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Growth and instability in area, production and yield of major millets in Rajasthan

Shashank Sharma, Giridhari Lal Meena Latika Sharma, Hari Singh and RS Chaudhary

Abstract
The present study has been conducted to study the growth and instability in area, production and yield of major millets in Rajasthan state. The study has been conducted based on secondary data. The data was collected for the periods from 1970-71 to TE 2019-20 from various governmental publications. The compound growth rate and instability index are also calculated. The results of compound growth analysis show that growth was negatively significant in area of sorghum and pearl millet, positively significant in production of sorghum and pearl millet, positively significant in yield of sorghum and pearl millet. The results of instability indicated that variability in area and productivity of millets was lower than that production.

Keywords: Compound growth, instability, coefficient of variation, sorghum, pearl millet

Introduction
Millets are cultivated across India, covering around 15.48 million hectares, with a yield of 1111 kg/hectare and almost 11.5 million metric tonnes (Directorate of Economics and Statistics, Ministry of Agriculture, Cooperation and Farmers Welfare, GOI). Rajasthan, Maharashtra, and Karnataka are major millet producing states in India. Sorghum (4.73 MT), Pearl millet (10.28 MT) and Ragi (1.7MT), contribute to more than 88 per cent of total millet production in the country. The major share of millet is contributed by Rajasthan (45%) during the year 2019-20(Directorate of Economics and Statistics 2019- 20).
The millet grains contain substantially high amount of fat, fibre and minerals in comparison to cereals like wheat and rice. The protein content in millets like *Jowar* (10.4%), *bajra* (11.6%), proso millet (12.5%), foxtail millet (12.3%) and barnyard millet (11.6%) is comparable with wheat (11.8%) and much higher than rice (6.8%). Though the finger millet contains lesser protein (7.3%) but it is rich in mineral matter and calcium in comparison to wheat and rice. All the millets contain more fibre than fine cereals. Particularly, the small millets namely barnyard millet (14.7%), kodo millet (9%), little millet (8.6%) and foxtail millet (8.0%) are the richest in fibre in comparison to wheat (1.2%) and rice (0.2%). Therefore, millets are now being pronounced as "Miracle grains/ *Adbhut Anaj* and nutria-cereals".
Sorghum is growing probably due to the wide diversity of species in East Central Africa, Ethiopia and Sudan or other countries. In the India region, sorghum is grown mainly as a rainfed crop (92 per cent of the area) during both the rainy and autumn seasons (85 per cent of the production in Maharashtra, Karnataka and Andhra Pradesh, which are all warm and semi-arid, and have a large concentration of 85 per cent. Sorghum [*Sorghum bicolor* (L.) Moench] is the fifth most important cultivar worldwide. In developing countries in Asia and Africa, more than 70 per cent of the world's total production of sorghum is produced using water-limited and nutritious products.
Pearl millet's primary source is in Africa where it is distributed to India and others. Pearl millet (*Pennisetum typhoides*) naturally hybridizes with elephant grass (*Pennisetum purpureum*) of African provenance, also thought to be the common ancestor of both species. In India, Pakistan, China, and Southeast Asia, it is a significant crop of cereal. It is the most important millet in India, which even on poor soils and unfavourable climatic conditions thrive well. In the country's generally arid areas it offers the impoverished with basic food for a short time. Cereals and millets are the most drought-tolerant crop. It is mentioned in Ayurvedic texts as 'Nali' under Trunadhanya or Kudhanyavarga. Bajra grains comprise about 11.6 per cent, proteins, 5 per cent lipids, 67.5 per cent carbs and approx. 2.3 per cent minerals. Pearl millet

(Bajra) grains cooked like rice, or bajra flour like maize flour or sorghum like chapatis. Considering the importance of the millets crop, this study has been performed to estimate the growth and instability of millet crops in Rajasthan.

Materials and Methods

The state of Rajasthan comprises a substantial portion of India's millet production. Hence, the state of Rajasthan was purposefully chosen for this study**.** Sorghum and Bajra were chosen from among all millets produced in Rajasthan based on their share of total annual production. This study was conducted from 1970-71 to 2019-20 comprises of three periods that is Period-I (1970-71 to 1985-86), Period-II (1986-87 to 2010-11), and Period-III (2011-12 to 2019-20). The growth rate was examined using compound growth rate functions, and the instability was assessed using the coefficient of variation and the Cuddy Della Valle index.

Estimation of Growth Rate

Sorghum and Bajra compound annual growth rates (CAGRs) were estimated individually using an exponential equation.

$$Y = AB^{t} \quad \ldots\ldots\ldots\ldots\ldots\ldots (1.1)$$

$$\log Y = \log A + t \log B$$

Where,

Y =Area, production or yield of crops A = constant,

B = regression coefficient, T = time in years

Then, the compound growth rate (per cent per year) r = [(Antilog B) – 1] × 100

The significance of estimated coefficients was tested by using 't' test.

Where; Calculated 't'= b

Se(b)

b = Estimated coefficient of the model

Se(b) = Standard error of the estimated coefficient

Measurement of Instability

The coefficient of variation (CV), as well as the Cuddy Della Valle Index (CDVI), were used to investigate the variability in the area, production, and productivity of millets. The coefficient of variation (CV) was calculated by using the following formula, Instability Index:

CV = SD÷AM × 100

CV is Coefficient of variation

SD is Standard deviation

AM is Arithmetic mean

The instability index of Cuddy-Della Valle Index is given by the expression. CDVI = CV $\sqrt{}$ (1 – R2)

Where,

CV=Coefficient of variation (in%)

R2 = Coefficient of determination calculated by time trend regression and adjusted by the number of degrees of freedom.

Result and Discussion

Growth rate in area of Sorghum

The compound growth of area under sorghum cultivation in Period-I, Period-II, Period III and overall period has been estimated and presented in Table 1 and Figure 1. Total area allocated by the farmers under sorghum cultivation in the state was decreased from 1179 thousand hectares to 983 thousand hectares during Period-I, from 1006 thousand hectares to 726.90 thousand hectares in period-II but in period-III, it was increased from 553.80 thousand hectares to 642.84 thousand hectares. The growth analysis indicates that sorghum area was decreased with a compound growth rate of 0.06 per cent during Period-I, 0.75 per cent in period-II and 0.81 per cent in period-III and 0.52 per cent in overall period. The negative growth was observed in area of Sorghum, which is consistent with the findings of Naik and Thimappa (2001) [1] and Shende *et. al.* (2013) [3].

Table 1: Compound growth trend in area of sorghum

Particulars	Period of study			
	First (1970-71 to 1985-86)	Second (1986-87 to 2010-11)	Third (2011-12 to 2019-20)	Overall (1970-71 to 2019-20)
Area in beginning year ('000 Hectares)	1179.00	1006.00	553.80	1179.00
Area in ending year ('000 Hectares)	983.00	726.90	642.84	642.84
No. of observation	16	25	9	50
CAGR (%)	-0.06	-0.75*	-0.81**	-0.52*

* Significant at 1% level of significance ** Significant at 5% level of significance

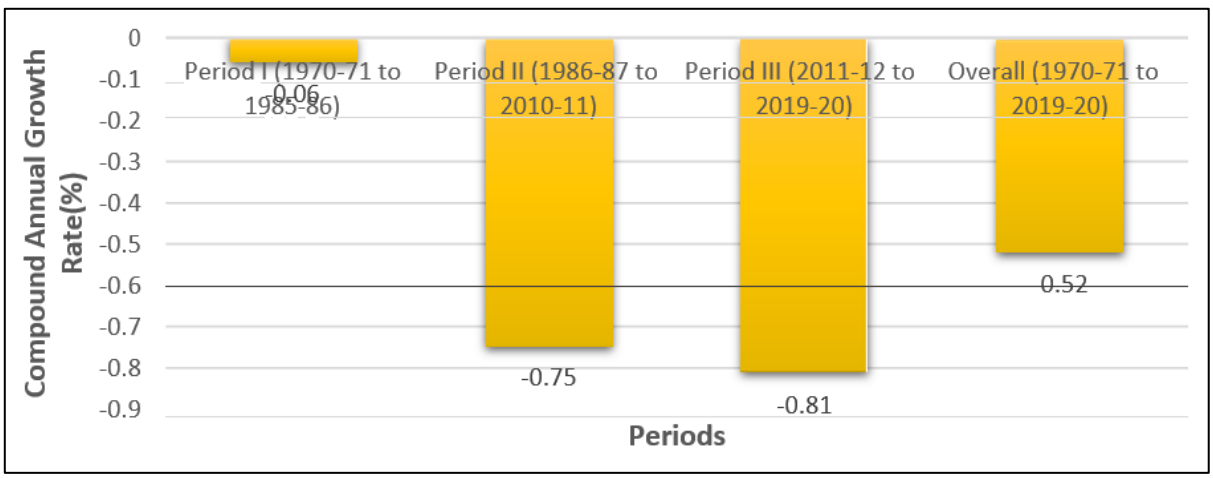

Fig 1: Compound Growth in Area of Sorghum

Growth rate in production of sorghum

The production analysis of the sorghum is given in Table 2 and Figure 2. In 1970-71, total sorghum production was 573 thousand tonnes and it was decreased to the level of 375 thousand tonnes by the year 1985-86. It was 239 thousand tonnes in year 1986-87 and increased to 508.90 thousand tonnes in 2010-11 and slight increase from 410.10 thousand tonnes in year.

2011-12 to 455.77 thousand tonnes in year 2019-20. The growth analysis indicates that sorghum production was increased with a compound growth rate of 1.00 per cent during period-I and decreased with compound growth rate of 0.32 per cent in period-II and 0.56 per cent in period- III and in overall period, it was declined with a compound growth rate of 0.03 per cent. The negative growth was observed in production of Sorghum, which is consistent with the findings of Naik and Thimappa (2001) [1] where growth rate of production of pulses in nineties was lower as compared to eighties due to the negative growth rate.

Table 2: Compound growth trend in production of sorghum

Particulars	Period of study			
	First (1970-71 to 1985-86)	Second (1986-87 to 2010-11)	Third (2011-12 to 2019-20)	Overall (1970-71 to 2019-20)
Production in beginning year (‘000 tonnes)	573.00	239.00	410.10	573.00
Production in ending year (‘000 tonnes)	375.00	508.90	455.77	455.77
No. of observation	16	25	9	50
CAGR (%)	1.00*	-0.32*	-0.56*	0.03*

Significant at 1% level of significance

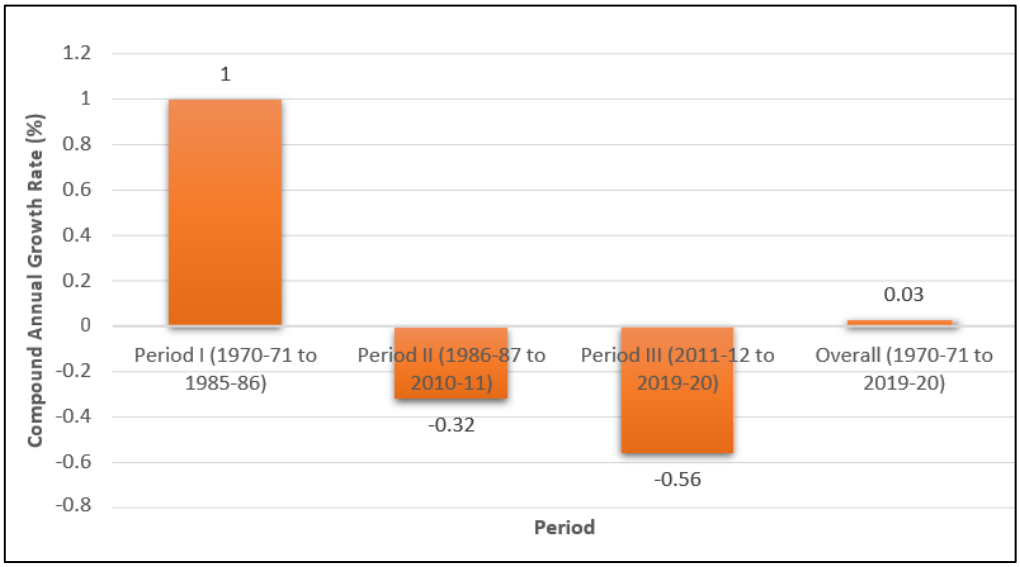

Fig 2: Compound Growth in Production of Sorghum

Growth rate in yield of sorghum

Per hectare yield of sorghum given in Table 3 and Figure 3 showed that it was decreased from 486.00 to 381.00 kg per hectare during 1970-71 to 1985-86 of period-I, in period-II, there is increment of 237.00 kg per hectare to 700.00 kg per hectare and in period III there is slight decrease from 741.00 kg per hectare to 709.00 kg per hectare. Finally, it was increased from

486.00 kg per hectare to 709.00 kg per hectare during overall period. The growth analysis of yield revealed that it was increased with a compound growth rate of 1.07 per cent during period- I, 0.47 per cent in period-II, and 0.21 per cent in period-III of study and 0.57 per cent in overall period.

Table 3: Compound growth trend in yield of sorghum

Particulars	First (1970-71 to 1985-86)	Secon (1986-87 to 2010-11)	Period of study dThird (2011-12 to 2019-20)	Overall (1970-71 to 2019-20)
Yield in beginning year (kg/hectare)	486.00	237.00	741.00	486.00
Yield in ending year (kg/hectare)	381.00	700.00	709.00	709.00
No. of observation	16	25	9	50
CAGR (%)	1.07**	0.47	0.21	0.57**

** Significant at 5% level of significance

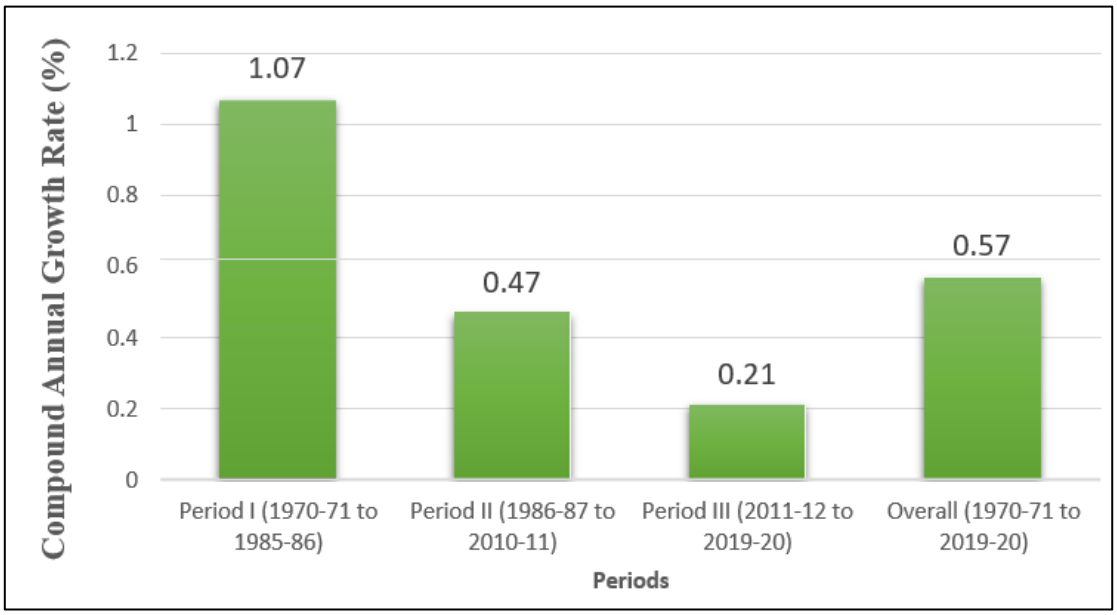

Fig 3: Compound Growth in Yield of Sorghum

Growth rate in area of pearl millet

The compound growth of area under pearl millet cultivation in Period-I, Period-II and Period III is presented in Table 4 and Figure 4. Total area allocated by the farmers under pearl millet cultivation in the state was decreased from 5127.00 thousand hectares to 4769.00 thousand hectares during 1970-71 to 1985-86, it was increased from 3945.20 thousand hectares to 5488.70 thousand hectares in period-II that is 1986-87 to 2010-11 but in period-III it was again decreased from 5019.90 thousand hectares to 4287.17 thousand hectares. The growth analysis indicates that it was decreased with a compound growth rate of 0.06 per cent during period-I, 0.28 per cent in period III and 0.02 per cent in overall period while it was found to be increase with 0.09 per cent in period-II. In this study, the negative growth in overall period was observed in area of Pearl millet. The negative growth in overall period was observed in area of Pearl millet, which is consistent with the findings of Naik and Thimappa (2001) [1] and Shende *et. al.* (2013) [3].

Table 4: Compound growth trend in area of Pearl millet

Particulars (1970-71 to 1985-86)	Period of study First	Second (1986-87 to 2010-11)	Third (2011-12 to 2019-20)	Overall (1970-71 to2019-20)
Area in beginning year (‘000 Hectares)	5127.00	3945.20	5019.90	5127.00
Area in ending year (‘000 Hectares)	4769.00	5488.70	4287.17	4287.17
No. of observation	16	25	9	50
CAGR (%)	-0.05*	0.09*	-0.27*	-0.02*

* Significant at 1% level of significance

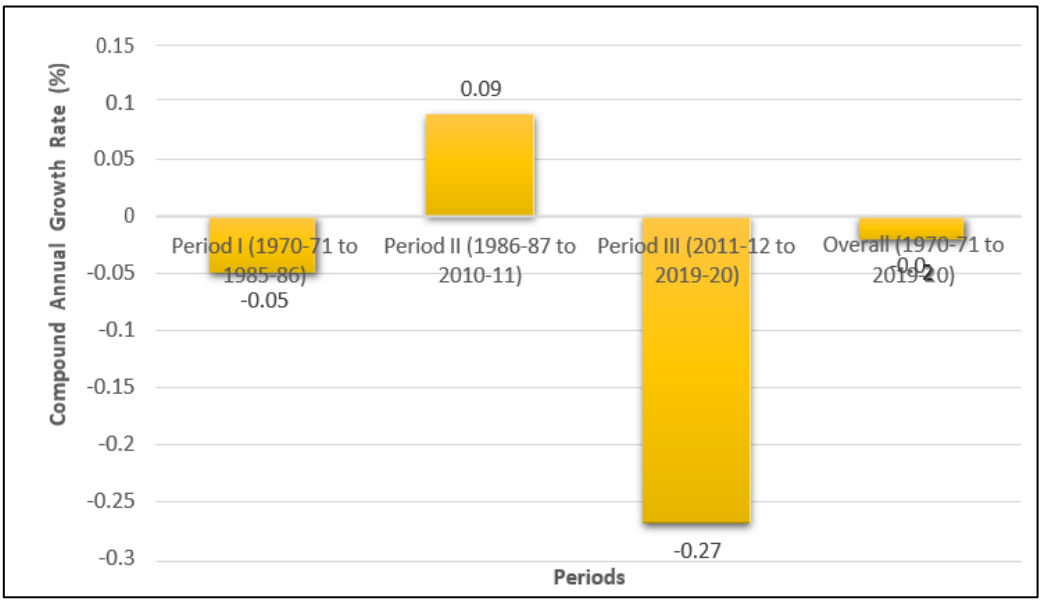

Fig 4: Compound Growth in Area of Pearl millet

Growth rate in production of Pearl millet

The production analysis of the pearl millet is given in Table 5 and Figure 5. In 1970-71, total pearl millet production was 2674.00 thousand tonnes and it was decreased to the level of 731.00 thousand tonnes by the year 1985-86. It was 1015.00 thousand tonnes in year 1986-87 and increased to 4566.60 thousand tonnes in 2010-11 of period II and slight increase in period.

III that is from 4593.20 thousand tonnes to 4685.88 thousand tonnes from year 2011-12 to 2019-20. The growth analysis revealed that it was increased with a compound growth rate of 0.16 per cent during period-I, 1.78 per cent in period-II and 1.48 per cent in overall period while it was decreased with 0.06 per cent during period III.

Table 5: Compound growth trend in production of Pearl millet

	Period of study			
(1970-71 to 1985-86)		**(1986-87 to 2010-11)**	**(2011-12 to 2019-20)**	**(1970-71 to 2019-20)**
Production in beginning year (‘000 tonnes)	2674.00	1015.00	4593.20	2674.00
Production in ending year (‘000 tonnes)	731.00	4566.60	4685.88	4685.88
No. of observation	16	25	9	50
CAGR (%)	0.16	1.78**	-0.06	1.48*

*Significant at 1% level of significance ** Significant at 5% level of significance

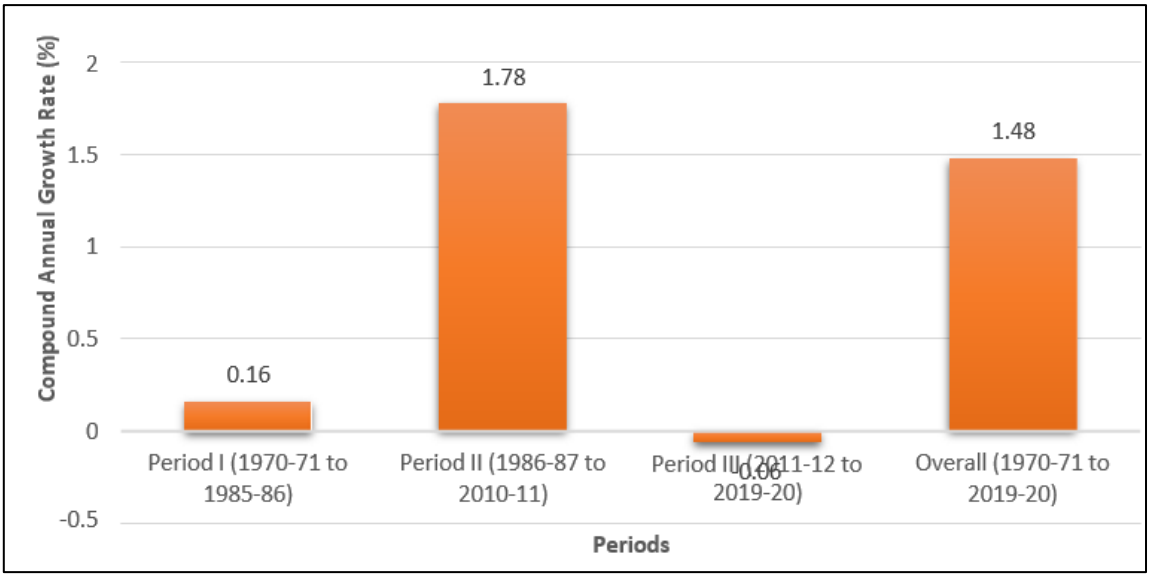

Fig 5: Compound Growth in Production of Pearl millet

Growth rate in yield of Pearl millet

Analysis of yield of pearl millet is presented in Table 6 and Figure 6 showed that it was decreased from 521.00 to 153.00 kg per hectare during 1970-71 to 1985-86 of period-I. In period- II, there is increment of 192.00 kg per hectare to 832.00 per hectare and in period-III there is increase in yield that is from 915.00 kg per hectare to 1093.00 kg per hectare.

The growth analysis of yield indicates that it was increasing with a compound growth rate of 0.26 per cent during period-I, 1.72 per cent in period-II and 0.19 per cent in period-III and 1.52 per cent in overall period. The per hectare yield of pearl millet was observed to be significantly increased during overall period only. These findings were similar to results observed by Swain and Bhakar (2006) [4].

Table 6: Compound growth trend in yield of Pearl millet

	First	**Period of study**		**Overall**
		Second	**Third**	
Particulars	**(1970-71 to 1985-86)**	**(1986-87 to 2010-11)**	**(2011-12 to 2019-20)**	**(1970-71 to 2019-20)**
Yield in beginning year (kg/hectare)	521.00	192.00	915.00	521.00
Yield in ending year (kg/hectare)	153.00	832.00	1093.00	1093.00
No. of observation	16	25	9	50
CAGR (%)	0.26	1.72**	0.18	1.52**

** Significant at 5% level of significance

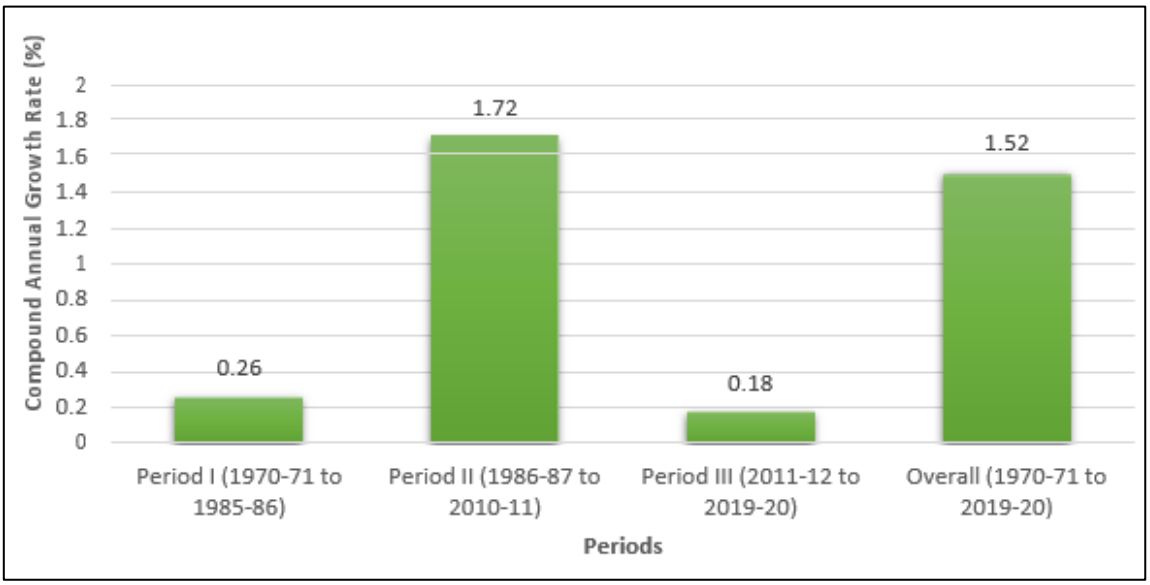

Fig 6: Compound Growth in Yield of Pearl millet

Instability in Area, Production and Yield of Sorghum

Table 7 and Figure 7 and 8 represents instability in terms of coefficient of variation and Cuddy Della Valle index of area, production and yield of Sorghum. The results showing that instability in area in terms of CDI values were more in Period-I that is 15.83 per cent than Period- II (11.11%) and Period III (8.37%) and 4.08 per cent in overall period. The highest variability in production in terms of CDI that is 53.44 per cent in Period-II followed by Period-I (25.50%) and Period-III (22.80%) with 41.41 per cent instability in overall period. Instability in yield reveals that highest variability of yield in terms of CDI that is 46.46 per cent in Period-II followed by Period-I (19.66%) and Period-III (15.06%) with 29.43 per cent instability in overall period. Instability in area in terms of coefficient of variation values were more in Period-II that is 21.43 per cent than Period-I (14.01%) and Period III (9.16%) and 23.48 per cent in overall period. The highest variability in production in terms of coefficient of variation that is 49.79 per cent in Period-II followed by Period-I (32.79%) and Period-III (16.88%) with 39.72 per cent instability in overall period. Instability in yield reveals that highest variability of yield in terms of coefficient of variation that is 43.54 per cent in Period-II followed by Period-I (26.21%) and Period-III
(14.48%) with 39.88 per cent instability in overall period. It can be concluded that production of Sorghum was more instable in comparison to yield and area in Rajasthan during all sub periods and overall period, which consistent with the findings of Wankhede *et. al.* (2009) [5] and Sharma (2012) [2].

Table 7: Instability in Area, Production and Yield of Sorghum.

(in per cent)

Particulars	Period I		Period II		Period III		Overall Period	
	CV	CDI	CV	CDI	CV	CDI	CV	CDI
Area	14.01	15.83	21.43	11.11	9.16	8.37	23.48	4.08
Production	32.79	25.5	49.79	53.44	16.88	22.80	39.72	41.41
Yield	26.21	19.66	43.54	46.46	14.48	15.06	39.88	29.43

CV=Coefficient of variation, CDI=Cuddy Della Valle Index, Period I =1970-71 to 1985-86, Period II =1986-87 to 2010-11 and Period III = 2011-12 to 2019-20

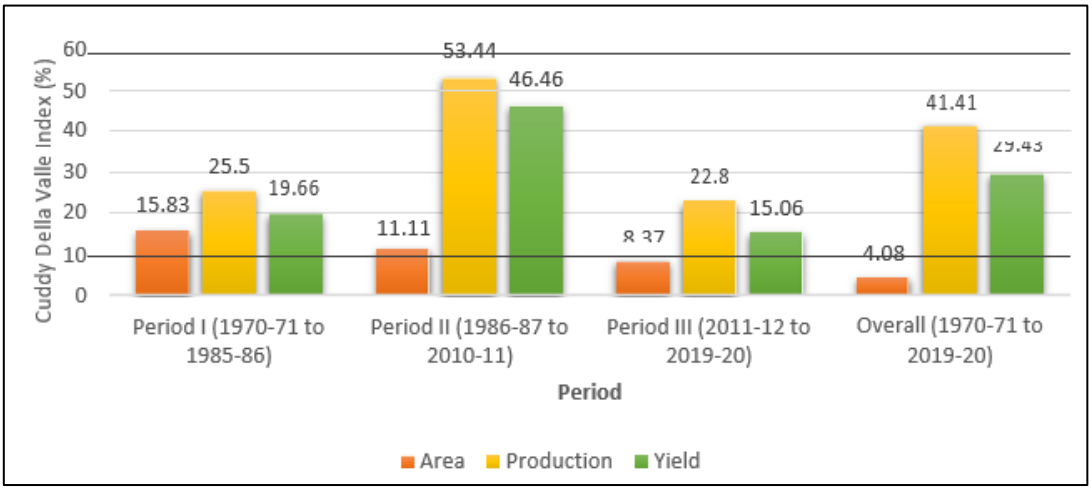

Fig 7: Instability based on Cuddy Della Valle Index in Area, Production and Yield of Sorghum

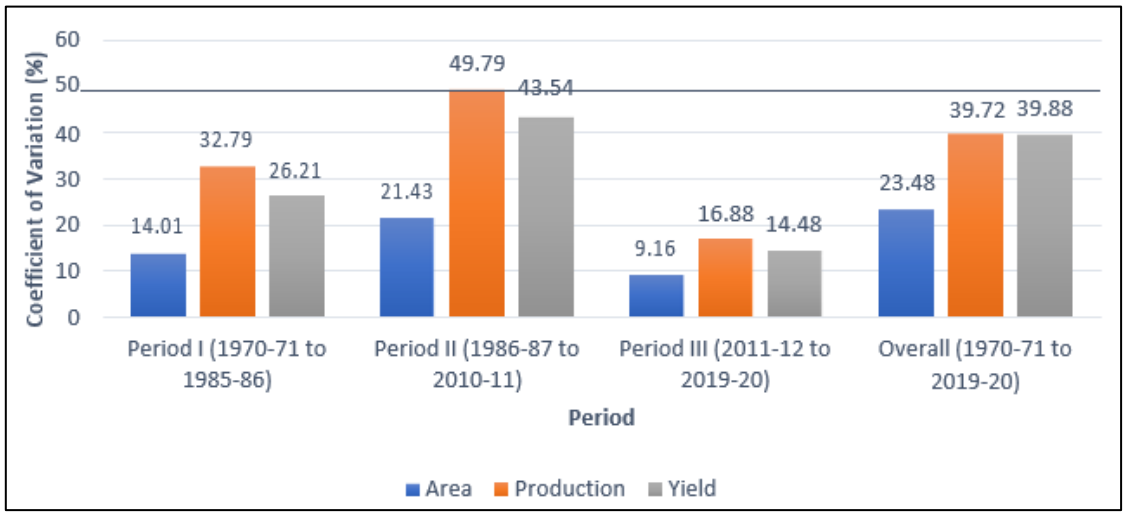

Fig 8: Instability based On Coefficient of Variation in Area, Production and Yield of Sorghum

Instability in Area, Production and Yield of Pearl millet Table 8 and Figure 9 and 10 represents instability in terms coefficient of variation and Cuddy Della Valle index of area, production and yield of Sorghum. The observations showing that instability in area in terms of CDI values were more in Period-I that is 14.43 per cent than Period-II (14.01%) and Period III (8.54%) and It was 12.68 per cent in Overall period. Instability in production reveals that highest variability in production in terms of CDI that is 60.38 per cent in Period-I followed by Period-II (33.96%) and Period-III (13.77%). The Overall period accounted for 16.87 per cent instability. Instability in yield reveals that highest variability of yield in terms of CDI that is 54.37 per cent in Period-I followed by Period-II (24.76%) and Period-III (14.00%). The overall period accounted for 11.47 per cent instability. Instability in area in terms of coefficient of variation values were more in Period-II that is 14.47 per cent than Period-I (12.44%) and Period III (7.34%) and 12.50 per cent in overall period. The highest variability in production in terms of coefficient of variation that is 57.72 per cent in Period-II followed by Period-I (52.73%) and Period-III (12.28%) with 60.77 per cent instability in overall period. Instability in yield reveals that highest variability of yield in terms of coefficient of variation that is 48.85 per cent in Period-II followed by Period-I (47.58%) and Period-III (11.47%) with 58.98 per cent instability in overall period. It can be concluded that production of Pearl millet is more instable in comparison to yield and area in Rajasthan during all sub periods and overall period.

Table 8: Instability in Area, Production and Yield of Pearl millet (In Per cent)

Particulars	Period I		Period II		Period III		Overall Period	
	CV	CDI	CV	CDI	CV	CDI	CV	CDI
Area	12.44	14.43	14.47	14.01	7.34	8.54	12.50	12.68
Production	52.73	60.38	57.72	33.96	12.28	13.77	60.77	16.87
Yield	47.58	54.37	48.85	24.76	11.47	14.00	58.98	11.47

CV=Coefficient of variation, CDI=Cuddy Della Valle Index, Period I =1970-71 to 1985-86, Period II =1986-87 to 2010-11) and Period III = 2011-12 to 2019-20

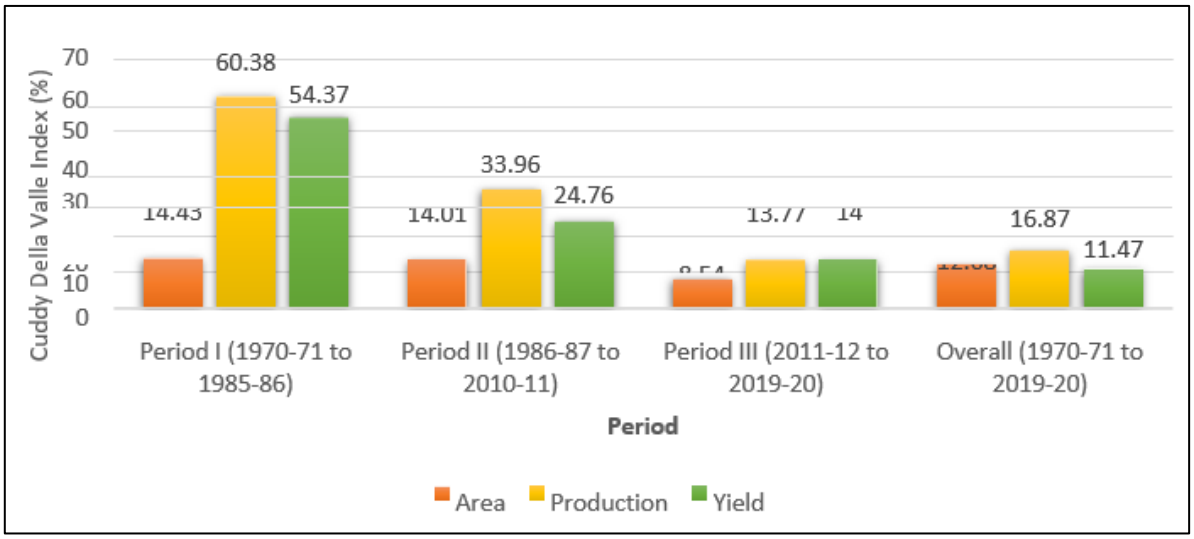

Fig 9: Instability based on Cuddy Della Valle Index in Area, Production and Yield of Pearl millet

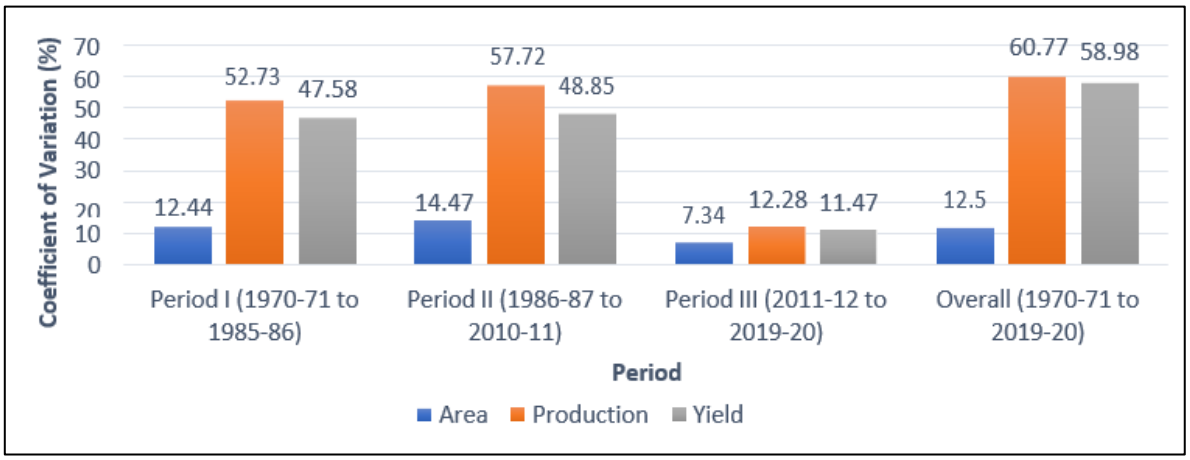

Fig 10: Instability based on Coefficient of Variation in Area, Production And Yield of Pearl millet

Conclusion and Policy Implications

The growth analysis suggests that area under millets cultivation in Rajasthan states was shrinking over the period of time. The compound growth in area, production and productivity of bajra was comparatively much higher than that of sorghum. The results of instability indicated that variability in area and productivity of millets was lower than that production which signifies that millets production in the state of Rajasthan was chiefly dependent on the area allocated by the farmers under sorghum crop and its productivity. But still the magnitude of instability in area, production and productivity of pearl millet is more pronounced in comparison to sorghum, which is a matter of serious concern as well as more risk in growing pearl millet crop in future too. Hence, the study points out to the significant policy interventions to maintain the stability of millets along with production in the wake of its increasing nutritional and commercial value in suiting to the fragile environmental conditions.

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