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Author (s):	Muhammad Wasim Amir
Affiliation (s):	Department of Statistics, University of Sargodha, Sargodha, Pakistan
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University of Management and Technology, Lahore, Pakistan

Apple Production of Pakistan: Time Series Modeling and Forecasting

Muhammad Waseem Amir*

Department of Statistics, University of Sargodha, Sargodha, Pakistan

Abstract

Apple is an important and popular fruit because it contains fiber, calories, vitamin C, and multivitamins, all of which are beneficial for human health. The demand for apples is increasing due to an increase in the population of Pakistan. Therefore, it is imperative to forecast apple production and to estimate the future trends of its production and consumption in the country. Hence, this study is concerned with forecasting the apple production of Pakistan. For this purpose, various time series models are fitted on the historical time series data (1958-2017) and the search for the best model is conducted based on the model selection criteria. The results indicate that the Autoregressive Integrated Moving Average or ARIMA (2, 1, 2) model is a suitable time series model to forecast the apple production of Pakistan. The assumptions of the selected model are also evaluated. On the basis of the ARIMA (2, 1, 2) model, the apple production of Pakistan is forecasted to be 697.651 thousand tons in 2030, under the assumption that no irregular pattern occurs.

Keywords**:** apple production, ARIMA, forecasting, model selection criteria, time series models

Introduction

The agriculture sector plays a dynamic role in Pakistan's economy. Around 65% of Pakistan's population is directly or indirectly associated with agriculture. This sector contributes 19.8% to the Gross Domestic Product (GDP) which is more than any other sector. More importantly, it is the largest employment providing sector as well as it employs 42.3% of the country's labor force (Government of Pakistan, 2016). The agriculture sector provides many crops, vegetables, and fruits. Some of these are largely utilized as raw materials for industrial purposes. Some food items, such as apple, banana, wheat, rice, sunflower, and onion contain a rich amount of carbohydrates which are a necessary part of the human body. The total production and the cultivated area of major crops in Pakistan were 8478.8

*Corresponding Author: muhammadwasim113@gmail.com

thousand tons and 611.7 thousand hectares, respectively (Fatima et al., 2013).

Across the world, apple is the most popular fruit. In 2014, the total world production of apples was approximately 85 Million Tons (MT), including 53 MT produced in Asia, 17.5 MT in Europe, and 11 MT in America (Opyd et al., 2017). The pomace of apple also contains a rich quantity of insoluble fiber (Li et al., 2104). Apple consumption reduces the risk of cancer, asthma, and heart disease (Boyer & Liu, 2004). Apples are predominant among fruits because of their disease-resistance and nutritional characteristics, taste, and ease of use (Morgan & Richard, 2003).

The forecasting of crop production is indispensable for a country's future planning and policies aimed to meet its population’s growing requirements. All over the world, many researchers use different statistical models to forecast crop production. This study aims to forecast the apple production of Pakistan. Karim et al. (2010) used regression modeling to forecast the wheat production of Bangladesh. Sabir and Tahir (2012) applied exponential smoothing to forecast the population and wheat production area of Pakistan. Amin et al. (2014) forecasted Pakistan’s wheat production by using the ARIMA (1, 2, 2) model. Ali et al. (2015) forecasted the yield and production of cotton and sugarcane in Pakistan. The study postulated ARIMA (2, 1, 1) as the finest model for forecasting cotton yield, whereas ARIMA (1, 1), ARIMA (0, 1), and ARIMA (1, 4) were designated as appropriate models to forecast sugarcane yield, cotton production, and sugarcane production, respectively. Naheed et al. (2015) applied the double exponential smoothing method to forecast the production of barley in Punjab, Pakistan. Celik et al. (2017) forecasted the groundnut production of Turkey. Their study aimed to build the finest model for groundnut production which could indicate the future trend in advance. ARIMA (0, 1, 1) was found to be the best model among all ARIMA models. Wali and Lokesh (2017) postulated that ARIMA (2, 1, 1) is the best model for forecasting cotton production in India. Shah et al. (2018) used the ARIMA model to forecast the yield of major crops in Khyber Pakhtunkhwa, Pakistan. Abid et al. (2018) forecasted the production and cultivated area of potatoes in Pakistan. They used a different time series model. The study revealed that exponential growth is the most suitable model to forecast potato area and production. Masood et al. (2018) applied S-curve, exponential smoothing, double exponential smoothing, quadratic trend, and

ARIMA model to forecast the wheat production of Pakistan. They found that ARIMA (2, 1, 2) is an adequate model for forecasting wheat production in Pakistan. Ullah et al. (2018) used the ARIMA model for forecasting the peach area and production of Pakistan. For this purpose, they used the cultivated area and production data of the previous 17 years to forecast for the next 11 years. Amir et al. (2021) applied a variety of time series models to forecast the onion production of Pakistan. In their study, they found that the ARIMA model is adequate to forecast onion production based on various model selection criteria.

Materials and Methods

To forecast crop and fruit production, various time series models are available in the literature. The current study attempts to fit the best time series model on the data on apple production of Pakistan, collected over the period 1958-2017 from the Agriculture Department of Pakistan. For this purpose, various time series models are applied to the data by using the Statgraphics software. Mathematical forms of some time series models are available in the literature and reported in Table 1. For choosing the best time series model, Akaike's Information Criteria (AIC) and Schwarz Bayesian Information Criteria (SBIC), along with some other relevant criteria, are taken into consideration. Furthermore, several forecasting accuracy measurement tools are reported in Table 2.

ARIMA Modeling

Autoregressive Integrated Moving Average (ARIMA), as propounded by Box and Jenkins (1976), is a time series model which is extensively applied to forecast time series data. The ARIMA (p, d, q) model is best described by using the following equation:

$$\left(1 - \sum_{j=1}^{p} \emptyset_j \, L_j\right)(1 - L)^d y_t = \left(1 + \sum_{i=1}^{q} \vartheta_i \, L_i\right) e_t,$$

where p, d, q represent the order of autoregressive (AR), integrated (I) , and moving average (MA), respectively. The main issue in ARIMA modeling is to select the best values for p, d, and q. Furthermore, the order of p and q are identified by the autocorrelation function (ACF) and partial autocorrelation function (PACF).

Table 1
Time Series Models

Sr. No	Model Name	Model Equation
1	Simple exponential smoothing	$x_t = \lambda x_t + (1 - \lambda)x_{t-1}$
2	Linear Trend	$x = x_t = a + bt + e_t$
3	Random with Drift	$x_t = x_{t-1} + \theta_0 + e_t$
4	ARIMA(0,1,1)	$x_t = x_{t-1} + \theta_0 + \theta e_{t-1}$
5	ARIMA (0, 1, 1) with constant	$x_t = x_{t-1} + \theta_0 + e_t + \theta e_{t-1}$
6	ARIMA (1, 1, 1) with constant	$x_t = (1 + \emptyset)x_{t-1} + \emptyset x_{t-2} + \theta_0 + e_t - \theta_1 e_{t-1}$
7	ARIMA (0, 1, 2) with constant	$x_t = x_{t-1} + \theta_0 + e_t - \theta_1 e_{t-1} - \theta_2 e_{t-2}$
8	ARIMA (1, 1, 1)	$x_t = (1 + \emptyset)x_{t-1} + \emptyset x_{t-2} + e_t - \theta_1 e_{t-1}$
9	ARIMA (0, 2, 2) with constant	$x_t = 2x_{t-1} - x_{t-1} + \theta_0 + e_t - \theta_1 e_{t-1} - \theta_2 e_{t-2}$
10	ARIMA (0, 2, 2)	$x_t = 2x_{t-1} - x_{t-1} + \theta_0 + e_t - \theta_1 e_{t-1} - \theta_2 e_{t-2}$
11	ARIMA (2, 0, 1)	$x_t = \alpha_1 x_{t-1} + \alpha_2 x_{t-2} + \theta_1 e_{t-1}$

Model Diagnostics

When the model is specified, it becomes essential to fulfill the required assumptions of the fitted time series model. Generally, the selected time series model requires the assumptions of normality, independence, no homoscedasticity, and no autocorrelation of residuals (Gujarati, 2009). Autocorrelation is detected by using ACF and PACF plots. The assumption of residual normality is checked trough a probability normal plot (Chatfield, 1995).

Forecasting Accuracy Measurement Tools

After model selection, the next key step in time series modeling is to measure the accuracy of the selected model. Several estimators are available for this purpose which include mean error (ME), mean percentage error (MPE), mean absolute error (MAE), mean absolute percentage error

(MAPE), and mean square error (MSE). The computation of these estimators is presented below in Table 2.

Table 2

Forecasting Accuracy Measurement Estimators

Accuracy measure tool	Estimator	References
ME	$ME = \frac{\sum_{t=1}^{n} e_t}{n}$	Makridakis et al., 2004
MAE	$MAE = \frac{\sum_{t=1}^{n} \lvert e_t \rvert}{n}$	Makridakis et al., 2004
MPE	$MPE = \frac{1}{n}\sum_{t=1}^{n} PE_t$	Makridakis et al., 2004
MAPE	$MPE = \frac{1}{n}\sum_{t=1}^{n} \lvert PE_t \rvert$	Makridakis et al., 2004
MSE	$MSE = \frac{\sum_{t=1}^{n} e_t^2}{n}$	Makridakis et al., 2004

where $e_t = x_t - \hat{x}_t$, $PE_t = \left(\frac{e_t}{x_t}\right) \times 100$ and F_t is the forecasted value for time *t*.

Results and Discussion

In this study, various time series models are fitted on the data on apple production of Pakistan. The purpose is to select an adequate model for more accurate forecasting. Table 3 presents the results of different time series models along with their validity and selection criteria. On the basis of AIC and SBIC time series model selection criteria, it was observed that ARIMA (2, 1, 2) has a minimum value of both AIC and SBIC. Further, the results of different fitted model diagnostics including independence/autocorrelation, normality, and homoscedasticity are accumulated. In Table 3, OK mean the model diagnostic test indicated the insignificance of a particular assumption. The selected model passes all the tests at 95% confidence interval. So, it is deemed adequate to forecast the apple production of Pakistan.

Table 3

Model Validity and Selection Criteria

Model	*RMSE*	*MAE*	*ME*	*MPE*	*MAPE*	*AIC*	*SBIC*	*HQC*	*RUNS*	*AUTO*	*RUNM*
a	48.2666	27.5253	11.1951	2.43	19.1471	7.75	7.75	7.75	OK	OK	OK
b	47.3533	25.5147	-3.37E-15	-25.36	31.7177	7.75	7.78	7.76	OK	OK	OK
c	86.5987	67.7565	-3.41E-14	77.53	133.287	8.99	9.06	9.02	***	***	***
d	84.8854	57.8409	-5.02E-14	29.4	77.1676	8.98	9.09	9.02	*	***	***
e	216.509	191.639	-4.55E-14	-551.76	589.58	10.79	10.82	10.8	***	***	***
f	195.413	123.564	-26.5893	-14.69	47.9063	10.62	10.69	10.64	***	***	***
g	218.571	162.432	104.602	-100.65	162.011	10.84	10.91	10.87	***	***	***
h	48.2665	27.0668	11.0095	2.39	18.8283	7.79	7.82	7.8	OK	OK	OK
i	49.0964	26.7393	1.5046	-2.27	18.0076	7.82	7.86	7.83	OK	OK	OK
j	54.5458	33.2564	16.5388	3.37	21.4275	8.03	8.07	8.05	OK	**	**
k	47.9538	25.352	-0.30485	-29.62	36.3089	7.81	7.88	7.83	OK	OK	OK
l	52.9715	30.5637	-0.16288	-4.84	20.3663	7.97	8.01	7.99	OK	OK	OK
m	48.2666	27.5253	11.1951	2.43	19.1471	7.75	7.75	7.75	OK	OK	OK
n	47.5569	25.1912	4.87968	-0.17	18.2559	7.76	7.79	7.77	OK	OK	OK
o	43.6159	25.6797	8.97	2.25	16.7552	7.68	7.82	7.74	*	OK	OK
p	45.8287	26.9373	6.2962	1.83	17.2593	7.75	7.85	7.79	**	OK	OK

Note. (***a***) Random walk, (***b***) Random walk with drift = 11.1951, (***c***) Linear trend = -98.154 + 11.3807 t, (***d***) Quadratic trend = -50.8988 + 6.80765 t + 0.0749687 t^2, (***e***) Constant mean = 248.958, (***f***) Exponential trend = exp (2.42471 + 0.0785785 t), (***g***) S-curve trend = exp (5.28403 + -5.93197 /t), (***h***) Simple exponential smoothing with alpha = 0.9999, (***i***) Brown's linear exp. smoothing with alpha = 0.527, (***j***) Simple moving average of 2 terms, (***k***) Holt's linear exp. smoothing with alpha = 0.9403 and beta = 0.0313, (***l***) Brown's quadratic exp. smoothing with alpha = 0.3882, (***m***) ARIMA (0, 1, 0), (*n*) ARIMA (1,0,0), (***o***) ARIMA (2, 1, 2), (*p*) ARIMA (1, 1, 2)

Fitted Time Series Model

Different time series models are fitted on the apple production data for the period 1958-2017. On the basis of Table 3 and Table 4, the best-fitted model for forecasting the apple production of Pakistan is ARIMA (2, 1, 2). Mathematically, it is given by the following equation:

$$\hat{x}_t = 0.5641\hat{x}_{t-1} - 0.4265\hat{x}_{t-2} + 0.8174\hat{e}_{t-1} - 0.9536\hat{e}_{t-2},$$

where $\hat{x}$ is the forecasted apple production for time t of the year,

$\hat{x}_{t-1}$ is the apple production forecasted at lag one year,

$\hat{e}_{t-1}$ is the residual at lag one year,

$\hat{e}_{t-2}$ is the residual at lag two year.

Table 4

Fitted ARIMA (2, 1, 2) Model Coefficient Summary

Parameter	Estimate	Stnd. Error	*t*-statistic	*Pr*-value
AR(1)	0.564167	0.134741	4.18706	0.000103
AR(2)	-0.42659	0.145882	-2.92422	0.005007
MA(1)	0.817483	0.040509	20.1802	0.000000
MA(2)	-0.95364	0.0412544	-23.1161	0.000000

Testing Selected Model Assumptions

Each model is fitted on the basis of certain assumptions. A model that fulfills its assumptions can be considered as the most precise and reliable model for forecasting. In the current study, the ARIMA (2, 1, 2) model requires the assumptions of normality, no heteroscedasticity, and no autocorrelation in the residuals. Table 3 and Figure 1 show that there is no autocorrelation among the residuals of the best-fitted model. Moreover, these residuals are also independent.

Table 5

Heteroscedasticity Tests of the Fitted ARIMA (2, 1, 2)

F-statistic	0.104972	Prob. F(3,53)	0.9568
Obs*R-squared	0.336682	Prob. Chi-Square(3)	0.9530
Scaled explained SS	1.310648	Prob. Chi-Square(3)	0.7266

Table 5 shows that the ARIMA (2, 1, 2) model residuals are homoscedastic because the *p*-value of the White test is greater than 0.05. So, the hypothesis that the residuals are homoscedastic at 5% level of significance cannot be rejected. Normality was checked by using periodogram, as shown in Figure 3. The figure shows the normality of the selected model residuals.

Figure 1

Residual Autocorrelation Plot of Apple Production for ARIMA (2, 1, 2) Model

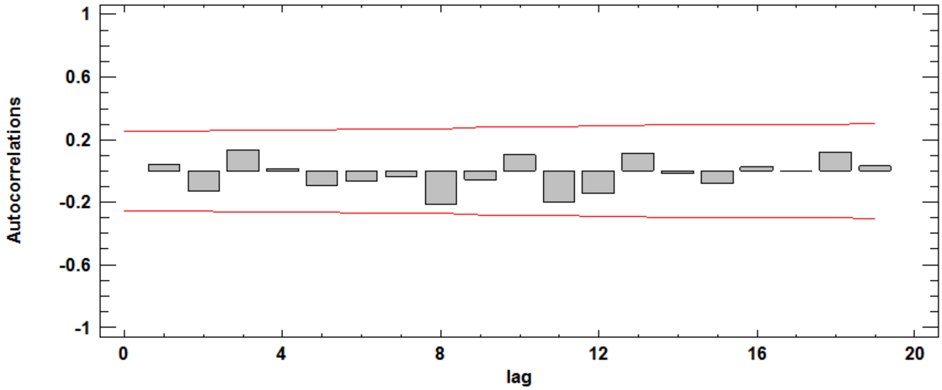


Figure 2

Residual Partial Autocorrelation Plot of Apple Production for ARIMA (2, 1, 2) Model

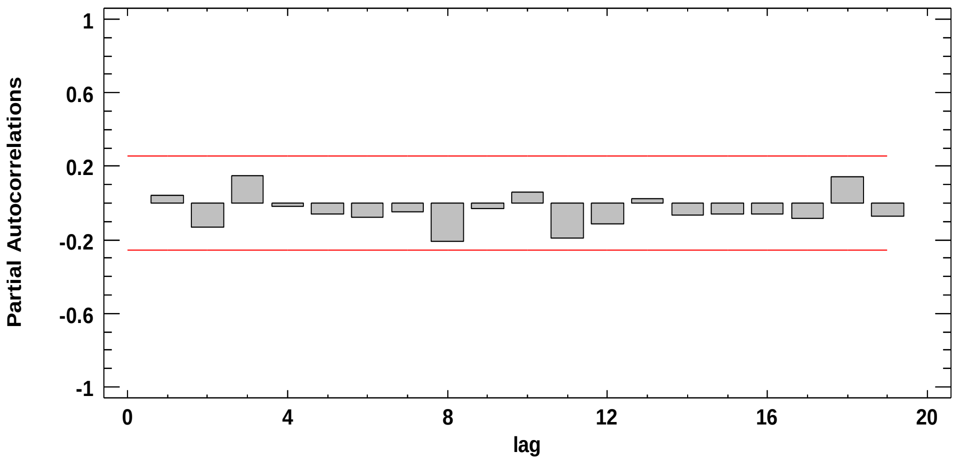


Figure 3

Periodogram of Apple Production Residuals for ARIMA (2, 1, 2) Model

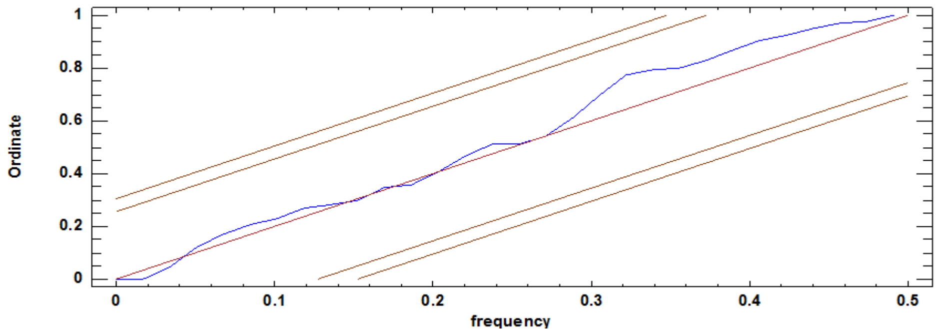


Table 6

Comparison of Actual and Forecasted Apple Production Based on ARIMA (2, 1, 2) Model Using 1948-2017 Data

Year	Actual (Thousand tons)	Forecasted (Thousand tons)	Residual
1958.0	9.4		
1959.0	16.2	5.44543	10.7546
1960.0	5.8	7.69234	-1.89234
1961.0	3.0	8.83479	-5.83479
1962.0	11.3	8.8221	2.4779
1963.0	7.9	9.58711	-1.68711
1964.0	18.6	6.18334	12.4167
1965.0	12.4	14.3277	-1.92769
1966.0	15.8	17.7545	-1.95453
1967.0	20.4	20.1225	0.277501
1968.0	21.0	19.454	1.54601
1969.0	23.3	18.377	4.92302
1970.0	31.6	21.7915	9.80851
1971.0	33.4	31.9779	1.42207
1972.0	36.2	39.0661	-2.86608
1973.0	34.2	40.7109	-6.51091
1974.0	51.5	34.4666	17.0334
1975.0	56.3	41.9797	14.3203
1976.0	66.8	56.1651	10.6349
1977.0	74.8	75.6388	-0.838751

Year	Actual (Thousand tons)	Forecasted (Thousand tons)	Residual
1978.0	87.7	85.6616	2.03836
1979.0	93.7	89.0988	4.60116
1980.0	99.2	89.7645	9.43552
1981.0	107.4	96.4179	10.9821
1982.0	114.1	109.7	4.3997
1983.0	128.6	121.258	7.34178
1984.0	128.1	132.116	-4.01622
1985.0	142.6	131.917	10.683
1986.0	166.0	138.43	27.5695
1987.0	195.6	160.666	34.9339
1988.0	212.0	200.051	11.9493
1989.0	215.1	232.171	-17.0713
1990.0	232.4	235.204	-2.80363
1991.0	243.0	226.85	16.1503
1992.0	295.3	225.724	69.5761
1993.0	339.0	278.808	60.1916
1994.0	442.6	358.488	84.1116
1995.0	533.1	471.047	62.0529
1996.0	553.5	569.447	-15.9474
1997.0	568.4	598.615	-30.2155
1998.0	573.1	577.596	-4.49619
1999.0	589.3	544.256	45.0437
2000.0	377.3	555.324	-178.024
2001.0	438.9	439.273	-0.373098
2002.0	367.13	394.624	-27.4937
2003.0	315.41	322.482	-7.07159
2004.0	333.74	296.409	37.3305
2005.0	351.91	328.884	23.0264
2006.0	351.24	371.118	-19.8778
2007.0	348.44	381.319	-32.8795
2008.0	441.58	355.068	86.5117
2009.0	441.06	393.244	47.816
2010.0	366.4	444.446	-78.0463
2011.0	525.9	433.902	91.9981
2012.0	598.7	498.099	100.601
2013.0	556.4	577.224	-20.8237

Year	Actual (Thousand tons)	Forecasted (Thousand tons)	Residual
2014.0	606.1	614.44	-8.34019
2015.0	617.2	639.144	-21.9435
2016.0	620.48	612.246	8.2344
2017.0	669.91	589.938	79.9724

Table 7

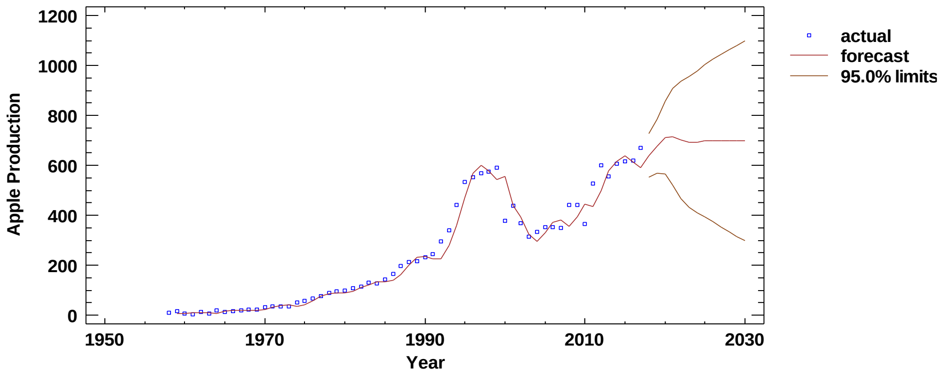
Apple Production Forecasted Values using ARIMA (2, 1, 2)

Year	Forecasted	95% Lower Confidence Limit	95% Upper Confidence Limit
2018.0	638.874	551.406	726.343
2019.0	676.543	567.382	785.705
2020.0	711.035	563.726	858.343
2021.0	714.424	519.72	909.129
2022.0	701.623	468.055	935.191
2023.0	692.955	431.339	954.57
2024.0	693.525	409.403	977.648
2025.0	697.545	392.28	1002.81
2026.0	699.569	373.333	1025.81
2027.0	698.997	352.523	1045.47
2028.0	697.81	332.397	1063.22
2029.0	697.385	314.27	1080.5
2030.0	697.651	297.71	1097.59

Based on the selected ARIMA (2, 1, 2) model, the comparison of actual and forecasted apple production for the year 1958-2017 is given in Table 6. While, the forecasted values of the best fitted ARIMA (2, 1, 2) model for the years 2019-2030 are presented in Table 7. Table 8 predicts that the production of apples in Pakistan would become 697.651 thousand tons with minimum/maximum apple production expected to 297.71/1097.59 thousand tons in 2030.

Figure 4

Time Series Plot with Forecasted Values of Apple Production in Pakistan



Conclusion

Pakistan's population has increased over time, therefore, it is essential to plan the nation's supply of apples to meet the demand of the growing population. Forecasting is a strategic device to signal the nation's need in advance. For this purpose, different time series models have been utilized on apple production data in this research. To select the best model, two model selection criteria, namely AIC and SBC, are applied and ARIMA (2, 1, 2) has been determined as the finest model for forecasting the apple production of Pakistan using these criteria. The selected model predicts that apple production is expected to become 697.651 thousand tons in 2030, under the assumption that no irregular pattern occurs in the country.

Conflict of Interest

The authors of the manuscript have no financial or non-financial conflict of interest in the subject matter or materials discussed in this manuscript.

Data Availability Statement

The data associated with this study will be provided by the corresponding author upon request.

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References

Abid, S., Nasir, J., Anwar, M. Z., & Zahid, S. (2018). Exponential growth model for forecasting of area and production of potato crop in Pakistan. *Pakistan Journal of Agricultural Research*, *31*(1), 24–28.

Ali, S., Badar, N., & Fatima, H. (2015). Forecasting production and yield of sugar cane and cotton crops of Pakistan for 2013-2030. *Sarhad Journal of Agriculture*, *31*(1), 1–10.

Amin, M., Amanullah, M., & Akbar, A. (2014). Time series modeling for forecasting wheat production of Pakistan. *The Journal of Animal & Plant Sciences*, *24*(5), 1444–1451.

Amir, M. W., Amin, M., & Nazir, H. Z. (2021). Sstatistical modeling and forecasting for onion production of Pakistan. *Journal of Agriculture Research*, 59(2), 171–176.

Box, G. E. P., & Jenkins, G. M. (1976). *Time series analysis: Forecasting and control*. Holden-Day.

Boyer, J., & Liu, R. H. (2004). Apple phytochemicals and their health benefits. *Nutrition Journal*, *3*(1), Article e5. https://doi.org/10.1186/1475-2891-3-5

Celik, S., Karadas, K., & Eyduran, E. (2017). Forecasting the production of Groundnut in Turkey using Arima model. *The Journal of Plant and Animal Science*, *27*(3), 920–928.

Chatfield, C. (1995). *The analysis of time series an introduction* (5th ed.). Chapman & Hall/CRC.

Fatima, A., Abid, S., & Naheed, S. (2015). Trends in wholesale prices of onion and potato in major markets of Pakistan: A time series Analysis. *Pakistan Journal of Agricultural Research*, *28*(2), 152–158.

Government of Pakistan. (2016). *Agricultural statistics of Pakistan*. https://www.finance.gov.pk/survey/chapters_16/02_agriculture.pdf

Gujarati, D. N. (2009). *Basic econometrics*. Tata McGraw-Hill Education.

Karim, M. R., Awal, M. A., & Akter, M. (2010). Forecasting of wheat production in Bangladesh. *Bangladesh Journal of Agricultural Research*, *35*(1), 17–28. https://doi.org/10.3329/bjar.v35i1.5863

Li, X., He, X., Lv, Y., & He, Q. (2014). Extraction and functional properties of water-soluble dietary fiber from apple pomace. *Journal of Food Process Engineering*, *37*(3), 293–298. https://doi.org/10.1111/jfpe.12085

Masood, M. A., Raza, I., & Abid, S. (2018). Forecasting wheat production using time series models in Pakistan. *Asian Journal of Agriculture and Rural Development*, *8*(2), 172–177. http://dx.doi.org/10.22004/ag.econ.342176

Morgan, J., & Richards, A. (2002). *The new book of Apples: Tthe definitive guide to apples, including over 2000 varieties*. Ebury Press.

Naheed, S., Raza, I., Anwar, M. Z., Habib, N., Zahra, N., & Siddiqui, S. (2015). Forecasting area and production of barley in Punjab, Pakistan. *Pakistan Journal of Agricultural Research*, *28*(3), 304–309.

Opyd, P. M., Jurgoński, A., Juśkiewicz, J., Milala, J., Zduńczyk, Z., & Król, B. (2017). Nutritional and health-related effects of a diet containing apple seed meal in rats: The case of amygdalin. *Nutrients*, *9*(10), Article e1091. https://doi.org/10.3390/nu9101091

Sabir, H. M., & Tahir, S. H. (2012). Supply and demand projection of wheat in Punjab for the year 2011-2012. *Interdisciplinary Journal of Contemporary Research in Business*, *3*, 800–808.

Shah, S. A. A., Zeb, N., & Alamgir, A. (2017). Forecasting major food crops production in Khyber Pakhtunkhwa, Pakistan. *Journal of Applied and Advanced Research*, *2*(1), 21–30.

Ullah, A., Khan, D., & Zheng, S. (2018). Forecasting of peach area and production wise econometric analysis. *Journal of Animal and Plant Sciences*, *28*(4), 1121–1127.

Wali, V. B., & Lokesh, D. B. H. (2017). Forecasting of area and production of cotton in India and Karnataka using ARIMA Modelmodel. *Indian Journal of Economics and Development*, *13*(4), 723–728.