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Analysis of Growth Rate and Instability Index of Potato Crop in Punjab

Kawaljeet Kaur and Sunish Sharma

Department of Agriculture, Khalsa College, Amritsar

Abstract

The present study was carried out to investigate the growth performance and instability in area, production and productivity of potato in Punjab using Compound Annual Growth Rate (CAGR) and Instability Index. The study was based on secondary time series data collected from various online portals like INDIASTAT and issues of Statistical Abstracts of India and Punjab for the period of 30 years i.e., 1992-93 to 2021-22. Further, five major potato growing districts of Punjab namely Jalandhar, Hoshiarpur, Ludhiana, Kapurthala and Amritsar were selected for the comparative study of growth and instability analysis. The overall growth with respect to area and productivity was observed higher in Punjab (3.58 and 5.54 per cent) than in India 2.67 and 5.15 per cent whereas the productivity growth rate was higher in India 2.29 per cent as compared to Punjab (1.81 per cent). The instability indices of area under potato were seen slightly higher than that in India but a decline is noticed in both cases during the recent years (2012-2022). The study concluded that there is a need for proper policies and programs to concentrate on increasing the production and productivity of potato by increasing area under cultivation to include non-traditional areas and encourage the farmers to perform recommended package of practices. Extension services should be strengthened in the study areas to educate the potato growers on more use of certified seeds as well as new and improved technologies and innovations.

Keywords: Punjab, Instability Index, Compound Annual Growth Rate, Comparative Analysis.

JEL classification: Q11, Q16, O13

Introduction

India with diverse soil and climate comprising of several agro-ecological regions provides ample opportunity to grow a variety of horticultural crops. Diversification from grain crops to vegetable crops has emerged as an important strategy for agricultural growth to create gainful employment, increase revenue, and prevent further deterioration of natural resources (Mohapatra *et al*., 2018). India has emerged as the second largest vegetable producer next to China contributing about 12.3 per cent to the world vegetable production. Among all the vegetable crops India stands on top in production of okra, chilli, pepper, onion and bean whereas in case of tomato, potato, peas and cabbage its rank stands to be at second (FAO, 2022). The area under vegetables in India has increased significantly from 5.05 million hectare in 1992-93 to 11.35 million hectare in 2021-22 whereas the production hiked from 63.81 million tonnes to 204.84 million tonnes and the productivity of vegetables has increased from 12.65 t/ha to 18.05 t/ha during the same time period). Statistical abstract of Punjab,2022.

Corresponding author email: sunishsharma2743@gmail.com

Potato (*Solanum tuberosum*) popularly known as 'The king of vegetables', is the third most important food crop in the world after wheat and rice. Hundreds of millions of people in developing countries depend on potatoes for their survival for which potato is also referred as the 'food of the poor' (Khan *et al*., 2020). Keeping in view the potential of potato in the food security of developing nations, FAO has rightly declared it as 'Future Food Crop'. Considering its importance, United Nations (UN) had declared 2008 as the 'International Year of Potato' (Sreepriya and Sidhu, 2020). In 2021, worldwide potato production reached 376 million tons with a total planted area of 18.13 million hectares spread throughout the world. Asia continent was the main centre for potato cultivation contributing about 51 per cent of world potato production. China is now the world's top potato producer followed by India, Ukraine, USA and Russia (FAO, 2021).

India produced about 53.39 million tonnes of potato on 2.20 million hectare area during the year 2021-22 (Directorate of Economics and Statistics, 2022). Potato is one of the most important vegetable crops, contributing to nearly one-third of the total vegetable production in India. Uttar Pradesh is

the leading state in potato production with about 16 million tonnes of potato in 6.2 lakh hectare area during 2021-22 with productivity of 26 t/ha during 2021-22. Other major potato producing states are West Bengal, Bihar, Gujarat, Madhya Pradesh, Punjab and Haryana.

During the year 2021-22, in Punjab the area under vegetables was recorded to be 3 lakh hectare, production 59.7 lakh tons and productivity 19.88 t/ha whereas the area under potatoes was 1.1 lakh hectare, production 28.5 lakh tons and productivity 25.91 t/ha respectively. Potato is one of the most important horticultural crops in the state of Punjab which stands 6th in total potato production with a grand figure of 2.85 million tonnes, recording the third highest productivity (25.91 t/ha) from an area of 0.11 million hectare in 2021-22 (Department of Agri. & Cooperation, 2022). Potato is grown in almost all districts of Punjab and is widely used due to its low cost, easy handling and transportation and its higher shelf life as compared to other vegetables. In the recent years, the top five districts of the state recorded in terms of area and production are Jalandhar, Hoshiarpur, Ludhiana, Kapurthala and Amritsar. The unique agro-climate of Punjab has enabled it to evolve as the major disease-free seed producer of the country, which meets 90 per cent of the total disease-free potato requirement of the country (Department of Horticulture, Punjab, 2022).

Potato crop is a staple food of many households and its cultivation is a profitable agricultural enterprise in the vegetable segment therefore, keeping in view the importance of potato as a vegetable the present study was carried out to investigate the growth performance and instability in area, production and productivity of potato with special reference to Punjab.

Data Sources and Methodology

The study was based on secondary data collected from various sources viz. Issues of Statistical Abstracts of India and Punjab, Government digests, websites like INDIASTAT, AGMARK and reports published by various government agencies. The study analysed the time series data regarding area, production and productivity of potato in India and Punjab which was recorded for the period of 30 years from 1992-93 to 2021-22. For conducting an empirical study, the entire period was broadly classified into three sub periods i.e., Period-I (1992-93 to 2001-02), Period-II (2002-03 to 2011-12) and Period-III (2012-13 to 2021-22) in order to demonstrate the trend of potato production in a more convincing and simple manner. Further, five major potato growing districts of Punjab namely Jalandhar, Hoshiarpur, Ludhiana, Kapurthala and Amritsar were selected on the basis of highest potato production. The data was analysed using Compound Annual Growth Rate (CAGR) and Instability Index to compute the development pattern of area, production and productivity of potato in Punjab.

Compound Annual Growth Rate

The compound annual growth rate (CAGR) is the annualized average rate of growth of a variable or data over a specified time period longer than a year, assuming growth takes place at an exponentially compounded rate. The compound annual growth rates (CAGR's) of area, production and productivity of potato were estimated using the following growth model:

$Y_t = AB^t$

Where,

Y_t = Area/ production/ productivity of potato for the year "t".

t = Time variable (1, 2….. n) for each period.

A = Constant

B = Growth coefficient

Log transformation of above function is:

$\ln Y_t = \ln A + t (\ln B)$

Where,

$\ln B = \ln (1+ r)$, and

t = [antilog (ln B) – 1]

CAGR (%) = [antilog (ln B) – 1] × 100

Student's t- test was used to test the significance of CAGR at one, five and ten per cent level of significance.

The annual growth rate of area, production, and productivity of potato for each year was calculated in percentage terms.

$Annual\ Growth\ Rate_t\ (\%) =$

$\{value\ in\ t^{th}\ year - value\ in\ (t-1)^{th}\ year\ /value\ in\ (t-1)^{th}\ year\} * 100$

To measure the variability of area, production and productivity of potato crop, the coefficient of variation (CV) has been used:.

Results and Discussion

Trends in Area, Production and Productivity of Potato in India

Table 1 examined the data on area, production and productivity of vegetables and potato in India for the time period of 1992-93 to 2021-22. The study revealed that the highest percentage share of potato in total vegetables in India with respect to area was observed during the year 2009-10 at 23.04 per cent and with respect to production was observed during the year 1996-97 at 32.26 per cent whereas the lowest percentage share of potato in total vegetables in India with respect to area was at 19.38 per cent during the year 2021-22 and production at 23.87 per cent during the base year 1992-93. The data also depicted that from the base year 1992-93 to the year 2021-22, the share of potato decreased by 1.43

per cent in total vegetable area because of area expansion under other vegetables whereas the share of potato increased by 2.19 per cent in total vegetable production in India due to the replacement of furrow irrigation with micro irrigation and also the considerable increase in productivity of potato during the whole study period. The highest productivity in vegetables as well as in potato in India has been recorded in the latest years as 18.52 t/ha in vegetables during 2019-20 whereas 25.53 t/ha in potato during 2020-21. (Kumar *et al*., 2009; Singh, 2013) The increase in productivity was due to the release of stress tolerant (drought and disease) and input responsive potato varieties, particularly of improved genetic potential, use of certified quality seeds and its frequent replacement (CPRI, 2019).

Trends in Area, Production and Productivity of Potato In Punjab

Table 2 computed the data on area, production and productivity of vegetables and potato in Punjab for the time period of 1992-93 to 2021-22 which revealed that the highest share of potato in total vegetables in Punjab with respect to area and production was recorded during the year 1998-99 with percentage values of 66.66 and 79.58. The lowest percent share of potato in total vegetables in Punjab with respect to area was recorded 36.66 during the year 2021-22 whereas production was 45.19 per cent during the year 1995-96. Table further depicted that the share of potato in total vegetable area and production in Punjab from the base year 1992 to the latest 2022 has decreased by 18.89 and 8.43 per cent due to the increasing farmers' preference towards other vegetable crops. The highest productivity in vegetables as well as in potato in Punjab has been recorded in the latest years as 21.07 and 27.32 per cent during the year 2019-20. The reasons behind considerable increase in productivity of potato specially in Punjab were the ecological conditions of Punjab with high fertility levels of soil and extensive irrigation facilities.

Comparative Growth Analysis of Area, Production and Productivity of Potato in India and Punjab

Table 3 predicts the comparative compound annual growth rates with respect to area, production and productivity of potato in India and Punjab for the time period 1992-93 to 2021-22. The empirical values of CAGR were positive and significant (except for productivity during period I in Punjab) at 10, 5 and 1 per cent level. In India, the highest growth rate with respect to area and production of potato was observed during period II (2002-12) with the CAGR values of 4.08 and 7.06 per cent followed by period I at 2.22 and 6.91 per cent respectively. Period III observed the lowest growth rate at 1.14 and 2.19 per cent CAGR values for area and production. Potato productivity declined significantly from period-I to II to III with the empirical values of CAGR at 4.13, 2.95 and 0.98 per cent.

In Punjab, the expansion of area under potato was significant during all the periods with the experimental CAGR values of 3.96, 2.66 and 2.88 per cent respectively. The growth rate in potato production declined significantly with time from period-I to II to III with CAGR values of 7, 5.38 and 3.32 per cent respectively. The potato productivity was non-significant during period I with CAGRvalue of 2.36 per cent. During the succeeding periods, the productivity declined significantly from 2.93 to 0.44 per cent.

The overall growth with respect to area and production in potato was observed higher in Punjab (3.58 and 5.54 per cent) than in India (2.67 and 5.15 per cent) whereas the productivity growth rate was higher in India (2.29 per cent) as compared to Punjab (1.81 per cent).

Instability in area, production and productivity of potato in Punjab with comparison to India

Table 4 portrays the instability in area, production and productivity of potato in Punjab with comparison to India. As evident from the instability index. At national level variability

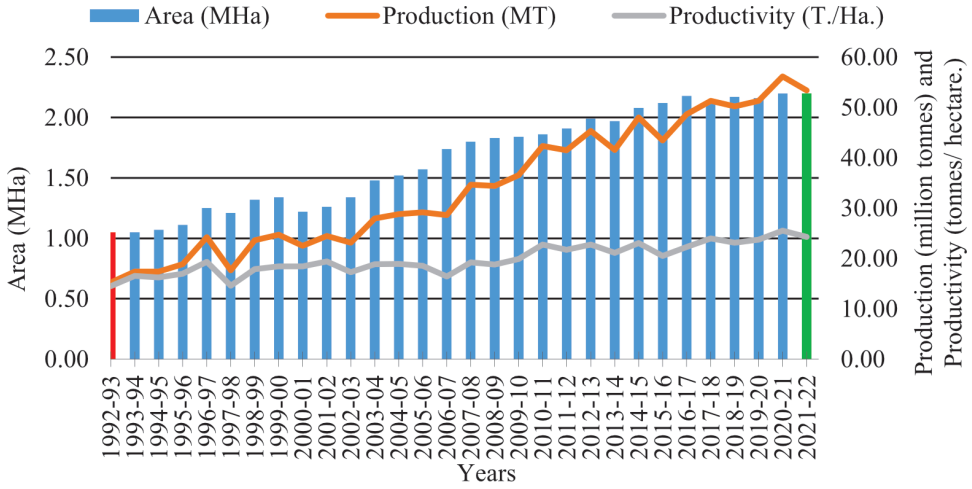

Fig 1: Trends in area, production and productivity of Potato in India

Table 1. Area, production and productivity of Potato in India during different periods

Years	Area (million ha)			Production (million tonnes)			Productivity (tonnes/ ha)	
	Vegetables	Potato	% of potato in vegetables	Vegetables	Potato	% of potato in vegetables	Vegetables	Potato
Period				Period I				
1992-93	5.05	1.05	20.81	63.81	15.23	23.87	12.65	14.50
1993-94	4.88	1.05	21.53	65.79	17.39	26.43	13.49	16.56
1994-95	5.01	1.07	21.34	67.29	17.40	25.86	13.42	16.26
1995-96	5.34	1.11	20.81	71.59	18.84	26.32	13.42	16.97
1996-97	5.52	1.25	22.67	75.07	24.22	32.26	13.61	19.38
1997-98	5.61	1.21	21.58	72.68	17.65	24.28	12.96	14.59
1998-99	5.87	1.32	22.48	87.54	23.61	26.97	14.90	17.89
1999-00	5.99	1.34	22.37	90.82	24.71	27.21	15.16	18.44
2000-01	6.25	1.22	19.52	93.85	22.49	23.96	15.02	18.43
2001-02	6.16	1.26	20.47	88.62	24.46	27.60	14.40	19.41
Period				Period II				
2002-03	6.09	1.34	22.00	84.82	23.16	27.31	13.92	17.28
2003-04	6.08	1.48	24.33	88.33	27.93	31.62	14.52	18.87
2004-05	6.74	1.52	22.54	101.25	28.79	28.44	15.01	18.94
2005-06	7.21	1.57	21.77	111.40	29.17	26.19	15.44	18.58
2006-07	7.58	1.74	22.95	114.99	28.60	24.87	15.17	16.44
2007-08	7.85	1.80	22.94	128.45	34.66	26.98	16.37	19.26
2008-09	7.98	1.83	22.93	129.08	34.39	26.64	16.17	18.79
2009-10	7.99	1.84	23.04	133.74	36.58	27.35	16.75	19.88
2010-11	8.50	1.86	21.90	146.55	42.34	28.89	17.25	22.76
2011-12	8.99	1.91	21.25	156.33	41.48	26.53	17.39	21.72
Period				Period III				
2012-13	9.21	1.99	21.62	162.19	45.34	27.96	17.62	22.78
2013-14	9.40	1.97	20.97	162.90	41.56	25.51	17.34	21.10
2014-15	9.42	2.08	22.09	166.57	48.01	28.82	17.69	23.08
2015-16	10.11	2.12	20.98	169.06	43.42	25.68	16.73	20.48
2016-17	10.24	2.18	21.29	178.17	48.60	27.28	17.40	22.29
2017-18	10.26	2.14	20.86	184.39	51.31	27.83	17.69	23.98
2018-19	10.07	2.17	21.54	183.17	50.19	27.40	18.18	23.13
2019-20	10.35	2.16	20.86	191.77	51.30	26.75	18.52	23.75
2020-21	10.86	2.20	20.26	200.45	56.17	28.02	18.45	25.53
2021-22	11.35	2.20	19.38	204.84	53.39	26.06	18.05	24.27

(Source: AGMARKNET & INDIASTAT, 2022)

Table 2: Area, production and productivity of Potato in Punjab during period-I, II &III

Years	Area (lakh ha)			Production (lakh tonnes)			Productivity (tonnes/ha)	
	Vegetables	Potato	% of potato in vegetables	Vegetables	Potato	% of potato in vegetables	Vegetables	Potato
Period				**Period- I**				
1992-93	0.9	0.5	55.55	14.6	8.2	56.16	170.6	175.2
1993-94	1.0	0.5	50.00	17.2	9.7	56.39	169	200.3
1994-95	1.0	0.5	50.00	17.2	9.7	56.39	167.9	200.3
1995-96	1.1	0.4	36.36	17.7	8.0	45.19	169	205.1
1996-97	1.1	0.5	45.45	16.1	8.5	52.79	142.8	181.8
1997-98	1.2	0.5	41.66	16.3	8.5	52.14	136.1	155.8
1998-99	1.2	0.8	66.66	19.1	15.2	79.58	162.9	192.8
1999-00	1.4	0.8	57.14	22.8	15.6	68.42	168.8	207.1
2000-01	1.3	0.6	46.15	23.1	11.9	51.51	176.3	199.9
2001-02	1.4	0.6	42.85	22.8	11.7	51.31	168.6	204.8
Period				**Period- II**				
2002-03	1.4	0.7	50.0	23.2	13.9	59.91	167.7	206.9
2003-04	1.5	0.7	46.66	25.9	13.8	53.28	169.2	207.9
2004-05	1.6	0.7	43.75	26.8	13.4	50	168.8	205.5
2005-06	1.5	0.8	53.33	24.3	12.2	50.20	160.1	163.1
2006-07	1.7	0.8	47.05	25.2	13.1	51.98	151	170.3
2007-08	1.7	0.8	47.05	27.7	14.8	53.42	161.5	187
2008-09	1.8	0.8	44.44	34.1	20	58.65	191.2	246.8
2009-10	1.8	0.8	44.44	35.2	21.2	60.22	192.1	254.6
2010-11	1.7	0.8	47.05	35.9	20.9	58.21	206	249.8
2011-12	1.8	0.8	44.44	36.7	21	57.22	206.2	250.2
Period				**Period- III**				
2012-13	1.8	0.9	50.0	37.8	21.3	56.34	205.5	250.1
2013-14	1.9	0.9	47.36	39.4	21.9	55.58	206.1	250.9
2014-15	2.1	0.9	42.85	41.7	22.6	54.19	200.3	251.4
2015-16	2.1	0.9	42.85	43.0	23.9	55.58	201.1	258.3
2016-17	2.3	1.0	43.47	45.6	24.2	53.07	196.4	248.3
2017-18	2.4	1.0	41.66	49.2	25.7	52.23	201.3	261
2018-19	2.5	1.0	40.0	52.1	27.2	52.20	208.9	264.3
2019-20	2.6	1.1	42.30	55.4	28.7	51.80	209.3	275.3
2020-21	2.9	1.1	37.93	58.6	29.5	50.34	203.8	270.8
2021-22	3.0	1.1	36.66	59.7	28.5	47.73	198.8	259.1

Source: Statistical Abstract of Punjab, 2022

in area under potato was the highest during period II with value 11.44 per cent followed by period I (10.25 per cent). The lowest variability was observed during period III at 3.87 per cent. The production and productivity variability in potato was the highest during period I at 18.64 and 10.31 per cent values followed by period II with instability values of 14.61 and 6.00 per cent respectively. The lowest variability in potato production and productivity was recorded during period III at values 7.73 and 5.45 per cent respectively.

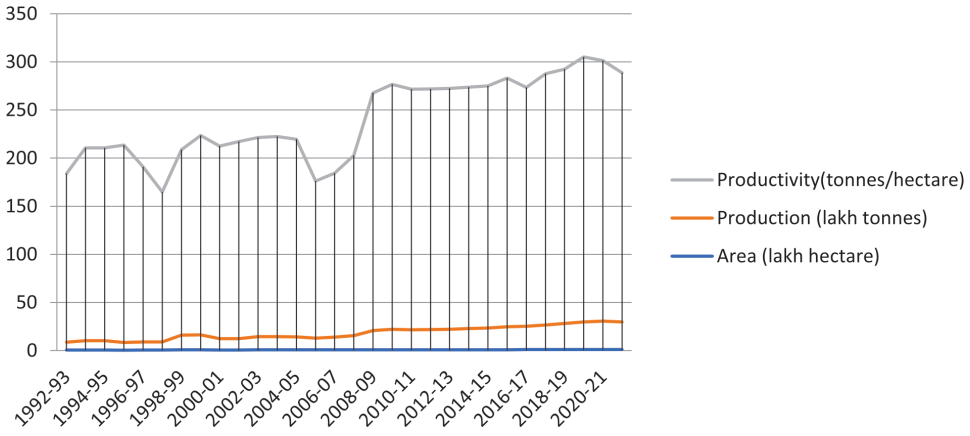

Fig 2: Trends in area, production and productivity of Potato in Punjab

In Punjab, the instability in area and production was the highest in period I with the values 23.27 and 26.54 per cent followed by period II at 9.80 and 23.15 per cent respectively. In case of productivity, it was the highest (16.10 per cent) in period II followed by period I (8.60 per cent). The lowest variability index in area, production and productivity was found during period III with values 8.96, 11.84 and 3.53 per cent respectively.

The overall results revealed that the estimated variability with regard to production in India was 37.33 per cent and in Punjab was 39.35 per cent. The instability indices of area and productivity of potato in India were 24.61 and 14.89 per cent whereas for Punjab the values came out to be 26.15 and 16.11 per cent. Both, the high instability in area as well as in productivity almost equally contributed towards the high instability in production.

Comparative Growth Analysis of Potato in Major Potato Growing Districts of Punjab

The compound annual growth rates with respect to variables area, production and productivity of potato in five major districts of Punjab during the time period of 2010-2022 were examined. The data in table 5 validates that district Ludhiana has observed the highest significant growth rate with respect to variables area and production at empirical values 11.63 and 12.87 per cent followed by district Amritsar with empirical values of CAGR at 5.75 and 6.01 per cent. District Hoshiarpur observed the maximum significant growth in productivity at 1.26 per cent followed by Ludhiana at 1.20 per cent. The table further revealed that the lowest growth rates for area and production were examined at 0.24 and 1.54 per cent (non-significant) values in district Hoshiarpur whereas with respect to productivity, district Amritsar recorded the lowest significant growth at 0.24 per cent.

Instability in Area, Production and Productivity in Major Potato Growing Districts of Punjab

The variability index for five major potato producing districts of Punjab for the time period 2010 to 2022 has been computed in Table 6. The table depicted that the highest empirical value for variability with respect to area and production was recorded in district Ludhiana at 34.15 and 38.08 per cent whereas productivity at 5.53 per cent in Hoshiarpur. Further the table showed that the lowest empirical value for variability with respect to area was recorded in

Table 3. CAGR of area, production and productivity of potato in Punjab with comparison to India, 1992-93 to 2021-22 (per cent)

Periods	India			Punjab		
	Area	Production	Productivity	Area	Production	Productivity
Period I (1992-2002)	2.22***	6.91***	4.13**	3.96**	7.00**	2.36
Period II (2002-2012)	4.08***	7.06***	2.95**	2.66***	5.38***	2.93*
Period III (2012-2022)	1.14***	2.19***	0.98**	2.88***	3.32***	0.44**
Overall CAGR	2.67***	5.15***	2.29***	3.58***	5.54***	1.81***

, ** and * significant at 10, 5 and 1 per cent level of significance.*

Table 4. Variability of area, production and productivity of potato in Punjab vis-a-vis to India, 1992-93 to 2021-22 (per cent)

Periods	India			Punjab		
	Area	Production	Productivity	Area	Production	Productivity
Period I (1992-2002)	10.25	18.64	10.31	23.27	26.54	8.60
Period II (2002-2012)	11.44	14.61	6.00	9.80	23.15	16.10
Period III (2012-2022)	3.87	7.73	5.45	8.96	11.84	3.53
Overall Variability	24.61	37.33	14.89	26.15	39.35	16.11

district Jalandhar at 7.08 per cent, production at 10.26 per cent in Kapurthala and productivity at 1.22 per cent in Amritsar.

Conclusion and Policy Implications

The findings of the study concluded that area, production and productivity of potato in India and Punjab has increased over the last 30 years. In India, during the study period (1992-93 to 2021-22) area under potato increased by 2.1 times, production by 3.5 times and productivity by 1.7 times while in Punjab, the increase in potato area, production and productivity was by 2.2, 3.5 and 1.5 times respectively. The instability indices of area, production and productivity of potato in Punjab was seen slightly higher than the country level but a decline is noticed in both cases during the recent years (period III) showing wide-scale spread and adoption of improved technology. This also infers that potato production has become less-riskier than was a past time. Still there is a need for proper policies and programs to concentrate on increasing the production and productivity of potato by introducing Better-yielding varieties-and by increasing area under cultivation to include non-traditional areas and encourage the farmers to perform recommended package of practices. Within Punjab, district Jalandhar recorded the maximum area and production in potato followed by Hoshiarpur, Ludhiana, Kapurthala and Amritsar whereas the highest productivity was found in district Moga followed by Jalandhar, Ludhiana, Kapurthala and Amritsar during the 2021-22. Extension services should be strengthened in the study areas to educate the potato growers on more use of certified seeds as well as new and improved technologies and innovations. Government should also provide the inputs

Table 5. Comparative growth analysis of Potato in major potato growing districts of Punjab during 2010 to 2022

Particulars	CAGR (%)		
	Area	Production	Productivity
Jalandhar	1.76***	2.54***	0.76***
Hoshiarpur	0.24^{NS}	1.54^{NS}	1.26***
Ludhiana	11.63***	12.87***	1.20***
Kapurthala	2.68***	3.37***	0.69***
Amritsar	5.75***	6.01***	0.24***

**** indicates significance at 1 per cent level respectively.*

Table 6. Variability of Potato in major Potato growing districts of Punjab during 2010 to 2022

Particulars	Variability (%)		
	Area	Production	Productivity
Jalandhar	7.08	10.51	3.42
Hoshiarpur	12.34	15.47	5.53
Ludhiana	34.15	38.08	4.80
Kapurthala	8.15	10.26	3.05
Amritsar	21.21	22.21	1.22

at a subsidized rate to potato seed growers, and extension services should also be provided to the farmers for judicious use of these inputs.

References

CPRI 2019. Annual Report 2018-19. ICAR-Central Potato Research Institute, Shimla, India.

Directorate of Economics and Statistics 2022. District wise Crop Production Statistics, Department of Agriculture & Farmers Welfare, Ministry of Agriculture & Farmers Welfare, Government of India, New Delhi. https://aps.dac.gov.in/APY/Public_Report1. aspx

FAO 2021. Food and agriculture data. https://www. fao.org/faostat/en/home

FAO 2022. Food and agriculture data. https://www. fao.org/faostat/en/home

Horticulture Statistics Division, Department of Agri. & Cooperation 2022. Horticulture statistics at a glance 2022, Government of India, Ministry of Agriculture & Farmers' Welfare. Department of Agriculture, Cooperation & Farmers' Welfare.

INDIASTAT, 2022. http://www. indiastat.com/agriculture/2/stats.aspx

Khan N, Rehman A, Salman M S, and Asif K 2020. Trends and perspectives of sustainable potato production in Aligarh district, India. *Journal of Global Resources* **6**: 29-36.

Kumar T L M, Munirajappa R, Chandrashekhar H and Surendra H S 2009. Seasonality in arrivals and prices of important vegetable crops in Bangalore market. *Mysore Journal of Agricultural Sciences* **43**: 738-743.

Mohapatra S, Singh J, and Kumar S 2018. Cointegration among major cauliflower markets in Punjab. *Indian Journal of Economics and Development* **14**: 330-335.

Sreepriya P and Sidhu J S 2020. An analysis of market arrival and price behaviour of Potato in India. *Economics Affair* **65**: 9-15.

Statistical Abstract, India 2022. file://D:/GOVT%20DATA/Statistical_Abstract%202022.pdf

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