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Forecasting the Production Results of Medicine Horticultural Plants (Biofarmacies) in North Sumatra in 2020 and 2021 Using Double Exponential Smoothing Brown Method

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Abstract. Indonesian medicinal plants have a high contribution to world drug production. North Sumatra is one of provinces that produces a variety of traditional medicinal plants. The data in this study is secondary data obtained from the Central Statistics Agency of North Sumatra which is data on the amount of production of medicinal horicultural plants (biopharmaceuticals) from 2007-2019 using the method Double Exponential Smoothing Brown. The purpose of this research is to get the parameters α and shape forecasting equation that can be used to estimate the amount of production of the total production of horticultural crops medicin from 2006 to 2018 by using the size of the precision of the forecasting Mean absoulte Percentage Error in the method of Double Exponential Smoothing Brown. The parameter α is best used to predict the amount of horticultural crop production of medicinal was 0.24 with a yield forecasting in 2020 amounted to 8,454,007.24 kg and in 2021 amounted to 7,779,411.27 kg.

Keyword: Double Exponential Smoothing Brown, Forecasting, Production Of Medicinal Horticultural Plants, Biopharmaceuticals

Abstrak. *Tanaman obat Indonesia memiliki kontribusi yang tinggi terhadap produksi obat dunia. Sumatera Utara merupakan salah satu provinsi penghasil aneka ragam tanaman obat tradisional. Data dalam penelitian ini adalah data sekunder yang diperoleh dari Badan Pusat Statistika Sumatera Utara yang merupakan data jumlah produksi tanaman horikultura obat (biofarmaka) dari tahun 2007-2019 dengan menggunakan metode Double Exponential Smoothing Brown. Tujuan dari Penelitian ini untuk mendapatkan parameter dan bentuk persamaan peramalan yang dapat dipergunakan untuk memperkirakan jumlah produksi jumlah produksi tanaman hortikultura obat (biofarmaka) dari tahun 2006 sampai dengan tahun 2018 dengan menggunakan ukuran ketelitian hasil peramalan Mean Absoulte Percentage Error pada metode Double Exponential Smoothing Brown. Parameter α terbaik*

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yang digunakan untuk meramalkan jumlah produksi tanaman hortikultura obat (biofarmaka) adalah 0,24 dengan menghasilkan peramalan pada tahun 2020 sebesar 8.454.007,24 kg dan tahun 2021 sebesar 7.779.411,27 kg.

Kata Kunci: *Metode Branch and Bound, Optimisasi Produksi, Program Linier, Program Bilangan Cacah.*

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1. Introduction

Forecasting is thinking of a quantity, for example the demand for one or more products in the future period. In essence, forecasting is only an estimate (guess), but by using certain techniques, forecasting becomes more than just an estimate [1]. To get accurate forecasting results, appropriate forecasting methods are used. So to predict the yield of medicinal horticultural crops (bio-pharmaceuticals) in North Sumatra, the author uses method Double Exponential Smoothing Brown's. According to Double Exponential Smoothing Brown'sis a linear model proposed by Brown [2]. This method is used when the data shows a trend. Trend is a smoothed estimate of the average growth at the end of each period.

For his research using the Method Double Exponential Smoothing Brown. The Double Exponential Smoothing method was chosen as the best forecast method for forecasting the consumer price index (CPI) in the city of Samarinda [3]. The results of forecasting the number of CPI in the city of Samarinda show that there is an increase from month to month throughout the year. Researched unemployment forecasting using the method double exponential smoothing in East Kalimantan Province [4]. For his research using the Double Exponential Smoothing Brown Method, the DES method is proposed to be superior in the accuracy and robustness of the data predicted from the Mean Absolute Percentage Error (MAPE) [5].

2. Related Work

2.1 Forecasting Basic Concepts

Forecasting is the thought of a quantity, for example the demand for one or more products in the future period. In essence, forecasting is only an estimate (guess), but by using certain techniques, forecasting becomes more than just an estimate [1].

2.2 Function and Purpose of Forecasting

The function of forecasting or *forecasting is* seen at the time of decision making. A good decision is a decision that is based on consideration of what will happen when the decision is implemented. If the predictions that we make are not accurate, the forecasting problem is also a problem that we always face [1].

2.3 Method *Smoothing* (smoothing)

Method *smoothing* is the method used to set the past data in accordance with the data that occur seasonally, by averaging a series of data up to a distance and amount of data tends to/almost balanced [6].

2.4 One-Parameter Linear Double Exponential Smoothing Method from Brown

To get accurate forecasting results, the right forecasting method is used. So to predict the yield of medicinal horticultural crops (biopharmaceuticals) in North Sumatera, the author uses method Double Exponential Smoothing Brown's. According to Double Exponential Smoothing Brown's is a linear model proposed by Brown [2]. This method is used when the data shows a trend. Trend is a smoothed estimate of the average growth at the end of each period. With the analogy used when departing from a single moving average to a it can also be departed from a double moving average to a double exponential smoothing. Such a move may be interesting because one of the limitations of the Single Moving Average (i.e. the need to store the last n values) is still the Double Moving Average. Double Exponential Smoothing can be calculated only by three data values and the value for α. This approach also gives decreasing weight to past observations. For this reason Double Exponential Smoothing is preferred over Double Moving Average as a forecasting method in most of the cases.

Steps in using Double Exponential Smoothing Brown is as follows:

1. Determine the value Smoothing first S'_t

$$S'_t = \alpha X_t + (1-\alpha)S'_{t-1} \tag{1}$$

2. Determining the value of Smoothing the second S''_t

$$S''_t = \alpha S'_t + (1-\alpha)S''_{t-1} \tag{2}$$

3. Determining the value of a constant period a_t

$$a_t = 2S'_t - S''_t \tag{3}$$

4. Determining the value of smoothing constant (bt)

$$b_t = \frac{\alpha}{(1-\alpha)}(S'_t - S''_t) \tag{4}$$

5. Determine the value of forecasting (F_{t+m})

$$F_{t+m} = a_t + b_t(m) \tag{5}$$

Description:

m = Number of future periods that are predicted

S'_t = Eksponential smoothing Single in t period

S''_t = Eksponential smoothing Double in t period

α = Exponential smoothing parameters $(0 < \alpha < 1)$

a_t, b_t = Smoothing constant

F_{t+m} = Forecating result for the next m period

To use this equation, the value of S'_{t-1} and S''_{t-1} must terse him. But at time $t = 1$, these values are not available. Because the value of this value should be determined at the beginning of the period.

2.5 Forecasting Accuraty

Forecasting accuracy is a fundamental thing in forecasting, namely how to measure the suitability of a certain forecasting method for a given data set. Accuracy is seen as a refusal criterion to choose a forecasting method. In time series modeling from past data, it is possible to predict situations that will occur in the future, to test the truth of this prediction, accuracy is used. Some of the criteria used to test the accuracy of the forecast are:

a. ME (Mean Error)

$$ME = \sum_{t=1}^{n} \frac{e_t}{n} \tag{6}$$

b. MSE (Mean Square Error)

$$MSE = \sum_{t=1}^{n} \frac{e_t^2}{n} \tag{7}$$

c. MAE (Mean Absolute Error)

$$MAE = \sum_{t=1}^{n} \frac{|e_t|}{n} \tag{8}$$

d. MPE (Mean Percentage Error)

$$MPE = \frac{\sum_{t=1}^{N} PE_t}{N} \tag{9}$$

e. SSE (Sum Square Error)

$$SSE = \sum_{t=1}^{n} e_t^2 \tag{10}$$

f. MAPE (Mean Absolute Percentage Error)

$$MAPE = \sum_{t=1}^{n} \frac{|PE_t|}{n} \tag{11}$$

The measure of forecasting accuracy is used to evaluate the value of the forecasting parameters. If X_t is the actual data for the period t and F_t is the forecast (or the value of a match) for the same period, then the error is defined as follows:

$$e_t = X_t - F_t \tag{12}$$

If there is a value of observation and predictions for n period time, there will be n errors. In this study to determine the size of the forecasting error, the author uses the relative error measure Mean Absolute Percentage Error (MAPE).

2.6 Mean Absolute Percentage Error (MAPE)

MAPE or absolute percentage error median value is the average of the overall percentage of error (difference) between the actual data with the value forcasting for MAPE calculating formula (13) is as follows:

$$MAPE = \sum_{t=1}^{n} \frac{|PE_t|}{n} \tag{13}$$

Table 1 Value MAPE for the Evaluation of Prediction

Value MAPE	Accuracy of Prediction
MAPE ≤ 10%	High
10% <MAPE ≤ 20%	Good
20% <MAPE ≤ 50%	is still well used
MAPE>50%	Low

percentage of error is an error percentage of a forecasting:

$$PE_t = \left(\frac{X_t - F_t}{X_t}\right) 100\% \tag{14}$$

Description:

e_t = error in the period to-t

X_t = actual data for the period to-t
F_t = the value of the forecast period to-t
n = number of times periode

2.7 Research Flow Chart

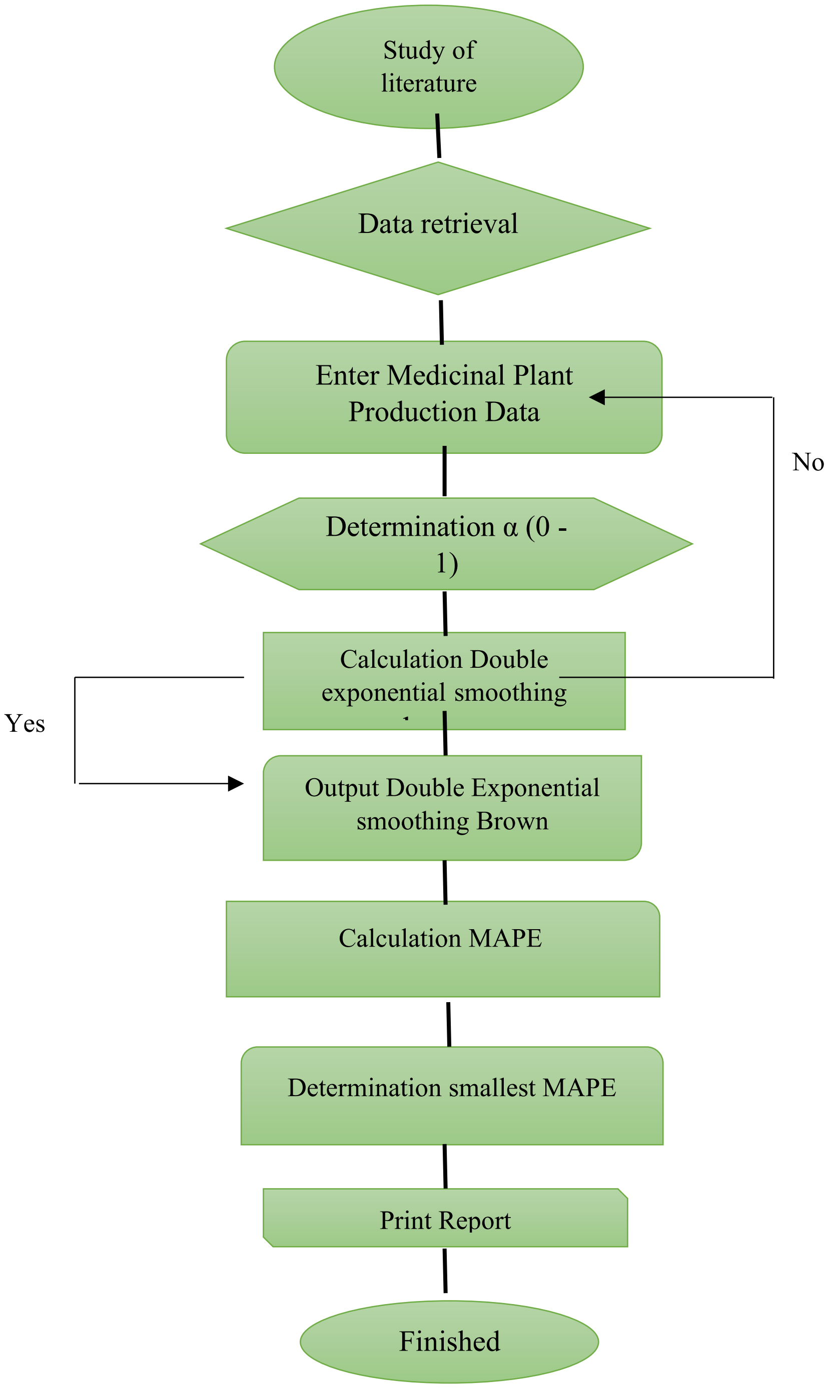

Figure 2. Research Step

3. Result and Discussion

3.1 Data Analysis

In this study the data used for forecasting is data horticultural crop production amount of drug (medicinal) in North Sumatra, the data obtained from the *Badan Pusat Statistik* from 2007 - 2019. the data have been magnified by as follows:

Table 2 Production of medicinal plants by type of crop year 2007-2011

No	Plant Type	2007	2008	2009	2010	2011
1	Ginger	3.777.224	5.820.524	8.555.608	5.692.250	4.718.540
2	Galangal	1.152.141	1.248.436	1.029.076	1.492.640	1.196.467
3	Aromatic Ginger	900.156	939.603	833.580	605.312	451.913
4	Turmeric	3.225.818	4.081.089	3.520.787	5.613.600	4.218.350
5	Bitter Ginger	158.193	119.815	404.679	424.915	63.662
6	Curcuma	151.646	156.767	171.026	146.565	55.590
7	Curcuma Aeruginosa	50.551	49.641	35.653	2.999	1.795
8	Fingerroot	4.868	14.050	17.078	7.474	3.579
9	Sweetroot	152.849	49.259	96.604	188.884	105.834
10	Cardamom	154.448	184.154	189.622	35.056	2.212
11	Noni	57.381	95.574	125.819	111.806	44.498
12	Crown of God	-	15.123	70.164	85.971	63.994
13	Obnoxious	1.432	1.200	2.587	3.596	3.713
14	Bitter	12.167	16.896	21.957	8.058	4.347
15	Aloe Vera	-	2.244	8.456	11.796	7.100
	Amount	9.798.874	12.794.375	15.082.696	14.430.922	10.941.594

Table 3 Production of medicinal plants by type of crop year 2012-2016

No	Plant Type	2012	2013	2014	2015	2016
1	Ginger	8.018.847	10.462.304	14.020.614	7.669.989	8.400.336
2	Galangal	895.393	2.373.388	1.184.701	956.970	729.991
3	Aromatic Ginger	249.770	238.444	346.683	367.775	315.861
4	Turmeric	4.469.263	9.384.621	5.960.304	3.894.542	1.913.923
5	Bitter Ginger	73.749	38.732	26.293	22.687	29.714
6	Curcuma	238.027	294.417	161.575	121.255	63.677
7	Curcuma Aeruginosa	3.495	17.679	15.617	8.518	4.338
8	Fingerroot	5.537	21.397	19.828	17.952	6.693
9	Sweetroot	56.080	105.032	20.165	31.290	9.691

10	Cardamom	52.638	39.203	134.191	103.129	66.500
11	Noni	17.742	22.131	295.288	183.919	34.715
12	Crown of God	83.272	57.743	176.694	275.135	35.970
13	Obnoxious	3.445	46.335	5.474	8.449	1.699
14	Bitter	2.417	17.962	9.919	51.124	2.865
15	Aloe Vera	-	4.302	5.380	3.351	658
	Amount	14.169.675	23.123.690	22.382.726	13.716.076	11.616.631

Table 4. Production of medicinal plants by type of crop year 2017-2019

No	Plant Type	2017	2018	2019
1	Ginger	7.263.534	5.452.774	2.814.772
2	Galangal	1.250.007	432.713	750.052
3	Aromatic Ginger	212.238	167.455	106.459
4	Turmeric	4.565.882	2.580.257	1.125.698
5	Bitter Ginger	15.539	11.105	20.138
6	Curcuma	50.502	50.553	50.285
7	Curcuma Aeruginosa	506	1.637	18.436
8	Fingerroot	993	1.185	3.734
9	Sweetroot	1.612	1.736	6.768
10	Cardamom	46.071	22.910	42.397
11	Noni	3.792	14.592	47.416
12	Crown of God	10.911	43.548	75.580
13	Obnoxious	352	927	3.601
14	Bitter	1.863	1.480	6.061
15	Aloe Vera	928	958	4.387
	Amount	13.424.730	8.783.830	5.075.784

Table 5. Total production of medicinal plants in North Sumatra in 2007 until 2019

Year	Total Production (kg)
2007	9,798,874
2008	12,794,375
2009	15,082,696
2010	14,430,922
2011	10,941,594
2012	14,169,675
2013	23,123,690

2014	22,382,726
2015	13,716,076
2016	11,616,631
2017	13,424,730
2018	8,783,830
2019	5,075,784

Source: National Statistics North Sumatra

Forecasting of method Double Exponential Smoothing Brown with used obtained a smoothing parameter that is α to smooth the actual data time series. In determining the smoothing parameter α whose magnitude is $0<\alpha<1$ by *trial and error* or guesswork produces Mean Absolute Percentage Error (MAPE) minimum.

3.2 Method Analysis

In solving the problem of the method, Double Exponential Smoothing Brown there are several steps that are used according to the specified formula, namely by using data on the amount of production of medicinal horticultural plants (biopharmaceuticals) in North Sumatra from 2007–2019 which can be seen in table 5.

From Table 5, forecasts can be made about the amount of production of medicinal horticultural plants (biopharmaceuticals) in the coming year. Double Exponential Smoothing Brown is also a method of linear equations of the parameters of Brown is se like the following:

Medicinal Plants Production Amount Forecasting with parameter α = 0.1:

For the year to-1 (2007):

S'_t = Specified amount of medicinal plant production per year (2007) which is 9,798,874 kg.

S''_t = Determined by the amount of production of biopharmaceutical plants for year (2007) which is 9,798,874 kg, because for t-1 it has not been obtained.

a_t = Undefined.

b_t = Undefined.

For year 2 (2008):

$X_2 = 12.794.375$

1. Determine the value Smoothing first S_t'

$S_t' = \alpha X_2 + (1-\alpha)S_{t-1}'$

= 0,1 (12.794.375) + (0,9) (9.798.874)

= 1.279.437,5 + 8.818.986,6

= 10.098.424,1

2. Determining the value of Smoothing a second S_t''

$S_t'' = \alpha S_t' + (1-\alpha)S_{t-1}''$

= 0,1 (10.098.424,1) + (0,9) (9.798.874)

= 1.009.842,41+ 8.818.986,6

= 9.828.829,01

3. Determining the value of a constant period *t (a*t)

$a_t = 2S_t' - S_t''$

= 2 (10.098.424,1) – 9.828.829,01

= 10.368.019,19

4. Determine the smoothing constant value *(b*t)

$b_t = \frac{\alpha}{(1-\alpha)}(S_t' - S_t'')$

$= \frac{0,1}{0,9}$ (10.098.424,1– 9.828.829,01)

= 29.955,01

5. Determining the forecast value (F_{t+m})

To find the value of F_{t+m} cannot be determined because the values of a_t and b_t have been determined in the previous year. The value of F_{t+m} can be found in the 3rd year.

For the 3rd year (2009)

X_3 = 15.082.696

1. Determine the value Smoothing first S_t'

$S_t' = \alpha X_3 + (1-\alpha)S_{t-1}'$

= 0,1 (15.082.696) + (0,9) (10.098.424,1)

= 1.508.269,6 + 9.088.581,69

= 10.596.851,29

2. Determine value Smoothing secondS_t''

$S_t'' = \alpha S_t' + (1-\alpha)S_{t-1}''$

= 0,1 (10.596.851,29) + (0,9) (9.828.829,01)

= 1.059.685,129+8.845.946,109

= 9.905.631,238

3. Determining the value of a constant period *t (a*t)

$a_t = 2S_t' - S_t''$

= 2 (10.596.851,29) – 9.905.631,238

= 11.288.071,342

4. Determine the smoothing constant value *(b*t)

$$b_t = \frac{\alpha}{(1-\alpha)}(S_t' - S_t'')$$

= $\frac{0,1}{0,9}$ (10.596.851,29– 9.905.631,238)

= 76.802,228

5. Determine the forecast value (F_{t+m}) The 3rd year forecast with m=1

$F_{2008+1} = a_{2008} + b_{2008}(m)$

= 10.368.019,19+ 29.955,01

= 10.397.974,2

The value *of* e_t for 2009 are:

$e_{2009} = X_{2009} - F_{2009}$

= 15.082.696– 10.397.974,2

= 4.684.721,8

Percentage error 2009 are:

$$PE_t = \left(\frac{X_t - F_t}{X_t}\right) 100\%$$

$$= \left(\frac{15.082.696 - 10.397.974{,}2}{15.082.696}\right) 100\%$$

=31 %

To determine the level of error is:

$$\text{MAPE} = \sum_{t=1}^{n} \frac{|PE_t|}{n}$$

$$= \frac{490{,}6\%}{11}$$

= 44,60 %

Where the number of n used is n = 11 because to find the value of F_{t+m} it cannot be determined because the values of a_t and b_t have been determined in the previous year. The value of F_{t+m} can be found in the 3rd year. Using the same calculation, it can be determined value Double Exponential Smoothing and forecast value that will come to α = 0.20 up to α = 0.90.

3.3 Selection of parameters Best *α*.

In this study the selection of parameter *α* best are selected based on the value of Absolute Mean Percentage Error (MAPE), the smallest value predetermined is 0.10, 0.20, 0.30, 0.40, 0.50, 0.60, 0.70, 0.80, and 0.90. Results calculation of Percentage Mean Absolute Error (MAPE), the smallest of the parameters *α*= 0.10 to *α*= 0.90 can be seen in Table 5 as follows:

Table 6. MAPE value for the parameter α = 0.10 to the α = 0.90

The parameter α	*Mean Absolute Percentage Error* (MAPE)
0.10	44.6%
0.20	**25.2%**
0.30	39.0%
0.40	33.4%
0.50	32.3%
0.60	32.1 %
0.70	31.7%
0.80	33.9%
0.90	34.4%

It is known that the value of parameter α the value percentage Mean Absolute Error (MAPE), the smallest is the value of α = 0.20. Table 6 shows value of the parameter α the smallest at α= 0.20 with MAPE value by 25.2%. And to assure value of the parameter α the relative that best writers determines the return value parameter α with 2 digits behind the decimal are 0.21, 0.22, 0.23, 0.24, 0.25, 0.26, 0.27, 0 .28, 0.29.

Table 7. MAPE value for parameter α = 0.21 to the α = 0.29

The parameter α	Mean Absolute Percentage Error (MAPE)
0.21	44.6%
0.22	44.1%
0.23	43.5%
0, 24	**25.1%**
0.25	42.3%
0.26	41.7%
0.27	41.0%
0.28	40.4%
0.29	39.7%

Table 7 shows that value of the parameter α the smallest is α= 0.24 with MAPE value of 25.1%. The best MAPE value that has been obtained by trial and error, then forecasting can then be done using the method Double Exponential Smoothing Brown.

3.4 Horticultural Crop Production Forecasting Total Medicinal After calculating

The value of smoothing first, second smoothing value, the value of a_t 'and the value of b_t by using the value of α = 0.24 then the next can be determined horticultural crop production forecast amount of medicinal in North Sumatra.

So to determine forecasting in the coming year, the formula $F_{t+m} = a_t + b_t(m)$. The values of a_t and b_t taken from 2019. Because the years to be forecast are 2020 and 2021, the number of future forecasts is determined by the number of previous years. The following is the process of completing forecasts for 2020 and 2021.

a. Forecast for 2020 (m=1)

$F_{t+m} = a_t + b_t$ (m)

$F_{2019+1} = a_{2019} + b_{2019}$ (1)

F_{2020} = 9.128.603,21+ (-674.595,97)

F_{2020} = 8.454.007,24

Based on the forecasting results, the number of production of medicinal horticultural plants (bio-pharmaceuticals) that will be forecasted in 2020 is 8,454,007.24 kg.

b. Forecast for 2021 (m=2)

$F_{t+m} = a_t + b_t$ (m)

$F_{2019+2} = a_{2019} + b_{2019}$ (2)

F_{2021} = 9.128.603,21+ (-674.595,97) (2)

F_{2021} = 7.779.411,27

Based on the forecast, the number of drug horticultural crop production (biofarmaka) to be foreseen in 2021 is a total of 7,779,411.27 kg.

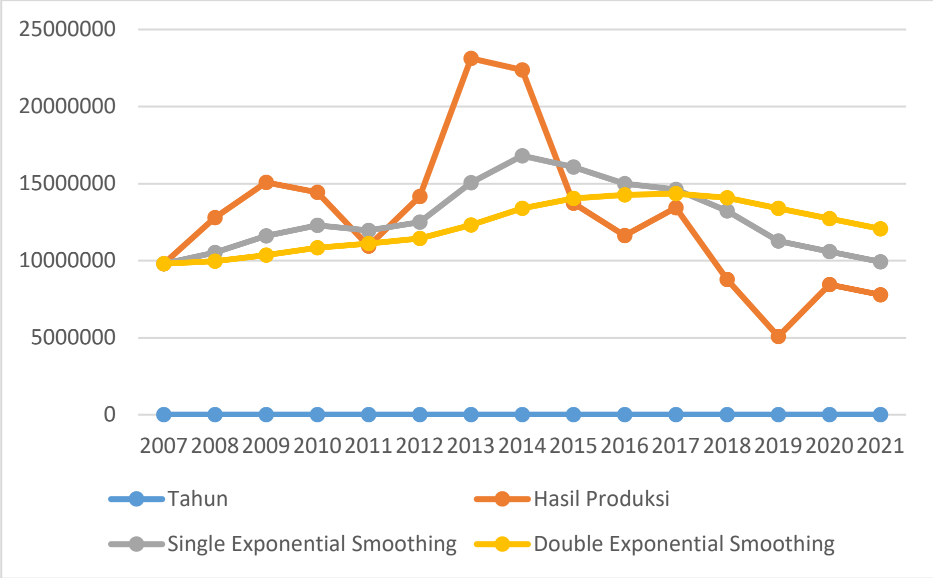

Figure 2: Graph Double Exponential Smoothing Brown with $\alpha = 0.24$ in horticultural crop production data on the number of drug (medicinal) in North Sumatra.

From Figure 2 above, it can be seen that the forecasting of the production of medicinal horticultural plants (biopharmaceuticals) in North Sumatra in 2020 has increased and in 2021 it has decreased.

4. Conclusions and Future Research

4.1. Conclusion

Based on the analysis and discussion that has been done can be that parameter α best obtained for forecasting the amount of horticultural production plants drug (medicinal) in North Sumatra from 2007 until 2019 is $\alpha = 0.24$ with MAPE by 25.1% with the production of medicinal horticultural plants (biopharmaceuticals) in 2020 amounting to 8,454,007.24 kg, and in 2021 it will be 7,779,411.27 kg.

4.2 Future Research

For further research in analyzing forecasting, other variables can be added that support forecasting the amount of production of medicinal horticultural plants (biopharmaceuticals), such as factors that affect production levels so as to maximize the work of this system analysis. Suggestions given for system development in future research is that this research is only in the scope of Sumatra Province. For further research, it is hoped that it will be carried out in various provinces.

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