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RESEARCH PAPER

Trends and Prospects of Citrus Crop in Haryana State

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ABSTRACT

The study has analyzed trends and prospects of citrus crop in Sirsa district and Haryana state. The study was based on secondary data collected for a period from 1990-91 to 2018-19. The compound growth rate, mean, co-efficient of variation, and ARIMA model were employed to calculate the results of the study. The fluctuated trends were observed in area, production, and productivity of citrus crop in Sirsa district and Haryana state. The third decade has shown a better result in Sirsa district and Haryana state. The study also revealed that the area's growth rate will be positive, and growth rate of production and productivity of citrus crop in Sirsa will be negative. The compound growth rate of area, production and productivity of citrus crop in Haryana will be 3.20%, 7.00% and 3.70%, respectively. Further, the production and productivity growth rate will be greater in Haryana compared to district Sirsa. In contrast, the area growth rate in district Sirsa will be higher than in Haryana.

HIGHLIGHTS

- The fluctuated trends were observed in area, production, and productivity of citrus crop in Sirsa district and Haryana state.
- The third decade has shown a better result in Sirsa district and Haryana state.
- The area's growth rate will be positive, and the growth rate of production and productivity of citrus crop in Sirsa district will be negative.
- The compound growth rate of area, production and productivity of citrus crop in Haryana will be 3.20%, 7.00% and 3.70%, respectively.

Keywords: Horticulture, Citrus crop, Trends, Future prospects

The agricultural sector is a primary source of livelihood for 58.00% of the Indian population and contributed 17% to the Gross Value Added (G.V.A.) in 2019. The horticulture sector is an allied sector of the agricultural sector. The horticulture sector is related to the cultivation of garden crops, fruits and vegetables (IBEF, 2021). The Indian horticulture sector has a significant role in the Indian economy by contributing 33.00% to the agriculture Gross Value Added (G.V.A.). It is a labour-intensive sector. It provides alternate rural employment opportunities, diversification in farm activities, and enhanced income to farmers (DA & FW, 2022). India has a second rank in the production of fruits and vegetables in the world after China. As per the National Horticulture Board, during 2021-22, India's production of fruits and vegetables was estimated at 107.24 million metric tonnes and 204.84 million metric tonnes, respectively. The cultivation area under fruits and vegetables stood at 7.05 million hectares and 11.35 million hectares, respectively. India has received opportunities for export from its vast production base. During 2022-23, fresh fruits and vegetables were exported of ₹ 6,219.46 crores and ₹ 6,965.83 crores, respectively (APEDA, 2023).

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Haryana is a fast-emerging and one of the leading states in the field of horticulture in India. The production of horticulture crops was 10596.92 thousand tonnes during 2019-20. Haryana rank 22nd in fruit production in the country with a total of 1178.92 thousand tonnes from an area of 67.17 thousand hectares and productivity of 19.36 tonnes per hectare (GoH, 2019). The citrus crop which is a part of the horticulture crop are grown in northern region of country. Mostly kinnow, pineapple, musambi, grape fruit and sweet orange etc. are grown along with lemon which is also member of citrus fruit. So, keeping in view the importance of horticulture in general and fruit crops in particular, the present study has been undertaken to analyse the trends and prospects of citrus crop in Haryana.

MATERIALS AND METHODS

The study was based on secondary data collected from 1990-91 to 2018-19 from the relevant official records from the District Horticulture Offices and Directorate of Horticulture Office, Panchkula, Government of Haryana. The district-wise average production of citrus crop was calculated for the last five years. The total average production of citrus in Haryana was 321321 million tonnes. Among the districts of Haryana, Sirsa district reported the maximum average production of citrus in Haryana, which is 71.21% of Haryana. So, Sirsa district was selected as the best representative district of Haryana based on the maximum average production of citrus.

The compound growth rate (C.G.R) was used to compute the growth of area, production, and productivity of citrus crop. For computing C.G.R, regression analysis was applied by the following formula:

$$Y = A\,[1 + r]^t$$

Where, Y = dependent variable

A = Constant, $B = 1 + r$, r = Compound growth rate.

t = time variable in years (1990-91 to 2018-19)

$$Log\ Y = log\ A + t\ log\ [1 + r]$$

OR $Y^* = a + bt$

Where $Y^* = log\ Y$

$a = log\ A$

$b = log\ [1 + r]$

$[1 + r] = Antilog\ b$

$r = Antilog\ b - 1$

In percentage term $r = [Antilog\ b - 1] \times 100$

The formula for calculating the co-efficient of variation is as follows:

$$C.V. = \frac{SD}{Mean} \times 100$$

Where SD, Standard deviation

To estimate the future prospects of citrus crop in Haryana, the time series data related to area, production and productivity of citrus crop was analysed using e-views software. Mishra *et al.* (2013), Savadatti (2017), Devi *et al.* (2021), and Yadav *et al.* (2022) used the ARIMA model to study the prospects of area, production, and productivity.

Box and Jekins (1976) ARIMA (a non-seasonal) model was employed, which denotes ARIMA (*p, d, q*). ARIMA model is the blend of autoregressive [A.R. (*p*)] and moving average [M.A. (*q*)] with an integrated order or differences (d). The methodology of this model is based on the assumption that any time series is stationary or non-stationary. If time series is non-stationary, then it will be converted into stationary by taking the data's difference (once or more times) or log form. If data is stationary already, then the ARIMA (*p,d,q*) model becomes ARIMA (*p,q*) model (Gujarati, 2004).

The autoregressive (A.R.) model can be presented by following:

$$Y_t = B_0 + B_1 Y_{t-1} + B_2 Y_{t-2} + \ldots\ldots\ldots\ldots + B_n Y_{t-n} + U_t$$

Y_t = Dependent variable

$B_0, B_1, B_2, \ldots\ldots, B_n$ = Coefficients to be estimated

U_t = it is a white noise error term

$Y_{t-1}, Y_{t-2}, \ldots\ldots, Y_{t-n}$ = Previous legs of dependent variable

The moving average (M.A.) model can be expressed by following:

$$Y_t = C_0 + C_1 U_t + C_2 U_{t-1} + \ldots\ldots\ldots\ldots + C_n U_{t-n}$$

Y_t = Dependent variable

C_0, C_1, C_2, ……., C_n = Coefficients to be estimated

U_t = error term at time t

U_{t-1}, U_{t-2},……., U_{t-n} = Previous legs of Error terms

Autoregressive integrated moving average: ARIMA (p, d, q) is a general model.

$$Y_t = B_0 + B_1 Y_{t-1} + B_2 Y_{t-2} + \ldots\ldots + B_n Y_{t-n} + U_t - CtU_{t-1} - C_2 U_{t-2} - \ldots\ldots - C_n U_{t-n}$$

Augmented Dickey-Fuller test (unit root), graph and correlogram were employed to identify the time series data is stationary or non-stationary. To check the stationary, the graph of autocorrelation function (A.C.F.) and partial autocorrelation function (PACF) have been used which process can be expressed as follows:

Table 1: Condition to Determine the Model through A.C.F. and PACF Graph

Model	ACF	PACF
AR (p)	Geometric	Cut off after q
M.A. (q)	Cut off after p	Geometric
ARMA (p, q)	Geometric	Geometric

Researchers and experts have been used Augmented Dickey-Fuller test to check the stationary of time series data. The results of three were same (which showed stationary after de-trending the data).

Augmented Dickey-Fuller test can be expressed as follows:

$$\Delta Y_t = B_1 + B_2 t + B_3 Y_{t-1} + \sum_{i=1}^{m} \alpha_i \Delta Y_t - i + \varepsilon_t$$

ΔY_t = Dependent variable

m denotes the maximum length

For selection of model, there are many criteria have been used in the time series study i.e., R-squared (R^2), Adjusted R-squared (AR^2), Standard Errors of regression (S.E.R.), Sum squared residual (S.S.R.), Log likelihood (L.L.), F-statistic (F.S.), Mean dependent variance (MDV), S.D. dependent variance (SDDV), Akaike info criterion (A.I.C.), Schwarz criterion (S.C.), Hannan-Quinn criterion (H.Q.C.) and Durbin-Watson statistics (D.W.S.) values have been selected for forecasting the production of horticultural crops in Haryana. The optimum model was selected for the forecasting of horticultural production in Haryana. The maximum AR^2 (It means that the dependent variable is highly reliant on the independent variable) and minimum A.I.C. & S.C. (it means that a model has less information lose which exist with highest quality) were used to select the appropriate model for forecasting in B-J methodology (Gujarati, 2011).

RESULTS AND DISCUSSION

Trends of area, production, and productivity of citrus crop

Table 2 exhibits the trends regarding area, production and productivity of citrus crop in Sirsa district.

Table 2: Growth of area, production and productivity of citrus crop in Sirsa district *(Area in 000 hectare, production in 000 tonnes and productivity in 000 tonnes per hectare)*

Statistical tools	Area	Production	Productivity
Period-I (1990-91 to 1998-99)			
Mean	2.22	20.60	9.31
C.V.	12.03	15.97	11.27
C.G.R.	4.50	4.30	-0.30
Period-II (1999-2000 to 2008-09)			
Mean	3.39	38.02	11.76
C.V.	32.83	27.55	28.84
C.G.R.	7.90	7.30	-0.60
Period-III (2009-10 to 2018-19)			
Mean	9.15	174.77	18.62
C.V.	10.45	39.94	33.03
C.G.R.	3.40	15.10	11.30
Over all period (1990-91 to 2018-19)			
Mean*	5.01	79.77	13.36
C.V.*	64.03	101.65	42.50
C.G.R.*	7.40	11.10	3.40

Source: *Horticulture Department, Government of Haryana*

Note: *C.V. has been depicted in percentage form.*

**Shows the overall values of mean, C.V. and C.G.R.*

During the first period of the study, area increased at the rate of 4.50%, while, an increment in productivity was observed as -0.30%, which helped the production of the citrus crop in Sirsa to grow at the rate of 4.30%. However, the study's second period indicates more production increases due

to farmers' higher area allocation under this crop. During this decade, the area's contribution in production increased while productivity decreased by a slight margin. Pandey *et al.* (2017) found in their study that area and production of citrus crop continuously increased from 2000-01 in Nepal but production started to decline after 2010-11 consequently productivity decreased from 2009-10 to 2015-16.

This made the production to increase as the marginal decrease in productivity during the period under consideration was offset by the noticeable increase in area. We may also add that the increase in production was not the result of better crop yield but the outcome of their rational decision-making regarding allocating area and other resources under the concerned crops.

A very impressive picture emerged for the last decade of the study as all the variables selected for the study were found able enough to clinch all-embracing heed of the farmers irrespective of area allocation or their endeavour to realize more per unit yield in terms of being laborious on their farms. It was reflected in the growth behaviour of area, production, and crop productivity under consideration. An outstanding improvement was noticed in case of the productivity of the crop. It increased from -0.60% to 11.30% per annum during this period. It could be due to the commencement and implementation of the scheme "Mission for Integrated Horticulture Development in Haryana (MIDH)" in 2009-10 and National Horticulture Mission (N.H.M.) in 2005. Almost the same scenario was reflected in the growth behaviour of the citrus crop production in district Sirsa as the compound growth rate for production was 15.10%. The increase in productivity may be attributed to facilities like technology encouragement, planting material and an increase in the water supply through micro irrigation under MIDH and N.H.M.

So, based on the behaviour of growth in area, production and productivity, it can be concluded that the recent decade has shown better outcomes which may be attributed to the innovations in methods used for production, generation of state-of-the-art technology in terms of various input and refined marketing and transport facilities made available by throwing a motley of schemes by the government to induce the growers for the cultivation of new crops or fruit crops. The furnished results altogether support the fact that initiatives taken by authorities have started to bear fruits. The overall study period also gives the same reflections that carry forward the already discussed trends**.** The crucial factors that have contributed to boosting the production and productivity of citrus crop are the continuous adoption of improved citrus production technology by the farmers, technical know-how among the farmers, introduction of improved cultivars and rootstocks, and growing market demand for citrus (Aryal *et al.* 2021).

The trends of area, production and productivity for citrus crop in Haryana state have been depicted in table 3.

Table 3: Trends of area, production, and productivity of citrus crop in Haryana *(Area in 000 hectare, production in 000 tonnes and productivity in 000 tonnes per hectare)*

Statistical tools	Area	Production	Productivity
	Period-I (1990-91 to 1998-99)		
Mean	3.85	33.04	8.64
C.V.	16.84	17.54	13.54
C.G.R.	6.40	4.50	-1.80
	Period-II (1999-2000 to 2008-09)		
Mean	6.25	56.68	9.50
C.V.	32.47	21.95	26.54
C.G.R.	6.00	6.20	0.20
	Period-III (2009-10 to 2018-19)		
Mean	18.76	271.58	14.04
C.V.	11.21	46.36	38.80
C.G.R.	3.60	16.60	12.60
	Over all period (1990-91 to 2018-19)		
Mean	9.82	123.45	10.81
C.V.	17.13	106.24	39.07
C.G.R.	8.20	10.90	2.50

Source: *Horticulture Department, Government of Haryana.*

Note: *C.V. has been depicted in percentage form.*

**Shows the overall values of mean, C.V. and C.G.R.*

The C.G.R. of area under citrus crop kept declining throughout the study period. The C.G.R. of area was calculated 8.20% for the overall study period. The value of variance indicates fluctuations over the study period. It was witnessed as 16.84% during the first period, which increased to 32.47% during the

second period of the study ultimately coming down to 11.21% during the third period.

Regarding the growth behaviour of productivity, the worse results were observed during the first period of the study as the growth remained negative. However, fluctuation was observed in successive study periods. The productivity went up in the second study period. During the last decade of the study period, an impressive increase was observed for citrus crop. The C.G.R. of productivity remained at 2.50% during the overall study period. The values for the coefficient of variation remained within the range of acceptability during the first and second periods of the study, but it was not true for the last and overall study periods. This may be due to the non-stationarity of time series data used in the study.

Future prospects of area, production and productivity of citrus crop in Sirsa district and Haryana state

The findings related to the prospects of area, production and productivity of citrus crop in Sirsa district and Haryana for the next ten years (2019-20 to 2028-29) have been presented in table 4.

The original data on the area of citrus crop in the Sirsa district were found to be non-stationary at the first and second level of difference. For making the time series data stationary, log form of time series data was taken, but data was still non-stationary at level and first difference. The data were found to be stationary in log form at the second level of difference because the probability of given data was calculated as 0.00, which is less than 0.05. ARIMA (10, 2, 6) was selected for data analysis as it turned out to be the best model for forecasting the area. It was the best model because it gave the maximum value R^2 (0.7025) and minimum value for A.I.C. (-2.7692) and S.C. (-2.6208). In addition, time series data of citrus crop production was found to be non-stationary at the original level but stationary at first difference because the value for the probability of given data was calculated as 0.0057, which was less than 0.05. ARIMA (12, 1, 7) was found to be the best model for forecasting the production as the result revealed through this model that R^2 was maximum (0.5595) and the value of A.I.C. (8.8910) and SC (9.0358) was minimum. Hence, ARIMA (10, 2, 6) and (12, 1, 7) were used for calculating the future prospects of area and production of citrus crop in Sirsa district.

The time series data of area and production of citrus crop in Haryana were found to be non-stationary at the original level and first difference. After taking the second difference, it was revealed that the time series data were stationary as the values for probability of given data were found to be 0.00 and 0.0087 for area and production, respectively. These are less than 0.05. ARIMA (1, 2, 6) was found to be the best model for forecasting the area as the result revealed that R^2 was maximum (0.7132) and the values of A.I.C. (1.7605) and SC (1.9045)

Table 4: Prospects of area, production and productivity of citrus crop in Sirsa district and Haryana state *(Area in 000 hectares, production in 000 tonnes and productivity in tonnes per hectare)*

Year	Sirsa			Haryana		
	Area	Production	Productivity	Area	Production	Productivity
2019-20	10.49	345.54	32.95	21.16	626.46	29.61
2020-21	11.19	378.15	33.78	21.49	675.16	31.42
2021-22	12.20	376.12	30.84	22.00	779.30	35.42
2022-23	13.25	355.48	26.82	22.51	868.76	38.59
2023-24	14.58	301.89	20.71	23.41	966.21	41.27
2024-25	16.33	325.70	19.95	24.35	946.80	38.88
2025-26	17.94	372.33	20.75	25.23	998.86	39.59
2026-27	19.80	322.98	16.31	26.07	1072.84	41.15
2027-28	21.51	356.47	16.57	26.88	1120.77	41.69
2028-29	24.08	339.00	14.08	27.68	1177.44	42.54
C.G.R	9.80	-0.70	-9.60	3.20	7.00	3.70

Source: *Horticulture Department, Government of Haryana.*

were minimum. In addition to it, ARIMA (12, 2, 6) was found to be the best model for forecasting the production because it gave the maximum value of R^2 (0.3720) and minimum value of A.I.C. (10.6927) and SC (10.8375). Thus, ARIMA (1, 2, 6) and (12, 2, 6) models were used for calculating the prospects of area and production of citrus crop in Haryana state.

The results predict that a tremendous increment will be observed in the area's growth rate in Sirsa district. It is expected to increase from 10.49 thousand hectares in 2019-20 to 24.08 thousand hectares in 2028-29. The compound growth rate was predicted to be 9.80%.

The furnished result shows that the projected citrus crop production will fluctuate. There will be an increment in the production of citrus crop in the year 2020-21 (378.15 thousand tonnes), 2024-25 (325.70 thousand tonnes), 2025-26 (372.33 thousand tonnes) and 2027-28 (356.47 thousand tonnes). The rest of the years will witness a declining growth rate in production. The study has predicted a negative growth rate in the production of citrus crop with compound growth rate of -0.70%.

As far as the forecasted data for the growth rate of productivity of citrus crop in Sirsa is concerned, it will decrease from 32.95 to 14.08 tonnes per hectare. The compound growth rate has been predicted to be -9.60%.

A comparative analysis reveals that the area's growth rate will be positive, and growth rate of production and productivity of citrus crop in Sirsa district will be negative. The growth rate of area under citrus crop in Haryana will increase from 21.16 (2019-20) to 27.68 (2028-29) thousand hectares without any ups and downs. The compound growth rate of area has been predicted as 3.20% during the decade. In addition, the forecasting for production growth rate shows a robust incremental trend from 626.46 to 1177.44 thousand tonnes per hectare during the decade. No fluctuation has been predicted in production except 2024-25 and 2027-28. The compound growth rate has been expected to be 7.00%. It means a sufficient production will be available in future for consumption (Ahmad & Mustafa, 2006).

The productivity of citrus crop in Haryana is predicted to increase from 29.61 to 42.54 tonnes per hectare during the forecasting period. The value of compound growth rate has been predicted to be 3.70 %. We may conclude that the prospected compound growth rate of area, production and productivity of citrus crop will be 3.20%, 7.00% and 3.70%, respectively. Further, the production and productivity growth rate will be greater in Haryana compared to district Sirsa. In contrast, the area growth rate in Sirsa district will be higher than in Haryana.

CONCLUSION

The fluctuated trends were observed in area, production, and productivity of citrus crop in Sirsa district and Haryana state. The third decade has shown a better result in Sirsa district and Haryana state. The study also revealed that the area's growth rate will be positive, and growth rate of production and productivity of citrus crop in Sirsa will be negative. The compound growth rate of area, production and productivity of citrus crop in Haryana will be 3.20%, 7.00% and 3.70%, respectively. Further, the production and productivity growth rate will be greater in Haryana compared to district Sirsa. In contrast, the growth rate of area in Sirsa district will be higher than in Haryana state.

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