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THE FORECAST OF CORN PRODUCTION FIELDS IN TURKEY WITH ARIMA MODEL

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ABSTRACT

Corn has an important place in animal nutrition in addition to its importance in human nutrition in Turkey. Correct agricultural policies and strategies should be developed to increase corn production, which is a very important agricultural product in both human nutrition and animal husbandry. In this context, considering the corn cultivation areas of 1970-2019, predicting future corn cultivation areas is very important in terms of developing correct policies and planning production. This study aims to predict the cultivation areas of corn in the years 2020-2030 as a product that has not been analyzed using ARIMA models before. To accomplish this objective, data from a total of 50 years during the period 1970-2019 and the Autoregressive Integrated Moving Average (ARIMA) model were used to estimate the corn cultivation areas in Turkey.

Keywords: corn, unit root test, ARIMA, Turkey.

INTRODUCTION

Grains have an important place in human nutrition. For this reason, grain cultivation areas are very large. Corn is one of the most produced grains in the world with its versatile usage area and efficiency. Turkey has the largest acreage of corn, after wheat and barley, among the types of grain and corn is important in human nutrition as well as animal nutrition. Corn is used in two ways as grain and stems. As the grains of corn are used directly in human nutrition (as bread making and snack food), it is used as a raw material in edible oil, starch, glucose, and feed industry and even in biodiesel production (Şahin, 2001). Its stems are used as animal feed and also used in papermaking and small wicker handicrafts.

Corn cultivation areas in the world were 192 million hectares in 2019 and the total production was 1,118,000 tons. An examination of the world's corn cultivation areas reveals that China is in the top five with 22% followed by the USA 18%, Brazil 10%, India 5%, and European Union countries 5%. In the last 5 years, an increase in the world's corn cultivation areas is observed with an increase of 2.4 million hectares in Argentina, 2.1 million hectares in Brazil, 815,000 hectares in Ukraine, and 694,000 hectares in India.

Turkey's corn cultivation area was 6.4 million hectares in 2019, while 6.9 million hectares in 2015, and corn production was 6.4 million tons in 2015 and 6 million tons in 2019. Investigations exhibit the fact that corn cultivation areas have decreased by 7% in the last 5 years. Especially in 2018 and 2019, farmers showed a tendency to produce cotton, which was competing with corn, for more yield and this caused a reduction in cornfields and production (https://www.tarimorman.gov.tr). The provinces of Turkey that corn is planted and their shares in the total cultivation area are Konya 18%, Adana 12%, Mardin 8%, Osmaniye 6%, Sakarya 5%, Karaman 5%, Manisa 4%, Şanlıurfa 4%, Kahramanmaraş 3%, and Diyarbakır 3%, respectively. Corn produced in these provinces meets 70% of the total production. While corn is cultivated as the main crop in many provinces, it is cultivated as a second crop in provinces such as Şanlıurfa and Mardin.

75% of the corn offered to the market in Turkey is used in the feed sector and the highest share belongs to the poultry sector. The remaining 20% is used in the starch and

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glucose industry, and 5% in industry, oil production, and as seeds.

The average corn yield in the world in the year 2019 was 587 kg/decare, whereas this value in Turkey was 963 kg/decare. The decrease in corn cultivation areas in Turkey due to the policies applied and market conditions despite the higher yield than the world average cannot provide an increase in the total production.

According to the crop products balance sheet table prepared by the Turkish Statistical Institute, the rate of corn meeting the domestic demand (self-sufficiency ratio) of the domestic production of corn in the period of 2018/2019 is 70.3%. Turkey is a net importer of corn because of the increase in the demand for feed raw materials parallel to the increase of the production of eggs and poultry, the number of cattle, and the resulting inadequacy of domestic production in meeting the need. Corn imports have shown a significant increase in recent years, reaching 3,289,000 tons in 2019 (https://www.tarimorman.gov.tr)/.

Correct agricultural policies and strategies should be developed to increase corn production, which is a very important agricultural product in both human nutrition and animal husbandry. In this context, considering the corn cultivation areas of 1970-2019, predicting future corn cultivation areas is very important in terms of developing correct policies and planning production.

There are many studies in the literature that use time series to estimate the planting areas and production amounts of agricultural products. ARIMA models were widely used in making future predictions of plantation areas, production amounts, prices, imports, etc. of agricultural products (Bars et al., 2018; Uçum, 2016; Çelik, 2013; Özer and İlkdoğan, 2013; Akouegnonhou and Demirbaş, 2019; Berk and Uçum, 2019; Güler et al., 2017; Kurt and Karayılmazlar, 2019; Çelik, 2015; Caner and Engindeniz, 2020).

This study aims to predict the cultivation areas of corn in the years 2020-2030 as a product that has not been analyzed using ARIMA models before. To accomplish this objective, data from a total of 50 years during the period 1970-2019 and the Autoregressive Integrated Moving Average (ARIMA) model were used to estimate the corn cultivation areas in Turkey.

MATERIAL AND METHODS

The main material of this research consists of the corn production data of 50 years, namely 1970-2019, obtained from TMO (Turkish Grain Board). By using these data, the future 11-year corn production areas were estimated with the ARIMA model using SPSS 23 and Eviews 11 package programs. As in many studies, in cases where variable values increase exponentially, a linear relationship was obtained by transforming the data used in model estimation to logarithms (Caner and Engindeniz, 2020) and the logarithm of the data was used in this study.

Time series analysis is a method that aims to make predictions for the future based on past observations. Working on future predictions, Box and Jenkins developed the Autoregressive Integrated Moving Average (ARIMA) method in 1970 which is used in the analysis of univariate time series. ARIMA model put forward by Box and Jenkins has been one of the most used time series models for predictions for the future (Zhang, 2003; Pai and Lin, 2005).

The general methodology of the Box - Jenkins approach includes (i) model identification, (ii) parameter estimation, and (iii) diagnostic control followed by prediction (Kavasseri and Seetharaman, 2009). ARIMA models are homogeneous non-stationary processes. The process of selecting the most suitable (p, d, q) structure in the ARIMA model is called model identification (determination).

The ARIMA model is usually denoted as ARIMA (p, d, q), in which p is the order of the autoregression (AR) component, d is the order of the differencing process to form a stationary times series, and q is the order of the moving average (MA) process. In an ARIMA model, the value of Y at time t is estimated as equation:

$$Y_t = \mu + \varphi_1 Y_{t-1} + \cdots + \varphi_p Y_{t-p} - \theta_1 e_{t-1} - \cdots . - \theta_q e_{t-q}$$

where Y_t is the value at time t, φ is the AR parameter, and θ is the MA parameter.

In the estimations made by the ARIMA method, the value of the series at any time is determined by a linear equation consisting of values belonging to the previous period and error terms. The variance of the series used in the model is assumed to be constant and the mean is zero, that is, the series is stationary (Şenyüz, 2019).

To analyze the ARIMA model, first of all, the reasons that distort the stationarity should be removed and the data series should be made stationary. The process of making the time series stationary is done by taking the first and second differences of the series. By applying the Augmented Dickey-Fuller Test, the series is made stationary with the different processes and the ARIMA model is determined.

To define the most suitable ARIMA model, autocorrelation (ACF) and partial autocorrelation (PACF) functions are taken into consideration and the significance of the most suitable p, d, and q parameters is checked. If the predictive power of a model is found to be insignificant, it cannot be used in prospective predictions. “Mean Absolute Percentage Error (MAPE)” statistics and “Theil’s U-statistic” values are used to make the prediction accuracy and determine the future predictive power of the model (Wong et al., 2005). The MAPE statistic is expressed in the following equation:

$$MAPE = \frac{\sum_{t=1}^{n} \left| \frac{Y_t - F_t}{Y_t} \right|}{n} \times 100$$

where Y_t: actual observation for period t, F_t: forecast for the same period, n: periods.

Models with a MAPE value of less than 10% are classified as very good, models between 10-20% are good, models between 20-50% are acceptable, and models with a MAPE value above 50% are classified as false and inaccurate (Caner and Engindeniz, 2020).

Theil’s U statistic equation shown below:

$$U = \sqrt{\frac{\frac{1}{n}\sum_{t=1}^{n}(e_t)^2}{\frac{1}{n}\sum_{t=1}^{n}(Y_t)^2}}$$

where U: theil’s U-statistic, e_t: forecast error for time period t, n: time periods, Y_t: actual observation for time period t.

Theil’s U statistic value being zero indicates the best predictive power of the model, while this value should be as small (less than 1) as possible (Özer and İlkdoğan, 2013; Wong et al., 2005).

RESULTS AND DISCUSSION

In the study, corn cultivation areas belonging to the 50 years covering the years 1970-2019 were used as time series (Table 1). Since the data did not show a linear relationship, their logarithms were taken and a linear relationship was provided (Figure 1).

Table 1. Corn cultivation areas in Turkey

Years	Cultivation area (hectares)	Years	Cultivation area (hectares)	Years	Cultivation area (hectares)	Years	Cultivation area (hectares)	Years	Cultivation area (hectares)
1970	648000	1980	583000	1990	515000	2000	555000	2010	594000
1971	635000	1981	580000	1991	518000	2001	550000	2011	589000
1972	617000	1982	580000	1992	525000	2002	500000	2012	622609
1973	625000	1983	550000	1993	550000	2003	560000	2013	659998
1974	620000	1984	550000	1994	485000	2004	545000	2014	658645
1975	600000	1985	567000	1995	515000	2005	600000	2015	688170
1976	600000	1986	560000	1996	550000	2006	536000	2016	680019
1977	580000	1987	570000	1997	545000	2007	517500	2017	639084
1978	580000	1988	500000	1998	550000	2008	595000	2018	591900
1979	585000	1989	510000	1999	518000	2009	592000	2019	638829

Source: Turkish Grain Board, 2020

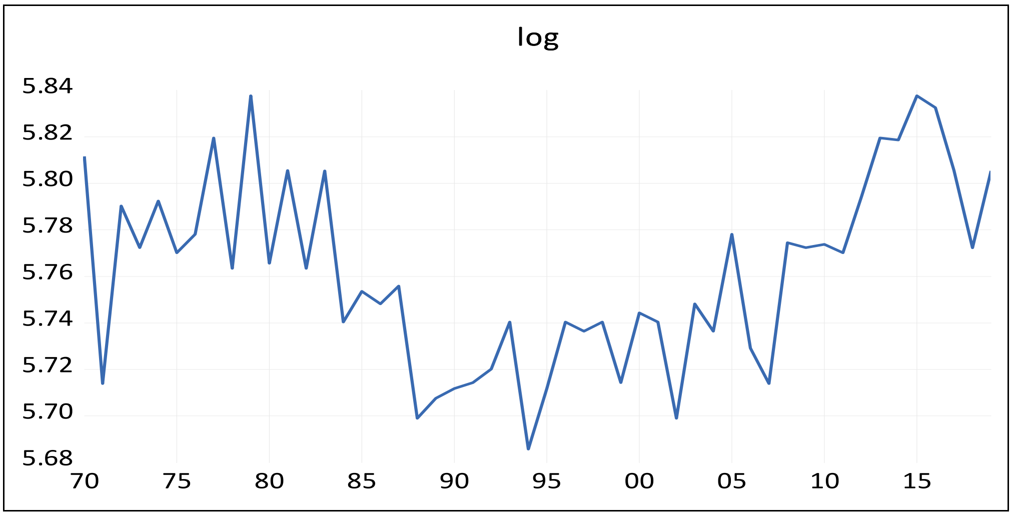

Figure 1. Corn cultivation areas (1970-2019)

To apply the ARIMA model to the time series data, the stationarity analysis should be done first. Augmented Dickey-Fuller (ADF) stationarity test was performed in the study. According to the results of the stationarity analysis test results, no stationarity was found in the data of the time series, and the series was made stationary by taking the first differences of the series (Tables 2 and 3).

Table 2. The results of the ADF unit root test

		t-statistics	Significance level
Augmented Dickey - Fuller test statistics		-1.591241	0.7818
Critical Values:	1% level	-4.161144	
	5% level	-3.506374	
	10% level	-3.183002	

Table 3. ADF unit root test results of the data with first difference

		t-statistics	Significance level
Augmented Dickey - Fuller test statistics		-14.77636	0.0000
Critical Values:	1% level	-4.161144	
	5% level	-3.506374	
	10% level	-3.183002	

When only the first-order differences of the series are taken, the degree of difference is determined as d = 1, since the stationarity is provided.

In determining the most suitable model for the data, ACF and PACF graphs of the first differences of the series were examined (Figure 2). In the ACF graph, it is observed that after the first delay, the size of the relationship decreases rapidly and approaches zero (q = 1) (Figure 2). An examination of the PACF graph reveals that the fourth delay is important (p = 4) (Figure 2).

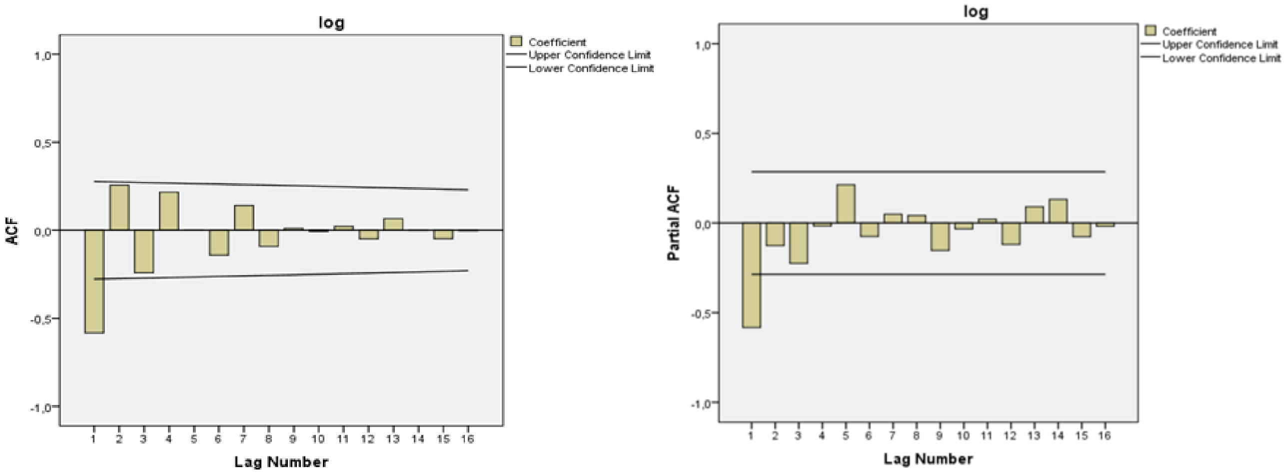

Figure 2. Autocorrelation graphs of the series

To decide on the most suitable model, the significance test results of the coefficients in the models and the compatibility of the prediction series and the original series were examined. ARIMA (1,1,4) model has been determined as the most suitable model. The parameter estimates of the ARIMA (1,1,4) model are given in Table 4. As a result of the analysis, the parameters of the ARIMA (1,1,4) model were observed to be statistically significant ($p<0.05$). According to the calculations, Theil 'U statistic value was found to be 0.0069, and the Mean Absolute Percentage Error (MAPE) value was found to be 37.1. Considering both Theil's U and MAPE values, the model is considered to be a valid model for estimation.

Table 4. Most appropriate ARIMA model results for corn production area

	Variable	Coefficient	Standard Error	t-statistics	P probability
ARIMA (1,1,4)	Coefficient	5.761737	0.014643	393.4693	0.0000
	AR (1)	0.610592	0.170853	3.573792	0.0009
	MA (4)	0.884489	0.293938	3.009105	0.0044
Standard Error of Regression		0.025284	Hannan-Quinn Criterion		-4.150941
Akaike Information Criterion (AIC)		-4.252877	MAPE		37.1
Schwarz Criterion (SBC)		-3.985193	Theil's U		0.0069

According to the ARIMA (1,1,4) model estimation made, the corn cultivation areas calculated for the years 2020-2030 are shown in Table 5. Corn cultivation areas were estimated to be 638,829 hectares in 2019 and 604,277 hectares in 2020. In 2030, on the other hand, the prediction reveals that corn cultivation areas will decrease to 577,065 hectares.

These projections were based on the two assumptions: the agricultural price structure and policies will remain unchanged and consumer preferences will remain the same.

Table 5. Predicted values of corn cultivation area ARIMA (1,1,4)

Years	Cultivation area prediction (hectares)	Years	Cultivation area prediction (hectares)
2020	604,277	2026	572,869
2021	594,151	2027	574,763
2022	528,909	2028	575,922
2023	556,625	2029	576,632
2024	564,756	2030	577,065
2025	569,780		

CONCLUSIONS

The use of corn, in a wide range from animal feed to corn syrup in processed foods, from energy sources to its use in basic foods, is increasing. This state shows that corn has a strong place in the markets and will maintain this in the coming years. However, production areas are decreasing gradually in Turkey. While Turkey's corn cultivation areas were 6.8 million decares in the 2015/2016 production season, the areas decreased by 14% in the 2018/2019 production season to the level of 5.9 million decares. According to estimates made for the years 2020-2030, considering the current agricultural policies, the corn cultivation areas of Turkey will decrease. These projections help the government to make policies concerning relative price structure, production, and consumption and also to establish relations with other countries of the world.

Considering that the corn yield per unit area of production in Turkey is above the world average, production increase will be possible by increasing the corn cultivation areas rather than increasing efficiency.

Therefore, it is very important to establish appropriate prices and support policies to motivate the producers about corn production. The increase in production, which will be achieved by increasing corn cultivation areas, will contribute to the decrease in corn imports and thus the agricultural foreign trade deficit.

The producer, who could not make enough profit due to the high input costs, has moved away from production. Taxes on fertilizers and fuel should be reduced or subsidies increased. Since the production amount does not meet the domestic demand, GMO corn is imported to be used as animal feed. GMO corn import should be reduced by increasing the yield obtained from both the cultivation area and the unit area.

Producers should benefit from organization, cooperatives, investment, and agricultural consultancy services. Post-harvest storage and marketing are insufficient. Licensed warehousing should be emphasized, an infrastructure that will benefit more from Turkish Grain Board facilities should be created and monopolization should be prevented (https://www.zmo.org.tr/).

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