COMPARATIVE ANALYSIS METHODS *FUZZY TIME SERIES* AND *FUZZY TIME SERIES CHENG* ON CORN PREDICTION

Yenni Rahman[1], M. Reza Faisal[2], Dwi Kartini[3], Andi Farmadi[4], Friska Abadi[5]
[1,2,3,4,5] Study Program of Computer Science FMIPA ULM
Jl. A. Yani Km. 36 Banjarbaru, South Kalimantan
Email: j1f115020@mhs.ulm.ac.id

Abstract

Domestic maize production for several years has not been able to meet the needs on a national scale. Many aspects affect this. This problem can be overcome by increasing production. One of the efforts to increase production is to predict future annual maize production using time series data. The time series data in question is data on corn production taken from the Ministry's Website. In this study, there are two prediction methods used to determine the annual maize yield for the coming year. Fuzzy Time Series and Fuzzy Time Series Cheng methods are the best prediction methods to be used in time series data where there are different stages between the two methods at the time of the formation of FLRG. In addition, researchers also used MAPE to compare the results of the accuracy of predicting corn production against the two methods. The corn production data used during 1970-2019 were 48 data. From the results of the tests carried out, the prediction results using the fuzzy time series method have a higher level of accuracy with the results of the corn accuracy value is 95.12% with a MAPE of 4.88% compared to the Fuzzy Time Series Cheng method with a result of 91,37%. with a MAPE of 8,63%.

Keywords: Time Series, Fuzzy Time Series, Fuzzy Time Series Cheng

1. INTRODUCTION

Corn is a food crop that has economic value and has the opportunity to be developed. However, domestic maize production has not been able to meet national needs. So that efforts are made to increase corn production to deal with various problems of shortage of corn production. One of them is by predicting future production results (Wahyudin et al, 2016).

Prediction is an activity to predict what will happen in the future using past data. One of the prediction methods is the fuzzy time series method. This method has been implemented at the University of Alabama based on existing historical data using simple arithmetic operations (Chen, 1996).

From several previous studies, such as that conducted by Steven et al (2013), conducted research on the Fuzzy Time Series and Holt Double Exponential Smoothing methods and concluded that the accuracy of the Fuzzy Time Series method is better. Then there is research conducted by Tauryawati and Irawan (2014) using the Box-Jenkins ARIMA and Fuzzy Time Series Cheng method and concludes that the Fuzzy Times Series Cheng method is a better method for predicting because it produces better accuracy.

From the two previous studies, it is concluded that Fuzzy Time Series and Fuzzy Time Series Cheng are both the best methods. The difference between the two is that the Fuzzy Time Series has no weight and Fuzzy Time Series Cheng gives weight to the formation of FLRG. Based on this, a study was conducted with the title Comparative Analysis of Fuzzy Time Series and Fuzzy Time Series Cheng Methods on Corn Plant Prediction which aims to

measure how accurate the two methods are in predicting and knowing which method has the better accuracy for predicting corn production.

2. RESEARCH PROCEDURES

The research flow carried out in this study is as shown below:

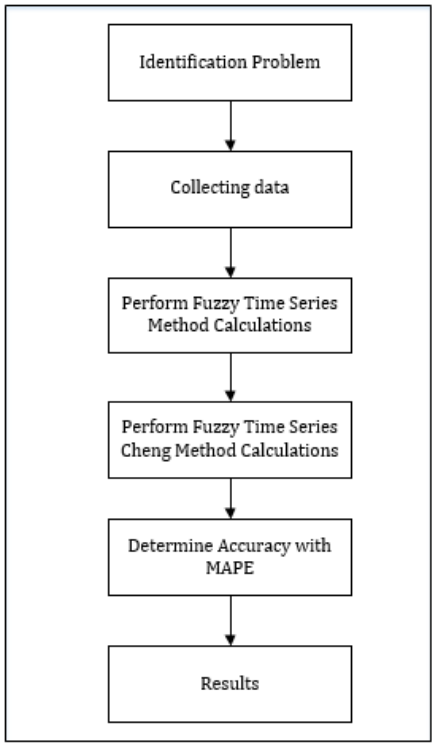

Figure 1 Research flow

2.1 Identification Problem

The initial step in this research is to identify problems by gathering various information related to research needs such. In this study, Fuzzy Time Series and Fuzzy Time Series Cheng is both the best method and of the 2 prediction methods fuzzy time series above there is formation Fuzzy Logical Relationship (FLR) and formation Fuzzy Logical Relationship Group (FLRG) but there are differences, namely: "On Fuzzy Time Series FLRG is formed without weighting while on Fuzzy Time Series Cheng FLRG is formed using weights.

Based on these differences, the analysis or hypothesis made in this study are: Methods Fuzzy Time Series Cheng which has a weighting system at the time of formation Fuzzy Logical Relationship Group (FLRG) is more accurate or produces better accuracy than the method Fuzzy Time Series which is weightless.

2.2 Collection Data

Collecting and analyzing data on food crop production. This data is a daily period of data from 1970 to 2017 which is obtained from the website of the Ministry of Agriculture.

2.3 Perform Fuzzy Time Series Method Calculations.

The following are the stages of forecasting the corn plant data Fuzzy Time Series:

a. Determining the set of the universe. The definition of the universe set is done using equations:
   |Dmin, Dmax | (1)
   where D min and D max are the minimum and maximum historical data values.

b. Determination of the width of the interval using a frequency distribution, by:
   1) Determine the range with the following formula:
   $R = d\max - d\min$ (2)
   2) Determine the number of class intervals using the Sturges Equation:
   $K = 1 + 3{,}322 \times \log n$ (3)
   3) Specifies the width of the interval. The formula is as follows:
   $I = \frac{R}{K}$ (4)
   Where (R) = Range of data; (K) = Number of class intervals
c. Forming fuzzy sets which represent the linguistic value of fuzzy variables.
d. Data fuzzification is done by converting historical data into linguistic values fuzzy.
e. The formation of the nth order Fuzzy Logic Relationship (FLR) is carried out by using fuzzy relations identified from the results of historical data fuzzification. If the time series variable F (t-1) fuzzified as A k and F (t) as A m, so A k is related to Am.
f. Fuzzy Logic Relationship Group (FLRG) was formed up to the nth order. Informing FLRG on fuzzy set, if a fuzzy set is related to more than one other fuzzy sets, then the left part of the relation is grouped into groups the same one.
g. Defuzzification is used to convert the fuzzy output into crips through values calculation. The defuzzification process in fuzzy time series is carried out by applying the following rules. Suppose that the fuzzification value of F (t-1) is Aj, then the forecasting results of F (t) are obtained from the following principles:
   1) If there is *one-to-one* relation in group A_j, for example $A_j \rightarrow A_k$ then the forecast results of $F_{(t)}$ equals the mean of u_k.
   2) If A_j is empty, $A \rightarrow \emptyset$, and the interval where A_j has a membership value u_j, the the forecasting result is equal yo the value of u_j.
   3) If *one-to-many* relationship in group relation A_j, then the forecasting result is calculated as the average value of the mean value $m_1, m_2, ..., mn$ dari $u_1, u_2, ..., u_n$. using the formula:
   $\frac{m_1 + m_2 + \cdots + m_n}{n}$, (5)
   Where: m is the middle value; n the number of middle value data
h. Perform prediction error calculation using MAPE calculation

2.4 Performs Fuzzy Time Series Cheng Method Calculations.

The following are the stages of forecasting the corn plant data Fuzzy Time Series Cheng:

a. The definition of the universe set is done using equations (1).
b. Determination of the width of the interval using equal (2), (3), and (4).
c. Forming fuzzy sets which represent the linguistic value of fuzzy variables.
d. Data fuzzification is done by converting historical data into linguistic values fuzzy.
e. Creating FLR table based on actual data. FLR can be denoted by:$A_i \rightarrow A_j$, where Ai is a called the current state and Aj is called Next State.
f. Fuzzy Logic Relationship Group (FLRG) was formed up to the nth order. Informing FLRG on fuzzy set, if a fuzzy set is related to more than one other fuzzy sets, then the left part of the relation is grouped into groups the same into the weighted matrix.
g. Then the weight obtained in the FLR relation is entered into a matrix form weighting (W) whose equation is written as follows:

$$W = \begin{bmatrix} w_{11} & w_{12} & \cdots & w_{1p} \\ w_{21} & w_{22} & \cdots & w_{2p} \\ \vdots & \vdots & w_{ij} & \vdots \\ w_{p1} & w_{p2} & \cdots & w_{pp} \end{bmatrix} \quad (6)$$

where **W** is the weighting matrix; *wij* is the matrix weight of the the row *i* and the column with *j* dengan *i*= 1, 2, …, *p*; *j*= 1, 2, …, *p*.

h. Then transfer the FLRG weight into a weighting matrixstandardized (W∗) whose equation is written as follows:

$$W* = \begin{bmatrix} w_{11}* & w_{12}* & \cdots & w_{1p}* \\ w_{21}* & w_{22}* & \cdots & w_{2p}* \\ \vdots & \vdots & w_{ij}* & \vdots \\ w_{p1}* & w_{p2}* & \cdots & w_{pp}* \end{bmatrix} \quad (7)$$

where **W**∗ is a standardized weighting matrix with $W_{ij}* = \frac{w_{ij}}{\sum_{j=1}^{p} w_{ij}}$

i. Defuzzification is used to convert the fuzzy output into crips through valuescalculation of the degree of membership that has been grouped in the Fuzzy Logical processGroup Relationship using the formula:

$$Fi = wi1* m1 + wi2* m2 + \cdots + wip* mp \quad (8)$$

where Fi is the forecast result; with $W_{ij}* = \frac{w_{ij}}{\sum_{j=1}^{p} w_{ij}}$

j. Perform prediction error calculation using MAPE calculation

2.5 Determine Accuracy using MAPE

Results AnalysisThe calculation of the error value is done using the MAPE equation. To get the MAPE value, an error calculation is performed using the formula:

$$Eror = \frac{|A_i - F_i|}{A_i} x\ 100\% \quad (9)$$

Meanwhile, the MAPE value is obtained by averaging the error values of all resultspredictions. Testing of forecasting results is done using o Mean o Absolute Percent Error (MAPE) which aims to o know how much error occurred onforecast results with actual data. The MAPE equation is as follows:

$$MAPE = \frac{\sum \frac{|A_i - F_i|}{A_i}}{n} x\ 100\% \quad (10)$$

3. RESULTS AND DISCUSSION

3.1 Results

The data used in this study is data on food crop production. This data is daily data from 1970 to 2017. Data from 1970 to 2008 will be used as training data, data from 2009 to December 31 2017 will be used as testing data. This data will be used as data for the prediction process using the Fuzzy Time Series and Fuzzy Time Series Cheng methods. The data will then be used as the main factor that will be used to make predictions using the Fuzzy Time Series and Fuzzy Time Series Cheng methods. The following is the actual time period data for food crops:

Table 1 Actual Data of Food Crop Production

Jagung	
Tahun	**Ton**
1970	8642
1971	6839
1972	9469
.....	.....
.....	.....
.....	.....
2006	26335
2007	31143
2008	25903

3.1.1 Prediction Results of Corn Testing with Fuzzy Time series method

The following is a description of the calculation of the predicted results of food crop production using the Fuzzy Time Series method.

a. Defining the Universe
Defining the set of universes is done using the equation (1), then the set of universes for the factors is obtained as follows:
U Result = [6,839, 31,143];

b. The result of data interval establishment:
1) The result of the range:
$R = d\max - d\min$
R= 31.143 – 6.839→R= 24.304
2) The result of the interval class:
$k = 1 + 3.3\ log\ n \rightarrow k = 1 + 3.3\ log\ 40$
$= 6{,}335\ \approx 7$
3) The result of interval width:
$I = \frac{24.034}{7} = 3.472$

Table 2 Interval of Maize Food Crop Production

Interval	Lower limit	Upper limit	MID
u1	6839	10311	8575
u2	10311	13783	12047
u3	13783	17255	15519
u4	17255	20727	18991
u5	20727	24199	22463
u6	24199	27671	25935
u7	27671	31143	29407

c. Definition *Fuzzy Set*
Based on the equation, the value is obtained fuzzy set for predictions are as follows:
A 1 = 1 / u 1 + 0.5 / u 2+ 0 / u 3+ 0 / u 4+ 0 / u 5+ 0 / u 6+ 0 / u 7
A 2 = 0.5 / u 1 + 1 / u 2+ 0.5 / u 3+ 0 / u 4+ 0 / u 5+ 0 / u 6+ 0 / u 7
A3 = 0 / u1 + 0.5 / u2+ 1 / u3+ 0.5 / u4+ 0 / u5+ 0 / u6+ 0 / u7
A4 = 0 / u1 + 0 / u2+ 0.5 / u3+ 1 / u4+ 0.5 / u5+ 0 / u6+ 0 / u7
A5 = 0 / u1 + 0 / u2+ 0 / u3+ 0.5 / u4+ 1 / u5+ 0.5 / u6+ 0 / u7
A6 = 0 / u1 + 0 / u2+ 0 / u3+ 0 / u4+ 0.5 / u5+ 1 / u6+ 0.5 / u7
A 7 = 0 / u 1 + 0 / u 2+ 0 / u 3+ 0 / u 4+ 0 / u 5+ 0.5 / u 6+ 1 / u 7

d. Data Fuzzyfication
Fuzzyfication data is done by changing historical data into the form of linguistic values fuzzy.

Table 3 Fuzzyfication Value of Corn Production

Original Data	Interval	*Fuzzyfication*
8642	U 1	A1
6839	U 1	A1
9469	U 1	A1
.....	.....	.....
.....	.....	.....
26335	U 6	A6
31143	U 7	A7
25903	U 6	A6

e. Formation of Fuzzy Logic Relationship (FLR). Based on the results fuzzyfication data on the main factor, the results of the formation are obtained Fuzzy Logic Relationship (FLR), identified from the results of historical data fuzzification. If variable time series F (t-1) fuzzified as Ak and F (t) as Am, then Ak related to Am. This relation is denoted by A k • A m,

Table 4 Fuzzy Logic Relationship

Original Data	*Fuzzyfication*	*FLR*
8642	A1	
6839	A1	A1 -> A1
9469	A1	A1 -> A1
... .	.....	.....
... .	.....	.....
26335	A6	A5 -> A6
31143	A7	A6 -> A7
25903	A6	A7 -> A6

f. *Fuzzy Logic Relationship Group (FLRG) Formation.* In forming FLRG on a fuzzy set, if a fuzzy set is related to more than one other fuzzy set, then the left part of the relation is grouped into the same group.

Table 5 FLRG

Group	*Fuzzy Logic Relations*
1	*A1, A2, A6*
2	*A1, A2, A4, A6*
3	*A5*
4	*A2, A3, A4, A5*
5	*A4, A5, A6*
6	*A4, A6, A7*
7	*A6*

g. Calculating the Prediction Results after forming the FLRG.The following are the results of the prediction for corn plants.

Table 6 Results of Corn Crop Prediction

Year	Ton	Defuzzification	PE
2010	25007	25935.00	0.0371
2011	23918	22463.00	0.0608
2012	19608	18991.00	0.0315
2013	16534	22463,00	0,3585
2014	23421	22463.00	0.0409
2015	17913	18991.00	0.0602
2016	21922	22463.00	0.0247
2017	16752	15519.00	0.0736
MAPE			**0.0488**

From this table, it can be seen that the results of the prediction of 8 data resulted in a high level of predictive accuracy because the MAPE value was 4.88% and the accuracy was 95.12%.

3.1.2 Prediction Results of Corn with Fuzzy Time Series Cheng Method

The following is a description of the calculation of the predicted results of food crop production using the Fuzzy Time Series method.

a. Defining the set of universes is done using the equation (1):
U Result = [6,839, 31,143];

b. Data intervals are formed using a frequency distribution. below is the interval table:

Table 7 Interval of Maize Food Crop Production

Interval	Lower limit	Upper limit	MID
u1	6839	10311	8575
u2	10311	13783	12047
u3	13783	17255	15519
u4	17255	20727	18991
u5	20727	24199	22463
u6	24199	27671	25935
u7	27671	31143	29407

c. Definition *Fuzzy Sets.*

Based on the number of intervals formed by using the equation to determine the number of class intervals, 7 classes are obtained. In this way, 7 linguistic values for the fuzzy set. Based on the fuzzy defining equation, the fuzzy set values are obtained as follows:

A 1 = 1 / u 1 + 0.5 / u 2+ 0 / u 3+ 0 / u 4+ 0 / u 5+ 0 / u 6+ 0 / u 7
A 2 = 0.5 / u 1 + 1 / u 2+ 0.5 / u 3+ 0 / u 4+ 0 / u 5+ 0 / u 6+ 0 / u 7
A3 = 0 / u1 + 0.5 / u2+ 1 / u3+ 0.5 / u4+ 0 / u5+ 0 / u6+ 0 / u7
A4 = 0 / u1 + 0 / u2+ 0.5 / u3+ 1 / u4+ 0.5 / u5+ 0 / u6+ 0 / u7
A5 = 0 / u1 + 0 / u2+ 0 / u3+ 0.5 / u4+ 1 / u5+ 0.5 / u6+ 0 / u7
A6 = 0 / u1 + 0 / u2+ 0 / u3+ 0 / u4+ 0.5 / u5+ 1 / u6+ 0.5 / u7
A 7 = 0 / u 1 + 0 / u 2+ 0 / u 3+ 0 / u 4+ 0 / u 5+ 0.5 / u 6+ 1 / u 7

d. Data Fuzzyfication

Fuzzyfication data is done by changing historical data into the form of values fuzzy.

Table 8 Fuzzification value

Original Data	Interval	*Fuzzyfication*
8642	U 1	A1
6839	U 1	A1
9469	U 1	A1
. . . .	. . . .	. . . .
. . . .	. . . .	. . . .
26335	U 6	A6
31143	U 7	A7
25903	U 6	A6

e. Based on the results fuzzyfication data on the main factor, then the results are obtained Fuzzy Logic Relationship (FLR) as follows:

Table 9 FLR

Original Data	*Fuzzyfication*	*FLR*
8642	A1	
6839	A1	A1 -> A1
9469	A1	A1 -> A1
. . . .	. . . .	. . . . .
. . . .	. . . .	. . . . .
26335	A6	A5 -> A6
31143	A7	A6 -> A7
25903	A6	A7 -> A6

f. In forming FLRG on a fuzzy set, if a fuzzy set is related to more than one other fuzzy set, then is grouped into the same group.

Table 10 Formation of Fuzzy Logic Relationship Group

FLRG	Current_State	Next_State
G1	A1	A1, A2, A6
G2	A2	A1, A2, A4, A6
G3	A3	A5
G4	A4	A2, A3, A4, A5
G5	A5	A4, A5, A6
G6	A6	A4, A6, A7
G7	A7	A6

Table 11 Determination of Fuzzy Logic Relationship Group

FLR1	LH	RH	FLRG
A1 -> A1	A1	A1	G1
A1 -> A1	A1	A1	G1
A1 -> A1	A1	A1	G1
....	....	....	....
A1 -> A6	A1	A6	G1
A6 -> A4	A6	A4	G6
A4 -> A2	A4	A2	G4
A2 -> A1	A2	A1	G2
A1 -> A2	A1	A2	G1

g. FLR who have current state which are combined into one group into a weighting matrix. Then the weight obtained in the FLR relation is entered into a weighting matrix form. FLR who have current state which are combined into one group into a weighting matrix. Then the weight obtained in the FLR relation is entered into a weighting matrix form. The following is the FLRG weighting table:

Table 12 Weighting of the FLRG

Weighting	A1	A2	A3	A4	A5	A6	A7
A1	7	1				1	
A2	1	7		1		1	
A3					1		
A4		2	1	4	2		
A5				1	1	2	
A6				3		1	**2**
A7							**1**

h. Then it is entered into a matrix which will then be normalized, how to change the weighting of the FLRG is for example the number of A1 formed is 9 then those that are paired with A1 (A1 → A1) are 7 then calculate the normalization is $\frac{7}{9}$ =0,777778 , A1→A2 is 1 then $\frac{1}{9}$ = 0,11111and A1→A6 is 1 then $\frac{1}{9}$ = 0,11111.Likewise for the next normalization process. The following is the overall result of weighting normalization:

Table 13 Standard-Weighted Matrixarisasi

Normalization	A1	A2	A3	A4	A5	A6	A7
A1	0,777778	0,111111				0,111111	
A2	0,1	0,7		0,1		0,1	
A3					1		
A4		0,25	0,125	0,5	0,25		
A5				0,25	0,25	0,5	
A6				0,5		0,166667	0,333333

i. After the weighting process then calculates the forecast value using Equation (8), namely by multiplying the normalized weight matrix (W (t)) to (Wn (t)) with a defuzzyfication matrix using:

$Fi = wi1 * m1 + wi2 * m2 + \cdots + wip * mp$
= ((0,777778*8575) +(0,111111*12047) +(0,111111*25935))
= 10889,67

where Fi is the forecast result.

Table 14 Results of Cheng Corn Plant Prediction

Year	Ton	Defuzzification	PE
2010	25007	25935.00	0.0371
2011	23918	22463.00	0.0608
2012	19608	18991.00	0.0315
2013	16534	22463,00	0,3585
2014	23421	22463.00	0.0409
2015	17913	18991.00	0.0602
2016	21922	22463.00	0.0247
2017	16752	15519.00	0.0736
MAPE			**0.0863**

From this table it can be seen that the results of the prediction of 8 data resulted in a high level of predictive accuracy because the MAPE value was 8.63% and the accuracy was 91.37%.

3.1.3 Comparison of Measures of Forecasting Accuracy

From the prediction results using the fuzzy time series method and the fuzzy time series Cheng will compare the error size value by calculating the value Mean Absolute Percentage Error.

Table 15 Matrix of Forecast Comparison Accuracy Fuzzy Time Series and FTS Cheng

Plant	MAPE		Accuracy	
	FTS	FTS Cheng	FTS	FTS Cheng
Corn	4.88%	8.63%	95.12%	91.37%

3.2 Discussion

Based on the research that has been done to prove that the Fuzzy Time Series Cheng which has a weighting system when forming a group of fuzzy relations can produce better accuracy than the Fuzzy Time Series, it cannot be proven based on the results of the tests that have been done. carried out in both methods using the same data because in this case the method. This is due to differences in the weighting of FLRG, where the FLRG Fuzzy Time Series method is formed based on the emerging FLR so that defuzzification is calculated based on this, while the Fuzzy Time Series Cheng method when FLRG is formed then weighting is carried out after that normalization is carried out.

Then at the time of defuzzification or calculation of predictive value, in the Fuzzy Time Series method, the defuzzification value is calculated based on the average value of the mean value added divided by the total middle value data. Whereas in the Fuzzy Time Series Cheng method the defuzzification results are calculated based on the mean value multiplied by the normalized weight of the FLRG. Based on this table, the magnitude of the forecast error shows that the forecasting on the test case data that has been done has the result that the Fuzzy Time Series method is more accurate than the Fuzzy Time Series Cheng.

4. Conclusion

From the research Method Fuzzy Time Series has a better level of accuracy than the method Fuzzy Time Series Cheng, where the accuracy value of maize was 95.12% with a MAPE of 4,88% while the MAPE of corn produced by FTS Cheng was 91.37% with a MAPE of 8,63%This is influenced by the difference factor in the formation of the FLRG. The Analyze that Fuzzy Time Series Cheng which has a weighting at shaping FLRG will be better than Fuzzy Time Series It turned out that the results were not suitable based on the tests carried out on the two methods due to differences in the weighting of the FLRG and differences in calculations at the time of defuzzification. This research can be developed that if further research is carried out using the same or different methods, more varied data can be used and use different interval determination.

REFERENCES

[1] Asih, K., Fatma Agus Setyaningsih dan Dwi Marisa Midyanti. 2017. *Aplikasi Prediksi Produksi Padi menggunakan Regresi Interval Dengan Neural Fuzzy di Kabupaten Kubu Raya*. Jurnal Coding. Vol. 5(2), hal.108-118.

[2] Djafar, Muh. Ihsan Sarita dan Yuwanda Purnamasari Pasrun. 2017*. Peramalan Jumlah Produksi Padi di Sulawesi Tenggara menggunakan Metode Fuzzy Time Series*. SEMANTIK. Vol.3, No.2, hal.113-120.

[3] Elfajar, A. B., Budi Darma Setiawan dan Candra Dewi. 2017. *Peramalan Jumlah Kunjungan Wisatawan Kota Batu menggunakan Metode Time Invariant Fuzzy Time Series*. Jurnal Pengembangan Teknologi Informasi dan Ilmu Komputer. Vol.1, No.2, hal. 85-94. Universitas Brawijaya.

[4] Gumelar, F.A, Rekyan Regasari Mardi Putri dan Indriati. 2018. *Implementasi Fuzzy Time Series pada Prediksi Harga Daging di Pasar Kabupaten Malang*. Jurnal Pengembangan Teknologi Informasi dan Ilmu Komputer. Vol.8, No.2, hal. 2724-2733. Universitas Brawijaya

[5] Nasmiati, C., Rahmanta Ginting dan Abdul Rahman. 2014. *Analisis Produksi dan Ketersediaan serta Kebutuhan Kedelai dalam Kaitannya dengan Ketahanan Pangan di Provinsi Sumatera Utara.* Agrica (Jurnal Agribisnis Sumatera Utara). Vol. 7, No. 1.

[6] Nugroho, K. 2016. *Model Analisi Prediksi menggunakan Metode Fuzzy Time Series*. Semarang: Amik JTC.

[7] Nurmawati, Widya Putri dan Retno Subekti. 2018. *Peramalan Jumlah Produksi Tanaman Jagung di Kabupaten Grobogan Dengan Model Arima Box-Jenkins menggunakan Program R*. KNPMP III. Universitas Negeri Yogyakarta

[8] Siregar, Gustina. & Saleh Nugraha. 2017. *Perkembangan Produksi dan Konsumsi Jagung di Provinsi Sumatera Utara*.e-ISSN: 2614-6037. *Journal Of Agribussiness Sciences*. Vol. 1, No. 1. Universitas Islam Sumatera Utara.

[9] Steven , S. Nurdiati dan F. Bukhari. 2013. *Perbandingan Metode Fuzzy Time Series Dan Holt Double Exponential Smoothing Pada Peramalan Jumlah Mahasiswa Baru Institut Pertanian Bogor*. Journal of Mathematics and Its ApplicationsVol. 12, No. 2. Institut Pertanian Bogor.

[10] Sumartini, Memi Nor Hayati dan Sri Wahyuningsih. 2017. *Peramalan menggunakan Metode Fuzzy Time Series Cheng.* Jurnal Eksponensial. Vol. 8, No. 1. Universitas Mulawarman.

[11] Taurywati, Mey Lista dan M. Isa Irawan. 2014. *Perbandingan Metode Fuzzy Time Series Cheng dan Metode Box-Jenkins untuk Memprediksi IHSG.* Jurnal Sains Dan Seni Pomits. Vol. 3, No. 2. Institut Teknologi Sepuluh Nopember.

[12] Wahyudin, A., Ruminta dan S. A. Nursaripah. 2016. *Pertumbuhan dan hasil tanaman jagung (Zea mays L.) toleran herbisida akibat pemberian berbagai dosis herbisida kalium glifosat.* Jurnal Kultivasi. Vol. 15, No. 2. Universitas Padjajaran.