Nutritional Control of Bell Peppers Growth with a Hydroponic System Using the Singh's Fuzzy Time Series Method

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Abstract. Research into Hydroponic technology is currently very interesting, especially with the increasingly narrow land area that can be utilized in agriculture. Hydroponic technology helps in the development of cultivated plants with limited land, even with limited sunlight. In this study, the authors conducted research on controlling the growth of bell pepper plants with Hydroponic technology. In controlling the growth of bell pepper plants, the author keeps records in monitoring and following up as needed so that the bell pepper plants can grow normally. In this research, the author used 5 units of bell pepper plants in a laboratory scale. The data recorded is the collection of water Ph data, nutrient levels based on PPM (Parts Per Millions). Data was taken for 29 days after 60 days of plant seedling period. After the supervision data is obtained, then analysis was carried out using the Fuzzy Time Series Singh Method, which was used to determine the pattern and forecasting of nutrition for bell pepper plants from time to time. The accuracy of forecasting in the provision of nutrients in this study the author sees from the resulting RMSE results of 22.573, and for MAPE 5.183%, with this data it can be concluded that the forecasting method is in a good category.

Keywords: bell peppe hydroponic · fuzzy time series · singh method

1 Introduction

The development of traditional agriculture is decreasing [1, 2], due to the narrowing of agricultural land. Some of the technologies used to overcome this problem are hydroponics [3] and aeroponics [4]. The application of this technology relatively does not require a large area of land, because it uses water media. The author's current research uses hydroponic technology. The data collection that the author did was by directly observing and recording the growth of bell peppers. The author records all activities in this hydroponic farming, the data recorded is the amount of nutrients that have been mixed with water for the nutritional needs of bell pepper plants from day to day for 29 days after 60 days of seedling period. The author uses AB mix fertilizer, for the nutrient content in the fertilizer consists of: nitrate, Fe, potassium nitrate, KH2PO4, (NH4)2PO4, KNO3, MgSO4, MnSO4, CuSO4, ZnSO4, borax acid, N, and Mo [5].

M. Fadilah et al. (Eds.): IcoBioSE 2021, ABSR 32, pp. 405–415, 2023.
https://doi.org/10.2991/978-94-6463-166-1_51

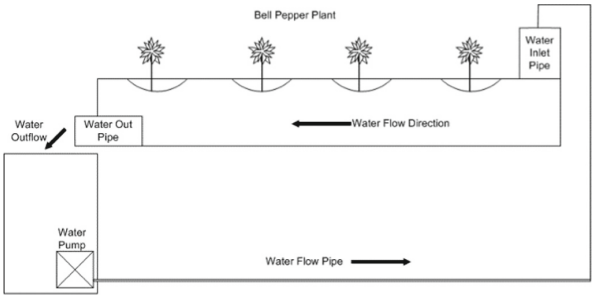

Fig. 1. Hydroponic scheme of bell pepper plants.

The author is interested in conducting research on bell peppers because the plant has a high economic value and is needed by consumers to full fill raw materials for cooking [6]. Nutrient measurements that the author uses in this study use 10 L of water that has 1200ppm nutrients, with 10 L of water containing these nutrients, the author records the provision of adequate nutrition every day. Measurement data every day for 29 days can be seen in Table 1. The hydroponic scheme of bell pepper plants in this study can be seen in Fig. 1.

The author conducted research on 5 bell pepper plants with a hydroponic system with Nutrient Film Technique (NFT) water flow, in the NFT system the plant roots will get nutrients from the continuous flow of water because there is a pump that allows water to circulate continuously [7].

2 Materials

2.1 Time Series Data

Time Series data can also be called time series data is a set of data obtained from direct or indirect observations, in this study, the authors used data directly from the object of research[8].Time series data is taken continuously based on a predetermined time. Forecasting can be done on the basis of existing data, or historical data collected from time to time continuously. Forecasting data based on historical data is one method that is quite effective and is often used by policy makers to make decisions in the future [9].

2.2 Singh's Fuzzy Time Series Method

Fuzzy time series, is a method used to perform forecasting based on historical data formed from linguistic values. The steps in calculating Singh's Fuzzy Time Series can be seen in the form of a flowchart in Fig. 3.

2.3 Measuring Forecasting Accuracy

In calculating accuracy for forecasting, the MAPE (Mean Absolute Percentage Error) formula is used, which is a comparison between forecasting data and actual data [10].

$$\text{MAPE} = \frac{\sum |\boldsymbol{A} - \boldsymbol{F}|}{\sum \boldsymbol{n}} \boldsymbol{x} 100\% \quad (1)$$

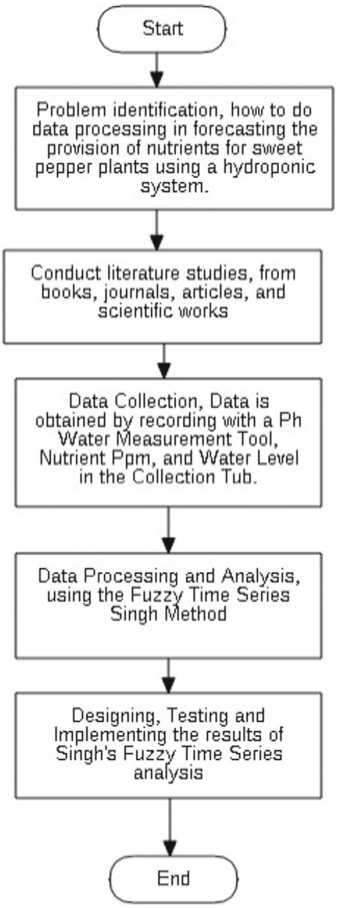

Fig. 2. Research method.

A = Actual data
F = Prediction Result
$\sum$n = A lot of data

Apart from using MAPE the author also uses RMSE (Root Mean Square Error) which is the sum of the predicted value minus the actual value [10].

$$\text{RMSE} = \sqrt{\sum \frac{(F-A)^2}{n}} \tag{2}$$

A = Actual data
F = Prediction Result
n = A lot of data

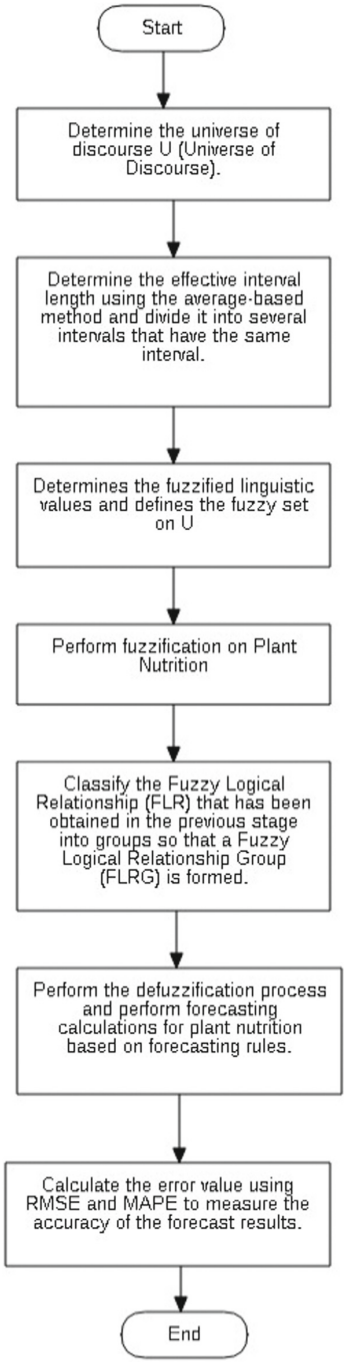

Fig. 3. Flowchart of Singh's Fuzzy Time Series Steps

3 Methods

The nutrient delivery process that the author recorded was obtained from the dissolved nutrient sensor, the water level in the reservoir, and the ph of the water. In agriculture with hydroponic systems, the recommended ph of nutrient solution in the system ranges from 5.5–6.5 [3], and for dissolved nutrients in water 1050–1700 [3]. The author makes direct observations and records data, then processed using fuzzy time series analysis. The method the author uses is described using a flow diagram, as shown in Fig. 2.

4 Results and Discussion

From the data that has been obtained, predictions can be made on the nutritional needs for plants over time. Based on the flowchart diagram as shown in Fig. 2, and the nutrient information data as shown in Table 1, the following data processing results from the process.

4.1 Determining the Talking Universe, where in this study the authors took 29 data in the addition of Nutrient Ppm,

$$U = [X_{min} - D1,\ X_{max} + D2] \tag{3}$$

X_{min} = Minimum Data
X_{max} = Maximum Data

D1, and D2 are positive integers determined by the author.D1=0 D2=10, So that we get U=[200-0 , 700+10], U=[200, 710].

4.2 Determining the length of the interval, where in this study the authors used the formula

$$n = 1 + 3.332 * \log_{10}(\text{A lot of data}) \tag{4}$$

The final result of the calculation after rounding is 6.

4.3 Determining the linguistic value that is fuzzified, so that the resulting data division can be seen in Table 2:
4.4 Perform Fuzzification on the Nutrition Administration data as shown in Table 3.
4.5 Perform FLR (Fuzzy Logical Relationship) classification, so that the data in Table 4 is obtained.
4.6 Perform Defuzzification and Forecasting process as shown in Table 5
4.7 Calculating the error value, with MAPE (Mean Absolute Percentage Error) = 5.183%, and RMSE (Root Mean Square Error) = 22.573, for the appearance of the comparison of actual data and forecasting data for nutrition can be seen in Fig. 4.

Table 1. Addition of Nutritious Water

No	High Water cm	PPM	ph	Addition of Nutritious Water
1	17,5	1200	5,7	500
2	19,5	1206	5,7	500
3	19,7	1416	5,7	250
4	19,6	1404	5,7	500
5	19,5	1303	5,7	700
6	19,7	1710	5,6	250
7	19,5	1606	5,7	500
8	19,8	1619	5,7	200
9	19,5	1706	5,7	500
10	19,5	1710	5,8	600
11	19,8	1618	5,9	250
12	19,5	1618	5,9	500
13	20	1514	6	250
14	19,75	1514	6,1	300
15	19,6	1514	6,1	300
16	19	1512	6,2	600
17	20,5	949	6,4	500
18	20	1410	6,5	500
19	19,5	1410	6,5	600
20	19,6	1499	6,5	500
21	19,6	1397	6,6	600
22	20	1418	6,6	300
23	19	1379	6,6	700
24	20	1402	6,7	300
25	19	1313	6,5	700
26	20	1303	6,7	300
27	18,5	1311	6,5	400
28	19,6	1405	6,6	500
29	19,1	1316	6,4	700

Table 2. Linguistic Value of Nutrition Feeding Data

No	Group	Smallest Value	Greatest Value	Center Value	Frequency
1	A1	200	285	242.5	5
2	A2	285	370	327.5	5
3	A3	370	455	412.5	1
4	A4	455	540	497.5	10
5	A5	540	625	582.5	4
6	A6	625	710	667.5	4

Table 3. Fuzzification of Nutrition Feeding Data

No	Actual Value	Fuzzification
1	500	A4
2	500	A4
3	250	A1
4	500	A4
5	700	A6
6	250	A1
7	500	A4
8	200	A1
9	500	A4
10	600	A5
11	250	A1
12	500	A4
13	250	A1
14	300	A2
15	300	A2
16	600	A5
17	500	A4
18	500	A4
19	600	A5
20	500	A4
21	600	A5

(*continued*)

Table 3. (*continued*)

No	Actual Value	Fuzzification
22	300	A2
23	700	A6
24	300	A2
25	700	A6
26	300	A2
27	400	A3
28	500	A4
29	700	A6

Table 4. FLR (Fuzzy Logical Relationship)

FLR (Fuzzy Logical Relationship)
A1- > A2,A4
A2- > A2,A3,A5,A6
A3- > A4
A4- > A1,A4,A5,A6
A5- > A1,A2,A4
A6- > A1,A2

Table 5. Defuzzification and Forecasting Process

No	Actual Value	Group Relationship	Forecasting Value
1	500	A4-x-NA	NA
2	500	A4 < --A4	NA
3	250	A1 < --A4	NA
4	500	A4 < --A1	498.7500
5	700	A6 < --A4	667.5000
6	250	A1 < --A6	242.5000
7	500	A4 < --A1	498.7500
8	200	A1 < --A4	242.5000
9	500	A4 < --A1	497.5000

(*continued*)

Table 5. (*continued*)

No	Actual Value	Group Relationship	Forecasting Value
10	600	A5 < --A4	582.5000
11	250	A1 < --A5	221.2500
12	500	A4 < --A1	498.7500
13	250	A1 < --A4	221.2500
14	300	A2 < --A1	327.5000
15	300	A2 < --A2	336.9444
16	600	A5 < --A2	582.5000
17	500	A4 < --A5	511.2500
18	500	A4 < --A4	499.1667
19	600	A5 < --A4	577.5000
20	500	A4 < --A5	498.7500
21	600	A5 < --A4	582.5000
22	300	A2 < --A5	327.5000
23	700	A6 < --A2	683.7500
24	300	A2 < --A6	327.5000
25	700	A6 < --A2	667.5000
26	300	A2 < --A6	327.5000
27	400	A3 < --A2	412.5000
28	500	A4 < --A3	486.2500
29	700	A6 < --A4	667.5000

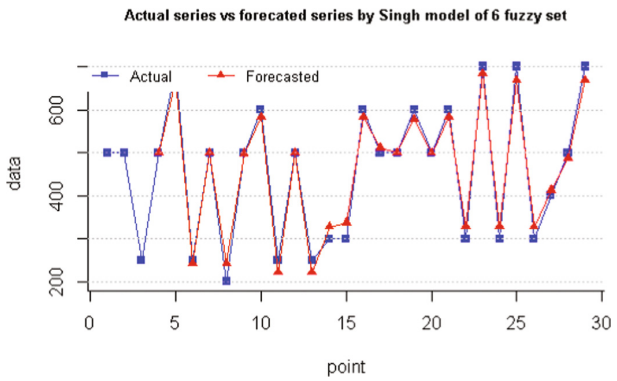

Fig. 4. Comparison of Actual Value and Singh's Fuzzy Timeseries Forecasting.

5 Conclusion

By looking at the results of the calculation of Mean Percentage Absolute Error MAPE = 5.183%, indicating that Fuzzy Time Series Sing can be used as an alternative method in forecasting the provision of nutrients to bell pepper plants by following the passage of time, with these results it can also be seen that forecasting is included in a very good category.

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