Content list available at JournalPark

Turkish Journal of Forecasting

Journal Homepage: tjforecast.xyz

Forecasting of Onion Sown Area and Production in Turkey Using Exponential Smoothing Method

B. Kilic Topuz[1,*], M. Bozoglu[2], N. Alhas Eroglu[3], U. Baser[2]

[1]*Igdır University, Faculty of Agriculture, Department of Agricultural Economics,76000 Igdir, Turkey,*
[2]*Ondokuz Mayis University, Faculty of Agriculture, Department of Agricultural Economics, 55139 Samsun, Turkey*
[3]*Regional Directorate of Turkish Statistical Institute, 55080 Samsun, Turkey*

A R T I C L E I N F O

Article history:

Received 17 December 2019
Accepted 31 December 2019
Available online 31 December 2019

Keywords:

Onion
Production
Sown area
Exponential smoothing method
Turkey

A B S T R A C T

In 2017, 144 countries in the world produced 97.862.928 tons onion at 5.201.591 hectares. Turkey produced 2.1 million tons onion in 68 thousand hectares. Turkey was the seventh-largest producer country of dry onion with a share of 2,18% in the world. The main aim of this research was to forecast the onion area and production of Turkey for the period of 2019-2026. The data of this study was obtained from the database of the Food and Agriculture Organization and the time series covered the period of 1961-2018. Three Exponential Smoothing Methods were compared to model onion area and production and Holt Exponential Smoothing model was determined as the most appropriate forecasting model. In the study, time series data were determined as non-stationary and so, stationarity was obtained after taking the first difference of the time series. Model results show that, in the 2019-2026 period, the forecasted sown area of onion would be increased from 58.873 hectares to 60.981 hectares, forecasted production of onion would be increased from 2.066.453 tons to 2.309.751 tons. In order to reduce the effect of Cobweb theorem, onion production should be planned by producer organizations. The supply gap can be avoided by taking appropriate policy measures and this is necessary to maintain Turkey's position in the world onion market.

1. Introduction

The onion is a herbaceous plant from the *Alliaceae* family, with a pungent scent and tubers and green leaves. It is one of the rare vegetables consumed by rich and poor families regardless of income level in the world. Onion provides important nutrients and health-promoting phytochemicals. It also contains high in vitamin *C*, calcium, iron, and has a high protein quality, low in sodium and contain no fat. Onion is a good source of dietary fiber, and folic acid [1].

In 2017, 144 countries produced 97.862.928 tons onion at 5.201.591 hectares (ha) area in the world. China and India were the biggest onion producer countries in the world with a share of 24,88% and 22,92%, respectively. Turkey was the seventh-largest producer country in the world. Turkey has 1,31% of the onion areas of the world and provides 2,18% of the world onion production (Table 1). In 2016, the export quantity and value of dry onion in the world were

*Corresponding author
E-mail address: *bakiyekilic@hotmail.com*

https://doi.org/10.34110/forecasting.660377

7.299.372 tons and 2.9 billion $, respectively. India was the biggest onion exporter in the world with 1.83 million tons. China and the Netherlands were the other largest dry onion exporter countries with 1.4 million tons and 1.2 million tons, respectively. The dry onion import quantity and value in the world were 7.260.763 tons and 2.9 billion $, respectively. Malaysia and the United States of America (USA) were the largest importer countries with 577 thousand tons and 521 thousand tons, respectively. Turkey was the tenth exporter country in the world with 248.175 tons [2].

Table 1. Onion sown area and production in the World

Country	Sown Area (ha)	%	Production (tons)	%
China	1.102.498	21,20	24.344.543	24,88
India	1.306.000	25,11	22.427.000	22,92
USA	55.850	1,07	3.731.940	3,81
Iran	61.661	1,19	2.379.096	2,43
Egypt	68.053	1,31	2.379.035	2,43
Russian	83.343	1,60	2.135.974	2,18
Turkey	68.136	1,31	2.131.513	2,18
Other countries	2.456.050	47,22	38.333.827	39,17
Total	5.201.591	100,00	97.862.928	100,00

Source: [2]

In 2017, 2.13 million tons of dry onion was produced in Turkey, mainly in the provinces Ankara (24,6%), Amasya (12,7%), Hatay (9,3%), Eskişehir (7,9%), Adana (7,9%), Çorum (6,3%), Tokat (5,7%), Bursa (5,4%), Konya (3,7%), Afyonkarahisar (1,9%) and other provinces (14,6%) [3].

While there had been an upward trend both in the onion sown area and production of Turkey in the period of 1961-1999, the sown area and production trends were seen as decreasing since 2000. Thus, onion sown area has increased from 56 thousand ha to 112 thousand ha during the period of 1961-1999, it has decreased to 52 thousand ha in 2018. The onion production has increased from about 410 thousand tons to 2.5 million tons in the period of 1961-1999, since the 2000s, the production has fluctuated around 2.000.000 tons. The previous year price together with the climate determines the current year sown area and production of onion. This fluctuates producer prices and incomes. There had been a steadily increasing trend in the onion yield per hectare from 7.3 to 31.3 tons in the examined period (Figure 1). In 2018, the onion yield level of the world was about half of Turkey (18.8 tons/ha).

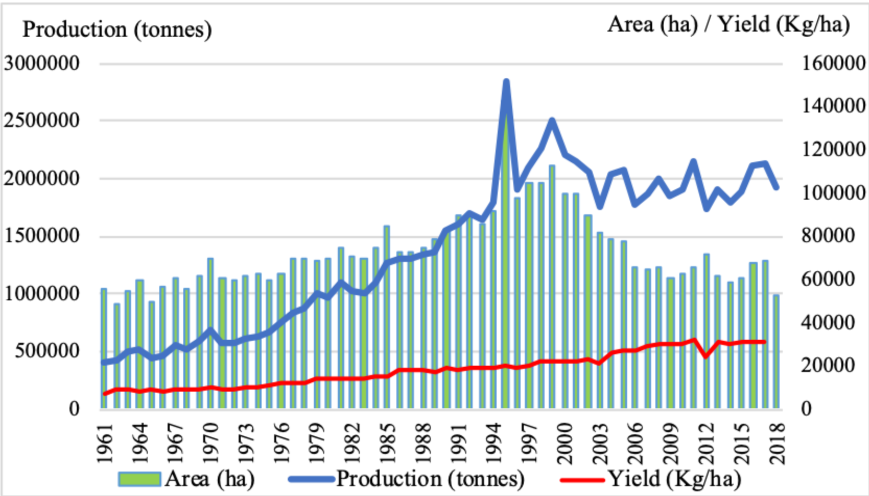

Figure 1. Sown area, production and yield of onion in Turkey [2]

Literature review shows that there have been some studies about onion to estimate the relationship between production and prices, the estimation of sown area, production and demand of onion. While using Almon model, Dogan and Gurler [4] examined that relationship between production and price of dry onion in Turkey, Simsek [5] analysed the relationship production and price of onion in Amasya province. However, Erdal and Erdal [6] was used the Koyck Model to examine the relation between production and prices of dry onion in Turkey. Adil *et al.* [7] also forecasted the area, production and demand of onion in Punjab (Pakistan) using the ARIMA model. Zhu *et al*. [8] forecasted the onion demand using Holt-Winters model. But sown area and production of onion has not been previously examined for Turkey in the last decade.

The marketing and price of onion occur in free-market conditions in Turkey. The farmer makes its production decision by looking at the price of the previous year. High prices lead to high production for the following year or low prices lead to low production in the following year. In other words, producer income increases one year while decreases in the following year. For this reason, fluctuates producer prices and incomes onion. This situation causes instability in producers' income. So, forecasting future of the sown area and production of onion in Turkey is very important to make a policy decision and to avoid any shortage in the country. The main aim of this research was to forecast the area and production of onion in Turkey for the period of 2019-2026.

2. Material and Methods

The data of time series for Turkey's onion sown area (ha) and production (ton) in the period of 1961-2018 was derived from the Food and Agriculture Organization (FAO). Time series forecasting method is an important part of the prediction method system. Time series forecasting methods include a variety of forecasting techniques. The exponential smoothing prediction method is one of the important methods [9]. There are three exponential smoothing methods as Holt, Brown (or Double) and Damped. In this study, these three exponential smoothing methods were comparatively used to forecasting the sown area and production of onion in Turkey.

Holt Exponential Smoothing (HES) is a kind of linear exponential smoothing method. HES has two basic smoothing formulas and a prediction formula (Formula 3). These two basic smoothing formulas for the two factors of time series are given Formula 1 and Formula 2;

$$S_t = \alpha y_t + (1-\alpha)(S_{t-1} - b_{t-1}) \quad (1)$$

$$b_t = \gamma(S_t - S_{t-1}) + (1-\gamma)b_{t-1} \quad (2)$$

Prediction formula is given in Formula 3 as;

$$\hat{y}_{t+T} = S_t + b_t T \quad (3)$$

In the formulas: α and γ are smoothing parameters: y_t is the actual observed value; T is extrapolation and prediction period number. Formula 1 is the smoothing of the time series trend factors. We can use the trend value b_{t-1} directly correct the smoothed values S_{t-1}, so the lag will be eliminated, and the S_t can almost be the latest data values. Formula 2 is the smoothing of the trend incremental and it is used for correcting the trend value b_t. The trend value is represented by the difference between two smoothed values. Due to randomness, we can take advantage of the smoothing parameters γ correct the difference between two smoothed values and add it to the prophase trend estimated value, then multiplies it by $(1-\gamma)$.

Brown (Double) Exponential Smoothing (BES) model should be used when the time series data has a trend without seasonality. The BES model is given by the model equation 4 and 5:

$$S_t^{(1)} = \alpha y_t + (1-\alpha)S_{t-1}^{(1)} \quad (4)$$

$$S_t^{(2)} = \alpha S_t^{(1)} + (1-\alpha)S_{t-1}^{(2)} \quad (5)$$

The BES method is mainly used for variable parameters linear trend time series prediction. Variable parameters of the linear trend forecasting model expressed as (Formula 6):

$$Y_{t+T} = a_t + b_t T \quad (6)$$

In the formula 4 and 5; $S_t^{(1)}$ is a single exponential smoothing value, $S_t^{(2)}$ is the double exponential smoothing value, α is the smoothing parameter and T is the predicted number of instalments starting from period t [9].

The damped trend exponential smoothing models are taken into account to perform excellent forecasting. The damped method is expressed in the following equations (Formula 7-9) [10].

$$S_t = \alpha Y_t + (1-\alpha)(S_{t-1} + \phi T_{t-1}) \quad (7)$$

$$T_t = \gamma(S_t - S_{t-1}) + (1-\gamma)\phi T_{t-1} \quad (8)$$

$$Y_t(m) = S_t + \sum_{i=1}^{m} \phi^i T_t \quad (9)$$

Grander and McKenzie [10] clarify that if $0 < \phi < 1$, then the trend is damped and the forecasts approach an asymptote given by the horizontal straight line $S_t + T_t\phi(1-\phi)$. If $\phi = 1$, the mentioned method is the same as the standard Holt method.

There are many selection criteria to compare the model results used in the time series for prospective forecasts. The most commonly used methods are the Root Mean Square Error (RMSE), Mean Absolute Percentage Error (MAPE), Mean Absolute Deviation (MAD), Mean Squared Error (MSE), Mean Percentage Error (MPE). It is usually desirable that these values be as small as possible [11–13]. To select the best model, model fit statistics were calculated as:

$$RMSE = \sqrt{\frac{\sum_{t=1}^{n}(Y_t - \bar{Y}_t)^2}{n}} \tag{10}$$

$$MAPE = \frac{\sum_{t=1}^{T}\left|{(y_t - \bar{y}_t)}/{y_t}\right|}{T} \times 100, \quad (y_t \neq 0) \tag{11}$$

$$MAD = \frac{\sum_{t=1}^{T}|(y_t - \bar{y}_t)|}{T} \tag{12}$$

$$MSE = \frac{\sum_{t=1}^{n} e_t^2}{n} \tag{13}$$

$$MPE = \frac{\sum_{t=1}^{n}\frac{e_t}{Y_t}}{n} \times 100 \tag{14}$$

3. Results and Discussion

Dry onion is a cash crop and its price is determined by market forces. The price of that year determined the sown area and production amount of the following year. Relationship between onion production and price from 1983 to 2018 in Turkey was given in Figure 2. Figure 2 shows that Cobweb theorem is valid for dry onion. In other words, dry onion producers make their production decisions based on the previous season prices. If prices are high, production increases in the following season or if prices are low, production decreases in the following season. In order to reduce the negative effects of Cobweb theorem, the production should be planned by farmer organizations. The studies also emphasized that production planning for onion is necessary for sustainable growth in the sector [4–6].

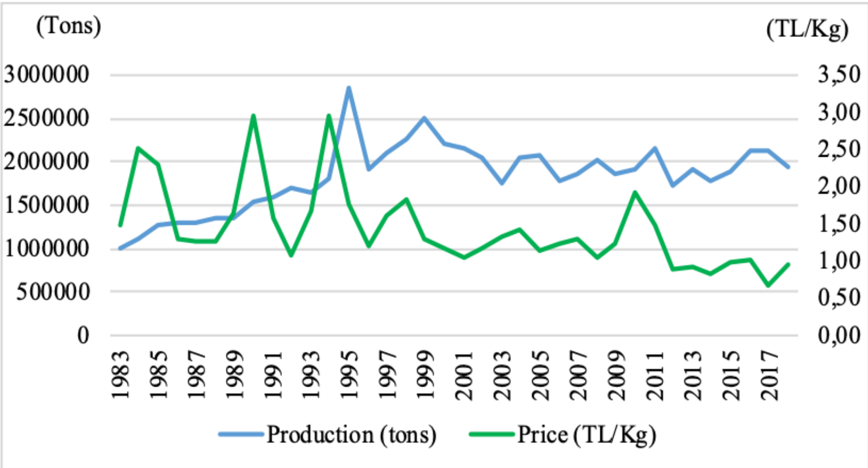

Figure 2. Dry onion production and real price in Turkey between 1983 and 2018

Time series graphs of the autocorrelation function (ACF) and partial autocorrelation function (PACF) were created to time trend for the sown area and production of onion (Figure 3). The autocorrelation function is a very constructive tool to find out whether a time series is stationary or not. If a time series is stationary, its behaviour is essentially determined by its ACF. In the ACF graphs, the sown area and production of onion were determined that the delays exceed the confidence limit. In Figure 3, the sample ACF and PACF of the data for that time period show that the process is stationary. In this case, the first difference was applied to the series and the series was tried to be cleared from the trend.

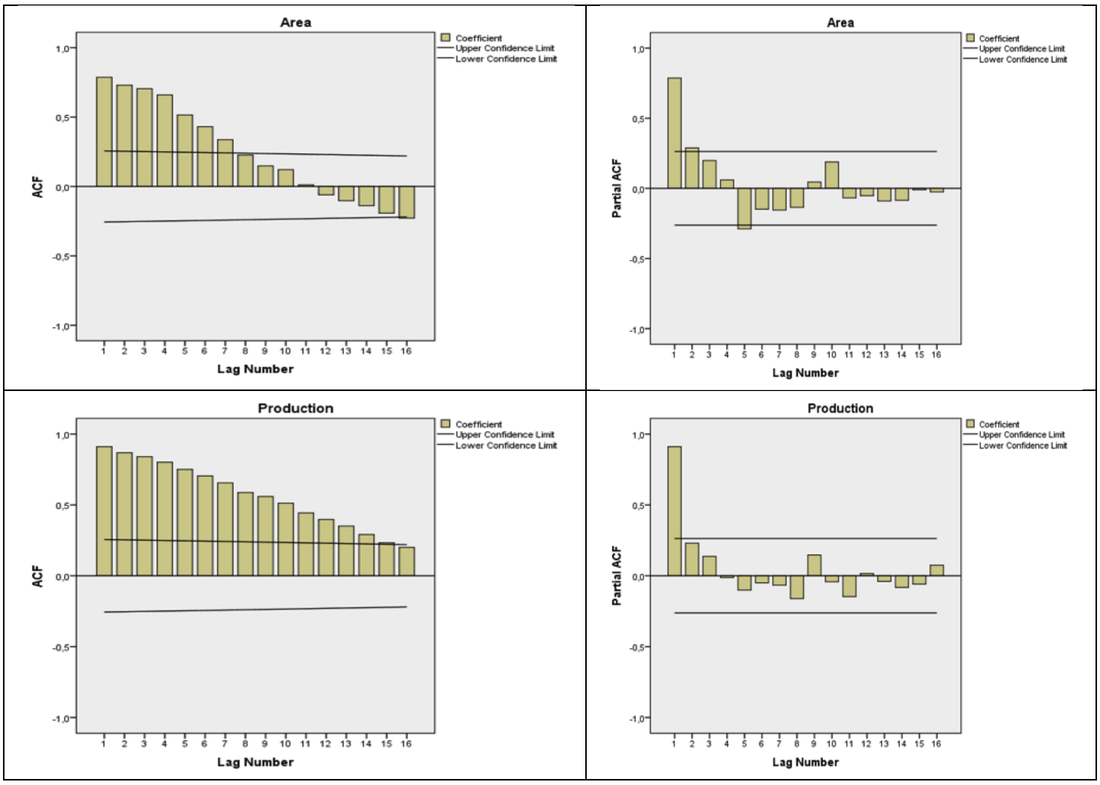

Figure 3. The ACF and PACF plots of onion area and production

ACF and PACF graphs of the onion sown area and production of the first difference were given in Figure 4, respectively. The ACF and PACF graphs illustrated that the first differenced time series of onion sown area and production are stationary.

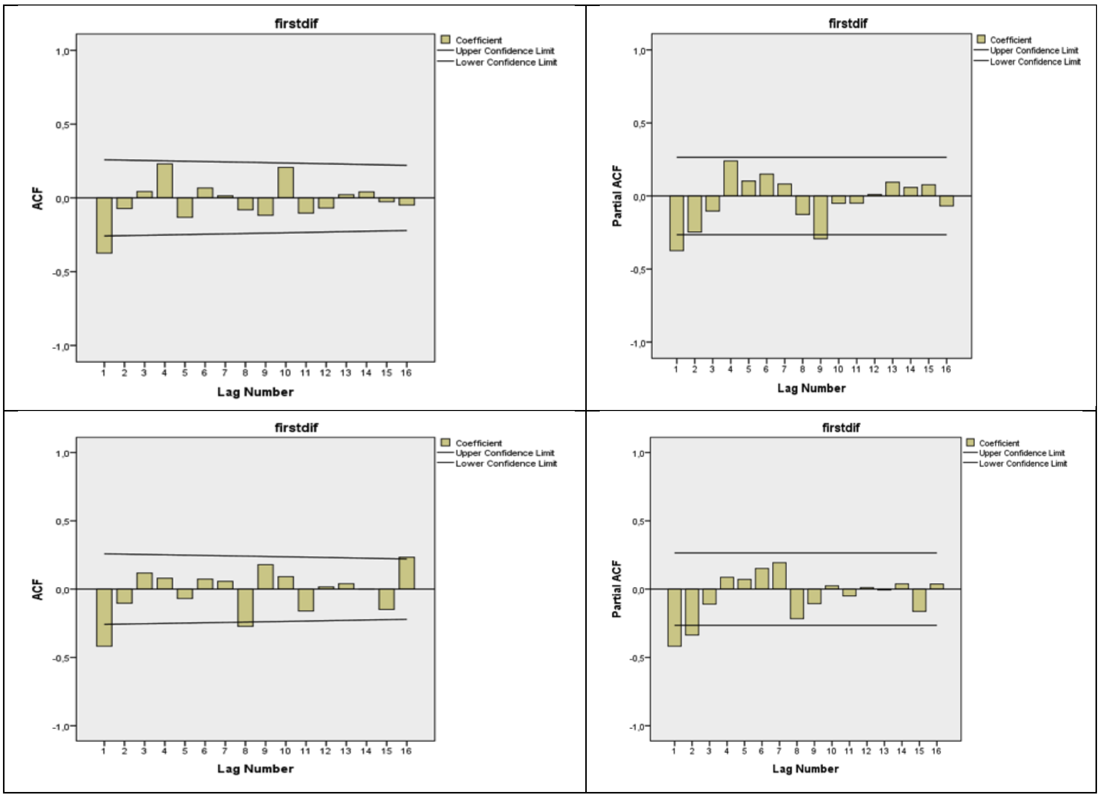

Figure 4. The ACF and PACF plots of onion area and production (the series of taken the first difference)

Performance of Holt, Brown and Damped trend exponential smoothing methods were compared by using model fit statistics such as Stationary R^2, R^2, RMSE, MAPE, MaxAPE, MAE, MaxAE and BIC. Results of model fit statistics for the methods are shown in Table 2. Brown exponential smoothing method showed the smallest BIC value both onion sown area and production models. But, stationary R^2 and R^2 values are the highest in Holt method for both onion sown area and production. Comparing Holt and Brown exponential smoothing methods, the values of RMSE, MAPE and MAE are the lowest in Holt model. So, to estimate onion sown area and production of Turkey, Holt Exponential Smoothing Method was selected because it has the lowest RMSE, MAPE, MAE and the highest R^2. Holt exponential smoothing is preferable to Brown exponential smoothing.

Table 2. Model fit statistics

	Sown Area			Production		
Fit Statistics	**Holt**	**Brown**	**Damped Trend**	**Holt**	**Brown**	**Damped Trend**
Stationary R^2	0.732	0.721	0.267	0.700	0.690	0.253
R^2	0.905	0.900	0.907	0.686	0.674	0.713
RMSE	204464.100	207564.500	203320.700	9875.100	9966.600	9531.900
MAPE	8.012	8.638	8.389	8.088	8.388	7.919
MaxAPE	37.423	35.714	37.373	36.643	34.952	35.227
MAE	119213.100	124887.700	123553.400	6238.200	6543.200	6169.500
MaxAE	1066548	1017848	1065131	52386.400	49969.100	50361.900
Normalized BIC	24.596	24.556	24.655	18.536	18.484	18.535
Ljung-Box Q	Statistics: 16.709 Significant: 0.405			Statistics: 13.324 Significant: 0.649		

Table 3 shows the Holt exponential smoothing model parameters. Holt model parameter coefficients and significant values were found as α=(0.492; 0.599) and p<0.01, respectively.

Table 3. Exponential smoothing model parameters

		Estimate	**SE**	**t**	**Significant**
Sown Area	Alpha (Level)	0.599	0.129	4.627	0.000
	Gamma (Trend)	2.412E-5	0.049	0.000	1.000
Production	Alpha (Level)	0.492	0.119	4.124	0.000
	Gamma (Trend)	1.148E-6	0.026	4.426E-5	1.000

Table 4. Onion sown area and production forecasts for the period of 2019-2026

	Sown Area			Production		
Year	**Forecast**	**Lower**	**Upper**	**Forecast**	**Lower**	**Upper**
2019	58.873	39.091	78.656	2.066.453	1.656.863	2.476.044
2020	59.174	36.118	82.231	2.101.210	1.644.812	2.557.608
2021	59.475	33.555	85.396	2.135.967	1.637.134	2.634.799
2022	59.777	31.278	88.275	2.170.724	1.632.794	2.708.654
2023	60.078	29.216	90.940	2.205.480	1.631.108	2.779.853
2024	60.379	27.322	93.436	2.240.237	1.631.601	2.848.874
2025	60.680	25.565	95.795	2.274.994	1.633.922	2.916.066
2026	60.981	23.922	98.040	2.309.751	1.637.807	2.981.695

This study forecasted the onion sown area and production for 8 years (Table 4). The results of the study showed that there will increase both onion sown area and production of Turkey in the following years (Figure 5, 6). Table 4 implies that in 2019, the onion sown area and production would be 58.873 hectares and 2.066.453 tons, respectively. However, in 2026, the onion sown area and production would be 60.981 hectares and 2.309.751 tons, respectively. The model results show that the onion sown area and production of Turkey in the next eight years would be increased by 3,5% and 11,7%, respectively. Adil *et al.* [7] also estimated that onion area and production in Pakistani Punjab would be 47.484 thousand hectares and 372.403 thousand tons in 2025, respectively and they determined that demand of onion is expected to exceed production in future in the province. Hanci [14] analysed that statistically significant positive correlation was found between the amount of yield and production quantities of onion while a statistically significant negative correlation was found between yield and area of onion in Turkey.

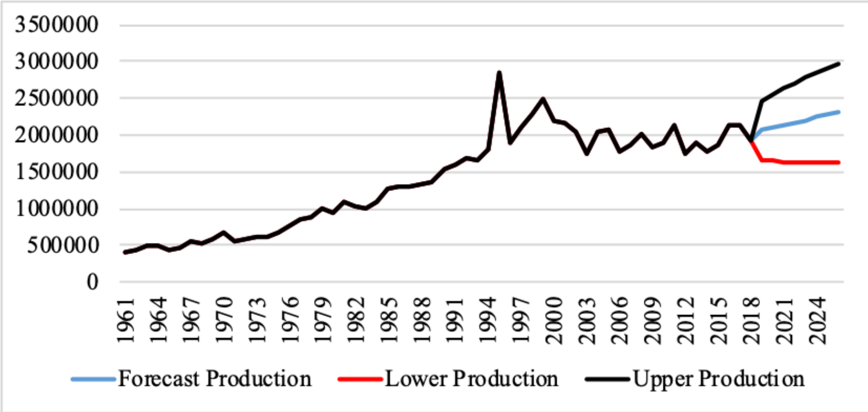

Figure 6. Onion production forecast (tonnes)

4. Conclusion

Onion is an important strategic and export product for Turkey. Thus, the expansion of onion production and area will increment farm incomes and foreign exchange income of the country. In this research, Turkey's onion sown area and production amounts were estimated for the period of 2019-2026 using the Exponential Smoothing method. The results of the study showed that there will be an increase in onion sown area and production of Turkey in the following years. In order to increase the production of onions in the country, the onion sown area should be planned according to the total demand and inputs should be used efficiently.

Dry onion producers make their production decisions according to the prices of the previous season. For this reason, especially in the high crop years, producers should be effectively organized under farmer cooperatives and they should supply dry onions to market according to the demand in the marketing seasons. This could increase and stabilize farmers' price and income. In order to reduce the negative effects of Cobweb theorem, onion sown area and production should be planned by the government and farmer organizations should be encouraged to fit production planning. This can stabilize domestic onion markets and increase the share of Turkey in the world market.

References

[1] Onion Health Research, (2019). https://www.onions-usa.org/all-about-onions/onion-health-research/ (accessed October 6, 2019).

[2] Food and Agricultural Organization, (2019). http://www.fao.org/faostat/en/#data/QC (accessed October 5, 2019).

[3] Dry Onion Agricultural Products Markets, 2018. https://www.agmrc.org/commodities-products/vegetables/onions.

[4] H.G. Dogan, Z. Gurler, Implementation on an Agricultural Product Selected of Econometric Model Distributed Lag (Almon Model Sample of Dry Onion), Akad. Bakış. 39 (2013) 1–12.

[5] E. Simsek, Analysis of Production and Price Relation of Growing Onion with Almon Approach: Amasya Case, J. Agric. Nat. Sci. 3 (2016) 118–125. https://dergipark.org.tr/en/download/issue-file/3045.

[6] G. Erdal, H. Erdal, The Interaction Between Production and Prices for Dry Onion, J. Agric. Fac. Gaziosmanpasa Univ. 25 (2008) 33–39.

[7] S.A. Adil, A. Maqsood, K. Bakhsh, S. Hassan, Forecasting demand and supply of onion in Pakistani Punjab, Pakistan J. Agric. Sci. 49 (2012) 205–210.

[8] Y. Zhu, Y. Zhao, J. Zhang, N. Geng, D. Huang, Spring onion seed demand forecasting using a hybrid Holt-Winters and support vector machine model, PLoS One. 14 (2019) 1–18. doi:10.1371/journal.pone.0219889.

[9] X. Li, Comparison and analysis between Holt exponential smoothing and Brown exponential smoothing used for freight turnover forecasts, in: Proc. 2013 3rd Int. Conf. Intell. Syst. Des. Eng. Appl. ISDEA 2013, 2013: pp. 453–456. doi:10.1109/ISDEA.2012.112.

[10] E.S. Gardner, E. Mckenzie, Forecasting Trends in Time Series, Manage. Sci. 31 (1985) 1237–1246. doi:10.1287/mnsc.31.10.1237.

[11] S.G. Makridakis, S.C. Wheelwright, R.J. Hyndman, Forecasting: Methods and Applications, 3rd ed., Wiley, 1997.

[12] I. Akgul, Geleneksel Zaman Serisi Yöntemleri, 2003.

[13] D.C. Montgomery, C. Jennings, M. Kulahci, Introduction to Time Series Analysis and Forecasting, John Wiley & Sons, 2008.

[14] F. Hanci, A Comprehensive Overview of Onion Production: Worldwide and Turkey, J. Agric. Vet. Sci. 11 (2018) 17–27. doi:10.9790/2380-1109011727.