FORECASTING ANALYSIS OF ORGANIC RED RICE'S DEMAND USING ARTIFICIAL NEURAL NETWORKS

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Abstract: Consumer demand for organic red rice in Banyuwangi is always fluctuating each period. This study aims to design an Artificial Neural Network (ANN) Architecture and forecast the demand of Red Rice Production at PT. Sirtanio Organik Indonesia located at Singojuruh, Banyuwangi. Demand forecasting is the level of demand product that is expected to be realized for a certain period in the future. The data used as input for this study are product prices, stocks, sales and demand in 2015-2017. This research used six architectures and Algorithm that used is Artificial Neural Network Backpropagation. The research result showed that highest demand for organic red rice is in August of 2018 and the lowest in April of 2018. The conclusion of this research showed that the best architecture is 3-20-1 with MSE value of 0.002 and R squared of 0.859 and this model is well used to predict organic red rice demand in Banyuwangi.

Keywords: Artificial Neural Network, backpropagation, Banyuwangi, MSE, organic red rice

Abstrak: Permintaan konsumen terhadap beras merah organik di Banyuwangi selalu berfluktuasi setiap periode. Penelitian ini bertujuan untuk merancang Arsitektur Jaringan Syaraf Tiruan (JST) dan meramalkan permintaan Produksi Beras Merah di PT. Sirtanio Organik Indonesia yang berlokasi di Kecamatan Singojuruh, Kabupaten Banyuwangi. Peramalan permintaan adalah tingkat permintaan produk yang diharapkan untuk dapat direalisasikan pada jangka waktu tertentu di masa depan. Data yang digunakan sebagai input untuk penelitian ini adalah data harga, stok, penjualan dan permintaan beras merah organik pada periode tahun 2015-2017. Penelitian ini menggunakan enam arsitektur dan Algoritma yang digunakan adalah Artificial Neural Network Backpropagation. Hasil peramalan menunjukkan bahwa permintaan tertinggi untuk beras merah organik adalah pada bulan Agustus dan terendah pada bulan April 2018. Kesimpulan dari penelitian ini adalah arsitektur jaringan terbaik yaitu 3-20-1 dengan nilai MSE=0,002, R squared=0,859, dan model jaringan syaraf tiruan yang dibentuk memiliki performa yang baik dalam memprediksi permintaan beras merah organik di Banyuwangi.

Kata kunci: Jaringan Syaraf Tiruan, propagasi balik, Banyuawangi, MSE, beras merah organik

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INTRODUCTION

Banyuwangi is a rice producer in East Java with an average production of 306.073 tons and consumption of rice reaches 175.295 tons in 2018 (BPS, 2018). In general, farming in Banyuwangi still implements conventional rice farming systems, but in recent years begin to shift to organic rice farming systems to create environmentally friendly agriculture.

Organic rice is rice that is cultivated organically or without the application of chemical fertilizers and chemical pesticides, the rice is free from chemical fertilizer and pesticide residues (Mulyana et al. 2014). Organic rice is very good for health because it is free of harmful chemicals compared to conventional rice. A healthy lifestyle or back to nature has become a new trend of society because people are increasingly aware that the use of chemicals, synthetic pesticides and growth hormones in agricultural production can have a negative effect on human health (Sulistyana et al, 2014). Not the trend of a healthy lifestyle, but the price, nutritional content and product information in packaging is important to note (Idaman et al. 2012)

PT. Sirtanio Organik Indonesia is a company engaged in organic agriculture, located at Jl. KH. Mahfud, Singojuruh - Banyuwangi which produces organic rice. Organic products that are produced by PT Sirtanio Organik Indonesia are red rice, black rice and white rice. Organic rice production in this company from 2015-2017 experienced a significant increase. Red rice is the highest production at PT. Sirtanio Organik Indonesia with an average production of 485 tons, black rice of 79.5 tons and white rice of 24.05 tons. Organic rice productivity is seen in Table 1.

Table 1 Organic rice production in 2015-2017 (ton).

Year	Red Rice	Black Rice	White Rice
2015	138	21.5	77
2016	156	20	73.5
2017	191	38	89
Average	485	79.5	24.05

Although Organic red rice productivity for the last three years is the highest production at PT. Sirtanio Organik Indonesia but Consumer demand always fluctuate each month as shown in Figure 1. The level of fluctuations will affect the pattern of production planning so that it disrupts the process of the company's activities.

Developed agricultural management need simple and accurate estimation techniques to predict rice production factors in the planning process (Dahikar et al. 2015). Companies need to manage production factors so that market demand for red rice production remains fulfilled. Therefore, demand forecasting is needed which is useful for knowing the level of future demand.

The use of artificial neural network (ANN) in forecasting has been widely carried out. Cassava production forecasting is carried out by Purba and Sitompul (2018). While (Revi et al. 2018) use ANN to predict rice production by province, while (Adi et al. 2018) predict rice production according to districts/cities in North Sumatra. In addition, ANN is also used (Fardhani et al. 2018) to predict the retail price of rice in traditional markets in 33 cities in Indonesia. Whereas (Hartato et al. 2018) use ANN to predict the biopharmaceutical harvest area in Indonesia.

Research related to forecasting demands using ANN has also been carried out. Nurmayasari et al. (2018) Used ANN to forecast of demand for the BREM product market at home industry. Febrina et al. (2013) used ANN to forecast the number of requests for the production of v-belts and conveyor belts located in Tangerang. Mufaidah et al. (2017) predicted the number of frozen shrimp demand, while (Marjiyono et al, 2018) predicted demand in retail companies. Whereas (Aprilianto et al. 2018) predicted Sales in Supporting the Development of Chocolate Agroindustry in Blitar District. Although the use of ANN has been widely carried out, the use of ANN in predicting demand for organic red rice has never been used. The differences between the earlier research and this research are the commodity which is used organic red rice, the research location is in Banyuwangi, and the research variables are product prices, stocks, sales, and organic rice demand.

This research used ANN with a backpropagation algorithm. Backpropagation ANN method is an ANN method with a controlled learning algorithm and is used to minimize errors in the output produced by multilayer. This study aims to design an Artificial Neural Network (ANN) Architecture and forecast the demand of Red Rice Production at PT. Sirtanio Organik Indonesia which time series data used as input is product prices, stocks, sales and the demand in 2015–2017.
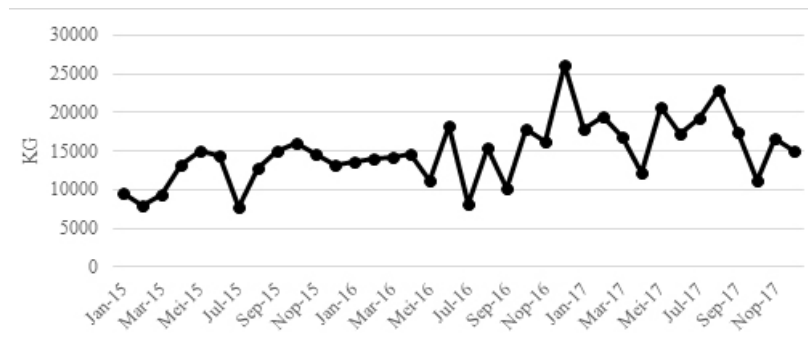
Figure 1. Demand for organic red rice 2015-2017

METHODS

This research was conducted at PT. Sirtanio Organik Indonesia located at Jl. KH. Mahfud, Singojuruh - Banyuwangi. This company is engaged in organic agriculture such as: organic white rice, organic red rice, organic black rice, and organic fertilizer. The research was conducted on June 2018 - November 2018. The data used in this study are secondary data from 2015 to 2017 which collected from PT. Sirtanio Organik Indonesia, with the types of data as follows: Price of organic red rice (Rp/Kg), Production stock of organic red rice (kg), Sales of organic red rice (Kg), and demand of organic red rice demand (Kg). All data used in this study are monthly data.

Data Normalization

Data normalization aims to prevent the network from failing when doing learning (training and testing). The data is normalized in intervals [0.1] because it is related to the binary sigmoid activation function.

$$X' = \frac{0,8 \times (x-a)}{(b-a)} + 0,1$$

Description: X' (real data); a (minimum data); b (maximum data).

Formation of ANN Architecture

This study uses a 1 input layer consisting of 3 neurons namely product prices (X1), stocks (X2), and sales (X3). All neurons in this layer can be connected to neurons in hidden layers. There are 2 layers of hidden layer and 1 layer of output with 1 neuron namely demand (Y). this architecture was created to form patterns of relationships between neurons

3. ANN Training

Data training is a network model of calibration. Data training is to get the best network by determining the number of neurons. the data used in the training are data from 2015-2016. The training parameters are arranged so that the optimal results of the neural network architecture consist of the following stages:

Determine Maximum Learning Parameters

a. Maximum Epoch

Maximum epoch is the maximum amount of epoch allowed during the training process. The iteration will be stopped if the epoch value exceeds the maximum value of the epoch. The maximum epoch in this research is 2000 goals.

b. Learning rate

Learning rate is the rate of learning to accelerate the iteration rate (epoch). The greater the learning rate, the faster the training process will be. However, if the learning rate is too large, the algorithm becomes unstable. Conversely, if the learning rate is too small, the algorithm will converge for a very long time. Learning rate in this study is 0.01.

c. Momentum constant

This function not only responds to local gradients but also considers the trends that have just occurred on the error surface. The magnitude of the change in weight is influenced by a constant known as the momentum number which is valued between 0 to 1. The momentum of the constant in this study is 0.5.

Determine the Activation Function

Binary Sigmoid function (logsig & tansig) is used in the process of weighing the input neurons into hiding with a range of 0 to 1, while in the output layer the activation function used is a linear (identity) function.

MSE (Mean Square Error)

Mean Squared Error (MSE) is a method for measuring the accuracy of a forecasting model. The MSE value represents the average absolute error between the forecast results and the actual values. the equation used is:

$$MSE = \sum \frac{(t - Yk)^2}{N}$$

Description: t (target output value); yk (network output value); N (number of data).

ANN Testing

The data used in the testing is data in 2017. In testing or validation of the model is using the R-squared (R2). R-squared is used to measure how far the ability of the model in explaining the variation of the dependent variable. The coefficient of determination is between 0 (zero) and 1 (one). A small R2 value means the ability of independent variables to explain the variation of the dependent variable is limited. the value close to one means that independent variables can be said to be stronger the model in explaining the influence of the independent variable (Ghazali, 2016).

This research begins with collecting price data, production stock, sales and demand data. The data is then normalized. after the ANN architecture is formed, data is trained and tested. Then forecasting can be done. this is shown in Figure 2.

RESULTS

The data obtained from observations are data on prices, stocks, sales results and demand of organic red rice in the period of January 2015 to December 2017 as in Table 2. Data on organic red rice prices from 2015 to 2017 tend to increase.

In 2015 prices rise from January to November, but prices fell down in December. In 2016, the price increased in July, while in other months it tended to be stable. Whereas in 2017 prices tend to be less stable (fluctuate). From the data, we can see that the price of rice is fluctuate. The price of agricultural production is always changing (unstable) when compared to prices of non-agricultural materials. This is due to the supply and demand curve for agricultural products is inelastic and there are changes that are difficult to predict on agricultural supplies due to agricultural production which is highly dependent on natural conditions (weather climate), pest diseases, and other factors (Anindita, 2004). Price movements reflect conditions developments in demand and supply, strength from the supply and demand side it has influence on changes and price fluctuations in world markets both exporters and importers markets (Khumaira et al. 2016).
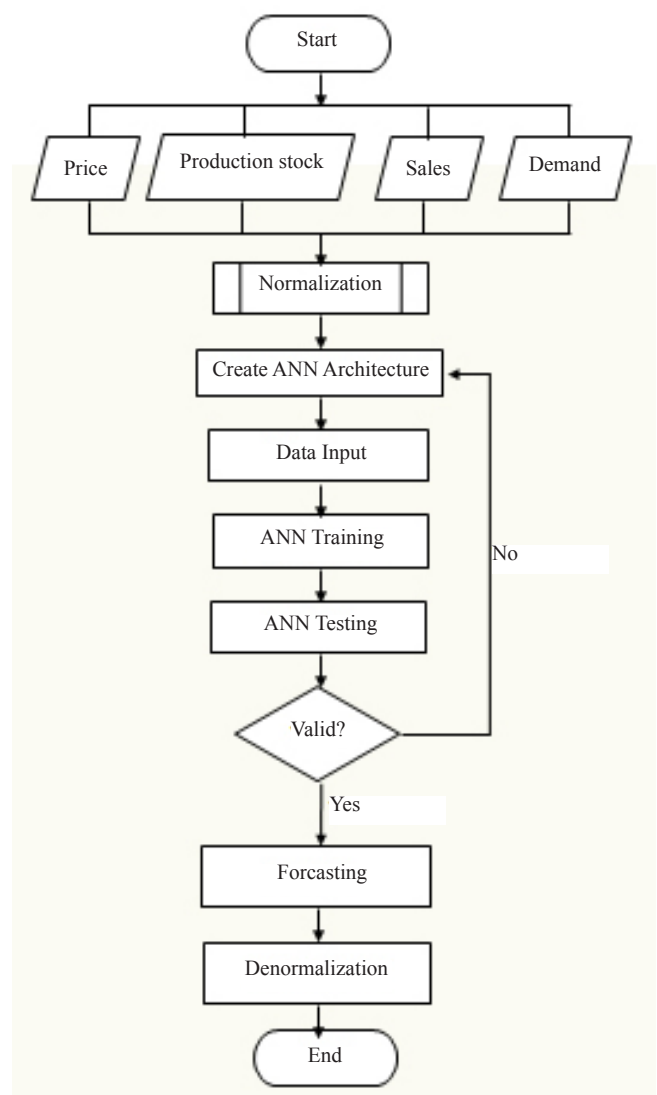

Figure 2. Research framework

Table 2. Results of actual observations

Year	Month	Price (Rp)	Stock (Kg)	Sales (Kg)	Demand (Kg)
2015	January	14,900	9957	8771	9672
	February	15,000	6993	7911	7958
	March	15,350	8345	8357	9375
	April	15,250	11238	12955	13295
	May	15,300	14728	14548	14954
	June	15,800	14198	13554	14353
	July	15,600	7188	7563	7729,5
	August	15,150	10144	12590	12782,5
	September	15,250	15195	13962,5	14970,5
	October	15,200	12941	15094	16069
	November	15,450	14815	13474	14527
	December	14,500	13157	11862	13127
2016	January	16,200	12866	8603	13561
	February	16,000	12916	11109	14017
	March	16,250	12967	10183	14133
	April	16,300	7851	9505	14659
	May	16,550	10767	7072	11199
	June	16,150	16992	15291	18304
	July	17,000	6774	3250	8142
	August	16,300	12082	11221	15363
	September	16,500	8565	6869	10223
	October	16,200	17296	13690	17839,5
	November	16,250	16364	11545	16277,5
	December	16,150	21277	13755	26083
2017	January	16,800	17658	14417	17941
	February	17,000	18396	10803	19518
	March	17,400	14740	11065	16823
	April	17,450	11675	8688	12283
	May	17,000	19977	13742	20679
	June	16,800	16523	13643	17259
	July	17,200	18808	10246	19296
	August	16,950	21183	16226	22993
	September	17,000	16476	12034	17376
	October	16,950	10510	5630	11182
	November	17,050	12312	10673	16611
	December	17,150	13687	8990	14954

Beside the rice's price fluctuation, demand for organic red rice tends to fluctuate horizontally from 2015 to 2017 (Figure 1). This indicates that organic red rice demand fluctuates around the average. In early 2015 demand tended to increase, then dropped dramatically in July 2015 and became the lowest period. Demand fluctuations in 2016 and 2017 have a large gap, so it can be concluded that the demand for organic red rice in this period is still not stable. This instability of demand is caused by the response of the community to organic rice products that are still trying. The highest demand for organic red rice was in December 2016 of 26,083 Kg, while the lowest demand was in July 2015 which was 7729.5 Kg. Demand is a function of various factors as; previous year's demand, the price of goods the price of other goods, per capita income, population, etc. Year request previously affected demand this year as a result of forming habits or habits formation (Kindangen et al. 2017).

Data Normalization

The effectiveness of artificial neural networks with backpropagation is strongly influenced by data normalization to achieve the best accuracy.

Normalization used in this research is normalization min max. The results of data normalization are presented in Table 3.

Table 3. Data normalization results

Year	Month	Price (Rp)	Stock (Kg)	Sales (Kg)	Demand (Kg)
2015	January	0.2085	0.2756	0.4404	0.1847
	February	0.2356	0.1121	0.3874	0.1100
	March	0.3305	0.1867	0.4149	0.1717
	April	0.3034	0.3462	0.6983	0.3426
	May	0.3169	0.5388	0.7965	0.4149
	June	0.4525	0.5095	0.7353	0.3887
	July	0.3983	0.1228	0.3659	0.1000
	August	0.2763	0.2859	0.6758	0.3203
	September	0.3034	0.5645	0.7605	0.4156
	October	0.2898	0.4402	0.8302	0.4635
	November	0.3576	0.5435	0.7303	0.3963
	December	0.1000	0.4521	0.6309	0.3353
2016	January	0.5610	0.4360	0.4300	0.3542
	February	0.5068	0.4388	0.5845	0.3741
	March	0.5746	0.4416	0.5274	0.3791
	April	0.5881	0.1594	0.4856	0.4020
	May	0.6559	0.3203	0.3356	0.2512
	June	0.5475	0.6636	0.8424	0.5609
	July	0.7780	0.1000	0.1000	0.1180
	August	0.5881	0.3928	0.5914	0.4327
	September	0.6424	0.1988	0.3231	0.2087
	October	0.5610	0.6804	0.7436	0.5407
	November	0.5746	0.6290	0.6114	0.4726
	December	0.5475	0.9000	0.7477	0.9000
2017	January	0.7237	0.7004	0.7885	0.5451
	February	0.7780	0.7411	0.5657	0.6138
	March	0.8864	0.5394	0.5818	0.4964
	April	0.9000	0.3703	0.4353	0.2985
	May	0.7780	0.8283	0.7469	0.6644
	June	0.7237	0.6378	0.7408	0.5154
	July	0.8322	0.7638	0.5313	0.6042
	August	0.7644	0.8948	0.9000	0.7653
	September	0.7780	0.6352	0.6416	0.5205
	October	0.7644	0.3061	0.2467	0.2505
	November	0.7915	0.4055	0.5576	0.4871
	December	0.8186	0.4813	0.4539	0.4149

ANN Architecture and Training

At the design and training of ANN is conducted by trial and error. The experiment is done by changing the number of hidden layer neurons from 4 to 24 hidden layers. The best architectural design is the number of hidden layer 20 neurons where the R squared =0.859, with MSE value of 0.002 (presented in Table 4), then the network architecture is validated and used as a reference in the forecasting process. while Figure 3 describes the relationship between training results and actual data.

Validation Results (Testing)

The validation data used is data in 2017. The mean square error (MSE) result is 0.0213 indicating fairly good performance. While the results of the mean absolute percentage error (MAPE) were 7.678%. The results of the validation of organic red rice demand are presented in Table 5. as follows. Validation plot as shown in Figure 4 indicates that between simulation and actually has a very strong correlation. Evidenced by the value of R2 = 0.91 (Figure 5).

After the testing process, the forecasting process is carried out to forecast demand in 2018. The forecasting results are still in the form of normalization data. To see the original data from forecasting, a denormalization process is carried out. The results of forecasting organic red rice demand in 2018 (Table 6) indicate that the highest demand is in August and the lowest demand is in October. The highest demand of rice usually occure during Indonesia's national holidays such as Ramadan, Christmas and New Year. Due to the necessity to provide large meals during these holidays, the consumer psychology is to increase the demand of meals and pay for food regardless of the cost (Kindangen et al. 2017).

Table 4. ANN Network Architecture with the best forecasting performance

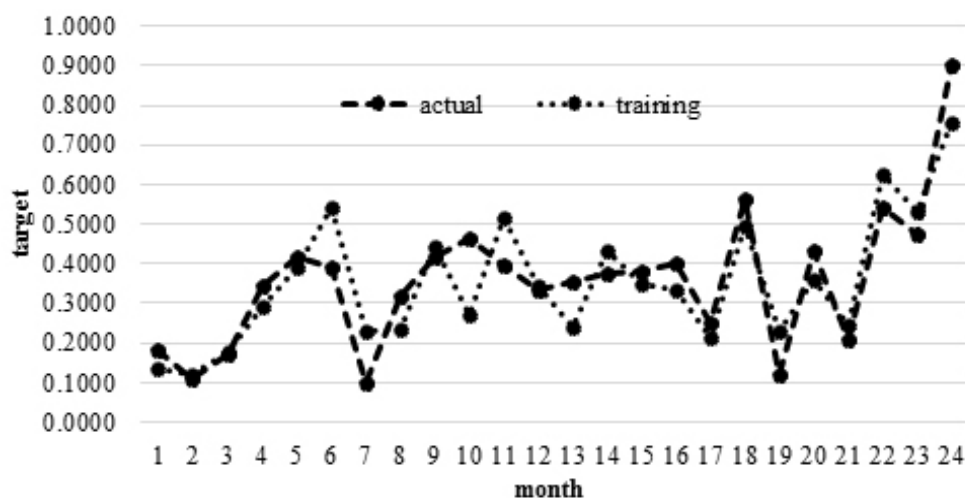| Number of hidden layers	Learning rate	Activation function		MSE	R-squared
		Hidden	output		
4	0.01	logsig	tansig	0.0026	0.620
8	0.01	logsig	tansig	0.0476	-0.685
12	0.01	logsig	tansig	0.0021	0.733
16	0.01	logsig	tansig	0.0071	0.836
20	0.01	logsig	tansig	0.0020	0.859
24	0.01	logsig	tansig	0.0053	0.796

Figure 3. plot of actual demand and training results

Table 5. The results of the validation of organic red rice demand

| Year	Month	actual demand	validation	error	squared error	Absolute percentage error (%)
2017	January	0.5451	0.6001	-0.0550	0.0030	10.082
	February	0.6138	0.5772	0.0366	0.0013	5.966
	March	0.4964	0.4787	0.0177	0.0003	3.556
	April	0.2985	0.3596	-0.0611	0.0037	20.486
	May	0.6644	0.6604	0.0040	0.0000	0.597
	June	0.5154	0.5570	-0.0416	0.0017	8.081
	July	0.6042	0.5844	0.0198	0.0004	3.279
	August	0.7653	0.7247	0.0406	0.0016	5.302
	September	0.5205	0.5372	-0.0167	0.0003	3.212
	October	0.2505	0.2823	-0.0318	0.0010	12.678
	November	0.4871	0.3986	0.0885	0.0078	18.173
	December	0.4149	0.4179	-0.0030	0.0000	0.724
	MSE				0.0018	
	MAPE					7.678
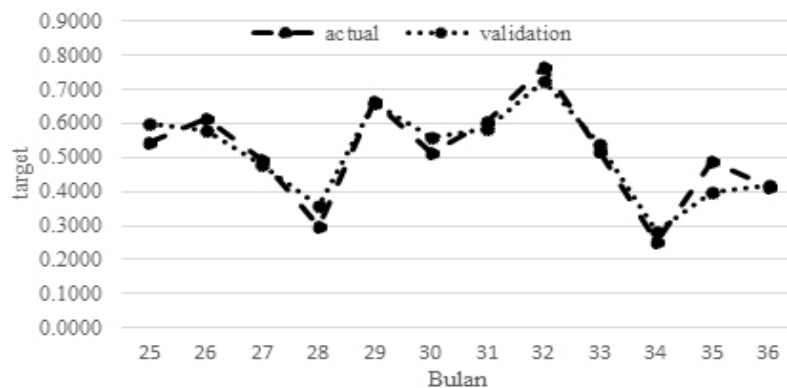
Figure 4. Actual request plot and validation results

Managerial Implications

Some managerial implications that can be applied by the management at PT. Sirtanio Organik Indonesia are; For Directors, the results of this study can be used as a material for consideration and evaluation of the opportunities, processes, problems, and performance of the company, especially those related to the production and demand for organic red rice. It can also be used as a reference for improvement and increasing production capacity of organic red rice.

For the Marketing Division, the forecasting it can be used to determine the marketing and promotion plans for organic red rice in the future. Marketing and promotion plans can be further enhanced if demand forecasting results show low results so that with the right marketing and promotion can further increase the demand for organic red rice.

For the Production Division, the forecasting result can be used to determine the amount of production of organic red rice to be produced. So that the total product produced can be maximal. For the Finance Division, it can maximize the benefits that will be obtained by PT. Sirtanio Organik Indonesia. The production of organic red rice in accordance with the results of forecasting demand for organic red rice can maximize the company's sales. So, the results of the profits obtained can also be maximized.

For the Cultivation Division, the forecasting results of organic red rice can be used to determine the number of plants to be planted by the cultivation division. Conformity between the number of plants that will be cultivated and the amount of demand for organic red rice is very necessary in order to obtain effective and efficient production. If the forecasting results of the demand for organic red rice are high, the cultivation

division must also plant large amounts of red rice. On the contrary, if the forecast demand for organic red rice shows a low yield, the number of organic red rice plants cultivated is also small, so there is no accumulation of organic red rice stock.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

Based on the research that has been done on the forecasting of organic red rice, the best network architecture is built from 20 hidden layers, the learning rate 0.01 with the resulting MSE is 0.002 and the resulting R squared is 0.859. Validation performance shows satisfactory results with R squared 0.91, MSE = 0.0018 and MAPE = 7,678%. Forecasting results indicate that the highest demand for organic red rice is in August amounting to 22.259 kg and the lowest in April is 12.809 kg. The formation of an ANN network can use other variables such as the number of consumer requests, consumer income, and taste. The accuracy of forecasting results requires a long time span so that longtime series data is needed.

Recommendations

There are several recommendations that can be given from this research such as: The formation of an ANN network can use other variables such as the number of consumer requests, consumer income, and taste. The accuracy of forecasting results requires a long time period so that long time series data is needed.

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