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## ORIGINAL ARTICLE

# 70 Years Growth and Instability Analysis of Potato Crop in India

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### ABSTRACT

*The present study deals with the 70 years growth and instability analysis of potato crop in India. The time series data of potato crop for the period seventy years from 1950-51 to 2019-20 have been utilized for the present study. The compound growth rates were computed with the help of exponential function and instability has been computed by using Cuddy Della-Valle Index method. Student's t-test was applied to test the significant trend of compound growth rates in area, production and yield of potato crop. The production of potato has been increased from 1.66 million tonnes to 51.31 million tonnes in 1950-51 and 2017-18 respectively, with a standard deviation of 14.97 million tonnes and coefficient of variation of 90.48%. The significant ( $p \leq 0.001$ ) compound growth rates in the production of potato was recorded as 5.35 per cent with a significant growth rates in area (3.25%) and yield (2.03%) in India during the 70 years of study period. The area, production and yield were more stable during the last decade (2010-2019) of the study period. The value of instability index was less than 13 per cent in the time series data of potato. This means that low instability was experienced in the area, production and productivity of potato in India.*

**KEYWORDS:** Compound growth rate, Cuddy Della-Valle Index (CDI), Potato, student's t-test.

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### INTRODUCTION

Horticultural crops play a definite role in achieving food and nutritional security worldwide [1]. Potato is one of the most important vegetable crops which come under the horticultural crops. Potato (*Solanum tuberosum* L.) belongs to family Solanaceae. It is the most important dicotyledonous tuber crop and holds major socio-economic importance worldwide. It is the fourth most cultivated food crop after wheat, rice and maize for billions of people across globe. Potato is a good and cheaper source of carbohydrates, vitamins, minerals and proteins. Developed and developing countries are making diversified use of potato as food, feed and raw material for proceeding products, starch and alcohol. India ranks second in the production of potato in the world after China [2]. As per estimates, India produced a record 51.30 million tonnes of potato during 2019-20. Potato occupies an area of 2.16 million hectares with productivity of 23.77 tonnes per hectare [3]. Potato is the most important vegetable in our country and contributes 26.75 per cent of total vegetable production. Most of the potato in India is consumed as vegetable. Uttar Pradesh is the highest potato producing state of the country followed by West Bengal and Bihar [4]. Being a cash crop, potato farming is a profitable venture for farmers and the marketing surplus can be up to 97.3% in this crop leading to higher income [5]. It is very important to study the growth and instability of potato crop due to gap between demand and supply. The price of potato fluctuates very much. During the harvesting period, the prices become very low. On the other hand, its price reached very high when most of the produce stored in cold storage. India has shown tremendous growth in potato production during the last decade, however, this growth is more due to the expansion of the area than the yield increment [2]. To fulfill the gap between demand and supply of potato, it is very essential to know the growth and instability in the area, production and yield of potato crop. Keeping in view of above facts, the present study investigates the 70 years growth and instability analysis of the area, production and yield of potato

in India. The study will be helpful for policy makers for implementation of new research and development related to the potato crop.

## MATERIAL AND METHODS

The statistical data related to area, production and yield of potato crop for the period of 70 years (1950-51 to 2019-20) were used for the present study. The data for the study were obtained from secondary sources. To analyze the growth and instability in area, production and yield of potato crop, time series data were obtained from Directorate of Economics and Statistics, Ministry of Agriculture and Farmers Welfare, Government of India for the period of 1950-51 to 2019-20. Area production statistics for the year 2019-20 were obtained from National Horticulture Board, Ministry of Agriculture and Farmers Welfare, Government of India as second advance estimates (Horticulture crops for 2019-20). Data were analyzed using various statistical tools and techniques such as average, variance, standard deviation (SD), coefficient of variance (CV), kurtosis, skewness, compound growth rate (CGR), student's t-test, and Cuddy Della-Valle Index (CDI).

### Compound growth rate (CGR) analysis

Following equation was used for estimation of compound growth rates (CGRs) of area, production and yield of potato crops:

$$Y = a + bt \quad (1)$$

where, Y= dependent variable for which growth rate is to be estimated,

t = time variable in year (1, 2, ..., 30)

a (intercept) and b (regression coefficient) are unknown constants to be estimated with the help of principle of least square method by changing the equation into logarithmic form as:

$$\log Y_t = \log a + t \log b$$

and now, compound growth rate (CGR) was calculated in per cent as:

$$CGR(r) = (b - 1) \times 100 \quad (2)$$

where, r is the compound growth rate

The significance of the estimated compound growth rate (CGR) in the area, production and yield will be tested with help of student's t-test by the following formula:

$$t = \frac{\bar{r}}{s_r} \quad (3)$$

Percentage change is given by

$$\% \text{ change} = \frac{(\text{current year value} - \text{previous year value})}{\text{previous year value}} \quad (4)$$

### Instability analysis of potato crop

The instability in the time series data of potato crop can be estimated by different methods, like the CV, Cuddy Della-Valle Index, Coppock instability index, and so on. CV is one of the very popular methods for estimating the instability in time series data. The coefficient of variation is expressed in percentage and is calculated as follows:

$$CV = \frac{SD}{\text{Average}} \times 100 \quad (5)$$

The instability measured by CV has limitations of overestimation [6]. To overcome the problem of overestimation of CV, Cuddy and Della-Valle [6] have been revised the CV by applying coefficient of determination ( $R^2$ ) referred Cuddy and Della-Valle Index (CDI) as follows:

$$CDI = \text{Coefficient of variation} \times (1 - R^2)^{1/2} \quad (6)$$

where,  $R^2$  is the adjusted coefficient of determination that takes into account the number of variables in a data set.

Cuddy Della-Valle Index (CDI) was preferred by the several researchers [7, 8, 9] for estimating the instability in time series data because CDI method first de-trends the given time series data and provide a clear direction of instability. Thus, in the present article, we have estimated the instability on the basis of Cuddy Della-Valle index.

## RESULTS AND DISCUSSION

### Area, production and yield of potato

In the present study, it is well-known fact that the potato is one of the most consumable tuber crops as a vegetable in India. Various statistical tools as mentioned in the previous section have been used to present the summary statistics for potato crop during 70 years (1950-2019). During, 1950-51 area under potato was 0.24 million ha. This area increased to 2.18 thousand ha in 2017-18 with standard deviation of

0.59 million ha and coefficient of variation of 60.99% along with average productivity of 13.90 tonnes/ha during the study period (Table 1). The production increased from 1.66 million tonnes to 51.31 million tonnes in 1950-51 and 2017-18 respectively with a standard deviation of 14.97 million tonnes and coefficient of variation of 90.48% in India during the 70 years of the study period. The yield of potato was minimum 6.03 t/ha in 1956-57 and maximum was 23.96 t/ha in 2017-18, with average of 13.90 t/ha in Uttar Pradesh (Table 1 and Fig 1). Thus, over the succession of years area, production and yield were increased from 1950-51 to 2019-20.

#### **Annual and decadal growth rate of area, production and productivity of potato**

Annual growth rate of area of potato were found to be 20.90 per cent (highest) and -14.81 per cent (minimum) in the year 1978-79 and 1979-80, respectively. In 1953-54, 1990-91 and 1993-94 per cent change remained zero, because areas were same in both the years. There was negative growth rate of production and yield in 1997-98, which was highest over a period of time, whereas maximum positive growth rate were found as 39.38 and 34.34 in production and yield of potato, respectively in 1964-65 (Table 2).

#### **Trends in area, production and yield of potato in India**

The area under potato cultivation in India was fairly accelerated from 0.24 million hectares during 1950-51 to 2.16 million hectares during 2019-20 which was increased nearly 800 per cent, this mean eighth times from the regaining of 1950-51 (Table 3 & Fig 1). This makes changes for increment in the production of potato had been almost thirty times during the last seven decades i.e. from 0.24 million tonnes during 1950-51 to 51.30 during 2019-20. This was because of the highest increase in productivity of potato during the last decade. It is evidence that the area and production under potato crop in India have been increasing over time since the 1950s in the same direction continuously.

#### **Growth and instability of potato in India**

The compound growth rate (CGR) of area, production and yield of potato in several periods in India is illustrated by Table 4. The significant ( $p \leq 0.001$ ) compound growth rate in the production of potato was recorded as 5.35 per cent with a significant growth rates in area (3.25 %) and yields (2.03%) in India during the 70 years of study period. The statistically significant growth in production was highest at 9.17 per cent than the area at 5.36% and yield (3.71%) in the decade of 1970-79 (Table 4). This was the period just after the green revolution launched in India. The annual growth rates of potato production were positive and significant ( $p \leq 0.001$ ) in the period I and period VIII whereas period I, V and Period VII showed a non-significant trend and overall showed an increasing trend over successive periods. The highest significant increase in production of potato during the period III was recorded due to highest significant growth in the area under potato crop at 5.36 per cent. Thus, during period III (1970-79), highest significant ( $p \leq 0.001$ ) growth in the area, production and yield were observed.

#### **Instability in area, production and yield**

The Cuddy Della-Valle index (CDI) is used to measure the instability index in potato crop. The instability was found to be the highest for production at 13.01 per cent for period VI (2000-2009) followed by period II (1960-69) at 12.65 per cent and it was also recorded as 12.17 per cent during the period VIII (1950-2019). The instability in the yield was experienced as 10.29 per cent and least for the area at 6.34 per cent during the 70 years of the study period VIII (1950-2019). The higher value of CDI shows more instability in the area, production and yield and vice versa. The CDI in different periods varied for the area, production and yield of potato in India. The area, production and yield were more stable during the last decade (2010-2019) of the study period. The value of instability index was less than 13 per cent in the time series data of potato (Table 4). This means that low instability was experienced in the area, production and productivity of potato in India. The study concluded that positive and significant growth occurred in the production (5.35%), area (3.25%) and yield (2.03%) of potato crop in India during the 70 years of the study period 1950-2020. In addition, there remained widespread stability in the growth of area, production and yield of potatoes throughout the study period.

**Table 1: Summary statistics of potato crop in in India during 70 years (1950-2019)**

Variable	Minimum	Maximum	Average	SD	CV(%)	Kurtosis	Skewness
Area (million ha)	0.24	2.18	0.97	0.59	60.99	-0.66	0.69
Production (million tonnes)	1.66	51.31	16.55	14.97	90.48	-0.04	1.03
Yield (tonnes/ha)	6.03	23.96	13.90	5.44	39.12	-1.18	0.16

**Table 2: Percentage change in area, production and yield during 70 years (1950-2019)**

Year	% change in area	% change in production	% change in yield	Year	% change in area	% change in production	% change in yield
1950-51	0.00	0.00	0.00	1985-86	-1.18	-17.10	-16.49
1951-52	4.17	3.01	-1.00	1986-87	-1.19	22.26	23.92
1952-53	4.00	16.37	14.08	1987-88	7.23	10.28	3.57
1953-54	0.00	-1.51	-2.57	1988-89	4.49	5.77	0.38
1954-55	3.85	-10.20	-12.86	1989-90	1.08	-0.61	-1.35
1955-56	3.70	5.68	0.11	1990-91	0.00	2.98	3.44
1956-57	3.57	-7.53	-9.20	1991-92	9.57	7.76	-2.15
1957-58	10.34	16.28	3.57	1992-93	1.94	-7.08	-9.09
1958-59	6.25	17.50	11.28	1993-94	0.00	14.18	14.88
1959-60	5.88	16.17	8.68	1994-95	1.90	0.06	-2.10
1960-61	5.56	-0.37	-3.96	1995-96	3.74	8.28	4.37
1961-62	-2.63	-9.93	-7.54	1996-97	12.61	28.56	14.16
1962-63	10.81	37.55	21.60	1997-98	-3.20	-27.13	-24.72
1963-64	2.44	-23.15	-23.34	1998-99	9.09	33.77	22.62
1964-65	2.38	39.38	34.34	1999-00	1.52	4.66	3.11
1965-66	11.63	13.02	1.41	2000-01	-8.96	-8.98	-0.21
1966-67	-2.08	-13.73	-12.60	2001-02	-0.82	6.36	7.62
1967-68	6.38	20.17	13.45	2002-03	11.57	-2.72	-12.65
1968-69	4.00	11.82	6.75	2003-04	-4.44	-0.90	3.39
1969-70	-3.85	-17.34	-12.46	2004-05	2.33	2.47	0.20
1970-71	-4.00	23.02	26.47	2005-06	6.06	1.18	-4.83
1971-72	2.08	0.42	-1.66	2006-07	5.71	-7.24	-12.40
1972-73	4.08	-7.87	-10.08	2007-08	4.73	28.36	22.67
1973-74	5.88	9.21	1.42	2008-09	18.06	20.79	2.61
1974-75	9.26	28.19	18.47	2009-10	0.55	6.37	6.07
1975-76	5.08	17.34	10.76	2010-11	1.09	15.75	13.90
1976-77	0.00	-1.92	-1.41	2011-12	2.69	-2.03	-4.27
1977-78	8.06	13.53	5.66	2012-13	4.19	9.31	4.63
1978-79	20.90	24.45	2.67	2013-14	-1.01	-8.34	-7.47
1979-80	-14.81	-17.77	-3.21	2014-15	5.58	15.52	9.81
1980-81	5.80	16.09	9.10	2015-16	1.92	-9.56	-11.32
1981-82	4.11	2.48	-1.98	2016-17	2.83	11.93	8.75
1982-83	-2.63	0.50	4.26	2017-18	-1.83	5.58	7.42
1983-84	6.76	21.99	12.92	2018-19	1.54	-2.18	-3.59
1984-85	7.59	3.46	-3.22	2019-20	-0.69	2.21	2.92

**Table 3: Decadal change in Potato area, production and yield during 70 years (1950-2019)**

Year	Area (million ha)	Production (million tonnes)	Yield (tonnes/ha)
1950-51	0.24	1.66	6.92
1960-61	0.38	2.72	7.25
1970-71	0.48	4.81	9.98
1980-81	0.73	9.67	13.26
1990-91	0.94	15.21	16.25
2000-01	1.22	22.49	18.40
2010-11	1.86	42.34	22.72
2019-20	2.16	51.30	23.77

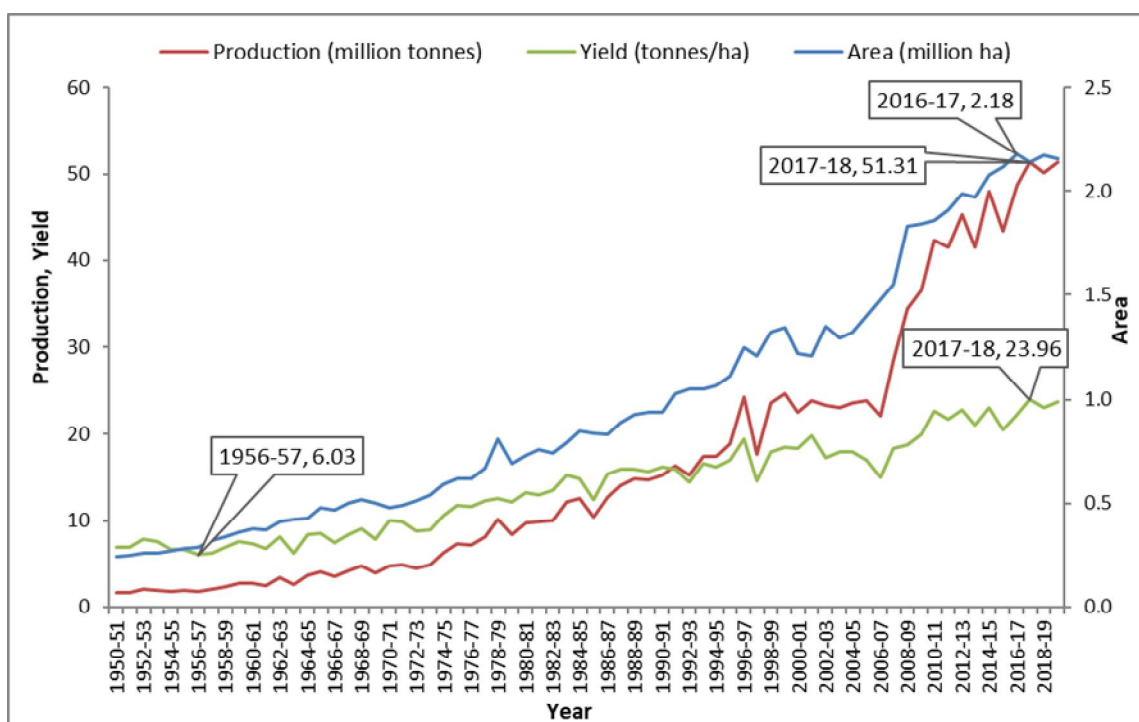
**Table 4: Compound growth rates of area, production and yield of potato in India during 70 years**

Period	Compound growth rate (%)		
	Area	Production	Yield
Period I (1950-59)	4.46 <sup>***</sup>	3.95 <sup>**</sup>	-0.56 <sup>NS</sup>
Period II (1960-69)	3.89 <sup>***</sup>	6.28 <sup>***</sup>	2.17 <sup>*</sup>
Period III (1970-79)	5.36 <sup>***</sup>	9.17 <sup>***</sup>	3.71 <sup>***</sup>
Period IV (1980-89)	2.92 <sup>***</sup>	5.17 <sup>***</sup>	2.19 <sup>**</sup>
Period V (1990-1999)	3.83 <sup>***</sup>	5.44 <sup>***</sup>	1.53 <sup>NS</sup>
Period VI (2000-2009)	4.81 <sup>***</sup>	4.86 <sup>***</sup>	0.04 <sup>**</sup>
Period VII (2010-2019)	1.79 <sup>***</sup>	2.48 <sup>***</sup>	0.69 <sup>NS</sup>
Period VIII (1950-2019)	3.25 <sup>***</sup>	5.35 <sup>***</sup>	2.03 <sup>***</sup>

\*: Significant @ 10 % level of significance, \*\*: Significant @ 5 % level of significance, \*\*\*: Significant @ 1 % level of significance and NS: Non-significant.

**Table 5: Instability in area, production and yield of potato in India during 70 years**

Period	Instability Index (%)		
	Area	Production	Yield
Period I (1950-59)	3.46	11.90	8.80
Period II (1960-69)	3.55	12.65	9.87
Period III (1970-79)	5.95	11.43	7.44
Period IV (1980-89)	2.60	7.65	7.01
Period V (1990-1999)	3.24	10.63	8.71
Period VI (2000-2009)	5.68	13.01	8.48
Period VII (2010-2019)	2.18	4.70	4.80
Period VIII (1950-2019)	6.34	12.17	10.29

**Fig 1: Growth pattern of potato crop in India during 70 years (1950-2019)**

## CONCLUSIONS

The current study emphasizes 70 years growth and instability analysis of potato crop in India during. The analysis results indicate that the area, production and yield of potato crop were improved in India during the 70 years of study period. The highest compound growth rates of potato area and production were recorded as 3.25% and 5.35%. These shown the stable growth rates were experienced in both area and

production of potato. The highest CGR of yield has been recorded as 3.71% during the period III (1970-79) just after the launch of green revolution in India. Low instability was experienced in the area, production and yield of potato in India. This is the evidence of stability in the growth of the area, production and yield of potato over the 70 years of study period.

### CONFLICT OF INTERESTS

The author has declared no conflicts of interests exist.

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