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Agricultural Productivity of Pulses in India

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ABSTRACT
Pulses are a key commodity category of crops that supply high-quality protein to the country's mainly vegetarian population, supplementing grain proteins. India is the world's largest producer of pulses, accounting for 30% of worldwide manufacture and consumption. In India, almost all types of pulse crops are grown. As a result, India has maintained its status as the world's leading producer of pulses. In 2018-19, India produced 19.27 million tons, making it the world's greatest producer. This paper investigates the growth trend, yield, and output value of pulses grown in India.

KEYWORDS
Pulses, Crops, Yield, Growth trend, Production, Output.

1. INTRODUCTION
Pulses are an important commodity crop type that provides high-quality protein to supplement cereal protein for the country's predominantly vegetarian population. Despite being the world's largest pulse crop farming country, pulses account for barely 6-7 percent of overall food grain production in the country. Pulse cultivation creates a nutrient-rich environment.
They have a mechanism for fixing nitrogen from the atmosphere into their root nodules, which allows them to meet their nitrogen needs to a large extent. Pulses can be grown with few resources in India, making them less expensive than animal protein. Pulses, compared to other vegetables, are high in protein, are less expensive, and can be grown as an intercrop or mixed crop. Pulses can be grown with few resources in India, making them less expensive than animal protein. Pulses are usually grown in rain-fed settings and do not require extensive irrigation, which is why they are planted in regions that are left over after cereal/cash crop demand has been met. Even in these cases, the pulse produces better results. From that, pulses have several other advantages, including high protein content, improved soil fertility and physical structure, compatibility with mixed/inter-cropping systems, crop rotations, and dry farming, as well as green pods for vegetables and nutritious fodder for cattle. Although this crop group is more essential nutritionally, there has been no major rise in area or production from 1950-51 to 2009-10.
Nevertheless, there has been significant growth in area and output over the previous five years (i.e., 2010-2011 to 2016-17). With the expansion of infrastructure and irrigation resources, people are ostracized, and they are pushed to another poor and marginal land plot. Pulse productivity increased by around 77 percent to 779 kg/ha in 2016-17, up from 441 kg/ha in 1950-51. It is important to note that the New Agriculture Technology (NAT) adopted in the mid-1960s raised food grain production from 50.82 million to 60.82 million tonnes in 1950-51 to 275.68 million tonnes with an increase in area from 97.32 million hectares to 128 million hectares, from 275.68 million tonnes in 1950-51 to 275.68 million tonnes in 2016-17. Food grain productivity has also increased dramatically, rising to 2153 kg/ha in 2016-17 from only 522 kg/ha in 1950-51. The ability of pulses to contribute to future global food security, nutrition, and environmental sustainability needs has been acknowledged through the UN declaration of the 2016 International Year of Pulses. Pulses are Smart Foods because they are essential for the food basket (dal-roti, dal-chawal), a good source of plant protein, and help with obesity, diabetes, and so on. In addition, pulses are highly water-efficient, may be grown in drought-prone areas, and aid in soil fertility improvement.

Objectives: The main objectives of the paper are following; TO investigate pulses expansion in terms of area, production, and productivity. Calculate the relative contribution of land and yield to pulse production growth.

2. REVIEW OF LITERATURE
Tingreet al. (2009) in the Vidarbha district of Amravati, researchers looked at the growth rates of area, production, and yield of main crops, changes in cropping patterns, and the trend in crop diversification and cropping intensity. During era, I, production growth rates in the majority of cereal crops rose substantially and were greater than during period II. Gajbhiyeet al. (2010) the growth and stability of an important crop, the chickpea. It implies that chickpea production remained almost consistent throughout time. Rao (2010) using time series data on area, output, and productivity, researchers assessed the patterns of growth and degree of instability, as well as evaluating the effects of explanatory factors on pulse production in Andhra Pradesh. Shiyani and Ardeshna (2011) the acreage, production, and yield of arhar, gram, and total pulses in various districts of Gujarat were investigated. The compound growth rates of arhar and grain productivity were negative, whereas those of total pulses were positive but non-significant in Gujarat. Acharyaet al. (2012) the compound growth function were used to assess the increase in area, output, and productivity of several crops in Karnataka. The area under pulses, vegetables, and spices, fruits, and nuts exhibited a considerable positive increase, while grains showed significant negative growth. Kumar and Ganesh-et al. (2012)rice and wheat, the two major grains produced and eaten in India. The findings indicated that the demand elasticity for rice, wheat, and pulses concerning total food expenditure was negative. Reddy (2013) the diversification of agriculture in Orissa was investigated, and it was discovered that agriculture in the state was extremely concentrated, with poor productivity, excessive water use, and showed a low degree of diversity.

3. METHODOLOGY
3.1 Studying Period
Total pulses, gram, and pigeon pea are decomposed using time series data from 2000 to 2019, while lentil, black gram, and green gram are decomposed using time series data from 2005 to 2019. The study was based on secondary data, which was gathered from a variety of sources, including the Ministry of Agriculture, Directorate of Economics and Statistics,

Indiastat.com, and the Indian Institute of Pulse Research (Kanpur).

4. FRAMEWORK FOR ANALYSIS

The compound growth rate (CGR) is the rate of change in 'Yt' per unit of time 't' represented as a percentage of the magnitude of 'Yt' itself. It may be stated mathematically as:

$$CGR = [(\frac{1}{Y_t})(\frac{dY_t}{dt})] = [(\frac{Y_{t+1}-Y_t}{Y_t})] \quad \dots (1)$$

The compound growth rate of 'Yt' in percentage terms is given by multiplying equation (1) by a hundred.

The log linear function (sometimes known as the exponential function) has the following mathematical form:

$$Y_t = Ae^{bt} \quad \dots (2)$$

This function's log transformation is as follows:

$$Log_e Y_t = Log_e A + bt$$

Differentiating it based on the letter 't'

$$[(\frac{1}{Y_t})(\frac{dY_t}{dt})] = b$$

The following is the formula for calculating CGR using the log-linear equation:

Let 'Y0' be the value of the studied variable in the baseline period.

Let 'Yt' represent the value of the variable at a time 't,' and

Let 'r' be the CGR value (compound growth rate).

Using the compounding formula that we've discovered,

$$Y_t = Y_0(1+r)^t$$

The above is transformed into a log format.

$$\log Y_t = \log Y_0 + t \log(1+r)$$

Assuming,

$$\log Y_0 = \log A,$$

$$\log(1+r) = b,$$

However, with the log-linear function, the estimate of 'b' is in semi-log terms. As a result, the following transformation is performed to return it to its original form of Yt:

Since,

$$B = \log(1+r)$$

$$\text{Antilog}(b) = 1+r$$

$$R = (\text{Antilog } b) - 1$$

$$\text{CGR in percentage} = [(\text{Antilog } b) - 1]*100$$

5. RESULTS AND DISCUSSION

5.1 Area, Output, and Yield Growth Rates in Total Pulses at the National Level

(Table 1) indicates that the area under total pulses increased from 22.78 million ha. to 26.21 million ha. In forty-eight years from 1971 to 2019 with a positive and non-significant growth rate indicating stagnation. Between 1971 and 2019, total pulse output rose from 10.42 million tons to 20.26 million tons. The total production increase was (1.8%) each year, which was mostly due to yield growth. (Table 1) shows that the highest rate of output increase occurred at the same time as the highest rate of area expansion, i.e., 1971-1980 (0) and 2011-19 (10.64%).

Table 1: Area, output, and yield growth rates in total pulses at the national level

Total Pulses	Particulars	Study period (1971-2019)	Sub-period				
			(1971-80)	(1981-90)	(1991-2000)	(2001-10)	(2011-19)
Area	Beginning year area (million ha)	22.78	22.78	23.84	22.54	22.01	24.52
	End year area (million ha)	26.21	22.47	24.67	20.36	22.56	26.21
	No. of observation	(48)	(10)	(10)	(10)	(10)	(9)
	Coefficient	0.04	0.07	0.03	-0.07	0.11	0.13
	R^2 (%)	3	9.1	0.5	21.5	49	52
	Growth rate	0.2	0.95	0.23	-1.37	2.6	3.6
Production	Beginning year production (million tonnes)	10.42	10.42	11.51	12.02	13.37	15.40
	End year production (million tonnes)	20.26	10.63	14.26	11.08	19.25	20.26
	No. of observation	(48)	(10)	(10)	(10)	(10)	(9)
	Coefficient	0.007*	0	0.015	0	0.035*	0.046
	R^2 (%)	53.7	0	27.3	0	77	46
	Growth rate	1.8	0	3.5	0	8.4	10.64
Yield	Beginning year yield (Kg/ha)	495	495	521	533	607	685
	End year yield (Kg/ha)	765	473	578	544	750	765
	No. of observation	(48)	(10)	(10)	(10)	(10)	(9)
	Coefficient	0.05*	-0.5	0.011**	0.7	0.23*	0.27
	R^2 (%)	61.3	2.3	41.2	8.3	75	53
	Growth rate	1.4	-1.1	3.28	1.6	5.7	7.5

Total pulse production by 1.4 % from 495 kg ha-1 to 765 kg ha-1 over the period studied (1991-2019). Between 2011 and 2019, yields grew at their highest rate (7.5%). (Table 1).

In 1971-80 and 2011-19, area and yield increased played a large role in productivity growth. Because agriculture and irrigation were prioritized in the first ten-year plan (1971-80), and large dam projects were prioritized in the second ten-year plan (1981-90), this good outcome happened between 1971 and 1980. It is possible to infer that throughout the post-green revolution era, particularly between 1971 and 2000, the expansion of pulse-growing regions was hampered by the diversification of cultivated lands away from pulses and toward other crops. Intensive and dynamic schemes (ISOPOM, A3P, NFSM) linked to pulses and price escalation resulted in a significant increase in area and productivity from 2001 to 2019.

5.2 At the National Level, the Rate of Increase in Area, Production, and Yield in Grams is as Follows

According to Table 2, the area under gram grew from 8.83 million hectares to 10 million ha in 48 years, with a ubstantial negative growth rate, from 1971 to 2019 (0.9%). In 1971-80, the greatest positive and substantial increase (6.3%) was recorded, followed by (9.7%) in 2011-19.

Between 1971 and 2019, gram output rose from 5.39 million tons to 10.53 million tons. The total performance of production increase was (1.7%) each year, which was mostly due to yield growth. The highest rate of output increase was recorded at the same era as the highest rate of area expansion, namely 1971-80 (14.5%) and 2011-19 (14.5%).

The gram production rose by 2.9 % from 498 kg ha-1 to 960 kg ha-1 over the period studied (1971-2019). Yields grew at their fastest rate (5.4%) from 1971 to 1980, then (6.7%) from 20011 to 2019.

In 1971-2019, yield increase was more important than area expansion in determining the pace of output growth. The bulk of chickpeas are produced on marginal soils and in rain-fed environments, this result is identical to that of Reddy and Mishra (2010), who found that yield contributed positively (0.7%) and area contributed negatively (-0.56%) to increase in chickpea production between 1971 and 2001. Intensive and dynamic schemes (ISOPOM, A3P, NFSM) linked to pulses and price escalation resulted in a significant increase in area and productivity from 2001 to 2019.

Table 2: At the national level, the area, output, and yield in grams are all increasing

Gram	Particulars	Study period (1971-2019)	Sub-period				
			(1971-80)	(1981-90)	(1991-2000)	(2001-10)	(2011-19)
Area	Beginning year area (million ha)	8.83	8.83	9.91	10.87	11.42	13.68
	End year area (million ha)	10.0	7.84	6.58	7.52	10.1	15.63
	No. of observation	(48)	(10)	(10)	(10)	(10)	(9)
	Coefficient	-0.03*	-0.27*	-0.7	-0.13	0.035*	0.052
	R^2 (%)	16.6	76.2	10	19.6	88.1	92.7
	Growth rate	0.9	6.3	1.8	-3.2	8.4	9.7
Production	Beginning year production (million tonnes)	5.39	5.39	6.47	7.48	5.47	8.45
	End year production (million tonnes)	10.53	7.2	5.33	6.36	9.55	10.53
	No. of observation	(48)	(10)	(10)	(10)	(10)	(9)
	Coefficient	0.5*	-0.6	-0.04	-0.05	0.55*	0.63
	R^2 (%)	16.2	2.3	1.4	1.1	85.8	88.02
	Growth rate	1.7	14.5	-1.8	-2.3	6.5	14.5
Yield	Beginning year yield (Kg/ha)	498	498	642	590	853	912
	End year yield (Kg/ha)	960	663	657	712	842	960
	No. of observation	(48)	(10)	(10)	(10)	(10)	(9)
	Coefficient	0.010*	0.024	0.003	0.009	0.05	0.012
	R^2 (%)	70.4	18.1	0.4	12.6	65	72
	Growth rate	2.9	6.2	5.4	2.2	4.7	6.7

([1]significant at 1% level and [2] significant at 5% level)

5.3 Pigeon Pea Area, Production, and Yield Growth Rates at the National Level

Table 3 shows that the area under pigeon pea grew by (2.7%) from 3.45 million hectares in 1971 to 4.1 million hectares in 2019. The years with the most favorable and substantial increase (3.9%) were 1971-1980 and 2011-19.

Table 3: Pigeon pea area, production, and yield growth rates at the national level

Pigeon pea	Particulars	Study period (1971-2019)	Sub-period				
			(1971-80)	(1981-90)	(1991-2000)	(2001-10)	(2011-19)
Area	Beginning year area (million ha)	3.45	3.45	2.46	2.37	3.55	4.34
	End year area (million ha)	4.1	2.44	2.67	2.85	3.64	4.1
	No. of observation	(48)	(10)	(10)	(10)	(10)	(9)
	Coefficient	0.9*	0.1	0.09*	0.16*	-0.02	0.18*
	R^2 (%)	88.7	0.7	66.6	75	4.7	56.7
	Growth rate	2.7	0.24	2.2	3.9	-0.47	3.9
Production	Beginning year production (million tonnes)	2.83	2.83	1.38	1.69	2.14	2.27
	End year production (million tonnes)	4.18	2.08	3.89	2.97	2.26	4.18

	No. of observation	(48)	(10)	(10)	(10)	(10)	(9)
	Coefficient	0.012*	0.007	0.032	0.018	0.012	0.039*
	R^2 (%)	65.7	0.5	26.1	15.1	5.1	62.1
	Growth rate	2.5	6.5	4.6	3.04	1.9	5.8
Yield	Beginning year yield (Kg/ha)	812	812	660	750	612	710
	End year yield (Kg/ha)	913	894	743	714	668	913
	No. of observation	(48)	(10)	(10)	(10)	(10)	(9)
	Coefficient	0	0.008	0.023	-0.007	0.05	0.09
	R^2 (%)	0.6	0.0	19.1	0.9	7.1	20
	Growth rate	0.0	0.52	7.7	5.03	2.9	2.7

([1]significant at 1% level and [2]significant at 5% level)

Pigeon pea output rose from 2.83 million tons to 4.18 million tons between 1971 and 2019. The total production growth was (2.5%) each year, which is mostly due to area expansion. In 1971-80 and 20011-19, the highest output growth rates were (6.5%) and (5.8%), respectively.
Pigeon pea production rose from 812 kg ha-1 to 913 kg ha-1 with a low growth rate during the given period (1971-2019).
It may be stated that pigeon pea is an important pulse crop that grew in popularity after the green revolution, with substantial increases in the area.

5.4 Rates of increase in area, output, and yieldin lentils at the national level

According to Table 4, the area under lentils grew from 0.87 million ha to 1.94 million ha in 48 years, from 1971 to 2019, with a positive (4.8%) growth rate. The years with the most favorable and substantial increase (6.4%) were 1971-80 and 1991-2000. In 20011-19, the lowest rate of area increase (0.4%) was recorded.
From 1971 to 2019, lentil output rose from 0.9 million to 2.02 million tons. The total performance of production increased by 8.4 % each year, which may be ascribed to area and yield growth. The highest and most significant rate of output increase (9.15%) was recorded in the period 1991-2000, as shown in the table.
Lentil output rose by (3.6%), from 581 kilograms per hectare in 1971 to 859 kilograms per hectare in 2019. Between 1981 and 1990, yields grew at their fastest rate (9.6%).

Table 4: Rates of increase in area, output, and yieldin lentils at the national level

Lentil	Particulars	Study period (1971-2019)	Sub-period				
			(1971-80)	(1981-90)	(1991-2000)	(2001-10)	(2011-19)
Area	Beginning year area (million ha)	0.87	0.87	1.13	1.33	1.70	1.89
	End year area (million ha)	1.94	0.97	2.19	2.46	2.34	1.94
	No. of observation	(48)	(10)	(10)	(10)	(10)	(9)
	Coefficient	0.046*	0.064	0.052*	0.057*	0.009	0.012
	R^2 (%)	96.1	35	95.5	85.2	0.9	0.11
	Growth rate	4.8	7.4	7.2	6.4	0.5	0.4
Production	Beginning year production (million tonnes)	0.9	1.2	0.5	0.9	1.42	1.54
	End year production (million tonnes)	2.02	0.52	0.95	1.09	1.06	2.02
	No. of observation	(48)	(10)	(10)	(10)	(10)	(9)
	Coefficient	0.032*	0.022	0.68	0.5**	0.7	0.09
	R^2 (%)	95.2	12.4	96.7	52.5	19.8	21.4
	Growth rate	8.4	5.0	20.29	9.15	3.6	5.7
Yield	Beginning year yield (Kg/ha)	581	581	529	694	697	712
	End year yield (Kg/ha)	859	518	747	719	796	859
	No. of observation	(48)	(10)	(10)	(10)	(10)	(9)
	Coefficient	0.18*	-0.09	0.42*	0.05	0.10	0.15
	R^2 (%)	74.8	9.3	89.1	0.8	14.3	15.1
	Growth rate	3.6	-1.7	9.6*	0.7	2.9	3.5

([1]significant at 1% level and [2]significant at 5% level)

5.5 At the National Level, the Acreage, Output, and Yield of Black Gram (Urad) are all Increasing

According to Table 5, the area under black gram has grown by 2.87 million hectares. 4.06 million hectares from 1971 to 2019, there was a 48-year period of positive growth (3.1%). In 1971-80, the greatest positive and substantial increase (9.6%) was recorded, followed by (6.9%) in 1981-90.

From 1971 to 2019, black gram output rose by 7.0 %, from 0.96 million tons to 2.7 million tons. The highest rate of output increase was (16.55%) in 1981-90, followed by (12.4%) in 1971-80. (Table 5).
Total pulse production rose by (3.8%) from 318 kg ha-1 to 596 kg ha-1 over the period studied (1971-2019). Between 1981 and 1990, yields grew at their fastest rate (8.1%).

Table 5: At the national level, the acreage, output, and yield of black gram (urad) are all increasing

Black gram	Particulars	Study period (1971-2019)	Sub-period (1971-80)	(1981-90)	(1991-2000)	(2001-10)	(2011-19)
Area	Beginning year area (million ha)	2.87	2.87	3.78	5.42	3.4	6.12
	End year area (million ha)	4.06	3.83	4.48	4.01	4.2	4.06
	No. of observation	(48)	(10)	(10)	(10)	(10)	(9)
	Coefficient	0.010*	0.69*	0.37*	-0.8	-0.7	0.13
	R^2 (%)	58	72.7	94.8	9.2	20.4	23.1
	Growth rate	3.1	9.6	6.9	-1.2	-2.9	3.2
Production	Beginning year production (million tonnes)	0.96	0.96	1.05	1.8	2.6	2.9
	End year production (million tonnes)	2.7	0.98	1.72	1.32	1.9	2.7
	No. of observation	(48)	(10)	(10)	(10)	(10)	(9)
	Coefficient	0.25*	0.53*	0.69*	-0.18	0.21	0.025
	R^2 (%)	76.5	79.2	96.1	20.6	25.4	27.8
	Growth rate	7.0	12.4	16.55	-3.7	5.7	6.7
Yield	Beginning year yield (Kg/ha)	318	318	396	485	496	514
	End year yield (Kg/ha)	596	350	485	475	548	596
	No. of observation	(48)	(10)	(10)	(10)	(10)	(9)
	Coefficient	0.014*	0.009	0.049*	-0.008	0.037*	0.068
	R^2 (%)	72	7.6	94	5.6	60.4	70.1
	Growth rate	3.8	1.8	8.1	-1.18	7.1	8.9

([1]significant at 1% level and [2]significant at 5% level)

1.6 At the National Level, the Acreage, Production, and Yield of Green Grams (Moong) are all Increasing

According to Table 6, the area under green gram has risen from 3.84 million hectares. 5.37 million hectares with a growth rate of (3.1%) from 1971 to 2019, in 1971-80, the greatest positive and substantial growth rate (9.24%) was recorded, followed by a negligible growth rate in 2011-19.

Green gram output rose by 4% each year from 1971 to 2019, from 0.78 million tons to 2.26 million tonnes. Between 1971 and 1980, the highest rate of output increase was recorded (15.46%).

Green gram production rose by (1.9%) from 352 kg ha-1 to 494 kg ha-1 over the period studied (1971-2019). Between 2011 and 2019, yields grew at their highest rate (7.8%). The yield increase was shown to be the driving force for production growth from 2011 to 2019.

Table 6: At the national level, the rate of increase in area, output, and yield in green grams

Green gram	Particulars	Study period (1971-2019)	Sub-period (1971-80)	(1981-90)	(1991-2000)	(2001-10)	(2011-19)
Area	Beginning year area (million ha)	3.84	3.84	4.45	5.12	6.09	7.25
	End year area (million ha)	5.37	3.84	4.36	4.01	4.63	5.37
	No. of observation	(48)	(10)	(10)	(10)	(10)	(9)
	Coefficient	0.012*	0.052*	0.030*	-0.009	0	0.019
	R^2 (%)	62.2	85.2	82.2	10	0	89.1
	Growth rate	3.1	9.24	6.2	-1.9	0	6.89
Production	Beginning year production (million tonnes)	0.78	0.78	2.06	2.38	1.11	3.17
	End year production (million tonnes)	2.26	0.11	2.38	2.03	1.70	2.26
	No. of observation	(48)	(10)	(10)	(10)	(10)	(9)
	Coefficient	0.018*	0.68**	0.39**	-0.32	0.35	0.042
	R^2 (%)	45	68	52.2	25.5	15.3	18.1
	Growth rate	4.0	15.46	8.4	-6.6	6.0	7.6
Yield	Beginning year yield (Kg/ha)	352	352	398	372	368	342
	End year yield (Kg/ha)	494	359	468	362	478	494
	No. of observation	(48)	(10)	(10)	(10)	(10)	(9)
	Coefficient	0.008**	0.025	0.009	-0.020	0.035	0.058
	R^2 (%)	14.4	28.2	6	18.1	20.5	22.1
	Growth rate	1.9	7.4	3.2	-4.06	6.9	7.8

6. CONCLUSION

Since post-independence, the area impact has been more significant than the yield effect in the decomposition study for total pulses, which explains why India is still lagging in terms of total pulse yield. By the decomposition analysis, it was estimated that the area was one of the important factors in the overall development of pulse production with a convincing and parallel yield contribution. The production of total pulses is still affected by the size of the region. At the national level, the largest area of variability was found at (14.5%) from 1971 to 2019. The Green gram (moong) had the most production (25.7%) and yield (21.96%) instability at the national level between 1971 and 2019. In total pulses, the minimum area (5.7%), production (12.4%), and yield (9.5%) variability were found from 1971 to 2019, revealing stagnancy in area and yield, resulting in stagnant production.

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