Research Paper

Growth Performance and Instability of Pearl Millet in Gujarat vis-à-vis India

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ABSTRACT

Pearl millet is one of the most important cereal in the world especially in Asia and African regions. In India, it is the fourth most widely cultivated food crop after rice, wheat and maize. Pearl millet crop was selected for the study. The period of study was from 1999-2000 to 2018-2019 and analysis was carried out using Compound Growth Rate and Coppock's Instability Index. From the analysis of compound growth rate, over the period of 20 years from 1999-2000 to 2018-19 it could be found that all the regions showed negative growth with respect to area parameter of Pearl millet. The production growth rate was observed positive in North Gujarat and Central Gujarat and negative growth in Saurashtra and South Gujarat region. In productivity of Pearl millet, the growth rate was observed positive in all the regions of Gujarat including Gujarat and India as whole. The growth-instability tradeoffs revealed the presence of 'desirable' (High Growth - High Instability) situation in terms of yield while area and production components showed not desirable situation, respectively in Pearl millet crop. The growth pattern is found to be acceleration with area and production parameter in all the regions of Gujarat, Gujarat and India as whole except Saurashtra region which showed stagnation type of growth pattern from 1999-2000 to 2018-19. In respect of productivity stagnation type of growth pattern in North Gujarat, Saurashtra, Gujarat and India as whole while Central Gujarat and South Gujarat region depicted acceleration type of growth pattern for the period of 20 years.

HIGHLIGHTS

◉ In case of area and production of pearl millet, all the regions showed negative growth and positive growth respectively.

◉ Growth-Instability tradeoffs revealed the presence of 'desirable' (High Growth - High Instability) situation in terms of yield while area and production components showed not desirable situation.

◉ Growth pattern is found to be in acceleration with area and production parameters in all the regions of Gujarat, Gujarat and India as whole except Saurashtra region.

Keywords: Pearl Millet, Compound Growth Rate, Coppock's Instability Index, Growth-Instability tradeoff

Pearl millet is one of the most important cereal in the world especially in Asia and African regions. It is one of the cereal crop that can be grown in semi-arid tropical environments and is also suited for drought regions. It is valued for both grain and stover: its grain is a main supply of nutritional carbohydrates in the human diet in western India and its stover forms the basis of cattle rations at some stage in the dry period of the year in northern Indian states. In India, pearl millet is the fourth most widely cultivated food crop after rice, wheat and maize. During the year 2019-2020, it was grown in an area of 7543 ha with 10,363 tonnes production and productivity of 1374 kg/ha (Ministry of Agriculture & Farmers Welfare, Govt. of India). States like

Rajasthan, Maharashtra, Gujarat, Uttar Pradesh and Haryana are the major states growing pearl millet with around 90 per cent acreage in the country. In states of Gujarat, Rajasthan and Uttar Pradesh, the crop is grown mainly in summer season (February-May). Maharashtra and Gujarat produces in small scale during (rabi) season (November- February). Among millets, pearl millet is the future crop which didn't receive much attention by the policy makers even though it has better adaptability to dry, marginal lines and can withstand extremely unfavourable weather.

Pearl millet production is concentrated in the developing countries which account for over 95 per cent of the production and acreage. India continues to be the single largest producer of pearl millet in the world, although the area has been declining in the traditional growing states of Gujarat, Rajasthan and Haryana. Exports and imports of pearl millet grain are negligible suggesting low demand, and/ or unreliable availability of marketable surpluses for this commodity in world markets.

Gujarat accounts for 5.64 per cent area and 9.80 per cent production under Pearl millet in India in the year 2015-16. The average yield of pearl millet in Gujarat is 20.04 qtl/ha which is almost double as compared to India, *i.e.*, 11.54 qtl/ha. The average yield of pearl millet in Gujarat has increased at the growth rate of 5.29 per cent while it has increased by 4.08 per cent in India over the last ten years *i.e.*, from 2005-06 to 2015-16 (Directorate of Economics & Statistics).

As day moves people are becoming more aware of their health and in country like India, where there is high incidence of diabetes, millets being complex carbohydrates with low GI [glycemic index], are indeed wonder grains and hence there is huge relevance in shifting consumers to millet and millet based products. In this context, it is necessary to evaluate the past scenario and present performance of area, production and yield of pearl millet in major growing states of India that is particularly in Gujarat and as a whole in India.

Objectives

1. To compute growth rate and growth pattern of Pearl millet in Gujarat and India

2. To estimate instability indices of Pearl millet and to work out their corresponding growth-instability trade-offs

MATERIALS AND METHODS

The study was conducted using secondary data from the year 1999-2000 to 2018-19. The study was carried on four regions of Gujarat, Gujarat and India as a whole.

The study was totally based on secondary data, which was collected from the following sources:

(i) Directorate of Agriculture, Department of Agriculture, Farmers' Welfare & Cooperation, Government of Gujarat;

(ii) Directorate of Economics and Statistics, Ministry of Agriculture and Farmers' Welfare, Government of India.

(iii) www.indiastat.com

(iv) https://aps.dac.gov.in/ Ministry of Agriculture and Farmers' Welfare, Government of India.

Growth rate

In the present study, compound growth rates were estimated using exponential model as given below:

$$Y_t = ab^t u_t \qquad \qquad ...(1)$$

Taking log on both the sides will transform the equation (1) as:

$$log\,(Y_t) = log\,a + t\,log\,b + log\,u_t \qquad ... (2)$$

Where,

$log\,(Y_t)$ = Log of time series data of area, production and yield of pearl millet,

log a = Constant term,

t = Time trend,

$log\,u_t$ = Error term with usual OLS assumptions, and

log b = Regression coefficient to be estimated by OLS technique.

Subsequently, compound growth rate (%) was calculated using following equation:

Compound Growth Rate (%) = [(*Antilog of* (*log b*–1)] *100 ...(3)

Where,

$\hat{g}$ = Compound growth rate in percentage per annum,

$\hat{b}$ = Antilog of log $\hat{b}$

log $\hat{b}$ = Estimated value of log b

The standard error of the growth rate $Se(\hat{g})$ was subsequently estimated by:

$$Se(\hat{g}) =$$

$$\frac{\log \hat{b}}{\log_{10}^{e}} \sqrt{\frac{\left[\sum(\log Y)^2 - (\sum \log Y)^2/N\right] - \left[\sum t^2 - (\sum t)^2/N\right](\log \hat{b})^2}{(N-2)\left[\sum t^2 - (\sum t)^2/N\right]}}$$

log_{10}^{e} = 0.4343

N = Number of observations; and

Other terms in the standard error specification have their usual meanings as already discussed.

Growth pattern

In order to estimate the pattern of growth and to determine whether there is acceleration, deceleration or stagnation in pearl millet production in the study area, quadratic equation in time trend variable was fitted as follows:

$$Log\ Y_t = \beta_o + \beta_1 t_i + \beta_2 t_i^2 + U_t \qquad \ldots (4)$$

All variables are same as defined in equation (2), wherein β_0, β_1 and β_2 are parameters to be estimated. In determining the pattern of growth, the main concern is on β_2 (i.e. coefficient of t_i^2) which reveals a measure of the growth pattern suggested.

Thereby,

If $\beta_2 > 0$, then there is acceleration in growth,

If $\beta_2 < 0$, then there is deceleration in growth,

If β_2 is positive or negative refers to stagnation.

Coefficient of Variation (CV)

It is the popular measure in instability. It is defined as;

$$CV = \frac{\left[\frac{1}{N-1}S(X_t - \overline{X})^2\right]^{1/2}}{\overline{X}} \times 100$$

Where,

N = Numbers of years

X_t = Area/production/productivity in the year 't'

$\overline{X}$ = Mean of Area/ production/productivity

S = Standard deviation.

Coppock's Instability Index

Instability or variability is an inherent characteristic of agriculture everywhere. Being dependent on weather conditions, the area, yield and production of crops are liable to substantial changes from year to year. There are several measures of instability such as coefficient of variation, Cuddy Della Valle Index and Coppock's Instability Index (CII). Among them, CII was employed in the present study since it is a close approximation of the average year to year percentage variation adjusted for trend (Coppock, 1962). CII is also called as log variance method and it is expressed algebraically in the following form:

$$CII = (Antilog\ \sqrt{log\ V} - 1) *100) \qquad \ldots (5)$$

Wherein, V log was obtained using the following formula:

$$V = \frac{1}{N}\sum_{t=1}^{n-1}\left(\log\left(\frac{X_{t+1}}{X_t}\right) - m\right)^2 \qquad \ldots (6)$$

And the arithmetic mean, 'm' is given by

$$m = \frac{1}{N-1}\sum\left[\log\frac{X_{t+1}}{X_t}\right] \qquad \ldots (7)$$

Where,

X_t = Demand and supply indicators in time period t;

N = Number of years in the series;

m = Mean of the difference between logs of X_{t+1}, X_t and

$log\ V$ = Logarithmic variance of the series.

Growth - instability trade-off

The analysis was carried out for the overall period and divided in to the categories with most desirable to not desirable as given below (Rao and Raju, 2005).

1. **High Growth-Low Instability (HG-LI):** The variables with growth rate higher than the critical point and the instability level

lower than the critical point *(Most Desirable Indicator)*;

2. **High Growth-High Instability (HG-HI):** The variables with growth rate higher than the critical point and the instability level greater than the critical point *(Desirable Indicator)*;

3. **Low Growth-Low Instability (LG-LI):** The variables with growth rate lower than the critical point and the instability level lower than the critical point *(least Desirable Indicator)*;

4. **Low Growth-High Instability (LG-HI):** The variables with growth rate lower than the critical point and the instability level higher than the critical point *(Not Desirable Indicator).*

RESULTS AND DISCUSSION

In this study an attempt has been made to measure the compound annual growth rate of area, production and productivity of pearl millet in different regions of Gujarat, Gujarat state as well as India as a whole. The growth rates were worked out for the period of twenty years from 1999-2000 to 2018-19.

Region wise growth dimensions of pearl millet in Gujarat vs India

In 1999-2000, Gujarat produced 8506 tonnes of pearl millet over an area of 9262 ha with the productivity of 918 kg/ha. Whereas in 2018-19, the production was 8926.22 tonnes of pearl millet over an area of 3915.75 ha with the productivity of 2279.57 kg/ha. Without much variation, the production of the crop has increased over the period of time within the precised area and yield also increased significantly.

Among different regions of Gujarat, North Gujarat has shown a significant increase in area, production and yield of pearl millet, followed by Saurashtra, Central and South Gujarat region. In North Gujarat, the area under pearl millet showed decreasing trend with 4060 ha of acreage in 1999-2000 to 2502.01 ha of acreage in 2018-19. And in Saurashtra it was found that area under the crop has decreased from 3414 ha in 1999-2000 to 558.37 ha in 2018-19. Central Gujarat was also showing declining trend of area with 1759 ha during 1999-2000 to 851.16 ha in 2018-19. South Gujarat had least area under pearl millet when compared with other three regions of

Gujarat, with 29 ha of acreage in 1999-2000 to 4.22 ha of acreage in 2018-19.

Similarly, the production and yield of pearl millet showed increasing trend in all the regions of Gujarat from 1999-2000 to 2018-19. The production and yield showed an increasing trend in North Gujarat with 5473.45 tonnes and 2187.62 kg/ha in 2018-19 from 3334 tonnes and 821 kg/ha in 1999-2000, followed by Saurashtra region with an increasing trend of 1049.8 tonnes and 1880.11 kg/ha in 2018-19 from 2377 tonnes and 696 kg/ha in 1999-2000. Central Gujarat showed 2247.01 tonnes of production and 2639.93 kg/ha of yield in 2018-19 which was higher than that of production and yield during 1999-2000, *i.e.* 2770 tonnes and 1574 kg/ha. While South Gujarat also showed increasing pattern with production of 11.89 tonnes and yield 2817.53 kg/ha in 2018-19 compared to 25 tonnes and 862 kg/ha in 1999-2000.

The trend in area, production and yield of pearl millet in India as whole varied over the study period. As per the latest data available in 2018-19, India produced 8.61 million tonnes of pearl millet from an area of 6.93 million ha with the productivity of 1243 kg/ha. While it was much less during 1999-2000 with 5.71 million tonnes of production under 8.9 million ha of acreage with the productivity of 650 kg/ha.

Table 1: Region wise growth dimensions of pearl millet in Gujarat Vs India from 1999-2000 to 2018-19

Sl. No.	Region	Area		Production		Yield	
		SD	Mean	SD	Mean	SD	Mean
1	North Gujarat	1236	4227	1673	5662	580	1456
2	Saurashtra	1006	1681	1267	2570	505	1732
3	Central Gujarat	351.5	1576	716.3	2737	429.1	1781
4	South Gujarat	15.76	27.40	25.11	42.18	583.1	1706
5	Gujarat	2324	7512	2579	10987	506.7	1586
6	India	1.100	8.598	1.701	8.524	223.8	1004

Note: 1. Gujarat: area in ha, production in tonnes and yield in kg/ha; 2. India: area in mha, production in mt and yield in kg/ha.

The mean and standard deviation (S.D) of area, production and yield of pearl millet in overall Gujarat along with four regions and India as whole is given in Table 1. It can be observed that among different regions of Gujarat, mean of total North Gujarat in terms of area, production and yield was

4227 ha, 5662 tonnes and 1456 kg/ha, followed by Saurashtra with total mean value as 1681 ha, 2570 tonnes and 1732 kg/ha, Central Gujarat showed total mean value as 1576 ha, 2737 tonnes and 1781 kg/ha, While South Gujarat recorded mean value as 27.40 ha, 42.18 tonnes and 1706 kg/ha, respectively.

As we can see that the mean of total Gujarat in terms of area, production and yield was significantly high with values 7512 ha, 10987 tonnes and yield of 1586 kg/ha whereas India as whole recorded total mean with values as 8.598 million ha of area, 8.524 million tonnes of production and yield 1004 kg/ha.

Spatio-temporal growth trend of pearl millet

Pace of agricultural development of a region can be ascertained through measuring growth in area, production and yield of crops in the region. Compound Growth Rate may be used for estimating change over time in important parameters of growth dimensions like area, production, and productivity at national as well as state level. Thereby, it is important to plot the growth particulars of a crop against its concerned study period. The data on area, production and productivity of pearl millet in different regions of the Gujarat, as well as total Gujarat state and India as a whole was employed for the period from 1999-2000 to 2018-19.

Region wise growth analysis of pearl millet in Gujarat vs India

The region-wise trend in the growth dimension of area, production and productivity of pearl millet in Gujarat vs India during the study period is presented in Table 2. From the analysis of compound growth rate it could be found that the regions of Gujarat that was North Gujarat (-4.048 % / annum), Saurashtra (-10.52 %), Central Gujarat (-2.632 %) and South Gujarat (-10.34 %) along with complete Gujarat state (-5.193 %) as well as India (-1.640 %) as whole showed negative growth rate w. r. t. area. Similarly, the compound growth rate of production was found to be positive and highest in North Gujarat (2.281 %) followed by Central Gujarat (0.931 %). Whereas, in Saurashtra (-6.706 %), South Gujarat (-5.912 %) along with complete Gujarat (-0.207 %) depicted negative growth rate, where as in India (1.688 %) it was found to exhibit positive growth rate. The productivity growth rate of North Gujarat was found to be highest (6.601 %) followed by South Gujarat with (4.945 %), Saurashtra (4.269%) and Central Gujarat (3.662 %). While Gujarat (5.258 %) and India (3.383 %) exhibited positive growth rates in pearl millet from 1999-2000 to 2018-19.

Table 2: Region wise growth analysis of pearl millet in Gujarat Vs India from 1999-2000 to 2018-19

Sl. No.	Region	Area CGR (%)	Production CGR (%)	Yield CGR (%)
1	North Gujarat	-4.048	2.281	6.601
2	Saurashtra	-10.52	-6.706	4.269
3	Central Gujarat	-2.632	0.931	3.662
4	South Gujarat	-10.34	-5.912	4.945
5	Gujarat	-5.193	-0.207	5.258
6	India	-1.640	1.688	3.383

Note: 1. CGR – Compound Growth Rate.

In Gujarat growth rate was found to be less when compared with India with respect to area and production parameters while productivity of Gujarat has higher growth rate of 5.258 % while India has 3.383 % of growth rate in pearl millet.

Types of growth pattern in pearl millet

In the analysis, the assessment of growth pattern is done by using the quadratic equation in time trend variable and determined whether there is acceleration, deceleration or stagnation in pearl millet production during the period 1999-2000 to 2018-19. The pattern of growth is analysed based on β2 (*i.e.*, coefficient of t_i^2) as given below:

If β2 > 0, then there is acceleration in growth,

If β2 < 0, then there is deceleration in growth,

If β2 is positive or negative refers to stagnation.

From the Table 3, Gujarat state as a whole along with their three regions *i.e.*, North Gujarat, Central Gujarat and South Gujarat showed that pearl millet recorded acceleration growth pattern while, Saurashtra region concluded stagnation type of growth pattern, whereas India also observed acceleration type of growth w.r.t area. The growth pattern w.r.t production recorded acceleration in all the regions of Gujarat except Saurashtra region which depicted stagnation type of growth pattern. In Gujarat state and India as whole showed acceleration type of growth pattern for pearl millet for the period of 20 years. In respect of productivity North Gujarat and Saurashtra depicted stagnation

type of growth pattern along with complete Gujarat and India as whole except central Gujarat and South Gujarat which depicted acceleration type of growth pattern from 1999-2000 to 2018-19.

Table 3: Region wise types of growth pattern of pearl millet in Gujarat vs India from 1999-2000 to 2018-19

Sl. No.	Region	Area	Production	Yield
1	North Gujarat	Acceleration	Acceleration	Stagnation
2	Saurashtra	Stagnation	Stagnation	Stagnation
3	Central Gujarat	Acceleration	Acceleration	Acceleration
4	South Gujarat	Acceleration	Acceleration	Acceleration
5	Gujarat	Acceleration	Acceleration	Stagnation
6	India	Acceleration	Acceleration	Stagnation

Spatio-temporal instability analysis of pearl millet

Instability or variability is an inherent characteristic of agriculture everywhere. The agricultural instability can be measured by different methods, such as the coefficient of variation (CV), dispersion, Coppock's Instability Index (CII), Cuddy Della Valle Index (CDV), *etc*. The present study applies the Coppock's Instability Index and coefficient of variation for measuring the instability. This index first de-trends the given series and gives a clear direction about instability. The use of coefficient of variation as a measure to show the instability in any time series data has some limitation. If the time series data exhibit any trend, the variation measured by CV can be over-estimated, *i.e.* the region which has growing production are at constant rate will score high in instability of production if CV is applied for measuring instability. Coppock Instability Index is a close approximation of the average year-to-year percentage variation adjusted for trend and the advantage is that it measures the instability in relation to the trend in prices. Thus, it is a better measure to capture instability in agricultural production. A higher numerical value for the index represents greater instability.

Region wise instability analysis of pearl millet in Gujarat vs India

The results of analysis in instability of pearl millet through Coppock's Instability Index method have

been represented in Table 4. From the analysis, it could be seen that the instability with respect to area of pearl millet was found to be highest in North region of Gujarat with CII value of 128.86 per cent followed by Saurashtra (124.96 %), Central Gujarat (110.48 %) and South Gujarat (48.43 %). The instability of the crop was high in the area in whole Gujarat state with CII value of 148.05 per cent where India accounts 24.85 per cent which was comparatively less. The instability of production was found to be highest in North Gujarat with CII value of 126.90 per cent followed by Central Gujarat (120.69 %) and Saurashtra (120.15 %) whereas South Gujarat recorded (47.87 %) instability in case of production which was least value among all the four regions of Gujarat. Gujarat accounted instability in production with 147.36 per cent which was relatively higher when it was compared with India's instability in production value of 24.70 per cent. In view of yield, instability was found to be higher in Central Gujarat (107.94 %), followed by South Gujarat (97.37 %) and North Gujarat (96.71%) whereas Saurashtra showed low instability in yield. Gujarat state accounts high instability with 97.95 per cent while India recorded 91.59 per cent.

Table 4: Region wise instability analysis of pearl millet in Gujarat Vs India from 1999-2000 to 2018-19

Sl. No.	Region	Area		Production		Yield	
		CV (%)	CII (%)	CV (%)	CII (%)	CV (%)	CII (%)
1	North Gujarat	29.24	128.86	29.55	126.90	39.86	96.71
2	Saurashtra	59.85	124.96	49.30	120.15	29.20	93.75
3	Central Gujarat	22.30	110.487	26.16	120.69	24.08	107.94
4	South Gujarat	57.55	48.43	59.54	47.87	34.17	97.37
5	Gujarat	30.93	148.05	23.47	147.36	31.94	97.95
6	India	12.79	24.85	19.96	24.70	22.27	91.59

Note: 1. CV- Coefficient of Variation (%), CII- Coppock's Instability (%).

Trade-off between growth and instability

The four-fold typology consisted of the following desirable and not desirable situation as given below:

- High Growth-Low Instability: Most desirable situation

- High Growth-High Instability: Desirable situation

- Low Growth-Low Instability: Least desirable situation

- Low Growth-High Instability: Not desirable situation

Accordingly, the classification of growth and instability in terms of area, production and yield of the pearl millet was studied with the four regions of Gujarat, along with Gujarat state as whole which were assumed in following order based on the critical point of the country as a whole.

Growth - instability trade-off for pearl millet in different regions of Gujarat as well as Gujarat as a whole

The growth - instability trade-off was carried out for pearl millet in terms of all the growth dimensions (*i.e.* area, production and yield) and the findings are furnished under the following sections:

Growth - instability trade-off for pearl millet area

High Growth - Low Instability (Most desirable situation): None of the regions has been found in this category.

High Growth - High Instability (Desirable situation): Under this situation or Category also not even single region was found.

Low Growth - Low Instability (Least desirable situation): None of the regions has been found in this category.

Low Growth - High Instability (Not desirable situation): In this growth – instability trade-off of non- desirable category, North Gujarat, Saurashtra, Central Gujarat and South Gujarat along with Gujarat state as a whole were placed. This underscores the need for providing special and specific interventions in future in these regions to retain pearl millet production at desired levels.

Table 5: Growth-instability trade off in area, production and yield of pearl millet in Gujarat during 1999-2000 to 2018-19

Area Particular	High growth	Low growth
High instability		North region (**-4.048**, *29.24*)
		Saurashtra region (**-10.52**, *58.85*)
		Central region (**-2.632**,*22.30*)
		South region (**-10.34**, *57.55*)
		Gujarat state (**-5.193**, 30.93)
Low instability		
Production Particular	**High growth**	**Low growth**
High instability	North region (**2.281**,*29.55*)	Saurashtra region (**-6.706**, *49.30*)
		Central region (**0.931**, *26.16*)
		South region (**-5.912**, *59.54*)
		Gujarat state (**-0.207**, *23.47*)
Low instability		
Yield Particular	**High growth**	**Low growth**
High instability	North region (**6.601**, *39.86*)	
	Saurashtra region (**4.269**, *29.20*)	
	Central region (**3.662**, *24.08*)	
	South region (**4.945**, *34.17*)	
	Gujarat state (**5.258**, *31.94*)	
Low instability		

Note: 1. Value in bold and italics indicate growth (%) and instability (%), respectively; 2. Criteria for classification: CGR of area (-1.640 %), production (1.688 %) and yield (3.383 %) for pearl millet in India during 1999-2000 to 2018-19; 3. Criteria for classification: CV of area (12.79%), production (19.96 %) and yield (22.27 %) for pearl millet in India during 1999-2000 to 2018-19.

Growth - instability trade-off for pearl millet production

Following area, growth – instability trade-off was obtained in terms of pearl millet production and the findings are furnished below:

High Growth - Low Instability (Most desirable situation): None of the regions has been found in this category.

High Growth - High Instability (Desirable situation): North region of Gujarat has been found with high growth- high instability situation which is desirable for further growth in the pearl millet production level.

Low Growth - Low Instability (Least desirable situation): None of the regions has been found in this category.

Low Growth - High Instability (Not desirable situation): Similar to the non-desirable situation existing in the acreage trade-off, Saurashtra, Central Gujarat, South Gujarat along with Gujarat state was also found to be placed in the "not desirable category" in terms of pearl millet production related trade-off as well. This would only mean that efforts should be put in place both in terms of area improvement and production stabilization.

Growth – instability trade-off for pearl millet productivity

High Growth - Low Instability (Most desirable situation): No regions fall under this category.

High Growth - High Instability (Desirable situation): North, Saurashtra, Central and South regions of Gujarat along with state as a whole fall under this category.

Low Growth - Low Instability (Least desirable situation): No regions fall under this category. There is need for improvement in both area and production aspect in order to achieve stabilized growth in productivity.

Low Growth - High Instability (Not desirable situation): No regions has been found in this category.

CONCLUSION

- North Gujarat (-4.048 % / annum), Saurashtra (-10.52%), Central Gujarat (-2.632 %) and South Gujarat (-10.34 %) along with complete Gujarat state (-5.193 %) as well as India (-1.640 %) as whole showed negative growth rate w. r. t. area.

- Compound growth rate of production was found to be positive and highest in North Gujarat (2.281 %) followed by Central Gujarat (0.931 %). Whereas, in Saurashtra (-6.706 %), South Gujarat (-5.912 %) along with complete Gujarat (-0.207 %) depicted negative growth rate, where as in India (1.688 %) it was found to exhibit positive growth rate.

- The productivity growth rate of North Gujarat was found to be highest (6.601 %) followed by South Gujarat (4.945 %), Saurashtra (4.269%) and Central Gujarat (3.662 %). While Gujarat (5.258%) and India (3.383 %) exhibited positive growth rates in pearl millet from 1999-2000 to 2018-19.

- In Gujarat growth rate was found to be less when compared with Indian growth rate with respect to area and production parameters while productivity of Gujarat has higher growth rate of 5.258 % while India with 3.383 % of growth rate in pearl millet.

- Gujarat state as a whole along with three regions *i.e.*, North Gujarat, Central Gujarat and South Gujarat showed that pearl millet recorded acceleration growth pattern while, Saurashtra region concluded stagnation type of growth pattern, whereas India also observed acceleration type of growth w.r.t area.

- The growth pattern w.r.t production recorded acceleration in all the regions of Gujarat except Saurashtra region which depicted stagnation type of growth pattern. In Gujarat state and India as whole showed acceleration type of growth pattern for pearl millet for the period of 20 years.

- In respect of productivity North Gujarat and Saurashtra depicted stagnation type of growth pattern along with complete Gujarat and India as whole except central Gujarat and South Gujarat which depicted acceleration type of growth pattern from 1999-2000 to 2018-19.

- Instability with respect to area of pearl millet was found to be highest in North region of Gujarat with CII value of 128.86 per cent followed by Saurashtra (124.96 %), Central Gujarat (110.48 %) and South Gujarat (48.43 %).

The instability of the crop was high in the area in whole Gujarat state with CII value of 148.05 per cent where India accounts 24.85 per cent which was comparatively less.

◆ The instability of production was found to be highest in North Gujarat with CII value of 126.90 per cent followed by Central Gujarat (120.69 %) and Saurashtra (120.15 %) whereas South Gujarat recorded (47.87 %) instability in case of production which was least value among all the four regions of Gujarat. Gujarat accounted instability in production with 147.36 per cent which was relatively higher when it was compared with India's instability in production value of 24.70 per cent.

◆ In view of yield, instability was found to be higher in Central Gujarat (107.94 %), followed by South Gujarat (97.37 %) and North Gujarat (96.71 %) whereas Saurashtra showed low instability in yield. Gujarat state accounted high instability with 97.95 per cent while India recorded 91.59 per cent.

◆ All the regions showed low growth and high instability with respect to area parameter, while in view of production growth instability trade-off represents low growth with high instability in all the regions except in North region of Gujarat. In respect of yield all the regions showed desirable character with high growth and high instability in pearl millet crop.

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