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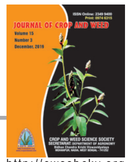

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Forecasting of area, productivity and prices of mango in Navsari district, Gujarat

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ABSTRACT

Horticulture is playing an important role in food production and industrial economy. Forecasting of area, production and the idea about price trend are used to provide support in decision making and proper planning for sustainable growth of the developing country. The cultivated area and yield of mango has more effects on the price of mango but in other ways pre or post-harvest management also effects on it. The problems regarding the price fluctuations arise due to seasonality in arrival and perishable nature. Therefore, forecasting of area, productivity and prices of mango play important role. In the current investigation, simple exponential smoothing (SES) was implemented to develop the forecasting models for area and productivity of mango. Under the SES, the error measurements at different values of alpha (a) for forecasting of area and productivity were observed that the value 0.8 and 0.9 of alpha (a) showed minimum Mean Absolute Percentage Error (MAPE) error i.e. 2.56%, and 2.89%, respectively. The study also developed time series ARIMA models for forecasting the prices of the mango (Keshar and Alphanso) for Navsari markets of Gujarat. It was revealed that ARIMA (5 1 2) and ARIMA (3 1 1) were found good models for forecasting the prices of the Keshar and Alphanso mango respectively in Navsari district of Gujarat.

***Keywords*:** ARIMA, exponential smoothing, forecasting, mango

India has been conferred with wide range of climate and physico-geographical environments and most suitable for growing various kinds of horticultural crops for example fruits, vegetables, flowers, nuts, spices, plantation crops etc. In the horticulture industry, fruit productivity and area consecration under mango stand at the top position and it covers 21.83 per cent of total fruits crops area and holds the second rank in total fruits production 35.53 per cent (Singh *et al.,* 2018). Our country is the largest producer of mango in the world comprising approximately 50 per cent of the whole supply. Uttar Pradesh is the largest producer state of mango in India in the year 2018-2019 (Anonymous, 2019). Gujarat is fifth largest mango producing state in India and Navsari is largest mango producing district with 294,835 million tons of production in Gujarat with 33,505 ha area under the mango crop.

The mango is with higher nutritive value and perishable in nature and also having the property of alternate bearing, thus the mango ranks in the uppermost category of high value commodities. In India, it has good scope for increasing the area and productivity of mango due to demand for mango fruit is growing per annum and the requirement is not meeting with rising rate of production. Considering the facts, the present study reviewed the several research conducted on forecasting of the area and productivity of mango and forecasting of prices of mango for different varieties. Sulaiman and Salau (2007) studied trend analysis for forecasting mango and citrus production in Nigeria.Khan *et al.* (2008) studied log linear model for estimating growth trends and ARIMA model to forecast production of mango. Hamjah (2014), Qureshi *et al.* (2014) and Pardhi *et al.* (2017) developed Box-Jenkins ARIMA model to forecast production of Mango. Rathod and Mishra (2017) developed weather based modelling for using methods of stepwise regression analysis and ARIMA model to forecast area and production of mango.Pardhi *et al.* (2018) made efforts on forecasting the prices of mango using ARIMA model. Jadhav *et al.* (2013) in the major markets of Karnataka, studied the price forecasting of cash crops i.e. Areca nut and Coconut. Omar *et al.* (2014) made valuable contribution in the price forecasting and spatial co-integration of banana. Areef *et al.* (2020) studied price behavior and forecasting of onion prices using ARIMA models.

METHODS AND MATERIALS

The study was undertaken for the Navsari district of Gujarat. Navsari is located at 20.95°N 72.93°E with an

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average elevation of 9m above sea level. The city is situated near the Purna River at the southern Gujarat. Major horticulture crops produced in the district are mango, sapota, papaya, cucurbits, banana and sugarcane.The study utilised the time series secondary data of area and productivity of the mango from the year 2002-03 to 2019-20 and it was collected from Directorate of Horticulture, Gandhinagar, Gujarat. The graphical representation of the data for Navsari district is given in the Fig.1.

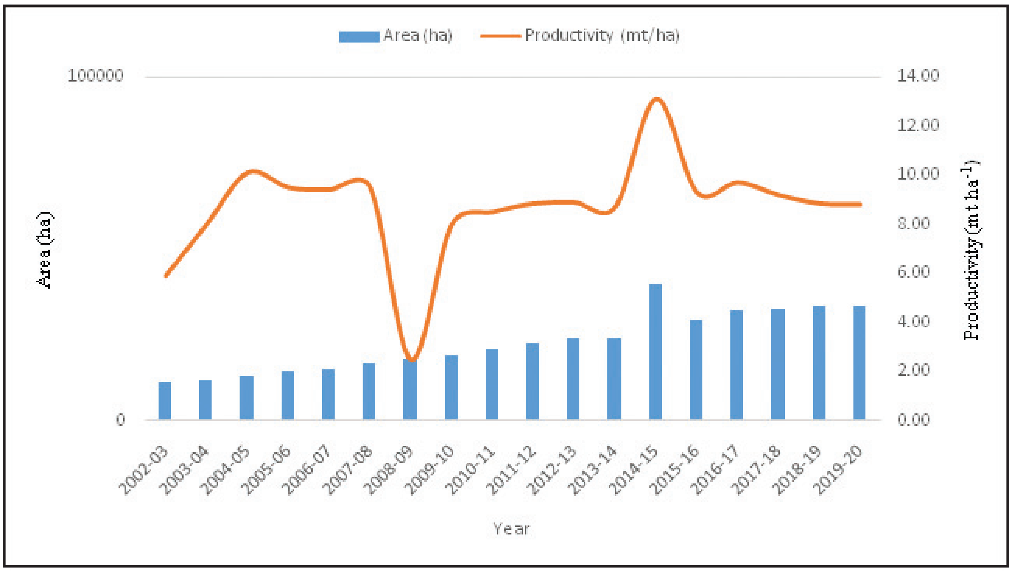


Fig. 1 : Area and productivity of mango in Navsari district

The price data of mango for different markets under Navsari was collected from website of Directorate of Marketing & Inspection (DMI), Ministry of Agriculture and Farmers Welfare, Government of India (https://agmarknet.gov.in/). The major markets of Navsari district viz. Vansda, Limzer (Vansda), Chikhali were selected as per data availability for the current study. In the present study, price forecasting was carried out for major growing varieties of mango i.e. Keshar and Alphanso. The weekly average of all market prices under the Navsari district was utilized for forecasting of the prices. The weekly missing price data were interpolated by cubic spline method. The graphical representation of the price data utilized in the study for Navsari is given in the Fig. 2.

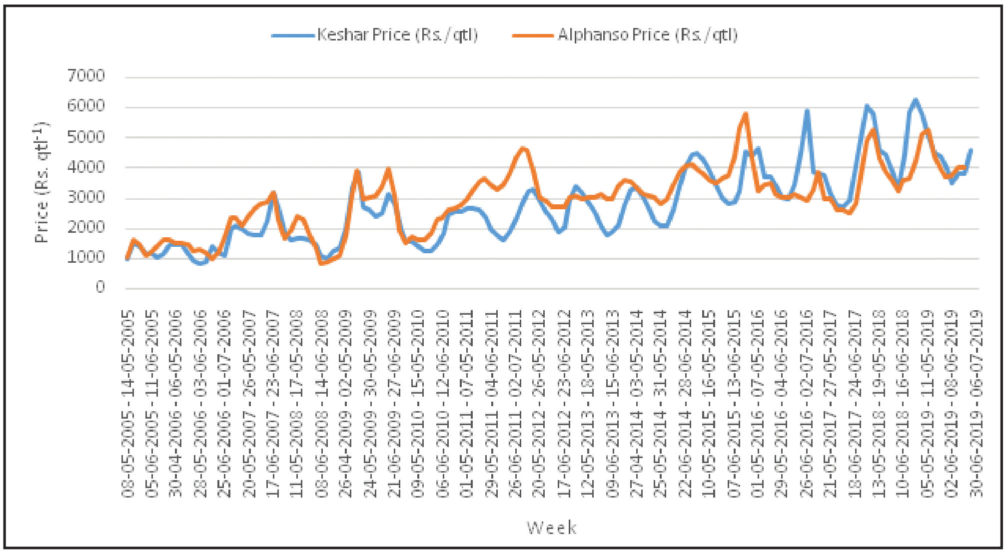


Fig. 2 : Weekly average mango (Keshar and Alphanso) price (Rs. qtl^{-1}) in Navsari district

Statistical techniques

The analysis of data was carried out by using Simple Exponential smoothing (SES) and Box-Jenkins Autoregressive models (ARIMA) techniques.

Simple Exponential Smoothing (SES)

The simple exponential smoothing (SES) technique is based on averaging series data in a series in a decreasing (exponential) manner. This method is suitable for forecasting data with no clear trend or seasonal pattern. Exponential Smoothing assigns exponentially increasing or decreasing weights (smoothing constant) to the data series over time. The smoothing constant value is higher for most recent value and lesser for the older data points. The value of smoothing constant i.e. alpha is always taken between 0 & 1 because if the value of smoothing constant is greater than 1, then the expression of single exponential smoothing acquires negative value which results failure of the method.

The forecast of area and productivity, for the period $t+1$

$$F_{t+1} = F_t + \alpha (Y_t - F_t)$$

$$F_{t+1} = \alpha Y_t + (1-\acute{a}) F_t \qquad (\textit{on simplification})$$

Where, F_{t+1}= Forecast value for period $t+1$

F_t= Forecast value for period t

α = Smoothing constant

Y_t= Actual value for period t (Area and productivity)

The value of α lies between 0 and 1. The large value of α (say 0.9) gives very little smoothing in the forecast, whereas a small value of α (say 0.1) gives acceptable smoothing. Alternatively, it can be chosen a from a set of values (say α = 0.1, 0.2, 0.3,…, 0.9) and finally choose the value that yields the minimum MSE value.

Box-Jenkins Autoregressive Integrated Moving Average (ARIMA) models

The stationarity of the data was carried out with Augmented Dickey-Fuller (ADF) Test (Unit root test) before proceed to the operational steps of ARIMA. The ARIMA is one of the most traditional methods of non-stationary time series analysis (Box *et al.*,1994). The model is usually stated as ARIMA (*p d q*), where, *p* denote order of auto-regression, *d* means integration (differencing) and *q* represent moving average.The Box and Jenkins propose a practical three stage procedure for finding a good model. a) Identification b) Estimation of parameters and c) Diagnostic checking. The forecasting through ARIMA model was carried by using E-Views 9.0 statistical software, viz., checking the stationarity through Augmented Dickey-Fuller (ADF) test, identification of tentative models based on scrutiny of the parameters of the selected models were estimated by maximum likelihood Estimation (MLE) method. The adequacy of the model was judged based on the value of Ljung-Box 'Q' Statistic using residual diagnostics.

Performance of developed models

The identification of the suitable forecasting models for area, productivityand prices of mango were done using different goodness of fit techniques viz. Adj.R^2,

$$Adj\ R^2 = 1 - \frac{(1-R^2)(N-1)}{N-p-1}$$

Mean absolute % error (MAPE),

$$MAPE = \left(\frac{1}{n}\sum \frac{|O_i - E_i|}{O_i}\right) * 100$$

Root mean square error (RMSE),

$$RMSE = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(Oi - Ei)^2}$$

Where, O_i and $E_i$are the observed and forecasted value of crop yield respectively and Thiel's inequality coefficient (U)

$$U = \sqrt{\frac{\frac{\Sigma(Oi-Ei)^2}{n}}{\frac{\Sigma O_i^2}{n} + \frac{\Sigma E_i^2}{n}}}$$

Where, *Oi* are the observed value and *Ei* are the corresponding forecasts. The predictive performance of the model is excellent, when $U = 0$. Also when $U = 1$ that means the forecasting performance is not improvedby just using the last observed value as a forecast (Friedhelm, 1973).

RESULTS AND DISCUSSION

Forecasting of the area and productivity of mango using exponential models

In the present study, the simple exponential smoothing (SES) was adopted to forecast the value of area (ha) and productivity (mt ha^{-1}) for the Navsari district. The Table 1 showed the error measurements at different values of alpha (α) for forecasting of area (ha) in the Navsari district. Here value of α were chosen from a grid of values viz. 0.2, 0.4, 0.6, 0.8, 0.9. Depending upon these values, the forecast with minimum error measurement and corresponding smoothing constant were selected.

It was observed from Table 1 that for the value 0.8 of alpha (α) showed minimum Mean Absolute Percentage Error (MAPE) i.e. 2.56% which was low among all other values of alpha. Also for other values of alpha, Root Mean Square Error (RMSE) was high and therefore appropriate value selected for smoothing constant was 0.8. The graphical representation of actual area (ha) and forecasted area (ha) of mango in Navsari district is given in Fig. 3.

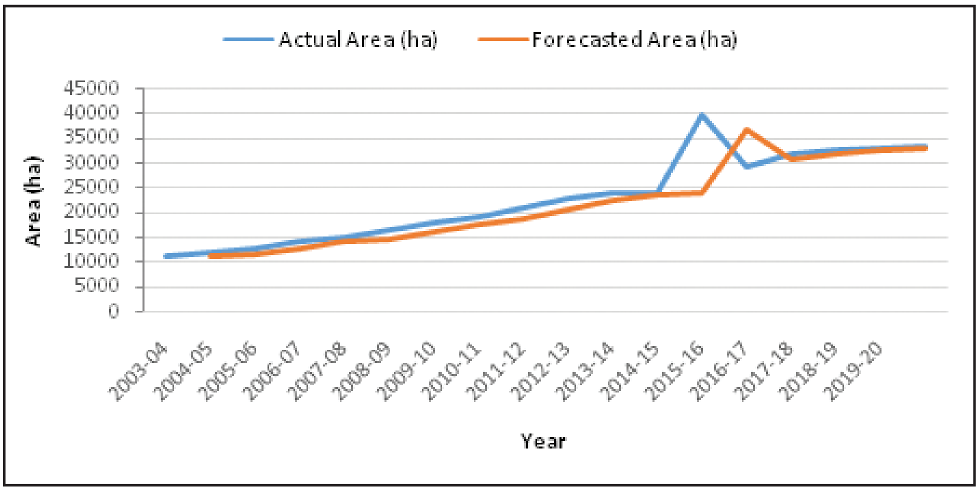


Fig. 3 : Graphical representation of actual area (ha) and forecasted area (ha) of mango in Navsari district

It was observed from Table 2 the error measurements at different values of alpha (a) for forecasting the productivity (mt ha^{-1}) of mango in the Navsari district. Depending upon these values, the forecast with minimum error measurement and corresponding smoothing constant were selected. From Table 2 it was observed that the value of the MAPE varies from the 2.89 to 5.85 for corresponding values of damping factor (1-á) from 0.1 to 0.8 respectively. It was observed that value 0.9 of alpha (a) showed minimum value of the MAPE i.e. 2.89% among all other values of alpha. For remaining values of alpha, RMSE was high and therefore appropriate value selected for smoothing constant was 0.9. The graphical representation of actual productivity (mt ha^{-1}) and forecasted productivity (mt ha^{-1}) of mango in Navsari district is given in Fig. 4.

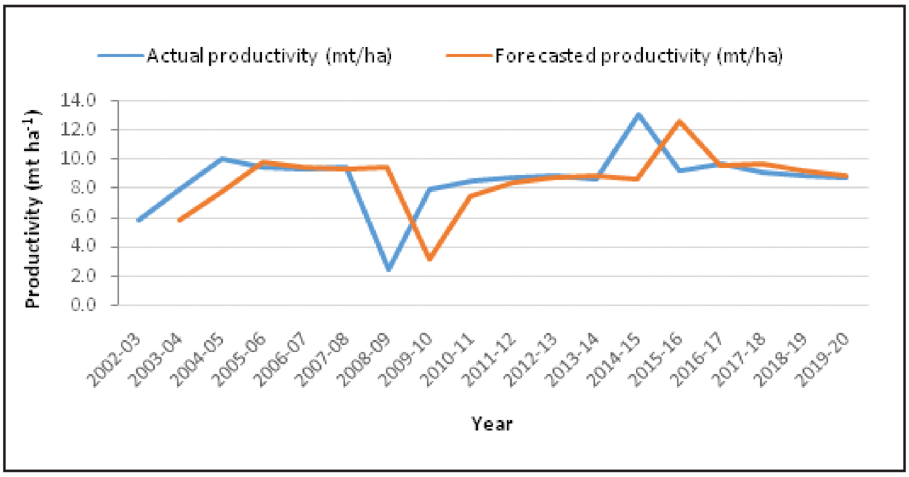


Fig. 4: Graphical representation of actual productivity (mt ha^{-1}) and forecasted productivity (mt ha^{-1}) of mango in Navsari district

Table 1 : Mango area (ha) forecast validation using different values of weight (α) for SES method

Navsari	α	Damping factor (1-α)	MSE	RMSE	MAPE (%)
Area	0.9	0.1	1279029.00	1130.94	2.83
	0.8	0.2	846573.53	920.09	2.56
	0.6	0.4	994035.25	997.01	2.96
	0.4	0.6	4286688.95	2070.43	6.14
	0.2	0.8	35503263.05	5958.46	17.95

Table 2 : Mango productivity (mt ha^{-1}) forecast validation using different values of weight (á) for SES method

Navsari	α	Damping factor (1-α)	MSE	RMSE	MAPE (%)
Productivity	0.9	0.1	0.10	0.32	2.89
	0.8	0.2	0.14	0.37	3.63
	0.6	0.4	0.27	0.52	5.47
	0.4	0.6	0.32	0.56	5.85
	0.2	0.8	0.15	0.39	3.82

Table 3: Stationarity (ADF) test at level

Null Hypothesis: KESHAR_PRICE has a unit root
Exogenous: Constant
Lag Length: 11 (Automatic - based on AIC, maxlag=13)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.055059	0.7319
Test critical values:	1% level		-3.482035
	5% level		-2.884109
	10% level		-2.578884

*MacKinnon (1996) one-sided p-values.

Table 4: Stationarity (ADF) test at 1st differencing

Null Hypothesis: D(KESHAR_PRICE) has a unit root
Exogenous: Constant
Lag Length: 10 (Automatic - based on AIC, maxlag=13)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-4.774302	0.0001
Test critical values:	1% level	-3.482035	
	5% level	-2.884109	
	10% level	-2.578884	

*MacKinnon (1996) one-sided p-values.

Table 5: Identification of ARIMA model

ARIMA Model →	(5, 1, 2)	(10, 1, 4)	(10, 1, 1)	(5, 1, 5)	(10, 1, 5)
SIGMASQ	216594.800	216753.900	219079.600	220265.400	228021.200
Adjusted R^2	0.213	0.213	0.204	0.200	0.172
AIC	15.199	15.200	15.208	15.219	15.246
SIC	15.287	15.288	15.296	15.307	15.334

Table 6 : Estimation of coefficients of ARIMA (5, 1, 2) model through residual diagnostics

Dependent Variable: D(KESHAR_PRICE)
Method: ARMA Maximum Likelihood (OPG - BHHH)
Sample: 2 132
Included observations: 131
Convergence achieved after 46 iterations

Variable	Coefficient	Std. error	t-Statistic	Prob.
C	27.05957	5.270977	5.133691	0.0000
AR(5)	-0.397731	0.072953	-5.451867	0.0000
AR(3)	-0.195391	0.082795	-2.359945	0.0198
AR(4)	-0.275053	0.091248	-3.014362	0.0031
MA(2)	-0.478061	0.081163	-5.890127	0.0000
MA(7)	-0.318425	0.075569	-4.213701	0.0000
SIGMASQ	176286.6	22859.11	7.711874	0.0000

R-squared	0.373915	Mean dependent var	36.95256
Adjusted R-squared	0.343620	S.D. dependent var	532.6684
S.E. of regression	431.5533	**Akaike info criterion**	15.04830
Sum squared resid	23093545	**Schwarz criterion**	15.20194
Log likelihood	-978.6639	Hannan-Quinn criter.	15.11073
F-statistic	12.34269	Durbin-Watson stat	1.768749
Prob(F-statistic)	0.000000		

Table 7: Validation of the ARIMA (5, 1, 2) model

Week	Actual price (Rs. qtl^{-1})	Forecasted price (Rs. $qt\ l^{-1}$)	Forecast error (%)
05-05-2019 - 11-05-2019	5054	5040	0.277
12-05-2019 - 18-05-2019	4513	4428	1.889
19-05-2019 - 25-05-2019	4386	3982	9.198
26-05-2019 - 01-06-2019	3958	3881	1.941
02-06-2019 - 08-06-2019	3481	4193	-20.457
09-06-2019 - 15-06-2019	3811	4634	-21.605
16-06-2019 - 22-06-2019	3792	5210	-37.388
23-06-2019 - 29-06-2019	4625	5405	-16.854
30-06-2019 - 06-07-2019	-	5323	-
RMSE	705.239		
MAE	539.033		
MAPE (%)	13.701		
Theil inequality coefficient	0.0796		

Table 8 : Stationarity (ADF) test at level

Null Hypothesis: ALPHANSO_PRICE has a unit root
Exogenous: Constant
Lag Length: 2 (Automatic - based on AIC, maxlag=13)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.900790	0.0479
Test critical values:	1% level		-3.478911
	5% level		-2.882748
	10% level		-2.578158

*MacKinnon (1996) one-sided p-values.

Table 9: Stationarity (ADF) test at 1st differencing

Null Hypothesis: D(ALPHANSO_PRICE) has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic - based on AIC, maxlag=13)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-9.576066	0.0000
Test critical values:	1% level		-3.478911
	5% level		-2.882748
	10% level		-2.578158

*MacKinnon (1996) one-sided p-values.

Table 10: Identification of ARIMA model

ARIMA Model →	(3, 1, 1)	(1, 1, 2)	(2, 1, 1)	(1, 1, 0)	(0, 1, 1)
SIGMASQ	141707.800	145109.800	146531.400	162338.100	148276.900
Adjusted R^2	0.229	0.211	0.203	0.124	0.200
AIC	14.764	14.788	14.797	14.883	14.793
SIC	14.852	14.876	14.885	14.949	14.859

Table 11: Estimation of coefficients of the ARIMA (3, 1, 1) model

Dependent Variable: D(ALPHANSO_PRICE)
Method: ARMA Maximum Likelihood (OPG - BHHH)
Sample: 3 132
Included observations: 130
Convergence achieved after 18 iterations

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	27.18961	46.77042	0.581342	0.5620
AR(3)	-0.214827	0.079816	-2.691533	0.0081
MA(1)	0.547163	0.070129	7.802227	0.0000
SIGMASQ	141707.8	13177.12	10.75408	0.0000

R-squared	0.247155	Mean dependent var	24.36813
Adjusted R-squared	0.229230	S.D. dependent var	435.5328
S.E. of regression	382.3695	**Akaike info criterion**	14.76421
Sum squared resid	18422013	**Schwarz criterion**	14.85245
Log likelihood	-955.6739	Hannan-Quinn criter.	14.80007
F-statistic	13.78837	Durbin-Watson stat	2.074717
Prob(F-statistic)	0.000000		

Table 12: Validation of the ARIMA (3, 1, 1) model

Week	Actual price (Rs. qtl^{-1})	Forecasted price (Rs. qtl^{-1})	Forecast error (%)
28-04-2019 - 04-05-2019	5083	4460	12.246
05-05-2019 - 11-05-2019	5267	4313	18.114
12-05-2019 - 18-05-2019	4343	4035	7.098
19-05-2019 - 25-05-2019	3946	3887	1.512
26-05-2019 - 01-06-2019	3677	3928	-6.821
02-06-2019 - 08-06-2019	3723	4027	-8.154
09-06-2019 - 15-06-2019	3975	4068	-2.330
16-06-2019 - 22-06-2019	4010	4024	-0.344
23-06-2019 - 29-06-2019	-	3954	-
RMSE	441.593		
MAE	325.648		
MAPE (%)	7.077		
Theil inequality coefficient	0.0526		

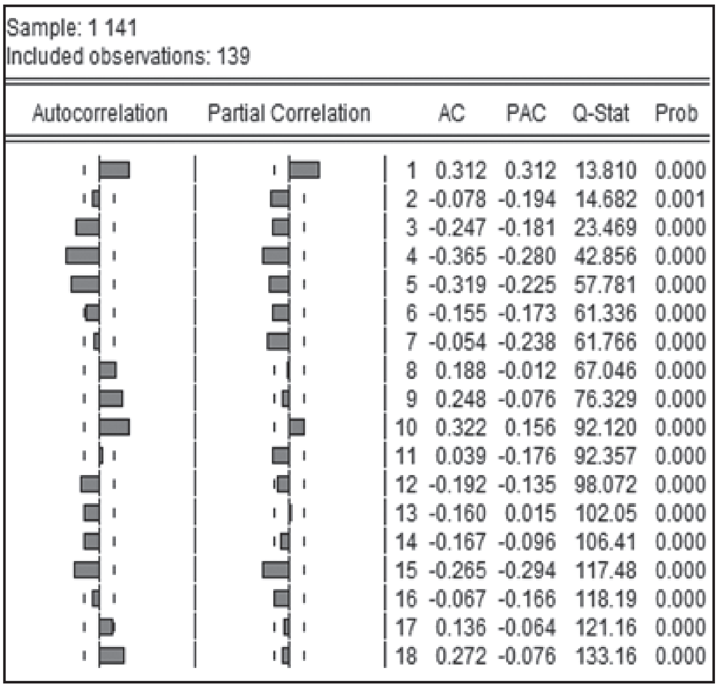
Forecasting of the prices (Rs. qtl^{-1}) of mango using ARIMA models

The detailed analysis of forecasting of mango prices (Rs. qtl^{-1}) for the variety of Keshar and Alphonso in Navsari district is presented separately under following subheads.

KESHAR

Stationarity check

The process of price (Rs. qtl^{-1}) forecasting was started with stationarity check of the data. The Augmented Dickey-Fuller (ADF) unit root test was applied to check the stationarity of the price data of Keshar mango in Navsari district. Table 3 revealed that Augmented Dickey-Fuller unit root test statistic was accepted the null hypothesis. It was indicated that prices data of Keshar mango has a unit root (non-stationary) as the t-statistic values were more than rejection values at 5% and 1% level of the significance (p-value 0.7319). The analysis was proceeding further by taking 1st differencing and again tested stationarity. Table 4 showed that null hypothesis for test statistic was rejected which indicated prices data of Keshar mango had stationarity (p-value 0.0001). Therefore ARIMA model identification was proceeded with taking value, d=1. It was also observed that the price series had become stationary after first differencing. Further, Fig. 5 showed that the presence of peak at first values clearly indicates suitability of the choice of non-seasonal difference d=1, to accomplish the stationary series.



Sample: 1 141
Included observations: 139

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.312	0.312	13.810	0.000
		2	-0.078	-0.194	14.682	0.001
		3	-0.247	-0.181	23.469	0.000
		4	-0.365	-0.280	42.856	0.000
		5	-0.319	-0.225	57.781	0.000
		6	-0.155	-0.173	61.336	0.000
		7	-0.054	-0.238	61.766	0.000
		8	0.188	-0.012	67.046	0.000
		9	0.248	-0.076	76.329	0.000
		10	0.322	0.156	92.120	0.000
		11	0.039	-0.176	92.357	0.000
		12	-0.192	-0.135	98.072	0.000
		13	-0.160	0.015	102.05	0.000
		14	-0.167	-0.096	106.41	0.000
		15	-0.265	-0.294	117.48	0.000
		16	-0.067	-0.166	118.19	0.000
		17	0.136	-0.064	121.16	0.000
		18	0.272	-0.076	133.16	0.000

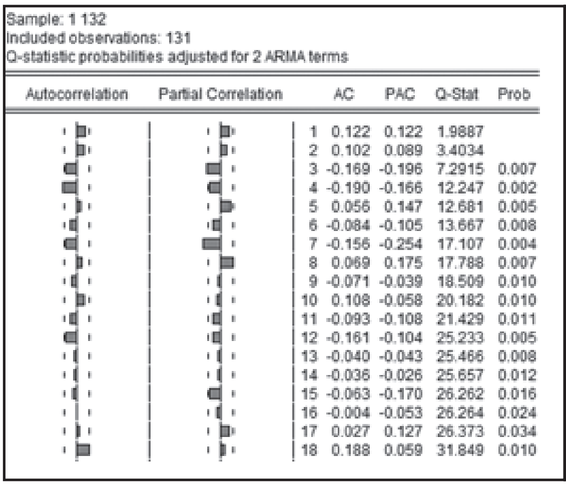
Fig. 5: Correlogram at first differencing

Identification of the model

The tentative models were first identified based on the Auto-Correlation Function (ACF) and Partial Auto-Correlation Function (PACF) plots (Fig. 5). The based on numbers of spike outside the confidence level in the correlogram (Fig. 5), the all possible combination of the p and q values were carried out for identification of the best model. The Method of ARMA Maximum Likelihood was applied for model development. The tentatively identified five best models for forecasting prices of Keshar mango in the Navsari district and are presented in Table 5. The table also indicated the values of Akaike Information Criteria (AIC) and Schwarz Bayesian Information Criteria (SIC) along with adjusted R^2 and SIGMASQ. Based on the lower the value of AIC, SIC and SIGMASQ with high value of Adjusted R^2 the selected model was stated better for forecasting. From Table 5, it was found that ARIMA (5, 1, 2) was good model for forecasting the prices of the Keshar mango.

Estimation and diagnostic check of parameters

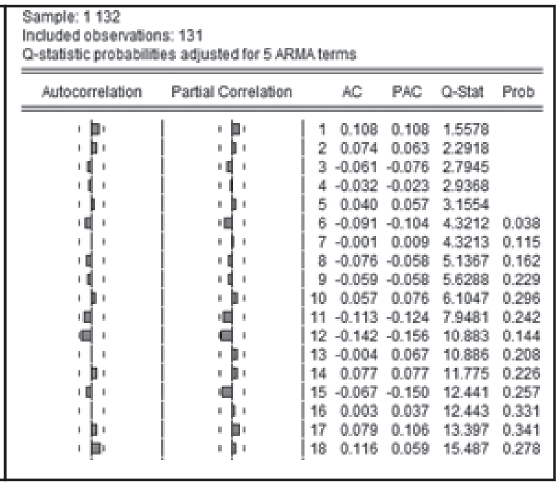
After identification of the ARIMA model, next estimation and diagnostic check of the parameters were carried out for selected best model ARIMA (5, 1, 2). The Table 6 showed the estimated coefficient of the ARIMA (5, 1, 2) model and it was found best suited model for forecasting the prices of Keshar mango with the value of the adj. R^2 = 34.362, AIC = 15.048 and SIC = 15.202.The graphical representation of the residuals of the correlogram is shown in Fig. 6 (a) & (b).



Sample: 1 132
Included observations: 131
Q-statistic probabilities adjusted for 2 ARMA terms

	AC	PAC	Q-Stat	Prob
1	0.122	0.122	1.9887	
2	0.102	0.089	3.4034	
3	-0.169	-0.196	7.2915	0.007
4	-0.190	-0.166	12.247	0.002
5	0.056	0.147	12.681	0.005
6	-0.084	-0.105	13.667	0.008
7	-0.156	-0.254	17.107	0.004
8	0.069	0.175	17.788	0.007
9	-0.071	-0.039	18.509	0.010
10	0.108	-0.058	20.182	0.010
11	-0.093	-0.108	21.429	0.011
12	-0.161	-0.104	25.233	0.005
13	-0.040	-0.043	25.466	0.008
14	-0.036	-0.026	25.657	0.012
15	-0.063	-0.170	26.262	0.016
16	-0.004	-0.053	26.264	0.024
17	0.027	0.127	26.373	0.034
18	0.188	0.059	31.849	0.010

Fig. 6(a): Correlogram ARIMA (5, 1, 2)



Sample: 1 132
Included observations: 131
Q-statistic probabilities adjusted for 5 ARMA terms

	AC	PAC	Q-Stat	Prob
1	0.108	0.108	1.5578	
2	0.074	0.063	2.2918	
3	-0.061	-0.076	2.7945	
4	-0.032	-0.023	2.9368	
5	0.040	0.057	3.1554	
6	-0.091	-0.104	4.3212	0.038
7	-0.001	0.009	4.3213	0.115
8	-0.076	-0.058	5.1367	0.162
9	-0.059	-0.058	5.6288	0.229
10	0.057	0.076	6.1047	0.296
11	-0.113	-0.124	7.9481	0.242
12	-0.142	-0.156	10.883	0.144
13	-0.004	0.067	10.886	0.208
14	0.077	0.077	11.775	0.226
15	-0.067	-0.150	12.441	0.257
16	0.003	0.037	12.443	0.331
17	0.079	0.106	13.397	0.341
18	0.116	0.059	15.487	0.278

Fig. 6(b): Residual diagnostic ARIMA (5, 1, 2)

Validation of model

The validation of the selected model was done based on RMSE, MAPE and Theil inequality coefficient. Fig. 7 showed actual price (Rs. qtl^{-1}) and forecasted price (Rs. qtl^{-1}) of Keshar mango in Navsari district.

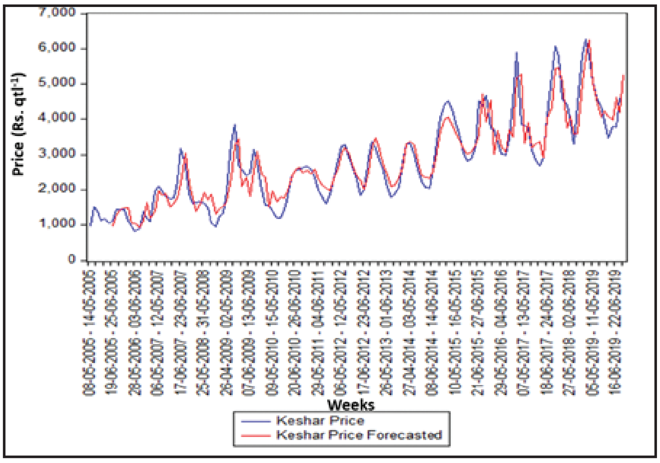


Fig. 7 : Graphical representation of actual price (Rs. qtl^{-1}) and forecasted price (Rs. qtl^{-1}) of Keshar mango in Navsari district

From Table 7 and Fig. 8, it was observed that the value of forecast error varies from the -37.388% to 9.198%. The value of RMSE and MAPE were observed low 705.239 and 13.701% respectively. The Theil inequality coefficient was 0.0796 which indicated that the predictive performance of the model was good.

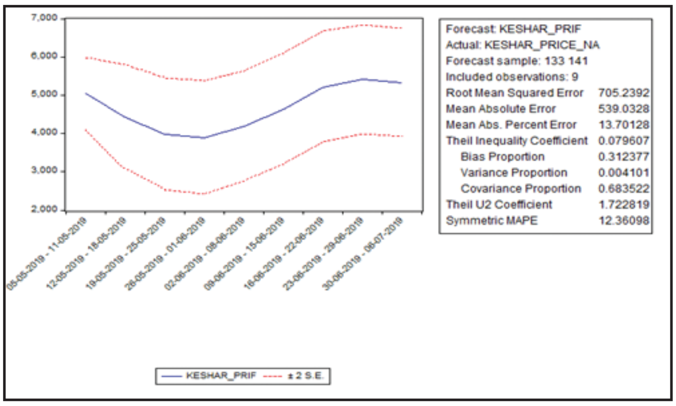
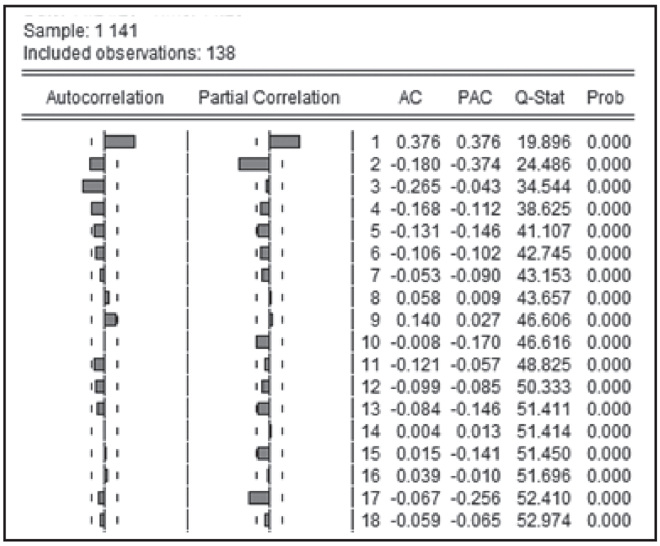


Fig. 8 : Validation of the forecast price (Rs. qtl^{-1}) of Keshar mango in Navsari district

ALPHANSO

Similar steps were followed as explained above for forecasting prices of Alphanso mango in Navsari district and results were discussed hereunder.

Table 8 showed that ADF unit root test statistic was accepted the null hypothesis which indicated that prices data of Alphanso mango has non-stationary as the t-Statistic values were more than rejection values at 5% and 1% level of the significance (p-value 0.0479). The analysis was proceeding further by taking 1st differencing. Table 9 showed that null hypothesis for test statistic was rejected that indicated prices data of Alphanso mango had stationarity (p-value 0.0000). Therefore ARIMA model identification was proceeded with taking value, d= 1. Further, Fig. 9 showed that the presence of peak at first values clearly indicates suitability of the choice of seasonal difference d=1, to accomplish the stationary series.


Sample: 1 141
Included observations: 138

Lag	AC	PAC	Q-Stat	Prob
1	0.376	0.376	19.896	0.000
2	-0.180	-0.374	24.486	0.000
3	-0.265	-0.043	34.544	0.000
4	-0.168	-0.112	38.625	0.000
5	-0.131	-0.146	41.107	0.000
6	-0.106	-0.102	42.745	0.000
7	-0.053	-0.090	43.153	0.000
8	0.058	0.009	43.657	0.000
9	0.140	0.027	46.606	0.000
10	-0.008	-0.170	46.616	0.000
11	-0.121	-0.057	48.825	0.000
12	-0.099	-0.085	50.333	0.000
13	-0.084	-0.146	51.411	0.000
14	0.004	0.013	51.414	0.000
15	0.015	-0.141	51.450	0.000
16	0.039	-0.010	51.696	0.000
17	-0.067	-0.256	52.410	0.000
18	-0.059	-0.065	52.974	0.000

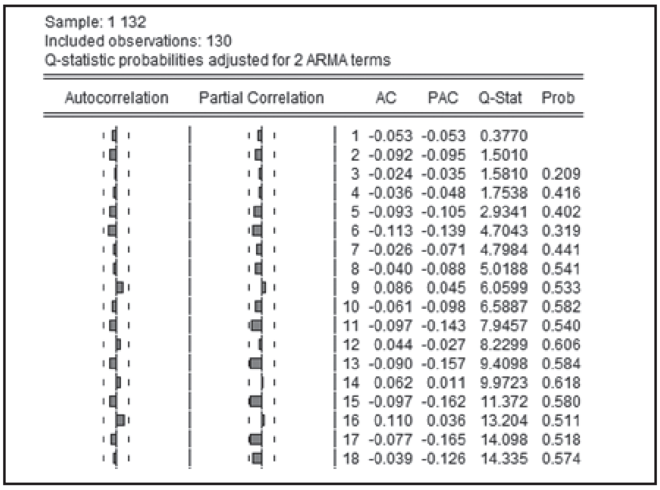
Fig. 9: Correlogram at first differencing

Identification of the model

From Table 10, it was found that ARIMA (3, 1, 1) was good model for forecasting the prices of the Alphanso mango based on the lower the value of AIC, SIC and SIGMASQ with high value of Adjusted R^2

Estimation and diagnostic check of parameters

The estimated coefficient of the ARIMA (3, 1, 1) model are given in Table 11 and it was found best suited model for forecasting the prices of Alphanso mango with high value of the adj. $R^2 = 22.923$ and low values of AIC(14.764) and SIC (14.852).The graphical representation of the residuals diagnostics is shown in Figure 10. The time series forecast was done using ARIMA (3, 1, 1) model.


Sample: 1 132
Included observations: 130
Q-statistic probabilities adjusted for 2 ARMA terms

Lag	AC	PAC	Q-Stat	Prob
1	-0.053	-0.053	0.3770	
2	-0.092	-0.095	1.5010	
3	-0.024	-0.035	1.5810	0.209
4	-0.036	-0.048	1.7538	0.416
5	-0.093	-0.105	2.9341	0.402
6	-0.113	-0.139	4.7043	0.319
7	-0.026	-0.071	4.7984	0.441
8	-0.040	-0.088	5.0188	0.541
9	0.086	0.045	6.0599	0.533
10	-0.061	-0.098	6.5887	0.582
11	-0.097	-0.143	7.9457	0.540
12	0.044	-0.027	8.2299	0.606
13	-0.090	-0.157	9.4098	0.584
14	0.062	0.011	9.9723	0.618
15	-0.097	-0.162	11.372	0.580
16	0.110	0.036	13.204	0.511
17	-0.077	-0.165	14.098	0.518
18	-0.039	-0.126	14.335	0.574

Fig. 10: Residual diagnostic ARIMA (3, 1, 1)

Validation of model

The validation of the selected model was done based on RMSE, MAPE and Theil inequality coefficient. The Figure 11 showed actual price (Rs. qtl^{-1}) and forecasted price (Rs. qtl^{-1}) of Alphanso mango in Navsari district.

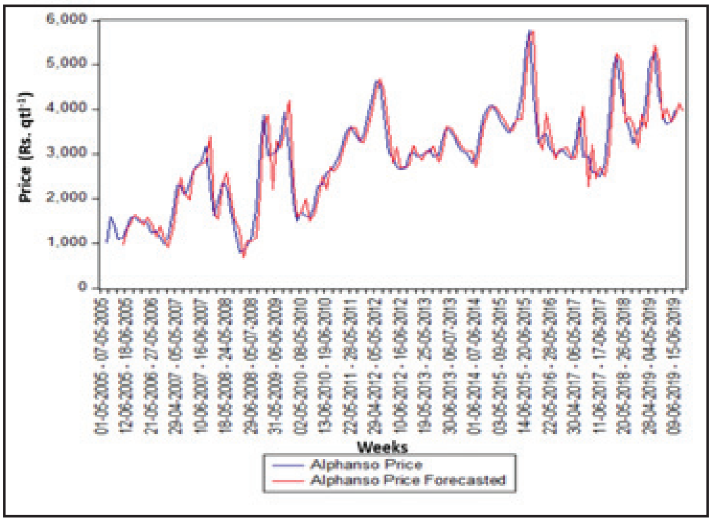


Fig. 11: Graphical representation of actual price (Rs. qtl^{-1}) and forecast price (Rs. qtl^{-1}) of Alphanso mango in Navsari district

From Table 12 and Fig. 12, it was observed that the value of forecast error varies from the -8.154% to 18.114%. The value of RMSE and MAPE were observed low 441.593 and 7.077 respectively. The Theil inequality coefficient was 0.0526 which indicated that the predictive performance of the model was good.

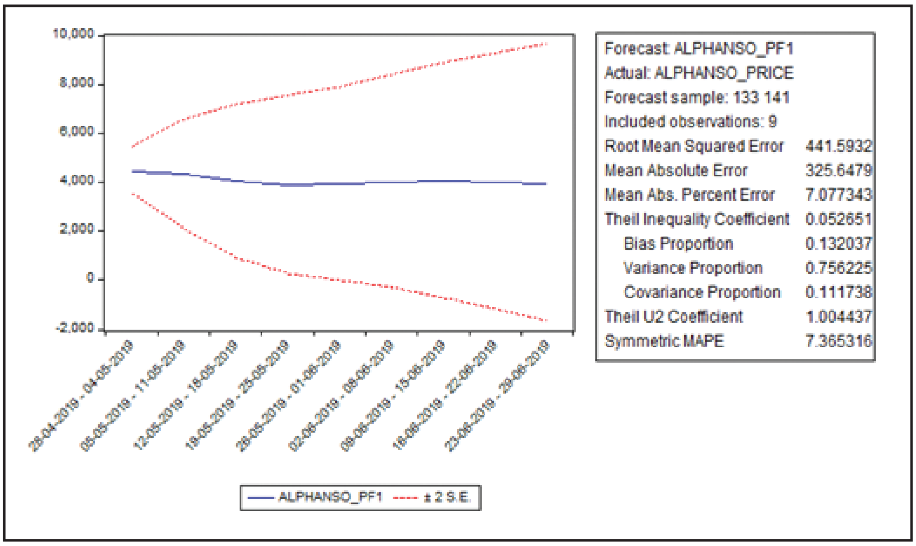


Fig. 12: Validation of the forecast price (Rs. qtl^{-1}) of Alphanso mango in Navsari district

CONCLUSION

The present study was carried out to develop forecasting models for area (ha), productivity (mt ha^{-1}) and also forecasting the prices (Rs qtl.$^{-1}$) of Mango (Keshar and Alphanso) in Navsari district of south Gujarat. It was concluded that SES can be utilized in time series analysis for reliable forecast. The price (Rs. qtl^{-1}) forecasting was carried out with most preferred and commonly used technique in time series analysis i.e. the ARIMA model. It was concluded that ARIMA models can be used for precise and consistent price forecast in future study. Based on the current study it is anticipated that the identification of the best forecast model may help to the producers, consumers as well as dealers in taking right decisions.

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