substantially to food and nutritional security across the country. Its capacity for biological nitrogen fixation enhances soil fertility, making it a key crop within sustainable rainfed agricultural systems. India dominates global pigeon pea production and consumption, accounting for over 80% of the world's output (FAOSTAT, 2020). Within India, Madhya Pradesh—especially Morena district—has witnessed significant expansion in pigeon pea cultivation area and production over the last two decades.

Beyond its production role, pigeon pea cultivation exerts a strong influence on rural livelihoods by contributing to both marketable and marketed surpluses, crucial parameters in agricultural marketing analysis. The marketable surplus refers to the portion of production available for sale after fulfilling household consumption, seed, feed, and social obligations, while the marketed surplus represents the actual quantity sold in the marketplace (Acharya & Agarwal, 2004) ^[2]. These surpluses play a vital role in shaping market supply dynamics, price stability, procurement policies, and food distribution networks.

In Morena district, analyzing the growth and surplus trends of pigeon pea reveals important insights into local agricultural practices and economic behavior. The volume of produce marketed by farmers is influenced by factors

such as family size, landholding capacity, storage facilities, consumption patterns, and anticipated market prices (Reddy & Reddy, 2010) ^[3]. For instance, favorable market prices or reduced household needs typically encourage farmers to sell more than their usual surplus. Conversely, expectations of price increases or limited market access often prompt farmers to retain a larger share, thereby reducing the marketed quantity.

The relationship between marketable and marketed surplus also reflects farmers' economic conditions and decision-making strategies. When these surpluses are equal, it indicates farmers' limited capacity to store produce and their need to sell immediately, often driven by urgent financial requirements. Alternatively, a marketed surplus exceeding marketable surplus signals distress sales, where farmers compromise essential on-farm retention due to pressing economic pressures. This study adopts the common definition of marketable surplus as total production minus on-farm retention to evaluate surplus behavior accurately.

Effective marketing infrastructure is essential for optimizing pigeon pea surplus management. A well-functioning agricultural marketing system minimizes post-harvest losses during storage, transportation, and processing, thus increasing the available surplus for sale. It also facilitates timely transmission of price signals, efficient distribution of modern inputs, and ensures fair returns for farmers by curbing middlemen exploitation and malpractices. Strengthening this system is crucial not only to boost market participation but also to enhance farm incomes and promote

regional agricultural development.

Given this backdrop, analyzing the growth patterns of pigeon pea and the key factors influencing its surplus in Morena district is imperative. Such analysis aids in designing targeted policies that support producers, stabilize markets, and secure food availability. This study examines these aspects over an 18-year period, providing comprehensive insights into production trends, surplus dynamics, and socio-economic variables affecting farmer decisions.

According to the latest available data for 2022-2023, pigeon pea was cultivated over approximately 4.9 million hectares across India, producing around 4.34 million tonnes with an average productivity of 861 kg/ha (Indian Institute of Pulses Research [IIPR], 2022). In Madhya Pradesh, pigeon pea occupied roughly 0.44 million hectares, contributing about 34.5% of the national production, with an average yield of 944 kg/ha (IIPR, 2022). Specifically, in Morena district, pigeon pea cultivation covered approximately 8.8 thousand hectares, accounting for 6.77% of the district's total pulse crop area, with an average productivity of 846 kg/ha (Singh *et al.*, 2015)^[5].

Research Methodology

The present study, focused on pigeon pea cultivation in Morena district of Madhya Pradesh, aims to achieve the following objectives:

1. To examine the trends in area, production, and yield of pigeon pea using compound growth rates over the study period.
2. To assess the levels of marketable and marketed surplus of pigeon pea, along with the quantities retained on farms for purposes such as household consumption, seed use, livestock feed, labor payments, and social obligations.

Data Sources

This study is based on both primary and secondary data sources.

- Primary data were collected directly from farmers through a structured and pre-tested questionnaire using the survey method. The questionnaire captured detailed information on production, farm retention, and marketed and marketable surplus.
- Secondary data were obtained from various published reports and official records, including those from the Department of Agricultural Statistics, Government of Madhya Pradesh; the Deputy Director Agriculture (DDA) Office; and the Krishi Vibhag, Morena district. These data primarily covered the period from 2000-01 to 2017-18 and were used to analyze the trends in area, production, and productivity of the selected crops.

Study Area and Crop Selection

The research was conducted in Morena district, Madhya Pradesh, which is one of the leading regions in the cultivation of Pigeon pea. The focus area was further narrowed down to Jaura blocks, as these blocks reported the highest levels of production for the selected crop.

Sampling Technique

A multistage random sampling technique was adopted for

selecting the study sample, which involved the following stages:

- **Stage I - Block Selection:** Out of the seven blocks in Morena district-Morena, Porsa, Jaura, Ambah, Kailaras, Sabalgarh, and Pahargarh- Jaura was purposively selected based on their significant area and production of pigeon pea.
- **Stage II - Village Selection:** From selected block, a comprehensive list of villages was prepared. Five villages were randomly selected, resulting in a total of 10 villages for the study.
- **Stage III - Farmer Selection:** A list of pigeon pea growers was compiled from each selected village. From this list, a total 80 farmers were selected using a proportionate random sampling method. The sample distribution was proportional to the number of crop growers in each village.

The formula used for proportionate random sampling is as follows:

$$n_h = \frac{N_h}{N} \times n$$

Where,

n_h = sample size for stratum h

N_h = population size for stratum h

N = total population size

n = total sample size

Analytical tools

Compound growth rates

Compound growth rates of area, production, and productivity of major crops were worked out for the Morena district of Madhya Pradesh during the period 2000-2001 to 2017-18. The compound growth rate was worked out by fitting the exponential function as given below:

$$Y_t = ab^t$$

Where,

Y_t = dependent variable on area, production, and productivity in the year 't'

a = constant,

b = regression coefficient,

t = time element which takes the value 1, 2, 3..n

After transforming the model into a linear form by taking logarithms, we get

$$\text{Log } Y_t = \text{log } a + t \text{ log } b$$

By putting $\text{Log } Y_t = y$, $\text{log } a = A$ and $\text{log } b = B$, the model becomes linear between y and t , as $y = A + Bt$, fit the model by the method of ordinary least squares (OLS) technique.

The compound growth rate (r) in percent was obtained by the following formula:

$$r = (b-1) \times 100 = (\text{antilog } b - 1) \times 100$$

The significance of the growth rate was tested by applying

the student 't' test statistic

$$T = r/S.E. (r)$$

Where,

$$SE(r) = \sqrt{\frac{\sum (Y_i - \hat{y}_i)^2}{(n-2)}} / \sqrt{\frac{\sum (x_i - \bar{x})^2}{n-2}}$$

Which follows distribution with (n-2) degree of freedom, n is the number of years considered under study. The compound growth rates were computed for the area, production, and productivity of major crops in the Morena district of Madhya Pradesh.

Marketable Surplus

The marketable surplus is computed by the following algebraic formula,

$$MS = P - C$$

Where,

MS = Marketable surplus,

P = Gross production in the year,

C = Total requirements in the same year for family use such as consumption (retention + purchase), payment of wages in kind, feed, seed, barter, payment of loan/ irrigation, and physical losses/ wastage in storage/ transportation/ threshing, etc.

Marketed Surplus

In case the quantity actually retained for consumption (and not the quantity actually required for consumption) is taken into account, the quantity calculated is the marketed surplus which is a gross concept, because the quantity sold will not include the buybacks by the producers. The marketable surplus will thus be according to the formula:

$$A - B = MS$$

Where,

A stand for production

B includes all the items mentioned

The term "Consumption by the farm family" of the cultivator households refers to the quantity actually retained for consumption by the family irrespective of the actual total requirements for the purpose.

Determinants of Marketed Surplus

A theoretical model of the marketed surplus response function has been used. The marketed surplus of a crop depends on various price and non-price factors. The empirical studies of marketed surplus have found that farmers respond positively to price changes, and this is consistent with economic theory. In addition to price, a number of other socio-economic, institutional, technological, and infrastructural factors influence marketed surplus. Among these are, farm size, the quantity of production, family size, wealth/income, risks, access to markets, market information, etc. A number of studies have reported that there exists a strong linear and, in some cases, a non-linear relationship between the quantity sold and variables like farm size, quantity produced, family size,

output prices, and socioeconomic and institutional variables for different categories of farmers.

The linear relation may be written as:

$$MS = \alpha + \beta_i X_i$$

Where MS denotes the marketed surplus, and X_i ($i = 1, 2, \dots, n$) represents the independent variables influencing marketed surplus.

The dependent variable, marketed surplus (MS), is defined as sales as a share of total output per household. The independent variables include farm size (ha), family size (numbers), awareness about minimum support price (MSP), access to the regulated market, distance to market(km), per household production of the crop (in quintals), sources of off-farm income, access to institutional credit, roads, markets and market information and price received for the produce.

Results and Discussion

The data presented in Table 1 and Figure 1a, 1b, 1c and Figure 2 clearly indicate a significant improvement in the area, production, and productivity of pigeon pea in Morena district during the period 2000-01 to 2017-18.

The area under pigeon pea cultivation showed a consistent increase from 7.8 thousand hectares in 2000-01 to 15.0 thousand hectares in 2017-18, registering an average of 10.80 thousand ha with a compound growth rate (CGR) of 9.47%, which was significant at the 1% level of probability. This positive trend reflects farmers' growing preference for pigeon pea due to its adaptability to local climatic conditions, better market price realization, and its role in improving soil fertility through nitrogen fixation.

The production of pigeon pea rose sharply from 6.8 thousand tonnes in 2000-01 to 20 thousand tonnes in 2017-18, with an average annual production of 16.23 thousand tonnes and a CGR of 17.47%, also significant at the 1% level. The increase in production has been faster than the growth in area, indicating substantial improvements in yield. This improvement can be attributed to favorable rainfall conditions, adoption of improved high-yielding varieties, and better crop management practices promoted by the agriculture department and extension agencies.

Similarly, the productivity of pigeon pea showed a steady upward trend, increasing from 872 kg/ha in 2000-01 to 1953 kg/ha in 2017-18, with an average productivity of 1243.66 kg/ha and a CGR of 6.67%, significant at the 1% probability level. The years 2012-13 to 2016-17 recorded the highest productivity levels (1899-2250 kg/ha), which may be attributed to favorable climatic conditions, better seed replacement rates, and adoption of modern agronomic practices.

Overall, the analysis indicates that Morena district has witnessed a strong and statistically significant growth in pigeon pea cultivation over the years. The estimated 'b' values (1.09 for area, 1.17 for production, and 1.06 for productivity) confirm positive and sustained growth trends. The increasing surplus of pigeon pea in recent years is the result of expanded cultivation area, improved yield potential, and enhanced technological dissemination among farmers. Hence, Morena district has emerged as a leading pigeon pea-producing region in Madhya Pradesh,

contributing notably to the state's pulse self-sufficiency and agricultural sustainability.

Table 1: Area, Production and Productivity of Pigeon pea in Morena district

Year	Pigeon pea crops		
	Area (thousand ha)	Production (thousand tonnes)	Productivity (Kg/ha.)
2000-2001	7.8	6.8	872
2001-2002	7.0	7.1	1081
2002-2003	5.1	3.0	592
2003-2004	5.2	4.0	769
2004-2005	3.8	3.0	788
2005-2006	4.5	3.5	790
2006-2007	4.1	2.7	675
2007-2008	4.30	3.20	790
2008-2009	2.50	2.50	867
2009-2010	7.50	5.80	750
2010-2011	9.60	14.00	1074
2011-2012	8.40	15.40	1791
2012-2013	16.00	32.09	1899
2013-2014	20.00	41.90	2095
2014-2015	8.00	16.80	2100
2015-2016	23.00	48.10	2250
2016-2017	29.00	62.30	2150
2017-2018	15.00	20.00	1053
Total	180.80	292.19	22386
Average	10.04	16.23	1243.66
CGR (%)	9.47**	17.47**	6.67**
'b' value	1.09	1.17	1.06

^{NS} Non significant, **Significant at 0.01 level of probability, *Significant at 0.05 level of probability

Source: DDA Office, Krishi Vibhag, Morena district, Madhya Pradesh

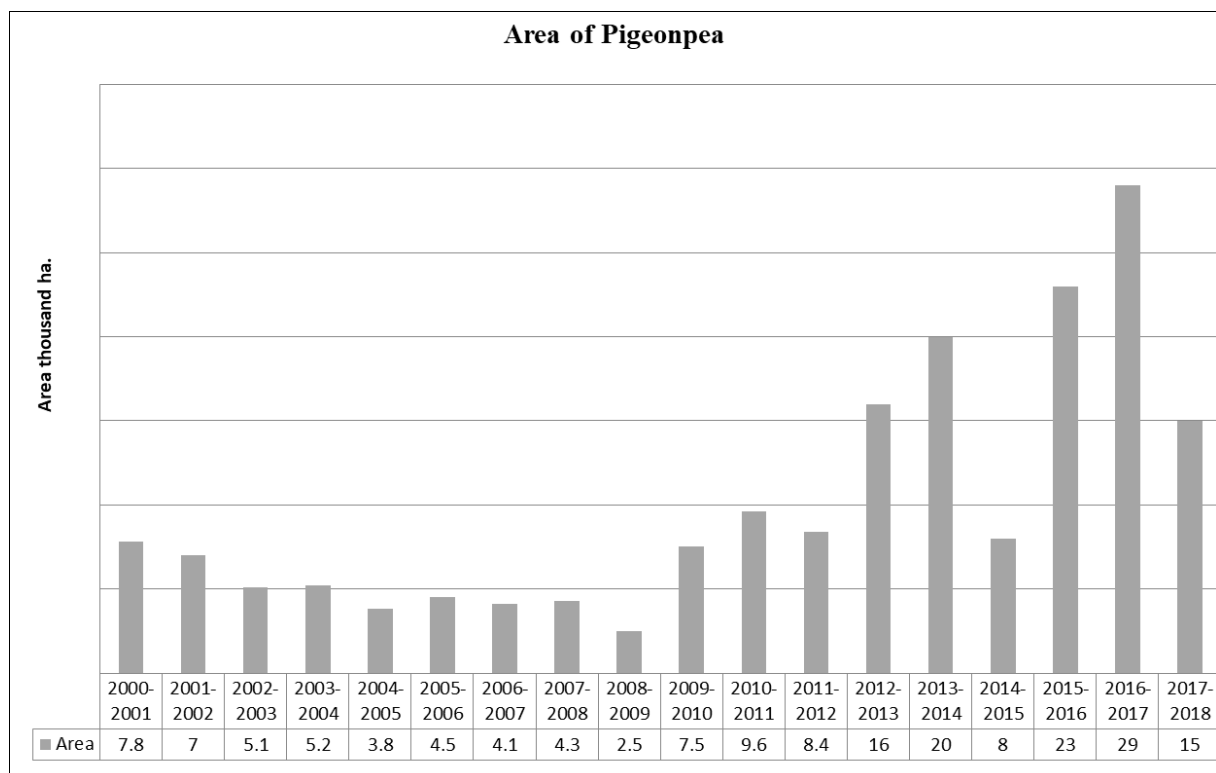


Fig 1a: Area, Production and Productivity of Pigeon pea in Morena district from 2000-01 to 2017-18

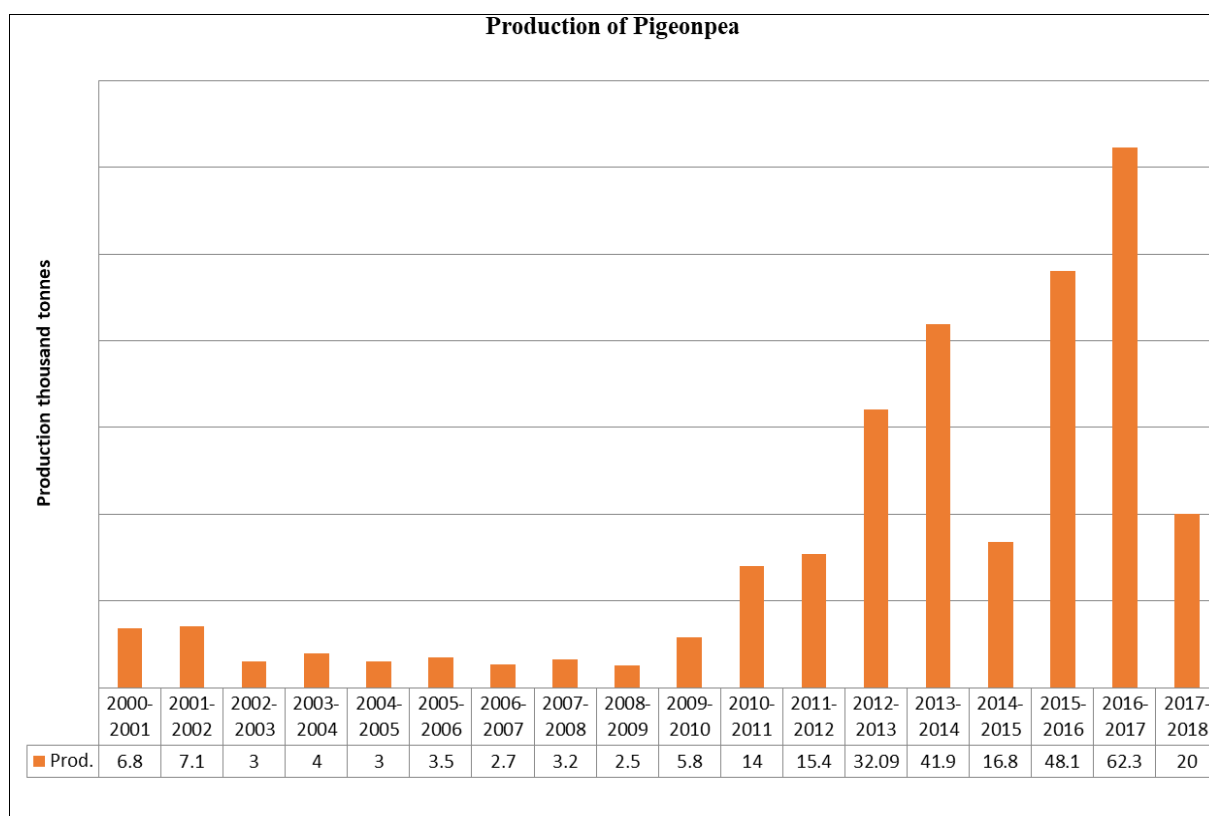


Fig 1b: Production of Pigeonpea in Morena district from 2000-01 to 2017-18

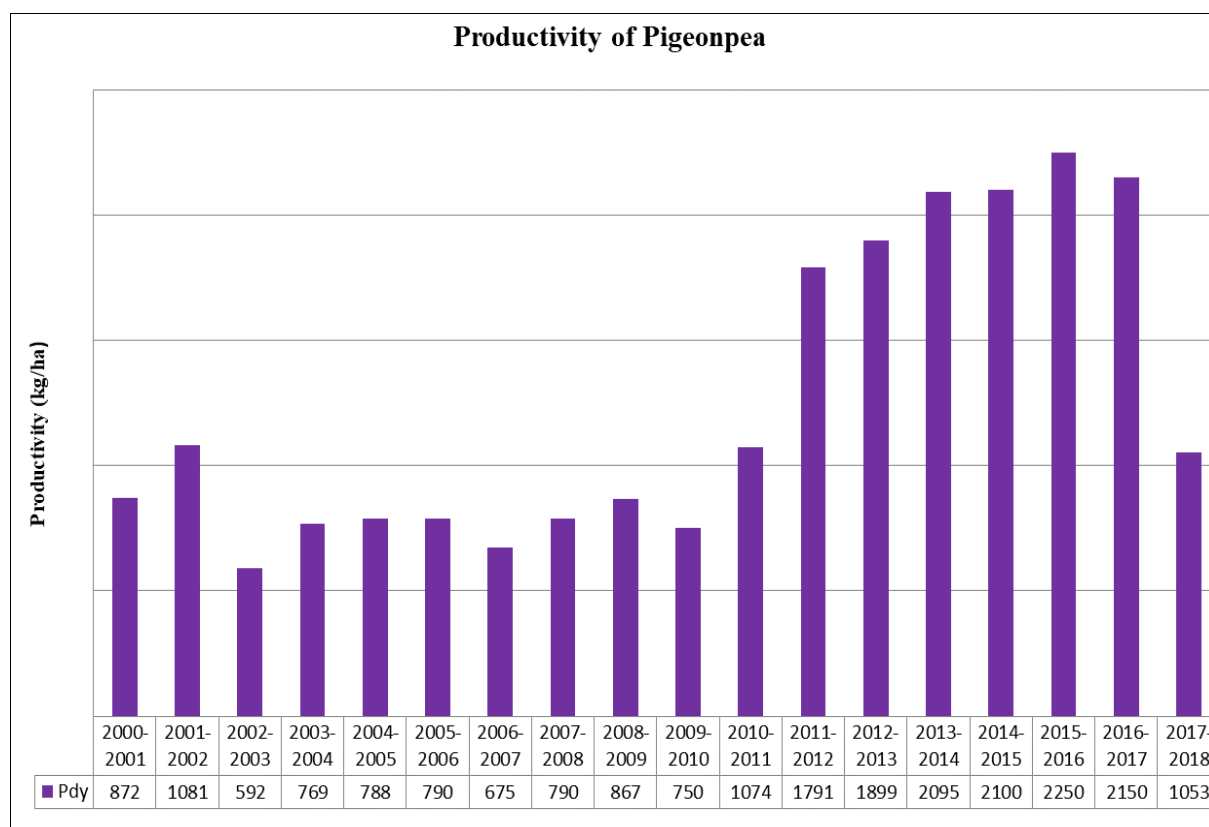


Fig 1c: Productivity of Pigeonpea in Morena district from 2000-01 to 2017-18

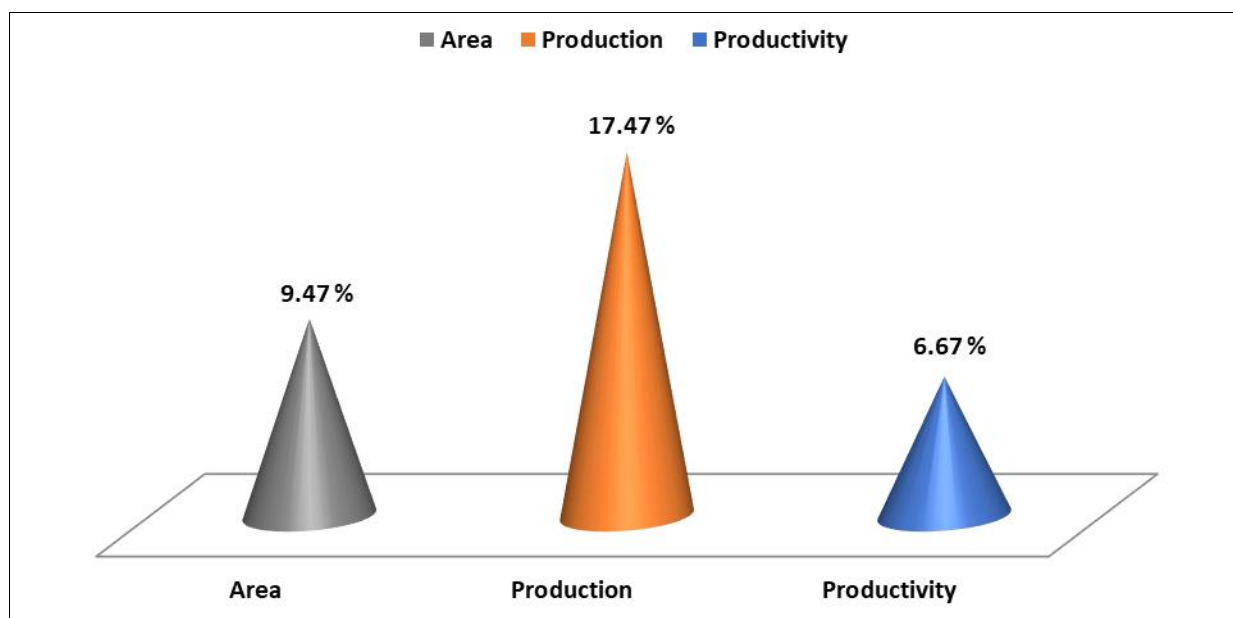


Fig 2: Compound growth rate(%) of Area, Production and Productivity of Pigeonpea in Morena district from 2000-01 to 2017-18

Marketable and marketed surplus of Mustard and Wheat crops in Morena

In this section, an assessment was conducted to estimate the marketable and marketed surplus, prevailing sale price, sale pattern, and realized price of the selected crop, pigeon pea, in Morena district. The findings related to marketed surplus are presented in Table 2.

On the sample farms, the total production of pigeon pea was recorded at 4,986 quintals, out of which 4,894 quintals were marketed, representing approximately 98.15% of total production. This high proportion of marketed surplus indicates that pigeon pea serves as an important cash crop

for the farmers in the region. The average selling price realized by the producers was ₹5,237 per quintal. A small portion, 91.15 quintals, was retained by the farmers, mainly for household consumption, seed preservation, or local sale. The data clearly show that pigeon pea production in Morena district is largely market-oriented, with minimal on-farm retention. The high marketed surplus ratio signifies the crop's commercial value and its role in supporting farmers' income. The limited storage quantity reflects the tendency of farmers to sell most of their produce soon after harvest, possibly due to immediate cash requirements or lack of adequate storage facilities.

Table 2: Total production, marketed surplus, selling price, and storage of mustard and wheat crops on a Farm basis in Morena district

Crops	Total production (qtl)	Marketed surplus (qtl)	Selling price (Rs/qtl)	Storage(qtl)
Mustard	4986	4894	5237	91.15

Production, requirement, marketable surplus, and marketed surplus of major crops (Farm basis)

Marketable surplus represents the quantity of produce available for sale after meeting the farmer's household and farm requirements, such as family consumption, seed, feed, and wages in kind. The data presented in Table 3 illustrate the estimation of production, requirement, marketable surplus, and marketed surplus for pigeon pea in Morena district.

It was observed that the average total production of pigeon pea per farm was 62.31 quintals. Out of this, the family consumption requirement accounted for 0.94 quintal, and seed requirement for the next sowing season was 0.21 quintal. The combined total requirement was therefore 1.15 quintals, while no quantity was utilized for feed or wages in kind. Consequently, the marketable surplus was calculated

at (61.16 quintals). Interestingly, the marketed surplus (61.17 quintals) was marginally higher than the marketable surplus, possibly due to the sale of small portions that were initially kept for home use or seed purposes. This indicates a strong commercial orientation of pigeon pea cultivation in the region, where farmers tend to sell nearly all their produce soon after harvest to meet cash flow needs.

The findings highlight that the marketable surplus of pigeon pea was slightly lower than the marketed surplus, suggesting that farmers sold even the small quantities originally set aside for self-use. This reflects the high market dependency and income-driven nature of pigeon pea cultivation in Morena district. The negligible household and seed requirements further reinforce its role as a key commercial pulse crop in the region.

Table 3: Production, requirement, marketable surplus, and marketed surplus of major crops (Farm basis)

Crops	Total Production	Requirement				Total Requirement	Marketable Surplus	Marketed Surplus
		Family consumption	Seed	Feed	Wages			
Pigeon pea	62.31	0.94	0.21	00	00	1.15	61.16	61.17

Estimation of farm retention for consumption seed, feed, wages, and other payments in kind

The farm retention pattern for the selected crops pigeon pea has been analyzed to understand the proportion of produce kept by farmers for various on-farm uses. The retention includes quantities reserved for family consumption, seed, feed, wages and payments in kind, gifts, and other household purposes. The results pertaining to pigeon pea are presented in Table 4.

It was found that an average pigeon pea grower retained 1.15 quintals of the total produce for self-use and farm-related requirements. Among these, the largest share was utilized for family consumption (0.94 quintal), followed by seed purposes (0.21 quintal) for the next cropping season.

There was no retention recorded for feed, wages, or payments in kind, reflecting the limited use of pigeon pea beyond household consumption and seed preservation.

This pattern indicates that the majority of the pigeon pea produce is commercially oriented, with only a very small proportion being retained for self-consumption.

The findings reveal that pigeon pea farmers in Morena retain only a minimal portion of their harvest, primarily for domestic consumption and seed. The absence of retention for feed or payments in kind suggests that pigeon pea is not commonly used as livestock feed or barter produce in the area. This further underscores the commercial significance of pigeon pea cultivation, as most of the produce is directed toward the market soon after harvest.

Table 4: Crops Retention Pattern of selected crops in Morena district (qtl.)

Crops	Family consumption	Seed	Feed	Wages	Payments in kinds	Total retention
	1	2	3	4	5	(1 to 5)
Pigeon pea	0.94	0.21	00	00	00	1.15

Factor influencing marketable and marketed surpluses

Understanding the determinants of marketed surplus is crucial for developing effective strategies in agricultural marketing, pricing policies, and resource management. The marketed surplus of a crop depends on both price and non-price factors such as landholding size, production level, family size, consumption pattern, and resource requirements for farm operations.

The data presented in Table 5 explain the relationship between various independent variables and the marketed surplus of pigeon pea in Morena district. A multiple regression model was applied to identify significant influencing factors. The model was found to be a good fit, with a coefficient of multiple correlation (R) value of 0.4683, indicating that nearly 47% of the variation in marketed surplus could be explained by the selected independent variables.

Among the variables studied, the size of family, landholding size, area under crops, total production, and requirements for seed/feed/wages exhibited positive and significant relationships with marketed surplus at the 1% level of probability. This suggests that larger farm households and higher levels of production contribute significantly to the marketed output.

The variables such as price of the commodity and consumption habit showed a positive but non-significant association, indicating that while they influence marketing decisions, their effect is relatively limited under existing conditions.

Table 5: Factors influencing marketed surplus

Variables	Mean value	S.D.	'r' value
Pigeonpea			
Size of family (no.)	3.183	0.356	0.543**
Size of land holding (ha)	2.750	0.308	0.954**
Size of area under crops (ha)	2.750	0.308	0.954**
Price of the commodity (Rs/qtl)	68.413	7.649	0.092 ^{NS}
Consumption habit (qtl)	0.383	0.043	0.514**
Total production (qtl)	55.146	6.166	1.000**
Requirements for seed/feed/wages (qtl)	0.378	0.042	0.488**
(Coefficient of Multiple regression) R	0.4683		

^{NS} Non-significant, **Significant at 0.01 level of probability

Conclusion

It can be concluded that the growth in pigeon pea production in Morena district was primarily driven by productivity improvements, complemented to some extent by expansion in cultivated area. Enhanced technological adoption, improved crop management practices, and efficient resource utilization contributed to this positive trend. Analysis of surplus behaviour indicated that the marketed surplus exceeded the marketable surplus, suggesting that farmers often sell more than initially intended, possibly due to favorable market conditions, immediate cash needs, or limited storage capacity. Factors such as landholding size, total production, and family size significantly influenced the marketed surplus, while commodity price showed a positive but non-significant effect, highlighting that production-related factors are more critical than price dynamics in determining surplus. Overall, the findings underscore the need to focus on productivity enhancement, robust market linkages, and improved post-harvest management to ensure sustainable growth and higher income realization for pigeon pea growers in Morena district.

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