MODELING OF MANGO PRODUCTION IN PAKISTAN

M. Nouman Qureshi, *M. Bilal, *R. M. Ayyub, *Samia Ayyub
Govt. Degree College Sharaqpur, Pakistan
*University of Veterinary & Animal Sciences Lahore, Pakistan
(Corresponding author: drranaayyub@gmail.com)

ABSTRACT-*A study of mango production in Pakistan has been carried out in this research. The forecast model has been developed for the mango production in Pakistan. The data for this study was obtained from 50-Years of Pakistan in statistics volume (1947-2012) [1], Economic Survey of Pakistan [9], Agriculture Statistics of Pakistan and Hydrological & Metrological Department of Weather Bureau Punjab. Three explanatory variables (Area, Temperature and rainfall) have been included in the model due to their practical significance.Mango is an important fruit of the country. All the provinces have their share in the total production of this fruit across the country. In this paper, ARIMA-X model has been fitted to forecast the mango production. The best model has been selected by comparing the estimates of the coefficients in the ARIMA-X models to ensure that the process is stationary / invertible, the standard error of regression, log-likelihood, Akaike information criterion (AIC) & Schwarz information criterion (SIC) and Durbin-Watson test statistic. Different types of diagnostic checks have been applied on the residuals to ensure the adequacy of the estimated models.*

Key words *Production of Mango, Temperature, Rainfall, Area and ARIMA-X.*

INTRODUCTION

Pakistan has a rich and vast natural resource base covering various ecological and climatic zones; hence the country has great potential for producing all types of commodities. Agriculture is the hub of economic activity in Pakistan. It lays down foundation for economic development and growth of the economy. It directly contributes 25% to Gross Domestic Product (GDP) and provides employment of 44% of the total labor force of the country.

Fruits production is playing a significant role in the economy of Pakistan. The climate condition of Pakistan is quite suitable for the production of various tropical and sub-tropical fruits. Especially agricultural climate of Indus plans is very well suited for all types of fruits production in Pakistan. Total production of various types of fruits is 5,751,800 (000) tons under the area of 681,070 hectors. [1].

Mango is one of the most popular, nutritionally wealthy and health promotingfruit.Mango has won the title of "king of fruits" due to its excellent flavor and delicious taste. Besides being a rich source of vitamins C and A, it also contains formidable amount of proteins, sugars, organic acids, ascorbic acid, carbohydrates and minerals. Mango is the delicious fruit cultivated in less than ninety tropical and sub tropical countries in the entire world. About 1595 varieties of mango are identified in the whole world.

Pakistan is standing at 4th rank of mango producer and exporter. At present it is grown on an area of 170.1 (000) acres with production 1727.9 (000) tones.The principle commercial cultivars of Pakistan are: Chaunsa, Dashehari, Anwar Ratul, Gulab-e-Khas, Langra, Siroli, Sindhri, Swarm, Rekha, Zafran, Maldha and Fajri.

In 1960 the total area under mango cultivation was 79 thousand acres. Fig.1 shows a consistent increase in production area, increasing to 420.50 thousand acres in the year 2008-09.

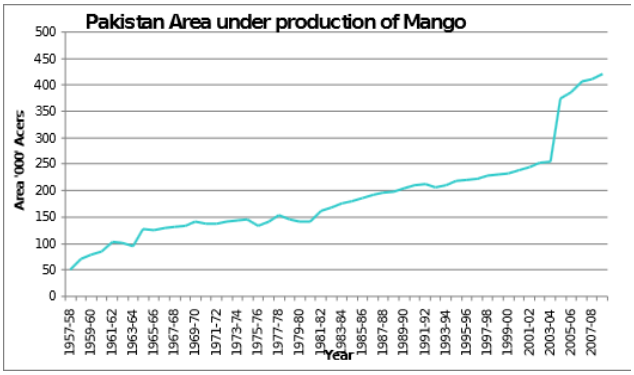

Fig. 1. Total cultivated area of mango production in Pakistan.

The production of mango was 202.00 thousand tones in 1960 and has increased to 1727.93 thousand tones in 2008-09.

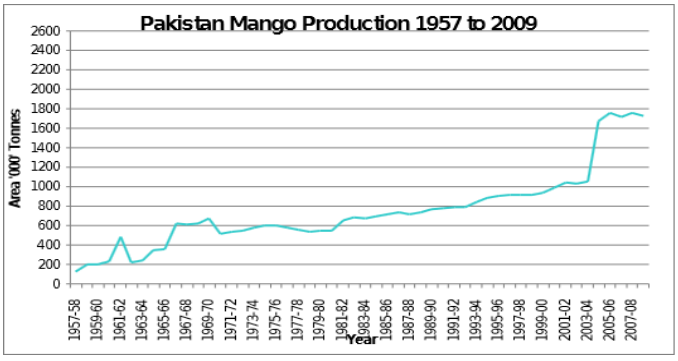

Fig. 2. Total mango production in Pakistan

Saifullah *et al.* [2] studied to assess communication gap concerning plant protection, harvesting and post harvest technologies among mango growers of tehsil Muzaffergarh. The results showed that the lack of information about recommended harvesting and post-harvest technologies on

the part of growers is the main factor that effect the quality of mango which relates to communication gap and directly associated with the guidance provided by various extension agencies and other sources.

Bakhsh *et. al.* [3] estimated the price of production and returns in growing mango orchard are compared in different ways to annual crops. They pointed out that Pakistani farmers could earn huge profit if mango orchards are planned for commercial purposes. The results show that investing one rupee in mango orchard would bring Rs. 2.61 returns to the farmers and can contribute towards earning foreign earnings reserves for their country.

Munir and Khan [4] predicted the value of Mango production for the year 2024 worked out as 1431010 metric tons, that shows that an increase productivity of mango would be available for utilization as well as for exports. They also highlighted the requirements for enchanting measure to expand the exports of mango by improving its quality, packing and complying with worldwide standards required under the WTO regime.

Hassan *et. al.* [5] concluded that the relation between education of the respondents and adoption of the recommendations regarding pit farming for mango plantation is highly significant but insignificant association exist between qualification of the respondent and the destruction of the diseased plant/plants parts by them. At the same time the relationship between age of the respondents and adoption of the recommendations regarding pit farming for mango plantation is significant but insignificant association existed between age of the respondent and the destruction of the diseased plant(s) parts by them.

Iqbal *et. al.* [6] investigated the prevalence incidence and intensity of various decline disorders prevailing in mango growing areas of the Punjab. Four disorders namely twig blight; tip dieback, gummosis and splitting were noted 55%, 50%, 25% and 25% prevalence respectively while the incidence percentage in the same order was 3.17%, 4.43%, 0.62% and 1.25% whereas the intensity ranged from 16% to 50% with maximum intensity 5.17% for quick decline was noted in Sahiwal district. Chaunsa proved to be the most susceptible cultivar with 6.95% and 3.14% incidence and intensity respectively.

Ishaq *et. al.* ascert [7] ained that mango mealy bud and fruit fly are serious pests of mango and are difficult to control by insecticides. Testing several treatments developed an integrated pest management strategy and concluded that the strictly bands along with burning and burying treatments significantly reduced the incidence of infestation by mango mealy bug. Burlap bands reduced population of mango mealy bug. Methyl eugenol traps were extremely effective to trap and kill fruit fly. Stem injection could achieve a very high level of mortality of sucking insects. The mortality rates achieved with insecticide sprays were up to 55% and the non chemical methods have been found to be superior in mealy bug and fruit fly control.

MATERIALS AND METHODS

In this research, the main objective is to build up the suitable and most appropriate forecast model that can be used to generate the forecast values of mango production in Pakistan. The basic assumption of the forecasting is that the past patterns of the variables will remain same for the future. In this study firstly, we have discussed stationarity of the time series using Correlogram and unit root test.Correlogram of auto correlation (AC) and partial auto correlation (PAC) [8] based on the graphical tools whereas the unit root test is a mathematical approach to check the stationarity of the time series data.

Secondly, Box-Jenkins methodology [7] has been employed. Under this method, ARMA-X (p,d,q,X) is applied which is the generalized form of ARIMA modeling. In ARIMA-X (p,d,q,X) model, p, d, q and X represents AR terms, 'd' difference of the series, MA terms and explanatory variables respectively. The model is defined as:

$$Y_t = c + \sum_{i=1}^{p} \alpha_i Y_{t-i} + \sum_{j=1}^{q} \beta_j \varepsilon_{t-j} + \sum_{k=1}^{b} \eta_k X_{k-1} + \varepsilon_t$$

Finally, diagnostic checks have been applied which includes ARMA structure of the estimated ARIMA-X model, Durbin-Watson (DW) test, Breusch-Godfrey serial correlation LM test, Akaike information criterion (AIC) & Schwarz information criterion (SIC)and One sample Kolmogrov-Smirnov test.

RESULTS AND ANALYSIS

The basic purpose of this research is to built up the forecast model of mango production in Pakistan. Initially the time plot of mango production given below is describing the behavior of stationarity.

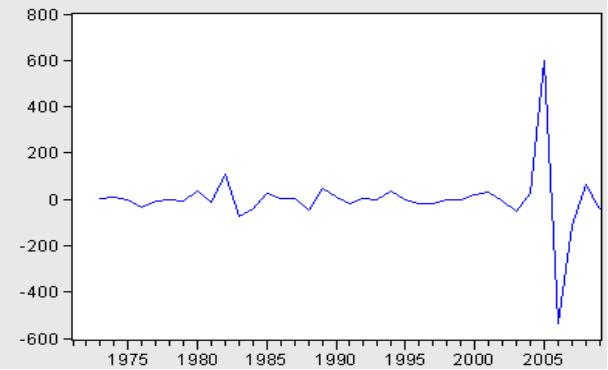

Fig. 3. Time plot of mango production at 1st difference

The time plot of mango production is stationary at first difference indicating that the series is I (1).

The Augmented Dickey Fuller test ADF [9] is applied to check the stationarity in the data of mango production after taking the first difference.

Table-I: Unit Root Test of mango at 1st difference

Null Hypothesis: D(MANGO_PK) has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic based on SIC, MAXLAG=9)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-5.659647	0.0002
Test critical values:	1% level	-4.226815	
	5% level	-3.536601	
	10% level	-3.200320	

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

Table I clearly indicating that we reject the null hypothesis that the series has unit root because t-statistics lies in the critical region.

The following Correlogram after taking the first difference of the data also reveal that the series is stationary.

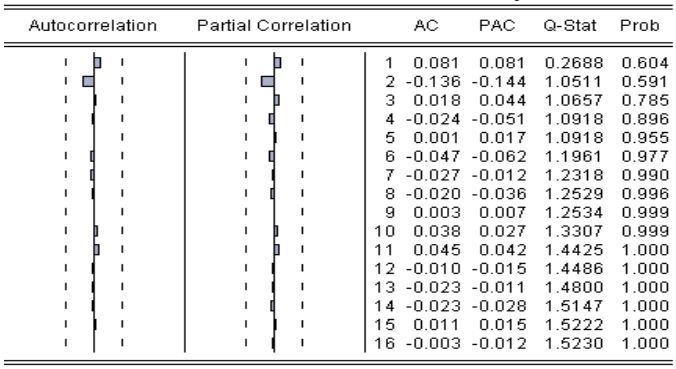

Fig. 4. Correlogram of mango production at 1st difference

The above figure of Correlogram shows that all the spikes of auto-correlation and partial auto-correlation are under the control limits indicating that the series is stationary at first difference. The conclusion taken from unit root test is identical to the subjective approaches of Correlogram and time plot.

Secondly, the most appropriate and adequate Auto-Regressive Integrated Moving Average (ARIMA-X) model with exogenous variable applied to the series of mango production of Pakistan. The final selected model with summery is given below:

$$\Delta^d Y_t = c + X_{A.c} + X_{T.c} + X_{R.c} + \sum_{i=1}^{p} \alpha_i \Delta^d Y_{t-i} + \sum_{j=1}^{q} \beta_j \Delta^d \varepsilon_{t-j} + \varepsilon$$

Table II: ARIMA-X of Mango Production

ARIMA-X (1, 1, 1) for Mango_pk				
Variables	**Coefficient**	**Standard Error**	**t-Statistic**	**P-Values**
C	3085.35	625.01	4.93	0.0000
AREA	1.20	0.17	6.80	0.0000
TEMPERATURE	-105.09	19.84	-5.29	0.0000
RAINFALL	-0.27	0.20	-1.31	0.1979
AR(2)	-0.66	0.08	-7.90	0.0000
MA(4)	-.99	0.09	-11.13	0.0000

The ARIMA-X model with their coefficients, standard error, t-statistic and p-values have been given in the table II, displaying that the overall model is significant except the rainfall effect. Further the coefficients of all the explanatory variables are found to be significant as the p-values are less than 10% level of significance.

Estimated ARIMA-X model is:

$$\Delta Y_t = 3085.35 + 1.20 X_{A.m} - 105.09 X_{T.m} - 0.27 X_{R.m} - 0.66 Y_{t-2} - 0.99 \varepsilon_{t-4}$$

Table III: Diagnostics of ARIMA-X Model for Mango

Model	**DW**	**R^2**	**AdjR^2**	**SC**	**F**	**F(p-val)**	**AIC**	**SIC**
(1,1,1)	1.80	52 %	45%	0.65	6.61	0.0002	11.69	11.96

The above table III is clearly indicating that the overall ARIMA-X (1, 1, 1) model is significant as F= 6.61 with p value (0.0002). As the value of DW test is near to '2' indicating that errors terms are white noise. Moreover the overall variation control by the independent variables is 52%.Whereas AIC and SIC are used to decide about the most parsimonious model are least than the other models estimated for mango production of Pakistan.

We have also applied LM test to check the effect of serial correlation among the residual terms. The result is given in the above table indicating that the null hypothesis of no serial correlation is not rejected (residuals are uncorrelated).

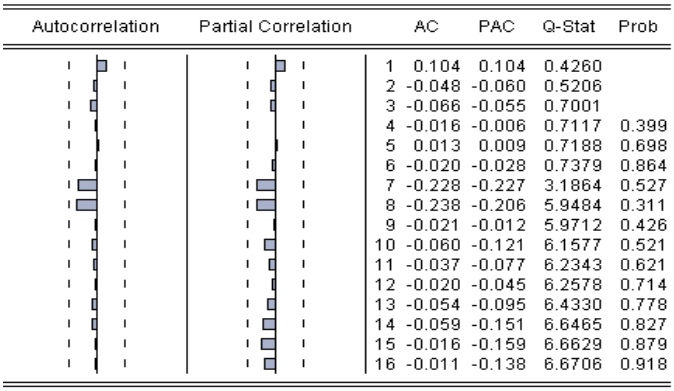

Fig. 5. Q-Stat and Correlogram of standardized residuals

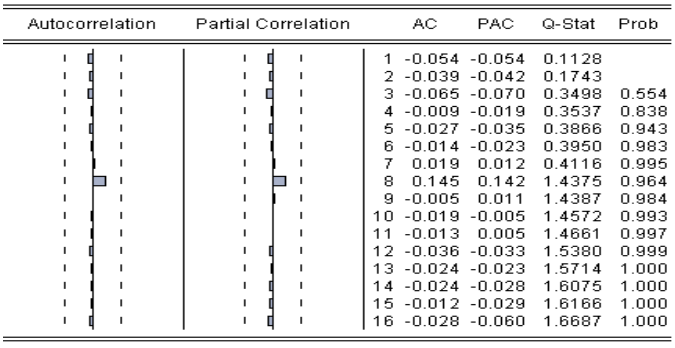

Fig. 6. Q-Stat and Correlogram of standardized squared residuals.

Fig. 5 and 6 display the Correlogram of AC and PAC of standardized residuals and square residuals generated from ARIMA-X (1, 1, 1) model, showing that the successive residuals are mutually independent as well as homoscedastic (no autocorrelation).

Table IV: One sample Kolmogrov-Smirnov Test for the residuals of Citrus

		Citrus
N		43
Normal Parameters(a,b)	Mean	870.1833
	Std. Deviation	366.51760
Kolmogorov-Smirnov Z		1.225
Asymp. Sig. (2-tailed)		0.099

The normality of residual is also tested through Kolmogrov-Semirnov test [10,11]. The results showing in table-IV, indicating that we do not reject H_0 and concluded that the behavior of residual is normal of the mango production in Pakistan.

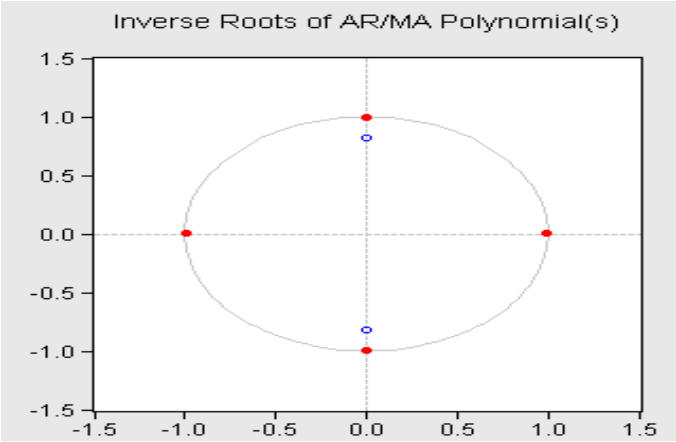

Fig. 7. ARMA structure of mango production

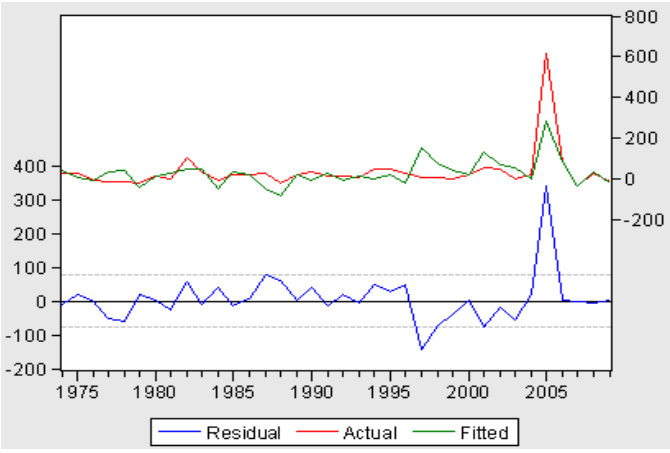

Fig. 8. Fitted and Actual values of mango production

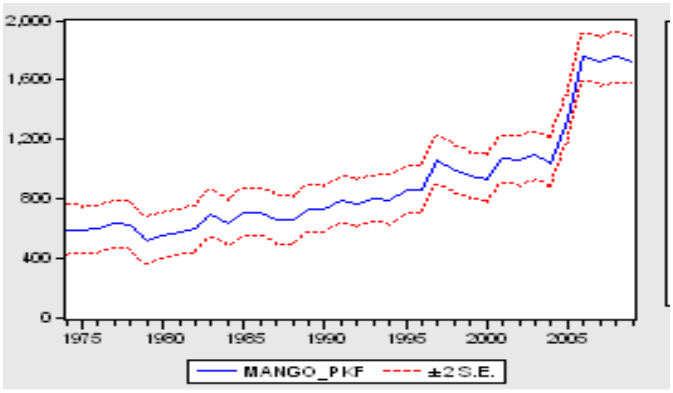

Fig. 9. Fitted and Actual forecast values of mango production

Fig. 7. reports that the ARMA structure of the estimated model [12,13] in which all the inverse roots of AR and MA polynomials are within the unit circle indicating that the estimated AR process is stationary and estimated MA process invertible as well.Also fig. 8 reports that the fitted and actual values are very close to each other and indicating that the model is adequate for forecasting [14,15]. Fig. 9 is indicating the graph of static forecast. It reveals that the forecasted production of mango in Pakistan lies within the confidence limits of ±2 (standard error). Hence the fitted ARIMA-X model is sufficient for the forecasting of mango production in Pakistan.

CONCLUSION AND RECOMMENDATIONS

After the analysis, it has been observed that the time series of the mango is not stationary at level. To make the series stationary, we applied both the subjective and objective approaches and concluded that the series are stationary at first difference. It means that the mango production series is I . In this paper, different ARIMA-X models are developed for mango production but the most appropriate models is to be selected for the forecasting purpose.

Practically, it has been observed that most of the extraneous factors affect the fruits production. Therefore we included three explanatory variables (Area, Temperature and Rainfall) and found that the cultivated area and temperature have a significant affects on the production of mango fruits.Although rainfall is insignificant in this model but we cannot eliminate its effect practically. By using the ARIMA-X, the coefficient of determination is found to be high which indicating that the overall variation control by the independent variables is very high. Also the standard error is minimized and hence making the forecast models adequate for forecasting.

The estimated ARIMA-X models have undergone in all diagnostic checks and found to be suitable for forecasting purposes. Hence the model is developed here can be used to forecast the mango production for the convenience of government to take precautionary measures by studying deeply the forecasted values of various fruits and their trend as well.

In spite of all the care taken in the developing the ARIMA-X modelto forecast the different production, there are definitely some limitations in this paper. The variable'area weighted rainfall' is taken as independent variable in this study is not significant. But we have included this variable due to its practical significance. Although this variable is insignificant but provides better estimates for the mango production. Some other factors like export demand for foreign earning, local demand and prices of fruits are also recommended to take as independent variables in ARIMA-X and Panel Models for the further study.

REFERENCES

1. Anonymous, *50-Years of Pakistan in statistics volume (1947-2012),* Federal Bureau of Statistics (FBS), Statistics Division Government of Pakistan (GOP), (2012).
2. Saifullah, M. Muhammad, S. and Lodhi, E. T.*Communication Gap Regarding Mango Protection Technology*, Pak. J. of Agri. Sci., **44**(4): 654-659(2007).
3. Bakhsh, K., I. Hassan and S. M. Akhter,*Profitability and Cost in Growing Mango Orchards*.J. of Agriculture & Social Sciences,**2**: 46-50 (2006).
4. Khan, M., Mustafa K. and Shah,*Forecasting Mango Production in Pakistan, an Econometric Model Approach.*Sarhad Journal of Agriculture, **24**(2):455-458 (2008).
5. Hassan Y.Z.M. Siddiqui, N.B and Irshad, N.M. *Effect of Socio-Economic Aspects of Mango Growers on the Adoption of Recommended Horticultural Practice*. Pak. J. Agri. Sci.,**39**(1):20-21 (2002).
6. Iqbal Z and Muhammad, S.*Determination of Different Decline Disorders in Mango Orchards of the Punjab, Pakistan,*Pak. J. of Botany, **39**(4): 561-568 (2007).
7. Ishaq, M., M. Usman, M. Asif and I. A. Khan *Integrated Pest Management of Mango against Mealy Bug and Fruit Fly*, Int. J. of Agri.& Biology, **6**(3): (2004).
8. Chatfield, C.*The Analysis of Time Series*: *An introduction*, 3rd ed., Chapman and Hall, London. (1984).
9. Fuller, W. A. *Introduction to Statistical Time Series*, John Wiley, New York (1976).
10. Akaike, H.,*Time series analysis and control through parametric models*, Applied Time Series Analysis, D.F. Findley (ed.), Academic Press, New York, (1978).
11. Anderson, T. W.*The Statistical Analysis of Time Series*, John Wiley, New York, (1971)
12. Box, G. E. P. and Jenkins,G.M. *Time Series Analysis: Forecasting and Control*, Holden-Day, San Francisco, (1970)
13. Box, G. E. P. and D.A. Pierce, *Distribution of residual autocorrelations in auto-regressive integrated moving average time series models*, J. Amer. Statistics. Association. (1970)
14. Anonymous, *Economic Surveys of Pakistan for the years 1962 to 2012*.Economic Division, Govt. of Pakistan, (2012).
15. Ljung, G. M. and Box, G. E. P. *On a measure of lack of a fit in time series models,*Biomertika.(1978).