International Journal of Multicultural and Multireligious Understanding

http://ijmmu.com
editor@ijmmu.com
ISSN 2364-5369
Volume 7, Issue 8
September, 2020
Pages: 682-689

Planting Scheduling of Organic Water Spinach (IpomoeaereptansPoir) Vegetables with Dynamic Simulationin CV. Tani Organik Merapi

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http://dx.doi.org/10.18415/ijmmu.v7i8.2016

Abstract

One of vegetable commodity that has a high level of demand in Indonesia is water spinach (*Ipomoeae reptans poir*). Water spinach commodities are very important in improving people's welfare and improving farmers' income if done through good cultivation and techniques. One of the farming techniques in Indonesia that has good prospects is by organic cultivation. Organic water spinach producer in Yogyakarta is CV. Merapi Organic Farm. TOM must be able to maintain the availability of its products in order to be able to meet the demands of its customers. Therefore, this study is forecasting to find out how consumers demand organic water spinach and how to plan scheduling of organic water spinach. Forecasting is done by obtaining the most optimal ARIMA method for predicting organic kale is ARIMA (0,1,1). Based on the forecasting, it can be seen that the total demand for organic water spinach is 1128 kg. Planning for planting organic water spinach is done with a dynamic simulation, results for total amount of organic water spinach is 27297.6 plants and total land area is 225.6 m^2.

Keywords: *Organic Water Spinach; Forecasting; Dynamic Simulation*

Introduction

The economic growth of Indonesian society is largely determined by efforts to increase the productivity of agricultural commodities. This is because Indonesia is an agricultural country where most of the population earn income from the agricultural sector. An agricultural commodity that is very important to be cultivated in Indonesia is vegetables. Vegetables have excellent potential as food ingredients that can fulfill community nutrition and increase people's income. Nowadays, vegetable commodities are increasingly needed because they have a tendency of increasing demand every year, in line with the growth of the population in Indonesia. One vegetable commodity that has a high level of demand is water spinach (Ipomoeaereptanspoir). The highest level of consumption of vegetables per capita in 2017 was water spinach with a total of 4,171 kg / capita. This can be seen from Table 1 where there are five vegetable commodities with the highest per capita consumption value in 2017. Apart from having a high demand, Kangkung also contains various nutrients such as fat, carbohydrates, protein, calcium, phosphorus, sodium., potassium, iron, vitamin A, vitamin B, and vitamin C (Febriyono et al., 2017).

Table 1. Levels of Consumption of Vegetables per Capita in 2017

Vegetable	Consumption per Capita (kg/capita)
Water Spinach	4.171
Spinach	3.546
Carrot	2.920
eggplant	2.711
Long beans	2.571

Source: (Anonim, 2018)

The water spinach commodity is very important in improving people's welfare and improving farmers' income if it is done through good cultivation and techniques. One of the agricultural cultivation techniques in Indonesia that has good prospects is organic cultivation or organic farming. Organic agriculture is an agricultural cultivation activity that uses natural ingredients. The use of natural ingredients is intended to replace the use of synthetic chemicals that can damage the environment due to the residue left behind. The residue resulting from the continuous use of synthetic chemical fertilizers will damage soil conditions, both in terms of soil chemistry and physics. Improving the quality of contaminated soil can be done with good land management; such as tillage and organic fertilizers. According to Hartatik et al. (2015), the use of appropriate organic fertilizers both in quantity, quality, and continuity can slow down soil damage and increase crop productivity.

Organic water spinach is water spinach that is cultivated by minimizing the use of chemicals. However, this method of cultivation can also cost a lot of money, so the selling price of organic kale is usually more expensive than the selling price of non-organic vegetables. According to Husnain et al. (2005), there are several standards that must be considered for organic farming, including: not using genetically modified seeds, synthetic chemical fertilizers, growth regulators, and pesticides. Pest control is carried out by mechanical, biological, and crop rotation. In addition, to increase soil fertility, organic fertilizers, crop residues and natural fertilizers can be added.

The main objective of organic farming is to optimize the productivity of soil, plant, animal, and human communities of organisms that are interdependent. In addition, other goals of organic farming include producing quality products, safe for consumption, and preserving the environment.

The producer of organic water spinach in Yogyakarta is CV. TaniOrganik Merapi (TOM). TOM is one of the main suppliers of organic vegetables in Yogyakarta which wants to continue to retain its customers and increase its market share and product sales. TOM must be able to maintain the availability of its products in order to meet consumer demand. Therefore, this study conducts forecasts to determine how consumer demand for organic water spinach in the future. Predicting future consumer demand can be done by studying demand data from the past (Permatasari et al., 2018). Analyzing and estimating consumer demand is also a very important marketing activity for TOM. The success of TOM can also be reflected in the ability of its management to take advantage of opportunities optimally so as to generate sales and profits as expected. Therefore, one of the important tasks of TOM management is to plan how to schedule organic water spinach planting, so that later, the availability of organic water spinach can match its demands.

Research Method

In this study, forecasting was carried out using the ARIMA method. The Autoregressive Integrated Moving Average (ARIMA) model is a model that completely ignores the independent variables in making forecasts. ARIMA method is a method of forecasting time series. The level of accuracy of time series forecasting depends on the characteristics of the time series from past data. If the formed pattern shows stability and periodicity, the accuracy of the forecasting will be high, whereas if the pattern is very irregular, the accuracy of the forecast tends to be lower (Matsumoto & Ikeda, 2015).

ARIMA was introduced by Box and Jenkins in 1971, in this model a p-order Autoregressive (AR) process occurs or a q-order Moving Average (MA) process or a combination of both. D-ordered differentiation is done if the time series data is non-stationary, to fulfill the AR and MA aspects of the ARIMA model which require stationary data. The data used to forecast in this study is the demand for organic water spinach in the CV. TaniOrganik Merapi from July 2017 to June 2018.

The method commonly used in making ARIMA models isthe Box-Jenkins method (Makridakis, et al., 1999) with the following procedure:

1. Model identification
   Model identification comes from a stationary data structure. From datawhich is stationary, a temporary model can be obtained, by observing the autocorrelation function (ACF) andpartial autocorrelation function (PACF).

2. Estimated parameters
   The number of parameters to be estimated depends on the number of coefficientsearly models. The parameter estimator is said to be influential if the absolute value of t,corresponding to the parameter is greater than the t-value of the tableat the real level α / 2 degrees of freedom n minus the number of parameters.

3. Model diagnostics
   Diagnostic model with Ljung-Box test, if all p-values of the model are greater than 0.05, then the model is eligible to become the data. The model diagnostic examination is performed to check whether {et} follow the white noise process by performing the residual independence test with the hypothesis:

$H_0 :\ \rho_1 = \rho_2 = \dots = \rho_K = 0$ (residual $independent$)

$H_1 :\ there\ is\ at\ least\ one\ \rho_1 \neq 0, for\ = \ 1,2,\dots,K$

$(residual\ dependent)$

Significance level : α = 0,05

Test statistics : *Ljung-Box*

$$Q = n\ (n+2)\sum_{k=1}^{K}(n-k)^{-1}\rho k^2 \qquad (1)$$

$Explanation:$

$k = difference\ in\ lag$

$K = lots\ of\ lag\ tested$

$\rho k = residual\ autocorrelation\ in\ period\ k$

Decisioncriteria: $H_0\ is\ rejected\ if\ Q_{hitung} > Q^2_{(\alpha,K-\rho-q)}$, where p is the total AR parameters and $q$is the total parameters of MA or$p - value < \alpha$.

4. Forecasting

Forecasting is a process for obtaining data for several periods time ahead. The calculation is done recursively, that is, counting forecasting one period then two periods, and so on up to a period x forward. After making the forecast, the accuracy of the forecast can be found by calculating the Mean Absolute Percentage Error (MAPE). Research conducted by Sungkawa&Megasari (2011) explains that MAPE is more appropriate to measure the accuracy of forecasting rather than using MSD (Mean Squared Deviation) and MAD (Mean Absolute Deviation). MAPE formula is:

$$MAPE = \frac{1}{n}\sum \frac{|X_m - X_d|}{X_d} x100\% \quad \text{(2)}$$

Explanation:

X_m = simulation result data

X_d = actual data

n = period / number

Then the organic water spinach vegetable planting scheduling is carried out using a dynamic simulation modeling approach. Dynamic system modeling is basically a continuous time simulation model that is supported by causality (Kunc et al., 2018). Causal relationships in modeling a complex system, as a basis for recognizing and understanding the dynamic behavior of the system. The use of system dynamics methodology is more focused on the objectives of increasing understanding of how system behavior emerges from its structure.

According to Rasjidin (2015), the dynamic systems approach can be categorized into two stages of analysis, namely qualitative and quantitative. The qualitative stage is carried out by thoroughly observing the system and selecting the best factors and variables to represent the system well. The quantitative stage is carried out by transforming into a simulation program using dynamic system software to develop dynamic models. Meanwhile, according to Widodo et al. (2010), the stages to simulate dynamic systems are carried out from system identification, formulating causal relationships between system elements, building models, then conducting model validation tests.

Result and Discussion

ARIMA model is a model that requires stationary data.One of the data stationarity test methods is to use a time series plotto see data patterns. A data can be said to be stationary if the data fluctuations are around a constant average value so that the data is in the same average range. In this study, a sampling of organic water spinach demand data was carried out from June 2017 to March 2018 as shown in Figure 1.

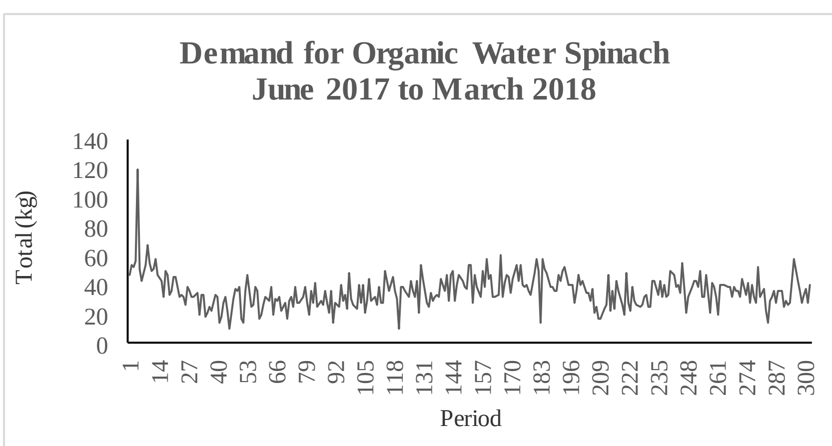

Figure 1. Graph of Demand for Organic Water Spinach from June 2017 to March 2018

When viewed based on the data plot in Figure 1, it can be seen that the data used is not stationary and more volatile. Testing data stationarity is not enough just by looking at the data pattern through the time series plot because the test is subjective, so the test is carried out using the Augmented Dickey Fuller (ADF) method. The ADF stationary test is a stationary test by determining whether the time series data contains the unit root. Data is said to be stationary if it does not contain a unit root. The ADF test is a mean stationarity test which has the following hypothesis:

H0: probability value> 0.005 (there are unit roots, data is not stationary)

H1: Probability value ≤ 0.005 (no unit roots, data is stationary)

Based on the ADF test that has been carried out, it can be seen that the probability value is 0.0171 and the probability value at the first differentiation level is 0.0024. The probability value at the first differentiation level is less than 0.005 so that it can be concluded that the data is stationary by making a one-time distinction and no further differentiation process is needed. Then the ACF and PACF plots were carried out to find out the AR and MA values. However, after seeing the ACF and PACF plots, it seemed that they did not have a real correlation value in various lags on the ACF and PACF plots, so it was necessary to carry out a trial and error process to get the best model. A model that is suitable for data is a model where all parameter values are significant to the data and passes the model diagnostic test where there is no autocorrelation between the rest of the data. After doing trial and error with the help of an Expert Modeler on SPSS 24 software to get the best ARIMA model, it is known that the best model that has been identified is ARIMA (0,1,1) with the MAPE value is 7.40%. Forecasting results can be seen in Figure 2. Based on the forecast results, the total demand for organic water spinach for July 2018 is 1128 kg.

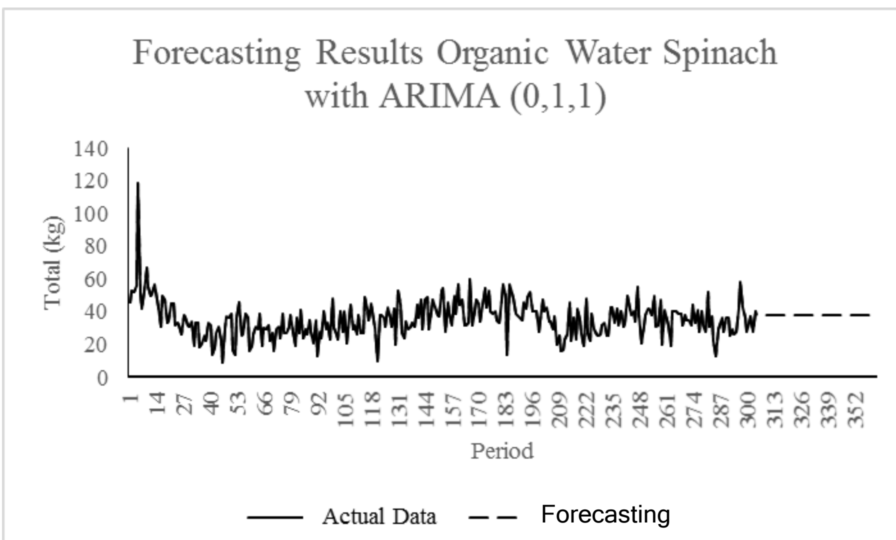

Figure 2. Forecasting Results Organic Water Spinach with ARIMA (0,1,1)

After forecasting with ARIMA, the next step is the preparation of dynamic modeling to obtain a planting schedule from organic water spinach that is in accordance with the forecast that has been carried out. The model that has been made is based on the organic water spinach production system approach at CV. Merapi Organic Farming can be seen in Figure 3. This figure is a stock and flow diagram, where the stock describes the system at a point in time and flow is a variable that can control the rate at which the stock decreases or increases (Duvvuru et al., 2012). In the model that has been compiled, several inputs are included such as the results of forecasting demand for organic water spinach for the month of July 2018 according to the results of the forecast that has been done, the water spinach planting age data for 30 days, the productivity of organic water spinach is 0.067 kg / plant, and plant density for organic water spinach is 36 plants / m2.

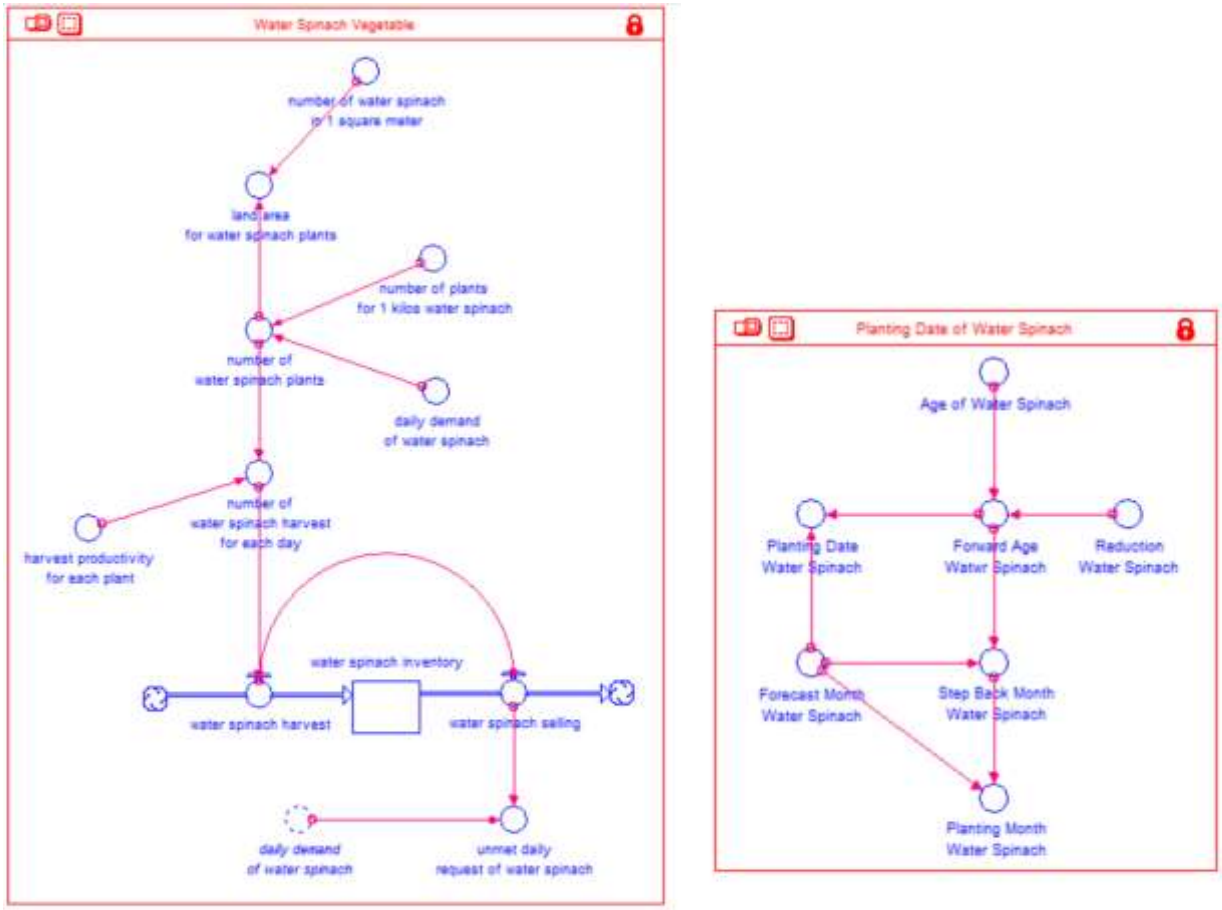

Figure 3. Stock and Flow Diagram of Organic Water Spinach Production

Based on the model that has been compiled, a simulation of organic water spinach planting scheduling can be carried out and the output is as shown in Table 2. The results of this simulation are based on the results of the forecasts that have been made to meet the need for organic water spinach in July 2018. In the simulation results, the number of plants is obtained. Organic water spinach that must be planted is 27297.2 plants and a land area of 225.6 m2 is required.

Table 2. Simulation Results of Organic Water Spinach Planting Schedule

Planting Date	Number of Plants	Required Area (m2)
02 May 2018	909,92	7,52
03 May2018	909,92	7,52
04 May2018	909,92	7,52
05 May2018	909,92	7,52
06 May2018	909,92	7,52
07 May2018	909,92	7,52
08 May2018	909,92	7,52
09 May2018	909,92	7,52

10 May2018	909,92	7,52
11 May2018	909,92	7,52
12 May2018	909,92	7,52
13 May2018	909,92	7,52
14 May2018	909,92	7,52
15 May2018	909,92	7,52
16 May2018	909,92	7,52
17 May2018	909,92	7,52
18 May2018	909,92	7,52
19 May2018	909,92	7,52
20 May2018	909,92	7,52
21 May2018	909,92	7,52
22 May2018	909,92	7,52
23 May2018	909,92	7,52
24 May2018	909,92	7,52
25 May2018	909,92	7,52
26 May2018	909,92	7,52
27 May2018	909,92	7,52
28 May2018	909,92	7,52
29 May2018	909,92	7,52
30 May2018	909,92	7,52
31 May2018	909,92	7,52
Total	27297,6	225,6

Conclusion

The forecasting performed shows that the most optimal ARIMA method for predicting organic water spinach is ARIMA (0,1,1). Based on this forecast, it can be seen that the total demand for organic water spinach for July 2018 is 1128 kg. Planning for planting organic water spinach is carried out with a dynamic simulation approach to meet the demand in July 2018, resulting in a total number of plants of 27297.6 water spinach plants and a required land area of 225.6 m2.

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