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Forecasting of Natural Honey Yield in Turkey through ARIMA Model

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Abstract: Agricultural forecasting is an essential element of country's planning and sustainable economic growth. Honey is a strategic product for Turkey. Although there has been an increase in the number of hives in recent years, there has been a decrease in natural honey yield in Turkey. The purpose of this article is to estimate the natural honey yield for the next decade. In this study, it was estimated with the Autoregressive Integrated Moving Average (ARIMA) model by using annual data between 1961-2019. Forecasting was made with ARIMA model (7, 1, 1), which is the most suitable model. According to the forecasting results, it was calculated that the honey yield increase rate would be an average of 0.82% per year. 'Honey Forest Action Plans' were prepared in 2018-2023 to increase honey production and yield in Turkey. With this plan taking full action, there may be a greater increase than expected honey yield. In addition, it is very important to protect bees' natural habitats and the environment for sustainable honey production. As a result, it may be suggested to minimize environmental factors that cause low honey yield for sustainable production.

Keyword: ARIMA, Honey, Yield, Turkey, Sustainability

ARIMA Modeli ile Türkiye'de Doğal Bal Veriminin Tahmini

Öz: Tarımsal öngörü ülke planlamasının ve sürdürülebilir ekonomik büyümenin temel bir elementidir. Bal Türkiye için stratejik bir üründür. Son yıllarda Türkiye'de kovan sayısında bir artış olmasına rağmen doğal bal veriminde düşüşler olmaktadır. Bu araştırmanın amacı gelecek on yıl için bal verim tahmini yapmaktır. Bu araştırmada otoregresif hareketli ortalama (ARIMA) modeli ile 1961-2019 dönem veriler kullanılarak bal verim tahmini yapılmıştır. Öngörü en uygun model olan ARIMA (7, 1, 1) Modeli ile yapılmıştır. Öngörü sonuçlarına göre bal verim artış oranı yıllık ortalama %0,82 olarak hesap edilmiştir. Bal üretimini artırmak için 2018-2023 yıllarını kapsayan 'Bal Ormanı Eylem Planı' hazırlanmıştı. Bu planın tamamen uygulanması durumunda beklenen bal verim artışından daha çok verim artışı olabilir. Ayrıca sürdürülebilir bal üretimi için arıların yaşam alanlarını ve çevreyi korumak çok önemlidir. Sonuç olarak sürdürülebilir bal üretimi için düşük bal verime neden olan çevresel faktörlerin en aza indirilmesi önerilebilir.

Anahtar Kelimeler: ARIMA, Bal, Verim, Türkiye, Sürdürülebilirlik

1. Introduction

The share of agriculture in the gross national income in Turkey was 5.8% in 2018 (TURKSAT, 2020). Turkey, which produced 109330 tons of honey in 2019, is among the leading honey producer countries in the world. Although there has been an increase in the number of beehives in recent years, there has been a decrease in honey yield (TURKSAT, 2020). According to the results of a study examining the effect of environmental pollutants on honey yield, it was emphasized that increase in pesticide use, CH_4, CO_2, and N_2O had negative effects on honey yield in Turkey (Karakas and Bal 2019). Turkey exported 24.581.000 $ of natural honey in 2019 (FAO, 2020). Honey, in terms of employment, farmer income and export, is a strategic product for Turkey. It is important to know what honey yield will be in the future in order to make agricultural planning in Turkey.

Since sequential observations are often dependent on each other in the time series, predictions can be made at reliable intervals (Vandaele 1983). ARIMA models are used to predict the future data of a variable based on historical data only (Mohammadi, Eslami et al.

2005). ARIMA is a popular forecasting method used in many fields (Tortum, Gozcu et al. 2014). Greenhouse gases were predicted in some articles using the ARIMA model. With ARIMA models in Brazil (Pao and Tsai 2011), in Malaysia (Ang, Morad et al. 2013) in China (Liu, Zong et al. 2014), in Iran (Lotfalipour, Falahi et al. 2013) and in America (Silva 2013) CO_2 predictions were made. In most of these studies, it was predicted that the CO_2 increase, which reduces honey yield (Karakas and Bal 2019), will continue.

Agricultural yield and prices forecasts were made using ARIMA Models in the world. A comparison of statistical models was done in Karnataka state of India to estimate mango and banana yield. According to the results of the comparisons, it was stated that the ARIMA Model performed better for forecasting (Rathod and Mishra 2018). In another study, paddy, ragi and maize prices were estimated with the ARIMA Model using the time series data from 2002 to 2016 in Karnataka, India. After the agricultural product prices were estimated with the ARIMA model it was emphasized that the model had a high forecast power (Jadhav, Chinnappa Reddy et al. 2017).

A forecasting was done using annual data for the 1936-2011 period for red meat production in Turkey. According to the results of the study, the annual average rate of increase in total red meat production was predicted to be 0.8 percent until 2020 (Çelik 2012). ARIMA modelling and forecasting studies have been made in Turkey. Chickpea production in Turkey estimated using ARIMA model was used 33 years of data. According to the results of the analysis, it was predicted that there will be an increase in chickpea production in 2019-2023 (Ali and İlkay 2019). In another study using 55 years of data, it was predicted that chestnut production and export wild increase in 2021 (Başer, Bozoglu et al. 2018).

According to the honey production estimate made using annual data in 1950-2014, it was predicted that the honey production will increase continuous between the years 2015-2020 in Turkey (Çelik 2015). In another study, it was estimated that honey production would increase continuously and it would be 121216 tons in 2023 (Burucu and Bal 2017). In addition, in another study in 2017, honey production and number of colonies were predicted with trend analysis. According to the results of the study, Turkey's honey production will be 115000 tons and the number of colonies was expected to reach 10 million by 2020 (Semerci 2017). In a study conducted by Saner et al., (2018) It was predicted that honey supply and demand will be insufficient to meet the demand, especially after 2020, although the increase in honey supply and demand is expected.

Recently a study on honey yield was published in Turkey. In this article, a five-year forecast was made using the data from 1969 to 2018. According to the research, it was predicted that honey yield will increase between 2,77-3,12% compared to 2018 (Abacı et al. 2020). In the literature, only one study found that honey yield estimate between 2019-2023 years in Turkey. Turkey's five-year development plans have been prepared already by 2023. Therefore, it is more important to make honey yield estimations for development plans after 2023. It is difficult to solve the problem of low honey yield caused by environmental problems in the short term. Therefore, longer-term forecasts are more important. The purpose of this research is to make honey yield forecasting with ARIMA model in Turkey in next decade.

2. Material and Methods

The data used in the study between 1991-2019 years were obtained from Food and Agriculture Organization of the United Nations and Turkish Statistical Institute (FAO 2020, TURKSAT 2020). Hectogram (hg) was used as honey yield unit. For reliable estimation of ARMA and ARIMA models, the number of samples is recommended to be more than 50 (Box and Tiao 1975). Since 59 years of natural honey yield data was used in this study, there was no problem with sample adequacy (Table 1).

Table 1. Natural honey yield (hg) in Turkey
***Çizelge 1**. Türkiye'de doğal bal verimi (hg)*

Year	Yield	Year	Yield	Year	Yield	Year	Yield	Year	Yield	Year	Yield
1961	54	1971	90	1981	128	1991	159	2001	146	2011	157
1962	57	1972	88	1982	134	1992	170	2002	179	2012	140
1963	69	1973	82	1983	128	1993	161	2003	162	2013	143
1964	58	1974	88	1984	134	1994	148	2004	168	2014	146
1965	62	1975	108	1985	139	1995	175	2005	179	2015	140
1966	70	1976	119	1986	153	1996	159	2006	173	2016	134
1967	76	1977	101	1987	123	1997	158	2007	153	2017	143
1968	74	1978	106	1988	143	1998	161	2008	166	2018	133
1969	72	1979	121	1989	130	1999	156	2009	154	2019	135
1970	83	1980	113	1990	156	2000	143	2010	145		

Autoregressive Integrated Moving Average (ARIMA) process consists of four steps (Gujarati 2003). In the first step, it is determined whether the data is stationary or not. Unit root tests and correlogram are performed to determine the stationarity of the data. If the data is stationary, ARMA (*p*, *q*) is applied. If the data is not stationary, ARIMA (*p*, *d*, *q*) is applied after the stationary is determined by making difference to the data. A correlogram shows the results of Partial Autocorrelation Functions (PACF) and Autocorrelation Functions (ACF) both graphically and numerically. The PACF shows the AR term (*p*), and the ACF shows the MA term (*q*) of the ARIMA model. In the ARIMA model, '*d*' is the order of differencing required for the data to make it stationary. In order to determine '*d'* the following Augmented Dickey-Fuller (ADF) unit root test was used in the study (Dickey and Fuller 1979).

$$\Delta Y_t = \alpha\, Y_{t-1} + \delta X'_t + \sum_{i=1}^{n} \beta_i\, \Delta Y_{t-i} + \varepsilon_t \qquad (1)$$

Where y is yield, Δyt is the first difference operator, y_{t-1} is the lagged value of yield, α and δ are the parameters to be estimated, x_t is the optional regressor and ε_t is the error term.

The second step in the ARIMA procedure is the identification of the tentative ARIMA model. The tentative ARIMA models are prepared according to PACF, ADF and ACF results (*p*, *d*, *q*). The third step in the ARIMA procedure is to determine which of the tentative ARIMA models is more appropriate ARIMA model. In order to select appropriate ARIMA models Schwarz-Bayesian Information Criterion (SBIC) and Akaike's Information Criterion (AIC) are used. In addition, most number of significant coefficients, lowest variance, highest adjusted R^2 are used. These five criteria results are examined and the more appropriate ARIMA model is selected. In order to make forecasting with this selected model ARİMA (*p*, *d*, *q*) the equation can be written as follows.

$$Y_t = c + \sum_{i=1}^{p} \theta_i\, Y_{t-i} + \sum_{j=1}^{q} \theta_j\, \varepsilon_{t-j} + \varepsilon_t \qquad (2)$$

Where c is intercept, θ_i and Y_{t-i} are the parameters and regressors for AR part of the ARİMA, θ_j and ε_{t-j} are parameters and regressor of the MA part of the ARIMA, and ε_t is the error term. In the fourth step, forecasting is made using equation 2. In addition, Mean Absolute Percentage Error (MAPE) and Root Mean Square Error (RMSE) were calculated to demonstrate the efficacy of the proposed model. The MAPE forecasting power was calculated and evaluated according to Lewis (1982) criteria. According to these criteria, if MAPE value> 50; weak and inaccurate, 20–50; reasonable, 10-20; good <10; highly accurate forecasting (Lewis 1982).

3. Results and Discussion

Honey yield in Turkey was examined the 1961- 2018 year. In this period, the average natural honey yield was 128.16 hg, while the lowest yield was 54 hg in 1961, the highest yield were seen as 179 hg in 2002 and 2005 years. The ADF unit root test was performed to determine the stationarity level of the data, as unit root tests or correlogram guides for subsequent operations. According to the ADF unit root test result, it was determined that the data are not stationary at level. It was observed that the non-stationary honey yield series was stationary after the first difference. According to the ADF stationarity tests results t statistic was significant at 1% level (Table 2).

After determining the stationary level, the first difference (*d=1*), a correlogram graph was drawn to determine *p* and *q*. Honey yield correlogram shows the ACF and the PACF both graphically and numerically. Lag 17 in the ACF shows significant and it is very close to the margin of confidence interval, this lag may be included in the model as it is at the point of transition from positive to negative (Figure 1).

Table 2. ADF stationarity tests results.
Çizelge 2*. ADF durağanlik test sonuçlari*

Level		First Difference	
t-Statistic	**Prob.**	**t-Statistic**	**Prob.**
-2.143281	0.2320	-11.38753	0.0000

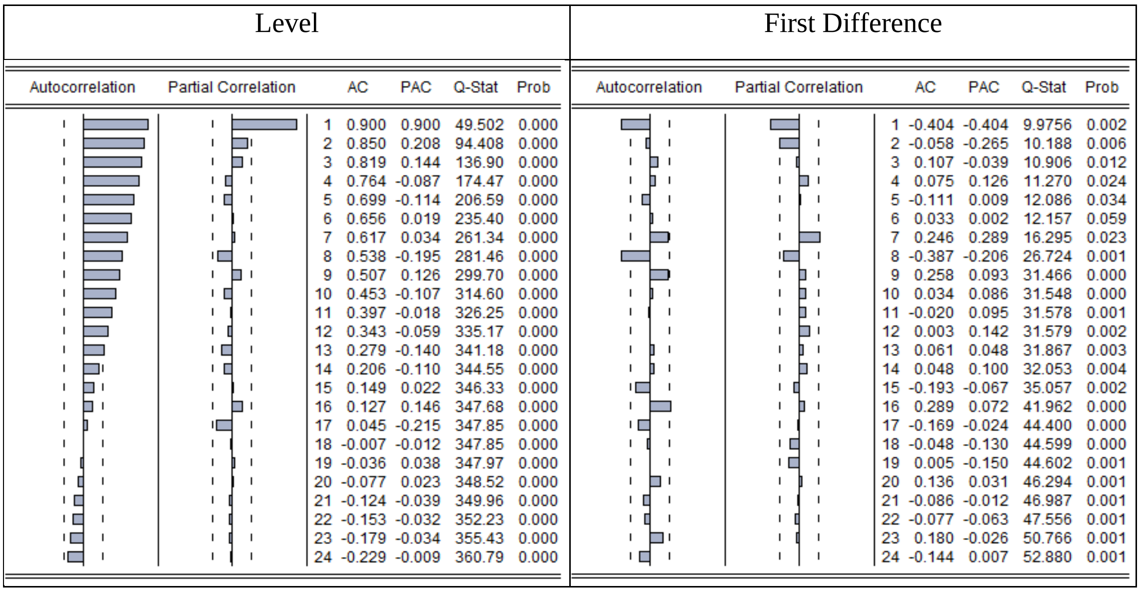

Figure 1. The correlogram of natural honey yield data for Turkey (1961–2019).
Şekil 1*. Türkiye için doğal bal verim verilerinin korelogram grafiği (1961–2019).*

In the ARIMA Modelling, ACF and PACF were examined to determine the significant lags in the first step. In the correlogram, the ACF (q) coefficients 1, 8 and 16 lags and PACF (p) coefficients 1, 2, and 7 lags were out of range. In light of this information obtained from the correlogram, 9 different tentative ARIMA models were prepared (Table 3). Among the tentative ARIMA models, ARIMA (7, 1, 16) was eliminated because its coefficient was not significant. Among the remaining ARIMA models, there was only one model that meets all decision criteria among the tentative models. The ARIMA model (7, 1, 1) was chosen as the most appropriate model since it has the lowest AIC, SBIC, variance and the highest adjusted R^2. Honey yield forecast was performed with the ARIMA model (7, 1, 1).

Diagnostic check determines whether residuals are heteroscedasticity and normally distributed. Jarque - Bera normality distribution (P; 0.695) and heteroscedasticity (P;0.359) values, which are model adequacy tests results, showed that the model was sufficient. In addition, the efficacy of the proposed model was tested with MAPE and RMSE. The MAPE (6.07%) and the RMSE (11.38) indicate that the forecasting model is reliable.

Table 3. Tentative ARIMA models
Çizelge 3. *Geçici ARIMA modelleri*

No	ARIMA	No. of Significant Coefficient	Variance (σ^2)	Adjusted R^2	AIC	SBIC
1	1 1 1	1	125.2136	0.165755	7.813000	7.956372
2	1 1 8	1	122.4644	0.184072	7.797049	7.940421
3	1 1 16	1	121.5581	0.190110	7.804090	7.947462
4	2 1 1	1	125.7554	0.162145	7.816953	7.960325
5	2 1 8	1	138.6790	0.076041	7.923906	8.067278
6	2 1 16	1	139.0894	0.073306	7.945348	8.088720
7	**7 1 1**	**1**	**118.5010**	**0.197456**	**7.759718**	**7.901817**
8	7 1 8	1	136.2024	0.092541	7.905080	8.048452
9	7 1 16	0	135.5078	0.097169	7.914518	7.914518

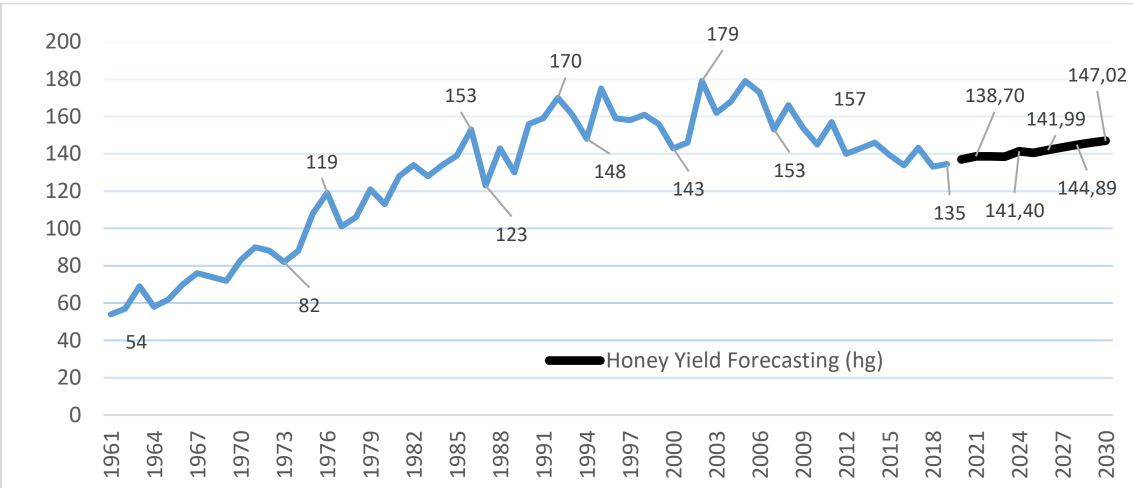

Figure 2. Natural honey yield forecasting (hg) in Turkey
Şekil 2. *Türkiye'de doğal bal verimi tahmini (hg)*

4. Conclusion

Honey yield increased nearly three times from 1961 to 1995 in Turkey. Honey yield, which decreased from 1995 to 2000, increased partially in the next 5 years, but it can be said that it has entered a downward trend since 2005. According to the forecasting results made with The ARIMA model (7, 1, 1), it was estimated that there will be an increase in honey yield. Honey yield, which was 135 hg in 2019, was predicted to be 147 hg in 2030 after a slight decrease in 2022, 2023 and 2025 years. In other words, it was predicted that honey yield would increase by approximately 9.3% in this period. In the study of Abacı et al., (2020) it was stated that an average increase of 2.7% is expected in the five-year forecast compared to 2018. This article, which was prepared by including 2019 and using 59 years of data, is similar to the results of Abacı et al., (2020).

It is very important to develop a long-term agricultural policy and planning for honey yield projection in the next decade. It was vital for planning that the honey yield prediction was made in accordance with this purpose. Identifying the causes of honey yield decrease is a basic step in the solution of the problem. According to the forecasting result, the honey yield increase rate was estimated at 0.82% annually from 2020 to 2030. Planning for longer periods should be done since it is difficult to solve the honey yield problem in the short term. Therefore, the implementation of the honey forest action plan is extremely important for beekeeping in the long run in Turkey.

The objectives of the honey forest action plan prepared by the Turkey Ministry of Agriculture and Forestry within the scope of sustainable beekeeping activities are to make forests productive, forestation, erosion control, pasture improvement, protection and development of vegetation suitable for beekeeping, preparation of functional plans for beekeeping and protection of forest ecosystems and biodiversity (Plan 2018). In addition, Turkey has adopted a holistic approach to increase productivity for all sectors in the 11th Development Plan. If these plans are successfully implemented, the honey yield predicted in the next decade may be higher than expected.

Honeybees, which have important functions in nature and agriculture, provide vital ecosystem services for sustainable agricultural production. However, global pollution and climate change, the effect of which has been felt more recently, threaten honeybees' life and productivity. As the result of the increase in environmental pollution, the narrowing of the bees' habitats causes the honey yield to decrease. Protecting the habitats of honeybees is also important in agricultural production, as they provide pollination in the sustainable ecosystem and lead to increased productivity. Although honeybees produce honey, which is a beneficial and healing product for humanity, humankind disrupts their habitats and ecosystem. In addition, switching to organic production methods for sustainable agricultural production and the environment can increase the yield of honeybees.

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