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Growth and Decomposition Analysis of Major Fruits Grown in Punjab

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ABSTRACT

Background: Punjab has been gifted with the suitable agro climatic conditions and topography for the cultivation of horticultural crops, particularly fruits and vegetables. Due to its easy cultivation on sandy loam soils, increased profitability, and good market value in comparison to several other crops in the state, Punjab has gained popularity among fruit growers.

Methods: The study was based on secondary data obtained on the basis of the largest area sown over the period of 13 years *i.e.*, from 2010-11 to 2022-23. Statistical tools like Compound Annual Growth Rate (CAGR), instability index and decomposition analysis were used to analyze the trends in area, production and productivity of major fruits in Punjab.

Result: Results revealed that growth rates of area, production and productivity had shown positive and significant in all the major fruits during the study period. The growth rate of area and production under kinnow was found to be lowest due to decline in area and production during the last three years. Cuddy-Della Valle Index indicates that fluctuations in area and production was found to be tremendously high under lemon and litchi. Decomposition analysis revealed that area under kinnow was the major contributing factor causing the change in production but it was the yield that played a major role in other fruits.

Key words: Decomposition, Fruits, Growth rate, Instability.

INTRODUCTION

India's total agricultural development has been driven by the expansion of the horticulture sector (Dev, 2012; Mehta, 2009). Due to its varied agro climatic conditions, abundant crop diversity, and rich genetic resources, India is able to produce a wide variety of horticulture crops all year long (jha *et al.,* 2019). India has emerged as world leader in the production of a variety of fruits like mango, banana, guava, papaya, sapota, pomegranate, Lime and aonla and is the second largest producer of fruits and vegetables (GOI, 2023). The challenge for further raising the production and productivity of horticulture crops is the increase in demand for horticultural produce brought on by growing health consciousness, rising income, increased need for exports, and growing population. After the introduction of the green revolution in Punjab, wheat and paddy have become major food grain crops grown in the state. However, in recent decades, crop diversification from wheat-rice monoculture to other alternative crops that require less water has been seen as one of the most pertinent ways to revitalize Punjab's agrarian economy and promote the sustainable growth of agriculture in the province. One possible strategy to diversify Punjab agriculture is to convert some areas from rice-wheat rotation to high-value crops like fruits and vegetables. It will improve income and employment opportunities while also potentially addressing the negative effects of rice-wheat monoculture (Singh, 2000). In Punjab, the total area under fruit cultivation is 11370 hectares, with a total production of 250736 MT during 2023-24 (GOI, 2023). It gained momentum among the fruit growers as it can be easily cultivated on the sandy loam soils and has higher profitability and good market value relative to some of the other crops in the state (Grover *et al.,* 2012). Major fruits produced in the region include Kinnow, Guava, Mango, Pear, Sweet Orange, Litchi, Peach, and Ber, while smaller fruits include Limes/Lemons, Amla, Grapes, Plum, Banana, Pomegranate, Phalsa, Sapota, Papaya and others. The purpose of this study is to examine the growth trend in the area, output and yield of Punjab's major fruit crops, examine the variation in area, productivity and production and to determine the contribution of sources of output growth in fruit production.

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MATERIALS AND METHODS

The study has been conducted in order to understand the growth performance of major fruits in Punjab. The study was based on secondary data for a period of 13 years *i.e.*, from 2010-2011 to 2022-2023, collected from Statistical Abstract of Punjab. The major fruits were selected on the basis of highest area sown. For analysing the data, descriptive statistics such as CAGR (compound annual

growth rate), Cuddy-Della Valle Index and decomposition analysis were employed.

Compound annual growth rate (CAGR)

The compound annual growth rate in the area, production, and productivity of major fruits were computed by following the exponential equation.

$$Yt = A\ (1 + r)^t \quad \ldots. (1)$$

After taking log on both sides of equation (1)

$$\ln Y_t = \ln A + t \ln (1 + r) \quad \ldots. (2)$$

Where,

Yt = Variable (area/production/productivity) for which growth calculated for the period of 13 years *i.e.*, 2010-11 to 2022-23.

r = Compound annual growth rate and ln is the natural logarithm.

CAGR was computed using this formula:

$$r = (\text{Antilog of } b - 1) \times 100$$

Cuddy-Della valle index

Variability in area, production and yield of major fruits is measured in relative terms by the Cuddy Della Valle index which is used as a measure of variability in time-series data (*e.g.* Singh and Byerlee, 1990 and Deb *et al.,* 1999). The simple coefficient of variation over-estimates the level of instability in time-series data characterized by long-term trends whereas the Cuddy-Della Valle index corrects the coefficient of variation by

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

Where,

CDI = Cuddy-Della Valle index, *i.e.*, corrected coefficient of variation (CV).

CV* = Simple estimate of the coefficient of variation (in per cent).

R^2 = Coefficient of determination from a time-trend regression adjusted by the number of degrees of freedom.

Decomposition analysis

It is used to compute the relative contribution of factors as area and Ln(Q) = ln (a) + t ln (1 + r) productivity in total output of individual fruit crops. Devi *et al.* (2017); Ruchi, (2017); Kamble and Wali, (2016) and Bastine and Palanisami, (1994) were applied component analysis models to examine the relative contribution of area and productivity in changing level of output. The general outline of decomposition model is expressed as:

$$Q = CY \quad \ldots. (i)$$

Where,

Q = Production of major fruits in Punjab.

C = Cultivated area under major fruits.

Y = Yield of major fruits.

Then,

$$Q_0 = C_0 \text{ and } Y_0 \quad \ldots(ii)$$

$$Q_t = C_t Y_t \quad \ldots. (iii)$$

Where

0 and t = Time periods such that t >0 by an accounting period (usually single year).

Now

$$(Y_t - Y_0) = \Delta Y_t$$
$$C_t - C_0 = \Delta C_t$$
$$(Q_t - Q_0) = \Delta Q_t \quad \ldots. (iv)$$

Now substituting the terms represented in (iv) equation into (ii) equation.

$$Q_t = (C_0 + \Delta C_t)\ (Y_0 + \Delta Y_t)$$
$$\Delta Q_t = (Qt - Q_0) = \{(C_0 + \Delta C_t)\ (P_0 + \Delta P_t)\} - C_0 P_0$$

Or

$$\Delta Q_t = (C_0 \Delta P_t) + (P_o \Delta Ct) + (\Delta C_t \Delta P_t) \quad \ldots. (v)$$

Table 1: Compound growth rate and Instability index of area, production and productivity of kinnow and sweet orange.

Year	Kinnow			Sweet Orange		
	Area	Production	Productivity	Area	Production	Productivity
2010-11	41207	872625	21177	2886	23072	7994
2011-12	42795	915005	21381	2857	22885	8010
2012-13	45851	988633	21562	2761	22165	8028
2013-14	47101	1017725	21607	2671	21457	8033
2014-15	48182	1108618	23009	2668	21910	8212
2015-16	49356	1140312	23104	2722	22424	8238
2016-17	50147	1162455	23181	2813	23250	8265
2017-18	51649	1208423	23397	3003	25087	8354
2018-19	53045	1246821	23505	3123	26154	8375
2019-20	54243	1328996	24501	3118	26919	8633
2020-21	44752	1177544	26313	2788	24179	8673
2021-22	46841	1254598	26784	3800	33281	8758
2022-23	47862	1284211	26832	4013	35316	8800
CAGR	1.06**	3.18***	2.10***	2.40***	3.31***	0.88***
Instability index	8.52	29.74	29.28	18.50	26.86	15.15

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

Change in production =Yield effect + Area effect +Interaction effect.

Thus, the total change in production is attributed due to area and yield that can be decomposed into three effects *viz*. yield, area and interaction effects.

RESULTS AND DISCUSSION

Compound growth rate and Instability index of area, production and productivity of kinnow and sweet orange (Table 1)

Kinnow is the chief cultivar of the region occupying more than 90 per cent of the total area under citrus varieties (Government of Punjab, 2020). It is grown in some of the districts like Fazilka, Ferozepur, Bathinda, Muktsar and Faridkot are well known for kinnow cultivation. The growth rate of area, production and productivity has been positive and significant with the rate of 1.06 per cent, 3.18 per cent and 2.10 per cent (Table 1). However, out of all the fruits, it grows the least in terms of area and production since area under cultivation has started declining which has been the main driver of production. The instability index shows that the productivity of kinnow has higher instability as compared to other fruits. This may be because of the rapid expansion in area under kinnow (Yogi *et al.,* 2019) and higher profitability and good market value relative to some

Table 2: Compound growth rate and Instability index of area, production and productivity of lemon ad mango.

Year	Lemon			Mango		
	Area	Production	Productivity	Area	Production	Productivity
2010-11	631	4794	7598	6509	103012	15826
2011-12	638	4860	7617	6564	104041	15850
2012-13	632	4830	7642	6664	105921	15895
2013-14	656	5020	7652	6743	107572	15953
2014-15	733	5628	7678	6752	113435	16800
2015-16	758	5836	7699	6744	113501	16830
2016-17	850	6557	7714	6748	113687	16848
2017-18	985	7623	7739	6896	116515	16896
2018-19	1120	8657	7730	7024	118759	16908
2019-20	1245	9654	7754	7012	118783	16940
2020-21	2655	21304	8024	7987	137281	17188
2021-22	3031	24520	8090	8897	156202	17557
2022-23	3113	25073	8054	9002	164581	18283
CAGR	15.45***	16.02***	0.50***	2.45***	3.52***	1.04***
Instability index	167.57	173.52	5.07	20.57	34.23	11.40

*** significant at 1 per cent level of significance.

Table 3: Compound growth rate and Instability index of area, production and productivity of litchi and guava.

Year	Litchi			Guava		
	Area	Production	Productivity	Area	Production	Productivity
2010-11	1628	23881	14669	7840	170967	21807
2011-12	1672	24548	14682	7938	173830	21898
2012-13	1752	26520	15137	8072	177570	21998
2013-14	1848	28003	15153	8205	180775	22032
2014-15	1988	32108	16151	8107	181970	22446
2015-16	2152	34882	16209	8117	182267	22455
2016-17	2320	37637	16223	8103	182089	22472
2017-18	2708	43958	16233	8692	195597	22506
2018-19	2885	46940	16270	9142	206106	22545
2019-20	3057	50091	16386	9645	217738	22575
2020-21	3142	51504	16392	9730	219850	22595
2021-22	3653	60390	16532	12173	276685	22729
2022-23	3775	62440	16540	12769	292872	22936
CAGR	7.86***	8.98***	1.04***	3.70***	4.08***	0.37***
Instability index	225.53	306.80	9.04	33.67	39.77	4.49

***significant at 1 per cent level of significance.

of the other fruit crops in the state (Grover *et al.,* 2012). However, Due to its limited harvesting season, which starts from mid-January to mid-February, kinnow fruit is currently causing significant challenges in the market. The limitation of this variety's harvesting period is causing a glut in the market, which lowers the producer's price. As a result, to break up the kinnow monoculture, new citrus types with different harvesting times are encouraged to be introduced (Chahal, 2023).

Table 1 showed annual growth rate of area, production and productivity under sweet orange found to be 2.40 per cent, 3.31 per cent and 0.88 per cent per annum in the study period respectively. The instability index showed that there was variability in area, production and productivity could be due to Punjab Agricultural University has recommended Early Gold, an early maturing variety of sweet orange (Kumar *et al.,* 2018) for commercial cultivation in the state to meet the demand for pre-winter maturing citrus cultivar. The shifting of some area from kinnow to Early Gold cultivation can play a vital role in enhancing the profitability in citrus cultivation of the region.

The growth rate in area, production and productivity of lemon and mango are presented in Table 2. The compound growth rate of area and production under lemon observed the highest growth among all the fruit crops at the rate of 15.45 per cent and 16.02 per cent respectively due to its wider adapt ability, high yield potential, tolerance to citrus canker, hardy to both hot and cold climatic conditions also have high variability in terms of area and production with the advent of high yielding varieties (Singh, 1992) While, productivity has a low variability.

Mango is the third most important fruit crop of Punjab following citrus and guava (Package of Practices PAU, 2019). Area, production and productivity of growth under mango shows positive and significant at the rate of 2.45 per cent, 3.52 per cent and 1.04 per cent during the study period. It has been observed that instability as it is severely damaged by a number of insect pests that, either directly or indirectly, result in significant output losses, which eventually lowers the profitability of mango growers. Singh 2018 and Singh and Sreedevi (2019) reported around 30 species of insect pests inflicting damage to different parts of mango trees in Punjab.

The perusal of theTable 3 reveals the trend of area, production under litchi had a huge growth rate with positive and significant at the rate of 7.86 per cent and 8.98 per cent respectively which is second highest growth next to lemon. The variation in terms of area and production was enormously high because of its increasing demand and profitability and better export potential (Pandey and Sharma, 1989; Cebeco, 2001). Unlike other states in India where litchi is grown, Punjab's litchi growers are able to reap large profits since fruits are available from mid to end of June (Singh *et al.,* 2022).

Guava is the second largest major fruit grown in Punjab. The compound growth rate in area, production and productivity was positive and significant for the study period at the rate of 3.70, 4.08 and 0.37 per cent per annum. There was a high instability found in area and production facing numerous horticultural and agronomic issues, including vulnerability to numerous diseases; particularly guava wilt caused by Fusarium *(oxysporium pv. psidii*). This results in limited fruit development, a short shelf life, a high seed content. and sensitivity to stress (Rai *et al.,* 2010).

Compound growth rate and instability index of area, production and productivity of pear was shown in Table 4. The growth rate of area, production and productivity was positive and significant at the rate of 4.08 per cent, 4.47 per cent and 0.37 per cent per annum during the study period. The instability was found to be high in terms of area and production due to pests and diseases although it provides favorable climatic conditions for growing a wide range of pears. In subtropical regions mainly Punjab pear cultivars like 'Baggugosha', 'Kiefferr' and Asian pear 'Patharnakh' (hard pear) are cultivated commercially both for table and

Table 4: Compound growth rate and Instability index of area, production and productivity of pear.

	Pear		
Year	Area	Production	Productivity
2010-11	2665	60174	22579
2011-12	2706	61113	22584
2012-13	2787	63040	22619
2013-14	2897	65624	22652
2014-15	2980	68286	22915
2015-16	2879	66047	22941
2016-17	2910	66811	22959
2017-18	3165	72779	22995
2018-19	3205	73784	23022
2019-20	3501	81892	23391
2020-21	3336	78236	23452
2021-22	4335	101573	23431
2022-23	4692	110236	23494
CAGR	4.08***	4.47***	0.37***
Instability Index	39.43	45.46	5.52

***Significant at 1 per cent level of significance.

Table 5: Contribution of area, yield and their interaction in the production of major fruits in Punjab, 2010-11 to 2022-23. (in percentage)

Factors	Kinnow	Sweet orange	Lemon	Mango	Litchi	Guava	Pear
Area effect	51.87	19.01	0.15	25.97	7.90	7.26	4.87
Yield effect	39.75	73.57	94.20	64.08	81.68	88.17	91.42
Interaction effect	8.38	7.42	5.66	9.95	10.42	4.57	3.71
Change in output	100	100	100	100	100	100	100

processing purposes and semi-soft cultivars like Punjab Beauty, Punjab Nectar and Punjab Soft are recommended for cultivation (Sawant *et al.,* 2021). The important insect and mite pests of Indian pear orchards are the codling moth, pear psylla, mites and borer (Verma *et al.,* 2010, Husain *et al.,* 2018).

Decomposition analysis of major fruits in Punjab

Decomposition analysis was carried out to estimate the percentage contribution of area effect, yield effect and interaction effect towards change in production. The perusal of the Table 5 reveals during the study period only area effect was the main contributor in the output growth under kinnow *i.e.*, area effect (51.87%), yield effect (39.75%) and interaction effect (8.38%). On the other hand, the yield effect was playing crucial role by offsetting the area and interaction effect among all the fruit crops except in kinnow.

CONCLUSION AND POLICY IMPLICATIONS

Area and production have grown positively overtime in the state except under kinnow. The area under kinnow has declined in the last few years due to introduction of new suitable citrus varieties with varying harvesting span to break the monoculture of kinnow. Production of fruits varied mainly due to changes in area, though productivity gradually remained to increase. As per the decomposition analysis, area under kinnow was the major contributing factor to cause change in production whereas, in other fruit crops it was the yield effect which plays a major role. Therefore, productivity can be increased by creating true-to-type nurseries for high-yielding fruit varieties, managing fruit orchards according to scientific principles, and enhancing farmers' ability to minimize fruit production losses both before and after harvest. Some major issues regarding the production and marketing of high value crops that inhibit the diversification from wheat-paddy such as inefficient marketing system, high price fluctuations, sensitivity to diseases and bad weather conditions, lack of storage facilities and thereby occurrence of post-harvest losses *etc*. Hence, better pricing policies and cold storage facilities should be developed in the state.

Conflict of interest

All authors declare that they have no conflicts of interest.

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