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Temporal Changes in Area, Production and Productivity of Maize in Punjab

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ABSTRACT

The present paper studies the trends in area, production and productivity of maize in Punjab. The study was based on the secondary data for the period of 1970-71 to 2012-13 collected from the major maize growing districts of Punjab state. Area under maize showed negative growth rate at -3.73 per cent per annum but productivity depicted positive growth rate at 2.32 per cent per annum during the period under study. There was a major shift of maize areas (about 76.46 per cent) to paddy in all the maize growing districts due to higher profitability of paddy as compared to maize in Punjab. There was a continuous surge in the productivity of maize with decline in production which can be attributed to a continuous decline in area under maize during the study period. The level of instability in maize area measured by Cuddy Della Valle Index for Punjab was estimated to be 4.59 per cent for the period 1980-81 to 1989-90, which declined to 3.73 per cent during the period 1990-91 to 1999-00 and to 4.25 per cent during the period 2000-01 to 2012-13. This was indicative of overall decline in level of instability in area under maize during the study period. The variability in the maize production for the state as a whole had increased marginally. This could be attributed to the substantial variability in the maize productivity over the years in the state. The decomposition in maize production showed that yield contributed positively but its benefit could not be sustained due to continuous downward change in maize acreage especially during the post green revolution period. The decomposition results were found to be in conformity with the results of growth analysis in the state, which shows that productivity is a major contributor to increased maize production. Maize crop can be promoted towards the crop diversification in Punjab because it is a less water consuming crop and gives reasonable returns.

Key words: Maize, Instability, Decomposition, Growth
JEL Classifications: Q12, Q13, Q130

INTRODUCTION

Maize is one of the most important cereals of the world and provides food for humans, feed for livestock and serves as a basic raw material for the production of starch, oil and protein, alcoholic beverages, food sweeteners and bio-fuel. Maize (*Zea mays*) is a versatile crop that adapts easily to a wide range of production environment. A comparison of the available data of wheat,

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maize and rice puts maize as the second most important cereal grain, after wheat. India is producing about only three per cent of total world production of maize. However, area, production and productivity in the country have increased for the last five decades. It is mainly grown during Kharif season in the country and its production largely depends upon monsoon rains. Maize is grown across all the states in India. However, Andhra Pradesh, Karnataka, Rajasthan, Bihar, Maharashtra, Uttar Pradesh and Madhya Pradesh are the major producing states. The maize production in 2010-11 was 21.73 million tons as compared to 16.72 million tons during 2009-10 which was a drought year. Similarly maize production in 2013-14 was 24.35 million tons as compared to 22.23 million tons during 2012-13. Punjab has a vast potential in most of its area, to adopt maize as an alternative of paddy crop, which requires a lot of water. It is pertinent to mention here that Punjab was traditionally a maize growing state which changed its status to paddy cultivation during the green revolution era. With changing rural-to-urban population and lifestyles in developing countries, there is a continuous shift to the consumption of wheat, which may have influenced maize production. Maize is the third most important Kharif season crop after paddy and cotton in Punjab.The area under maize in Punjab has declined from 1.65 lakh hectares in 2000-01 to 1.31 lakh hectares in 2012-13 and again declined to 1.30 lakh hectares in 2012-14. With an average productivity of 36.93 quintals per hectare, the total maize production in the state was 4.91 lakh tons during 2010-11. Similarly, with an average productivity of 38.98 quintals per hectare, the total maize production in the state was 5.07 lakh tons during 2013-14 (Anonymous 2014).

The demand of maize is going up day by day especially in the form of animal/poultry feed, yet the production of this crop could not keep pace with demand in the Punjab state. The dramatic productivity gains achieved in rice and wheat have not been realized in the case of maize. Therefore, more research also needs to be done to develop HYV of maize so that farmers are able to get better remuneration from maize than paddy. The Punjab state is facing various environmental problems such as depletion of underground water, soil degradation, pollution, etc. caused by the intensive cultivation of paddy. Maize can be a better alternative to diversify some area from paddy. The present study has been conducted with the objective to examine the trends in area, production and productivity of maize in Punjab.

METHODOLOGY

The study was based on the secondary data. The time series data regarding area, productivity and production of maize crop in major maize growing districts of Punjab, were collected from various published sources such as Statistical Abstracts of Punjab, Agricultural Statistics at a Glance, etc. The data were collected for the period 1970-71 to 2012-13.

Statistical tools used for analysis

Growth analysis

The compound annual growth rates (CAGRs) of area, production and productivity of maize were estimated for major maize growing districts of Punjab for

five periods viz. Period I:1970-71 to 1979-80, Period II: 1980-81 to 1989-90, Period III: 1990-91 to 1999-2000, Period IV: 2000-01 to 2012-13 and Period V: 1970-71 to 2012-13.

The growth model used is as under:

$Y_t = AB^t$

Where, Y_t = Area/production/productivity

t = Time variable (1, 2……., n)

A = Constant

B = Growth coefficient

Log transformation of above function is:

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

Where,

CAGR (%) = [antilog (ln B) -1] × 100

Student's-test was used to test the significance.

Decomposition analysis of growth in production

The growth in production of a crop can be decomposed in to area effect, productivity effect and interaction effect. The following additive scheme of decomposition has been used:

$\Delta P = A_1 \Delta Y + Y_1 \Delta A + \Delta A . \Delta Y$

ΔP = Difference in maize production during two periods

ΔY = Difference in average productivity of maize during two periods

ΔA = Difference in area under maize during two periods

A_1 = Area under maize crop during the base year

Y_1 = Average productivity of maize crop during the base year

Thus, the changes in production (ΔP) were due to area effect, productivity effect and interaction effect

i) $Y_1 \Delta A$ represents the area effect

ii) $A_1 \Delta Y$ represents productivity effect; and

iii) $\Delta A . \Delta Y$ represents the interaction of area and productivity effect.

The level of instability in area, production and productivity of maize has been computed by using Cuddy-Della Valle Index (Singh and Byerlee 1990). Since the simple coefficient of variation over-estimates the level of instability in time series data characterized by long-term trends, this index was used as it corrects the coefficient of variation. The level of instability has been computed for the major maize growing districts of Punjab for the five periods mentioned above.

The level of instability has been computed by using the following formula

$CV^* = CV \times (1-R^2)^{0.5}$

Where, R^2 is the estimated coefficient of multiple determination from growth analysis.

RESULTS AND DISCUSSION

Maize was cultivated on 8.71 million hectares in India and its production was 22.23 million tons during 2012-13. Among the major maize growing states, Andhra Pradesh had largest share (21.64%) in total maize production in India followed by Karnataka (15.54%), Bihar (10.48%), Maharashtra (8.19%), Rajasthan (7.92%) and Madhya Pradesh (6.79%). Punjab ranked 12th in maize production in India with the share of 2.11 per cent (Table 1).

Changes in cropping pattern of Punjab

The data presented in Table 2 pertaining to five-time periods show that the area under all the crops increased due to the development of irrigation facilities and other inputs in the state during all the periods. The profitability plays a major role in the adoption of any enterprise/crop and this has been proved true

TABLE 1: STATE-WISE AREA, PRODUCTION AND PRODUCTIVITY OF MAIZE IN INDIA, 2012-13

State	Area (Million ha)	Production (Million tons)	Productivity (kg/ha)
Andhra Pradesh	0.97 (11.14)	4.81 (21.64)	4959
Karnataka	1.31 (15.04)	3.43 (15.54)	2618
Bihar	0.69 (7.92)	2.33 (10.48)	3377
Maharashtra	0.84 (9.64)	1.82 (8.19)	2167
Rajasthan	0.99 (11.37)	1.76 (7.92)	1778
Madhya Pradesh	0.85 (9.76)	1.51 (6.79)	1776
Uttar Pradesh	0.74 (8.50)	1.23 (5.53)	1662
Tamil Nadu	0.33 (3.79)	1.19 (5.30)	3606
Gujarat	0.48 (5.51)	0.84 (3.78)	1750
Himachal Pradesh	0.28 (3.21)	0.63 (2.83)	2250
Jammu & Kashmir	0.31 (3.56)	0.51 (2.29)	1645
Punjab	0.13 (1.49)	0.47 (2.11)	3680
West Bengal	0.11 (1.26)	0.42 (1.89)	3818
Jharkhand	0.23 (2.64)	0.39 (1.75)	1696
Others	0.45 (5.17)	1.09 (4.90)	2956
India	8.71 (100.00)	22.23 (100.00)	2552

Source: Agricultural Statistics at a Glance, 2013 and Statistical Abstract of Punjab, 2013

in the case of Punjab agriculture. As is clearly indicated by the results pertaining to all the periods, there was a major shift in area in favour of paddy in Punjab. An overall scenario clearly indicates that paddy and wheat was the major gainers as for as shift in area was concerned. It can be seen that area under maize had declined substantially during 1972-73 to 2012-13 continuously. This area directed to paddy crop, as it was more remunerative and thereby, more lucrative as compared to maize crop.

The results clearly show that rice and wheat were the major gainers at the cost of other crops like oilseeds, sugarcane, cotton, pulses, etc. On the whole, the maize lost the ground in terms of its share in gross cropped area in the state and was substituted by other relatively profitable crops in the Punjab.

District-wise Status of Maize Acreage in Punjab

The results pertaining to the district-wise status of maize acreage is given in Table 3. Area under maize during the TE1972-73 was 555 thousand hectares, which decreased to 339.33 thousand hectares during the TE1982-83 in Punjab.Thereafter, the area declined to 185.33 thousand hectares in TE (Triannium Ending) 1992-93 and then to as low as 160.67 thousand hectares in TE2002-03 and 130.67 thousand hectares in TE2012-13. The area under maize had been declining substantially, which may be due to the advent of high yielding varieties of paddy along with the price policy in favour of paddy crop. The highest area under maize was recorded in Hoshiarpur district (61 thousand hectares).

District-wise Status of Maize Productivity in Punjab

The results pertaining to the status of maize productivity is given in Table 4. There was continuous increase in productivity of maize in Punjab during the study period. The productivity as such increased from 1576 kg/

TABLE 2: AREA UNDER DIFFERENT CROPS IN PUNJAB, TE1972-73 TO TE2012-13

(000' ha)

Crops	TE1972-73	TE1982-83	TE1992-93	TE2002-03	TE2012-13
Maize	555	339.33	185.33	160.67	130.67
	(9.61)	(4.94)	(2.46)	(2.03)	(1.66)
Paddy	446	1255.67	2055	2543	2835.83
	(7.71)	(18.28)	(27.32)	(32.19)	(35.97)
Cotton	492.66	686.67	700	457.27	501.67
	(8.53)	(9.99)	(9.38)	(5.79)	(6.36)
Sugarcane	103.33	93.67	96.67	120.67	73
	(1.79)	(1.36)	(1.28)	(1.53)	(0.93)
Wheat	2323.67	2925.33	3264.33	3413	3519.33
	(40.22)	(42.59)	(43.39)	(43.20)	(44.64)
Total pulses	383.33	288.67	116.8	52.23	87.33
	(6.63)	(4.20)	(1.55)	(0.66)	(1.11)
Total oilseeds	289	206	170.23	93.43	104.17
	(5.00)	(2.99)	(2.26)	(1.18)	(1.32)
Other crops	1185.01	1072.32	936.3	985.44	623.34
	(5.00)	(15.61)	(12.44)	(12.47)	(7.91)
Gross cropped area (GCA)	5778.00 (100.00)	6869.00 (100.00)	7523 (100.00)	7900.67 (100.00)	7884.67 (100.00)

Source: Statistical Abstract of Punjab (various issues).

Figures in the parentheses are percentages to their respective total.

ha in TE1972-73 to 3790 kg/ha in TE2012-13. The figures for the TE1982-83, TE1992-93 and TE2002-03 and TE2012-13 were 1740 kg/ha, 2011 kg/ha and 2517 kg/ha respectively.

The average productivity of maize had shown an upward trend in all the major maize growing districts of Punjab during the study period. The productivity of maize continued to show improvement even during the nineties. The highest figures were found to be 2303 in Jalandhar district, 3633 kg/ha in Ludhiana district and 5334 kg/ha in Kapurthala district during the TE1992-93, TE2002-03 and TE2012-13 respectively. The above discussion clearly shows that there had been spectacular increase in productivity of maize from TE1972-73 to TE2012-13.

District-wise Status of Maize Production in Punjab

The results pertaining to the status of maize production show that inspite of ever increasing productivity levels, the production has decreased due to continuous fall in the area under maize. The results clearly exhibit that the production did decrease from 867.67 to 587.33 thousand metric tons from the TE1972-73 to TE1982-83.

During the TE2002-03, when the production increased to 406.33 thousand metric tons compared to 372.33 thousand metric tons in the TE1992-93. During the TE2012-13, the production increased to 496.33 thousand metric tons due to significant increase in productivity in spite of the decline in area.

TABLE 3: STATUS OF MAIZE ACREAGE IN THE MAJOR MAIZE GROWING DISTRICTS OF PUNJAB, TE1972-73 TO TE 2012-13

Acreage (000' ha)

District	TE1972-73	TE1982-83	TE1992-93	TE2002-03	TE2012-13
Gurdaspur	36	18.33	17.33	12.67	10.67
	(6.49)	(5.40)	(9.35)	(7.89)	(8.17)
Hoshiarpur	78.33	69.33	73.67	64.33	61.00
	(14.11)	(20.43)	(39.75)	(40.04)	(46.92)
Jalandhar	76	59.33	28.67	15	8.33
	(13.69)	(17.48)	(15.47)	(9.34)	(6.37)
Kapurthala	16	8.33	5.33	3.67	2.33
	(2.88)	(2.45)	(2.88)	(2.28)	(1.78)
Ludhiana	90	53.67	6.67	4.33	2
	(16.22)	(15.82)	(3.60)	(2.69)	(1.53)
S.B.S. Nagar	-	-	-	18	14
				(11.20)	(10.71)
Patiala	42.67	21.67	9	4.67	1
	(7.69)	(6.39)	(4.86)	(2.91)	(0.77)
Rupnagar	39.67	35	30.67	27.33	22.33
	(7.15)	(10.31)	(15.55)	(17.01)	(17.09)
Other districts	176.33	73.67	13.99	10.67	9.01
	(31.77)	(21.71)	(7.55)	(6.64)	(6.90)
Punjab	555	339.33	185.33	160.67	130.67
	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)

Source: Statistical Abstract of Punjab (various issues).

Figures in the parentheses are percentages to their respective total.

Shift in Area, Production and Productivity of Major Maize Growing Districts in Punjab

The results pertaining to the shift in area

TABLE 4: STATUS OF MAIZE PRODUCTIVITY IN THE MAJOR MAIZE GROWING DISTRICTS OF PUNJAB, TE1972-73 TO TE 2012-13

Average productivity (kg/ha)

Districts	TE1972-73	TE1982-83	TE1992-93	TE2002-03	TE2012-13
Gurdaspur	1102	1468	1460	1910	2621
Hoshiarpur	1347	1754	2061	2582	3992
Jalandhar	1684	2034	2303	3006	3963
Kapurthala	1601	2120	2122	3056	5334
Ludhiana	2011	2106	2125	3633	3000
S.B.S. Nagar	-	-	-	2650	3976
Patiala	1479	1338	2074	2167	4334
Rupnagar	1160	1378	1696	2179	3444
Punjab	1576	1740	2011	2517	3790

Source: Statistical Abstract of Punjab (various issues).

TABLE 5: STATUS OF MAIZE PRODUCTION IN SELECTED DISTRICTS OF PUNJAB, TE1972-73 TO TE2012-13

	Production (000' metric tons)				
Districts	**TE1972-73**	**TE1982-83**	**TE1992-93**	**TE2002-03**	**TE2012-13**
Gurdaspur	39.67	27	25.33	24.33	28
	(4.57)	(4.60)	(6.79)	(5.99)	(5.64)
Hoshiarpur	105.67	120.67	152.33	166.67	243.33
	(12.18)	(20.55)	(40.84)	(41.02)	(49.03)
Jalandhar	128	120.33	66	45.33	33
	(14.75)	(20.49)	(17.69)	(11.16)	(6.65)
Kapurthala	25.67	17.67	11.33	11.33	12.67
	(2.96)	(3.01)	(3.04)	(2.79)	(2.55)
Ludhiana	181	111	14	15.67	6
	(20.86)	(18.90)	(3.75)	(3.86)	(1.21)
S.B.S. Nagar	-	-	-	47.33	55.67
				(11.65)	(11.22)
Patiala	63	30.33	18.67	10.33	4.33
	(7.26)	(5.16)	(5.01)	(2.54)	(0.87)
Rupnagar	46.33	48.67	52	60	76.67
	(5.34)	(8.29)	(13.94)	(14.77)	(15.45)
Other districts	278.33	111.66	33.34	25.34	36.66
	(32.08)	(19.01)	(8.94)	(6.24)	(7.39)
Punjab	867.67	587.33	372.33	406.33	496.33
	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)

Source: Statistical Abstract of Punjab (various issues).
Figures in the parentheses are percentages to their respective total.

of maize is given in Table 6. Maize exhibited a negative shift in area during all the decades. Shift in area was more towards the Hoshiarpur district (-22.12 per cent) followed by Rupnagar district (-43.71 per cent), Gurdaspur district (-70.36 per cent) for the overall period of TE1972-73 to TE20012-13. Area under maize crop was down in almost all periods. At overall level, shift in area under maize was continuously as declining i.e. -76.46 per cent.

All the districts showed improvement in productivity of maize for overall periods despite the negative shift in the area. At overall period, status of maize was better in Punjab as it scored higher increase in productivity (140.00 per cent). Productivity shift of maize was more in fourth decade (50.58 per cent) followed by third decade (25.16 per cent), second decade (15.57 per cent) and first decade (10.41 per cent).Shift in productivity of maize had a setback in the second decade as it recorded a negative shift of 0.54 per cent in Gurdaspur district, 17.42 per cent in fourth decade in Ludhiana district and -9.53 per cent first decade in Patiala district.

At Punjab level, shift in production of maize was negative in first decade i.e. -32.85 per cent, which further decline to -36.42per

TABLE 6: SHIFT IN AREA, PRODUCTION AND PRODUCTIVITY OF MAIZE IN MAJOR MAIZE GROWING DISTRICTS IN PUNJAB, TE1972-73 TO TE2012-13

(Percent)

Districts	Period				
	TE1972-73 to TE1982-83	TE1982-83 to TE1992-93	TE 1992-93 to TE2002-03	TE2002-03 to TE2012-13	TE 1972-73 to TE 2012-13
			Area		
Gurdaspur	-49.08	-5.46	-26.89	-15.79	-70.36
Hoshiarpur	-11.49	6.23	-12.68	-5.18	-22.12
Jalandhar	-21.93	-51.68	-91.13	-44.47	-89.04
Kapurthala	-47.94	-36.01	-31.14	-36.51	-85.44
Ludhiana	-40.37	-87.57	-35.08	-53.81	-97.78
S.B.S. Nagar	-	-	-	-22.22	-
Patiala	-49.21	-58.47	-48.11	-78.57	-97.66
Rupnagar	-11.77	-12.37	-8.95	-18.29	-43.71
Other	-58.22	-81.01	-23.73	-15.58	-94.89
Punjab	-38.86	-45.38	-13.31	-18.67	-76.46
			Productivity		
Gurdaspur	33.21	-0.54	30.82	37.23	137.84
Hoshiarpur	30.22	17.5	25.78	54.61	196.36
Jalandhar	20.78	13.23	30.53	31.84	135.33
Kapurthala	32.42	0.09	44.02	74.54	233.17
Ludhiana	4.72	0.9	70.96	-17.42	49.18
S.B.S. Nagar	-	-	-	50.04	-
Patiala	-9.53	55.01	4.48	100	193.04
Rupnagar	18.79	23.08	28.48	58.05	196.9
Punjab	10.41	15.57	25.16	50.58	140.48
			Production		
Gurdaspur	-31.94	-61.85	-3.95	15.08	-29.42
Hoshiarpur	14.2	26.24	9.41	46.00	130.27
Jalandhar	-5.99	-45.15	-31.32	-27.2	-74.22
Kapurthala	-45.27	-35.88	-	11.83	-50.64
Ludhiana	-38.67	-87.39	11.93	-61.71	-96.69
S.B.S. Nagar	-	-	-	17.62**	-
Patiala	-51.86	-38.44	-44.67	-58.08	93.13
Rupnagar	5.05	6.84	15.38	27.78	65.47
Other	-60.87	-70.14	-24.00	44.67	-86.83
Punjab	-32.85	-36.42	8.94	22.15	-42.80

Source: Statistical Abstract of Punjab (various issues).

cent in second decade. In the third decade, production shift of maize increased by 8.94 per cent and in fourth decade, further increase in production i.e. 22.15 per cent. At overall period, shift in production of maize declined by 42.80 per cent.

In inter-district, Gurdaspur, Jalandhar, Kapurthala and Ludhiana districts did not show any positive trend in production i.e. -29.42 per cent, -74.22 per cent, -50.64 per

cent and -96.69 per cent respectively. Production of maize was increased by large amount for overall period by 130.27 per cent in Hoshiarpur district followed by Patiala district (93.13 per cent) and Rupnagar district (65.47 per cent).

Growth Performance of Maize in Punjab

The compound annual growth rates (CAGR) of area, production and productivity of major maize growing districts of Punjab are given in Table 7. The CAGR of area, production and productivity were found to be -3.55, -3.21 and 0.20 per cent per annum respectively for the period 1970-71 to 1979-80 in the state. The corresponding figures for the period 1980-81 to 1989-90 were estimated to be -5.48, -6.67 and -1.26 per cent respectively. In the period 1990-91 to 1999-00 estimated figures were -1.91, 0.69, 2.65 per cent respectively. In the period 2000-01 to 2012-13 estimated figures were -2.32, 1.94 and 4.31 per cent respectively. In the period 1970-71 to 2012-13 estimated figures were -3.78, -1.54 and 2.32 per cent respectively. All these CAGR were found to be statistically significant, except productivity in period 1970-71 to 1979-80 and in period 1980-81 to 1989-90 production of maize in period 1990-91 to 1999-00 and in period 2000-01 to 2012-13 figures were statistically non-significant. Punjab had shown declining trend in area in all decades except third decade 1990-91 to 1999-00, where area increased significantly. The area under maize had shown downward trend during all the decades in Punjab the state level as well as in the major maize growing districts except in period 1990-91 to 1999-00.

These CAGR relating to area under maize in Punjab was highly significant in the above period. There was a persistent decline in the area under maize during post *Green Revolution* period because the attention was shifted to the cultivation of wheat and paddy in the state. During the period 1970-71 to 2012-13, there was some improvement in the production of maize in these maize growing districts with a significant CAGR i.e. Hoshiarpur (1.94 per cent), S.B.S. Nagar (2.34 per cent), and Rupnagar (1.20 per cent). But at state level, production had declined. Inspite of the significant decline in area, the production showed small increase due to positive productivity effect. The CAGR of the average productivity of maize was found to be highly significant in almost all the districts under study except in Ludhiana (-1.26 per cent), that was non-significant in the period of 2000-01 to 2012-13. The Highest CAGR for average productivity of maize was observed in Patiala district (6.32 per cent) followed by Kapurthala (5.37 per cent), Hoshiarpur (4.35 per cent), Rupnagar (4.30 per cent), S.B.S. Nagar (3.91 per cent), Gurdaspur (2.42 per cent) and Jalandhar (2.35 per cent). In 1970-71 to 2012-13, CAGR for average productivity of maize was observed to be statistically highly significant in all the districts, as well as, at the state level. At the state level, it was also found positively significant decades after decades. The introduction, awareness and adoption of improved cultivars were responsible for this increase in productivity of maize in Punjab.

Decomposition of Growth of Maize Production into Area, Productivity and Interaction Effects in Punjab

TABLE 7: GROWTH PERFORMANCE OF AREA, PRODUCTION AND PRODUCTIVITY OF MAIZE IN PUNJAB, 1970-71 TO 2012-13

(CAGR in percent)

Districts	Time period				
	1970-71 to 1979-80	1980-81 to 1989-90	1990-91 to 1999-00	2000-01 to 2012-13	1970-71 to 2012-13
			Area		
Gurdaspur	-6.44***	0.30NS	-3.36***	-1.88**	-2.64***
Hoshiarpur	-0.55NS	2.38***	-2.07**	-0.38NS	-0.61***
Jalandhar	-1.95NS	-6.52***	-8.99***	-5.44***	-5.90***
Kapurthala	-1.30NS	-4.25***	-4.18***	-4.19***	-4.76***
Ludhiana	-0.58NS	-14.98**	-9.56NS	-6.76***	-11.11***
SBS Nagar	-	-	-0.50NS #	-2.23***	-2.31***@
Patiala	-4.49**	-7.78***	-34.18NS	-15.27***	-9.29***
Rupnagar	-2.01**	-0.94NS	-1.75***	-2.05***	-1.47***
Punjab	-3.55***	-5.48***	-1.91***	-2.32***	-3.78***
			Production		
Gurdaspur	-8.15**	0.12NS	0.96NS	0.47NS	-0.59**
Hoshiarpur	2.23*	0.64NS	0.08NS	3.95***	1.94***
Jalandhar	-1.93NS	-7.78***	-7.14**	-3.21***	-3.68***
Kapurthala	-3.50**	-7.67**	0.61NS	0.95NS	-2.11***
Ludhiana	0.18NS	-15.33***	-5.08NS	-7.93***	-9.54***
SBS Nagar	-	-	7.66NS #	1.59NS	2.34***@
Patiala	-4.59*	-4.44NS	-10.56NS	-9.91***	-6.53***
Rupnagar	-3.90*	-0.64NS	1.72NS	2.16*	1.20***
Punjab	-3.21**	-6.67***	0.69NS	1.94NS	-1.54***
			Productivity		
Gurdaspur	-1.61NS	-0.18NS	4.46***	2.42**	2.10***
Hoshiarpur	2.80*	-1.70NS	2.18NS	4.35***	2.57***
Jalandhar	0.03NS	-1.35NS	2.03NS	2.35**	2.36***
Kapurthala	-2.28NS	-3.58NS	5.01**	5.37***	2.78***
Ludhiana	0.77NS	-0.41NS	4.99**	-1.26NS	1.77***
SBS Nagar	-	-	8.20NS#	3.91**	4.76***@
Patiala	-0.10NS	3.62NS	1.36NS	6.32**	2.29***
Rupnagar	-1.92*	0.31NS	3.54*	4.30***	2.72***
Punjab	0.20NS	-1.26NS	2.65*	4.31***	2.32***

Source: Statistical Abstract of Punjab (various issues).

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

NS: Non-significant.

 # The data of S.B.S. Nagar for 6 years (1995 to 2000) only.

@ The data of S.B.S. Nagar for 18 years (1995-2013) only.

The results pertaining to the decomposition in area, productivity and production of maize are given in Table 8. The results clearly show that the area remained a major contributor to the decreased production of maize in the period 1972-73 to

1982-83 in all the maize growing districts except Rupnagar (390.50 %), Hoshiarpur (198.24%) and Patiala (17.60%) in Punjab. The productivity effect contributed in increasing production in the state. The interaction effect in these districts was also found to be negative -8.66 per cent (Patiala district), -22.78 per cent (Hoshiarpur district) and -45.98 per cent (Rupnagar district). However, the negative productivity and interaction effects were more than compensated by quite strong positive area effect in case of Rupnagar and Hoshiarpur districts. The results pertaining to the decomposition of maize production for the period 1982-83 to 1992-93 indicated that the productivity remained a major contributor to the increased production in all the major maize growing district of Punjab except Rupnagar districts. It was found that in case of Rupnagar, Hoshiarpur and Gurdaspur districts, an area effect, productivity effect and interaction effect had contributed positively towards increased production. The productivity effect contributed in increasing production in all the districts except the Rupnagar district (156.65 per cent). An interaction effect in this district was also found to be negative (-36.23per cent). However, the negative productivity and interaction effects were more than compensated by quite strong positive area effect in case of Rupnagar district. In the remaining districts, the strong negative effects of the area and interaction of area and productivity decreasing effect except Gurdaspur, nullified the positive effect of the productivity on production.

Maize production data corresponding to the period 2002-03 to 2012-13 revealed that negative effect of productivity and interaction effect were more than compensated by quite strong positive area effect in case of

TABLE 8: DECOMPOSITION OF GROWTH OF MAIZE PRODUCTION IN PUNJAB, TE1972-73 TO TE2012-13

District	Area effect	Productivity effect	Interaction effect	Increas/ Decline
TE1972-73 to TE1982-83				
Gurdaspur	-103.09	152.49	50.6	-
Hoshiarpur	198.24	-75.46	-22.78	+
Jalandhar	-364.05	384.2	79.85	-
Kapurthala	-104.61	154.46	50.15	-
Ludhiana	-12.63	107.53	5.1	-
Patiala	17.6	91.06	-8.66	-
Rupnagar	390.55	-244.57	-45.98	+
Punjab	-31.52	119.27	12.25	-
TE1982-83 to TE1992-93				
Gurdaspur	9.13	91.37	-0.5	-
Hoshiarpur	70.43	25.16	4.41	+
Jalandhar	-29.24	114.13	15.11	-
Kapurthala	-0.26	100.17	0.09	-
Ludhiana	-1.01	100.13	0.89	-
Patiala	-154.42	164.13	90.29	-
Rupnagar	292.89	-156.65	-36.23	+
Punjab	-42.57	123.17	19.4	-
TE1992-93 to TE2002-03				
Gurdaspur	-715.06	622.79	192.28	-
Hoshiarpur	269.33	-135.19	-34.15	+
Jalandhar	-96.24	150.35	45.89	-
Kapurthala	-5091.29	3605.64	1585.66	-
Ludhiana	645.5	-319.04	-226.46	+
S.B.S. Nagar	123.58	-0.32	-20.93	+
Patiala	-9.73	105.04	4.69	-
Rupnagar	196.81	-75.38	-21.43	+
Punjab	307.79	-166.13	-41.67	+
TE2002-03 to TE2012-13				
Gurdaspur	239.33	-101.55	-37.78	+
Hoshiarpur	117.17	-11.1	-6.07	+
Jalandhar	-118.76	165.95	52.81	-
Kapurthala	689.14	-337.52	-251.62	+
Ludhiana	28.19	86.98	-15.17	-
S.B.S. Nagar	299.75	-133.14	-66.61	+
Patiala	-175.23	137.6	137.63	-
Rupnagar	199.23	-62.78	-36.45	+
Punjab	248.59	-95.14	-53.45	+

Source: Statistical Abstract of Punjab (various issues).

Gurdaspur, Hoshiarpur, Kapurthala, S.B.S. Nagar, Rupnagar and also state level. The study of production profile of maize for the period 2002-03 to 2012-13, revealed that maize production increased in five selected districts namely Gurdaspur, Hoshiarpur, Kapurthala, S.B.S. Nagar and Rupnagar and also at state level. These results clearly show that productivity of maize improved in the state over time but its benefits could not be sustained due to continuous fall in the area under maize cultivation especially during the post green revolution period.

Level of Instability in Area, Productivity and Production of Maize

The results pertaining to the level of instability in area, productivity and production of maize are given in Table 9. The level of instability in area was highest in Patiala district (12.61 per cent) and lowest in Hoshiarpur district (5.12 per cent) during the period 1970-71 to 1979-80. The level of instability in area had declined during the 1980-81 to 1989-90 in all the major maize growing districts of Punjab. It ranged between 4.34 per cent in Hoshiarpur district and 15.11 per cent in Patiala district. The level of instability in maize area measured by Cuddy Della Valle Index for Punjab was estimated to be 4.59 per cent for the period 1980-81 to 1989-90, which declined to 3.73 per cent during the period 1990-91 to 1999-00 and to 4.25 per cent during the period 2000-01 to 2012-13. This was indicative of overall decline in level of instability in area under maize during the study period.The coefficient of variation depicting the variability in productivity of maize ranged between 4.97 per cent in Ludhiana district to 29.26 per cent in Gurdaspur district during the period 1970-71 to 1979-80. The variability in the productivity increased to 9.37 per cent (Hoshiarpur district) and 24.72 per cent (Patiala districts) during the period 2000-01 to 2012-13. The results for state as a whole show that the variability had increased in productivity from10.85 per cent during the period 1970-71 to 1979-80 to 13.05 per cent during the period 1980-81 to 1989-90 and then declined to 9.29 per cent during 1990-91 to 1999 -2000 and ultimately decreased to 8.97 per cent during 2000-01 to 2012-13 and at overall level, during period 1970-71 to 2012-13, variability was 15.99 at Punjab level. During the period 1980-81 to 1989-90 the coefficient of variation with respect to production ranged between 17.13 per cent in Hoshiarpur district to 36.09 per cent in Patiala district.The coefficient of variation of maize production in the third period 1990-91 to 1999-00 was found to be 35.75 per cent in Ludhiana district followed by Patiala (30.21 per cent), Jalandhar (22.08 per cent), Kapurthala (14.73 per cent), Hoshiarpur (14.33 per cent), Rupnagar (13.21 per cent) and Gurdaspur (11.15 per cent). The variability in maize production during 2000-01 to 2012-13 was found to be highest in case of Patiala district (29.52 per cent) and lowest in Hoshiarpur district (10.45 per cent). The variability in maize production in Punjab declined from 12.00 per cent during the period of 1980-81 to 1989-90 to 10.43 per cent during the period 1990-91 to 1999-00 and then increased to 14.73 per cent during 2000-01 to 2012-13. The variability in the maize production for the state as a whole had increased marginally. This could be attributed

TABLE 9: LEVEL OF INSTABILITY IN AREA, PRODUCTIVITY AND PRODUCTION OF MAIZE IN PUNJAB, 1970-71 TO 2012-13

Districts	Time period				
	1970-71 to 1979-80	1980-81 to 1989-90	1990-91 to 1999-00	2000-01 to 2012-13	1970-71 to 2012-13
	Relative variability in area (CV*)				
Gurdaspur	7.85	8.61	4.39	7.55	13.78
Hoshiarpur	5.12	4.34	5.46	4.68	6.91
Jalandhar	10.85	11.5	16.66	7.24	14.97
Kapurthala	9.53	8.36	10.78	12.98	16.74
Ludhiana	9.73	10.11	36.23	23.14	37.33
S.B.S. Nagar	-	-	-	5.48	@
Patiala	12.61	15.11	35.26	17.98	69.23
Roopnagar	6.23	6.32	3.54	6.28	6.32
Punjab	7.43	4.59	3.73	4.25	15.87
	Relative variabilityin productivity (CV*)				
Gurdaspur	29.26	16.16	9.79	9.67	18.15
Hoshiarpur	10.92	17.09	10.31	9.37	15.73
Jalandhar	7.56	17.19	10.45	9.77	13.88
Kapurthala	11.7	20.03	10.48	14.13	23.26
Ludhiana	4.97	18.3	11.93	15.36	19.24
S.B.S. Nagar	-	-	-	14.14	@
Patiala	7.4	19.76	13.53	24.72	25.04
Roopnagar	12.71	20.15	11.42	11.26	18.15
Punjab	10.85	13.05	9.29	8.97	15.99
	Relative variability in production (CV*)				
Gurdaspur	28.43	22.41	11.15	13.56	26.72
Hoshiarpur	9.61	17.13	14.33	10.45	15.66
Jalandhar	10.86	19.1	22.08	11.99	19.53
Kapurthala	10.42	17.38	14.73	21.07	26.99
Ludhiana	10.14	19.49	35.75	23.99	45.63
S.B.S. Nagar	-	-	-	15.65	@
Patiala	17.9	36.09	30.21	29.52	18.55
Roopnagar	14.74	24.15	13.21	11.54	37.15
Punjab	8.1	12	10.43	14.73	26.02

Source: Statistical Abstract of Punjab (various issues).

CV Cuddy Della Valle Index, where CV* = (CV) (1-R^{22})0.5*

@ Data of S.B.S. Nagar for 18 years (1996-2013) only.

to the substantial variability in the maize productivity over the years in the state.

CONCLUSION

Maize is the third most important crop after wheat and paddy in Punjab. The area under maize had declined substantially during the period 1972-73 to 2012-13. Paddy crop was more remunerative and thereby more lucrative as compared to maize crop. It was pertinent to mention here that Punjab was

traditionally a maize growing state which changed its status to paddy cultivation during the green revolution era. There was continuous upward surge in the productivity of maize, which seemed to be the result of all effort put in for the development of improved and hybrid varieties of maize in the state. Decline in production can be attributed to a continuous decline in area under maize in spite of the increase in its productivity during the study period. The decomposition results were found to be in conformity with the results of growth analysis in the state, which showed that productivity was a major contributor to the increased maize production. The level of instability in the maize production at the state level had increased marginally, which could be attributed to the increased level of instability in its productivity over a period of time.

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