FORECASTING AGRICULTURAL PRODUCTS PRICES USING TIME SERIES METHODS FOR CROP PLANNING

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ABSTRACT
The cost of rice production in Thailand has continuously increased over time. To protect farmers from declining returns, there is a need for improving productivity of rice and use of crop rotation. This study aimed to apply predictive data analysis for rice cultivation planning to determine the suitable rotation crop from the following crops: turnips, muskmelons, kailan, peanuts, cantaloupes, and water mimosas under limited resources condition. Sixty-month selling data of Hom Pathum Rice and other six alternative crops was analyzed using the following time-series analysis methods: Least Square Method, Moving Average Method (3 months, 5 months, 7 months), Single Exponential Method, Double Exponential Method, and Winters’ Method. Prediction efficiency was measured by the Mean Absolute Percentage Error (MAPE), Mean Absolute Deviation (MAD) and Mean Square Deviation (MSD). Then the suitable prediction method was used to forecast selling price of rice and rotation crops for 12 case studies under 3 scenarios. We found that case study 6 gave the highest profit (% increase when compared with a traditional method).

Key words: Forecasting, Agricultural Products, Time Series, Crop Planning.

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1. INTRODUCTION
Rice is a major economic crop in Thailand with an export value of approximately 1.3 hundred-thousand million per year [1]. In reality, however, rice growers, or farmers, are in debt as they face financial hardships due to the rapid growth of a capitalist economy supported or facilitated by government policies in 2012 – 2014. This has caused farmers to focus on growing rice with the aim of producing maximum crop yields without appropriate production planning consistent with environmental conditions, soil conditions, irrigation limitations and resource limitations...
for reducing production costs. In addition, farmers tend to grow a single variety of crop repeatedly. Consequently, rice farmers are at a marketing disadvantage. As a means of solving this problem, Thailand’s government currently supports Thai farmers in smart farming nationwide. However, smart farming requires access to a significant amount of data to create decision-making guidelines for farmers [2] such as selling prices, weather conditions and irrigation water, etc. These data will aid farmers’ decisions in planning cultivation.

Access to data is important. Apart from fast access, data must be accurate. Data accuracy comes from data collected and analyzed in the past to predict future possibilities. For predictions to be as real as possible, a large amount of data is needed for big data analysis.

Big data has 4 characteristics or 4Vs [3] consisting of volume, velocity, variety and veracity. Volume means large offline or online data size and amount. Velocity means rapidly changing data at all times with continuous data transfer. Variety means data variety and veracity means unreliable data.

Predictive analysis uses historical data to predict future events, while predicted values are used in decision-making and planning in various areas such as finance, marketing and production, etc. Predictions can also be used in agricultural decision-making. For example, Pongtongkam and Chaveesuk [4] used the time series analysis to predict seasonal rice production volume and the results from time series analysis were compared with the answer model by using the Backpropagation Neural Network (BPN) method. According to the findings in this case study, BPN Model 12-7-1 had the highest accuracy and predictability at the ranges of one month and one year. Furthermore, predictions can be used to predict selling prices of agricultural products. In a study conducted by Komkul [5], a time series analysis model was created to predict cassava flour prices and prediction method effectiveness was tested by the Mean Absolute Percentage Error Method (MAPE) and the Root Mean Squared Error (RMSE) method. According to the findings, the method with the least deviation was the 3-month Moving Average Method. Moreover, a study conducted by Riansut [6] used the time series analysis technique to predict the prices of non-glutinous rice in husks with 15-percent humidity. This study revealed that the combined forecasting method was the prediction method with the least deviation.

In previous research, Ruekkasaem and Sasananan [7] applied linear programming in designing guidelines for allocating supplementing crop in addition to rice planting. By creating a crop decision planning model to determine the best values of plants which should be cultivated under conditions of resource limitations, the findings revealed a plan yielding the highest profit (1.4 million baht per year). However, the selling price of each plant was not taken into consideration.

This study applied predictive data analysis to predict the selling prices of agricultural produce that are suitable for planting in addition to rice with the goal of maximizing sales profit under assumption that irrigation is available. The data analysis in this study was performed as a monthly time series analysis of Hom Pathum Rice using selling prices for 60 months and price data for six other alternative crop varieties consisting of turnips, muskmelons, kailan, peanuts, cantaloupes and water mimosas. The framework for this study was composed of the following five parts: 1. introduction, 2. research procedures, 3. theoretical analysis, 4. mathematical equations for selecting crops to plant, 5. big data analysis for rice cultivation plan, 6. results and 7. conclusion.

2. RESEARCH PROCEDURES
The data used to create the predictive model in this study was divided into two parts. The first part was Hom Pathum rice sale prices (baht/kg.) from January 2013 – December 2017, for a total of 60 months in which data were obtained from the Thai rice mills association [8]. The
second part of data was the mean monthly sales data of six alternative crops (baht/kg.) consisting of turnips, muskmelons, Kailans, peanuts cantaloupes and water mimosas from January 2013 – December 2017, for a total of 60 months. The data were obtained from the mean common price of Simnummuang market, Thailand [9].

The data were analyzed with times series analysis by using the following seven methods: the Least Square Method, the Moving Average Method (3 months, 5 months and 7 months), the Single Exponential Method, the Double Exponential Method, and Winter’s Method. Prediction method efficiency was compared with Mean Absolute Percentage Error (MAPE), Mean Absolute Deviation (MAD) and Mean Square Deviation (MSD). The prediction concepts for this study are shown in Figure 1.

After obtaining suitable prediction methods for each type of plan by checking the lowest Mean Absolute Percentage Error (MAPE), selling prices were predicted in advance to appropriately plan cultivation of each type of plant at times with the best selling price.

**Figure 1** The concept of forecasting and crop planning
3. THEORETICAL ANALYSIS

3.1. Least Square Method
The Least Square Method is used to determine future value prediction trends by creating linear equations. The equation for the Least Square Method [10] is:

\[ Y = a + bx \]  
\[ a = \frac{\sum y}{n} \]  
\[ b = \frac{\sum xy}{\sum x^2} \]

Where
- \( Y \) is forecast value
- \( x \) is time value
- \( a, b \) are constants of linear equations
- \( y \) is data value

3.2. Moving Average Method
The Moving Average Method selects partial up-to-date information to determine mean scores and specify prediction periods such as three months or five months, depending on how smooth the predictor wants the data to be. With large amounts, the data is smoother. After obtaining one prediction value from determining the mean scores, the next value can be found by excluding data from the earliest period of the original dataset before using new data. This new set of data is then used to determine the mean scores. This method is repeated until the desired prediction value is obtained [11].

\[ F_t = \frac{\sum_{t=1}^{n} D_{t-1}}{n} \]

Where
- \( F_t \) is moving average forecast for period \( t \)
- \( D_t \) is actual demand of time \( t \)
- \( D_{t-1} \) is actual demand sales of time \( t - 1 \)
- \( n \) is number of data

3.3. Single Exponential Method
This prediction model is suitable for forecasting data that are relatively stable or those with low variation. The equation used for this prediction model is as follows [5, 11].

\[ F_{t+1} = \alpha d_t + (1 - \alpha)F_t \]

Where
- \( F_t \) is smooth exponential predictive value for end of time \( t \)
- \( F_{t+1} \) is smooth exponential predictive value for end of time \( t+1 \)
- \( d_t \) is demand value at time \( t \)
- \( \alpha \) is constant smooth adjustment with values between 0 and 1

The Single Exponential Method gave larger weights to more recent observations than to past observation. Thus, the Single Exponential Method is more popular than the Moving Average Method.
3.4. Double Exponential Method

The Double Exponential Method was expanded from the Single Exponential Method to accommodate data exhibiting some form of trend [12-13].

\[
L_t = \alpha Y_t + (1 - \alpha) [L_{t-1} + T_{t-1}] \\
T_t = \gamma [L_t - L_{t-1}] + (1 - \gamma) T_{t-1} \\
F_{t+1} = L_{t-1} + T_{t-1}
\]

(6) (7) (8)

3.5. Winters’ Method

Predictions using Winter’s Method result in good prediction in similar manner with to the Single Exponential Method. However, Winter’s Method has more advantages due to its ability to predict seasonal data and data exhibiting trends. Therefore, predictions require data from at least two seasons, including a model composed of three parts, namely, level estimate \(S_t\), trend estimate \(b_t\) (and seasonal estimate \(I_t\) which can be shown in the following equation [14-15].

\[
S_t = \alpha \left( \frac{X_t}{I_{(t-L)}} \right) + (1 - \alpha) \left( S_{(t-1)} + b_{(t-1)} \right) \\
b_t = \gamma (S_t - S_{(t-1)}) + (1 - \gamma) b_{(t-1)} \\
I_t = \beta \left( \frac{X_t}{S_t} \right) + (1 - \beta) I_{(t-L)}
\]

(9) (10) (11)

Where \(X_t\) is data at time \(t\)

\(L\) is time in each season

\(\gamma, \alpha \text{ and } \beta\) smoothing factors for the seasonality, level and trend

3.6. Comparison of Prediction Method Efficiency

The effectiveness of each method can be measured by comparing the differences between real data and predicted data using Mean Absolute Percentage Error (MAPE), Mean Absolute Deviation (MAD) and MEAN Square Deviation (MSD) respectively [5, 10-11]. In this research, the average of all the three measures called “Average Error (AE)” was used as follows.

\[
MAPE = \frac{100}{n} \sum_{t=1}^{n} \left| \frac{e_t}{Y_t} \right| \\
MAD = \sum_{t=1}^{n} \frac{|e_t|}{n} \\
MSD = \sum_{t=1}^{n} \frac{|e_t|^2}{n} \\
AE = \frac{(MAPE + MAD + MSD)}{3}
\]

(12) (13) (14) (15)
4. MATHEMATICAL EQUATIONS FOR SELECTING PLANTS FOR CULTIVATION

The data in this study came from farmers in Pathumthani due to the close proximity of this province to Bangkok, Thailand’s capital. The province was also selected due to the fact that 55 percent of Pathumthani’s area is used to plant rice [16]. In addition, farmers in Pathumthani prefer to plant Hom Pathum Rice because it is not sensitive to photo period and can be planted year-round.

However, farmers encounter problems with low production efficiency because farmers plant only one type of crop, leading to depletion of essential minerals. Therefore, it will be beneficial to plant alternative crops that will help restore the soil as well as increase farmers’ income. The data used in the calculations consisted of alternative crop data on production costs, water usage and harvesting periods for each crop from the Department of Agriculture Extension, Ministry of Agriculture and Cooperatives, Thailand, data on Hom Pathum rice prices in January 2013 – December 2017 from the Thai rice mill association [8] and alternative crop selling price data in January 2013 – December 2017 from the Simummuang market website [9].

Next, the data were applied to simulate linear programming of the study area and the following objective and condition equations were created.

Maximize profit: \[ \text{Max } Z = C_1X_1 + C_2X_2 + C_3X_3 + C_4X_4 + C_5X_5 + C_6X_6 + C_7X_7 \] (16)

Subject to

\[ W_{11}X_1 + W_{12}X_2 + W_{13}X_3 + W_{14}X_4 + W_{15}X_5 + W_{16}X_6 + W_{17}X_7 \leq T_A \] (17)

\[ X_1 + X_2 + X_3 + X_4 + X_5 + X_6 + X_7 \geq 0 \] (19)

\[ X_1 \leq B_1 \] (20)

\[ X_2 \leq B_2 \] (21)

\[ X_3 \leq B_3 \] (22)

\[ X_4 \leq B_4 \] (23)

\[ X_5 \leq B_5 \] (24)

\[ X_6 \leq B_6 \] (25)

\[ X_7 \leq B_7 \] (26)

\[ X_1 + X_2 + X_3 + X_4 + X_5 \geq 0 \] (27)

\[ B_1, B_2, B_3, B_4, B_5 \geq 0 \] (28)

Where \( C_i \) = the highest profit gained from each crop and \( X_i \) = Cropping area per type of crop

\( X_1 \) = Cropping area of Hom Pathum Rice

\( X_2 \) = Cropping area of Turnips

\( X_3 \) = Cropping area of Muskmelon

\( X_4 \) = Cropping area of Kailan

\( X_5 \) = Cropping area of Peanut

\( X_6 \) = Cropping area of Cantaloupe

\( X_7 \) = Cropping area of Water Mimosa

\( T_A \) = Total Area

\( A_i \) = the coefficient of cropping area
Forecasting Agricultural Products Prices Using Time Series Methods For Crop Planning

\[ E_s' = \text{the coefficient of water volume supply} \]
\[ T_w = \text{Water volume} \]
\[ W_i = \text{Water used per types of crop grown} \]
\[ B_i = \text{Maximum cropping area of } X_i \]
\[ i = \text{Types of crop grown (1, 2, 3…7)} \]

The \( A_i \) and \( E_s' \) parameters were set at 1, and 1, respectively [17].

5. BIG DATA ANALYSIS FOR RICE CULTIVATION PLAN

In agriculture, big data analysis is challenging due to the complexity, difficulty and uncertainty of climate data, soil conditions, irrigation limitations and plant varieties, etc. Further challenge is how to make use of these data in cultivation planning. For example, Sawant et al. [18] developed a farm management system by using the PRIDE cloud-based platform and mobile application to help farmers make decisions in seeking appropriate cost reduction guidelines, increasing productivity and accessing markets. The findings indicate a 64-percent increase in productivity for the first year and a 112 percent increase for the second year. Waldhoff et al. [19] properly identified crops to examine crop rotation with machine learning (scalable vector machines) and used data from remote sensing (satellite images) and historical data sets of land use for data analysis. The study led to crop classification with accuracy of 89 – 92 percent. Furthermore, food availability and security big data analysis was performed in a study conducted by Frelat et al. [20] who estimated food availability in sub-Saharan Africa by using Artificial Neural Networks (ANN) and statistical analysis. The findings indicate that bridging yield gaps is important, while improving market access is vital.

In this study, big data analysis was used in cultivation planning to address practical situations as much as possible. According to field data collection in Pathumthani, farmers were found to have a mean cultivation area of ten rai per family (1 rai = 0.16 ha). The assumption included planting rice at least once during the year. There are some constraints relating to cultivation time, and water usage. Table 1 showed the cost (baht), amount of water used (cubic meters) and harvest cycles (days). In addition to Hom Pathum Rice, this study included six other varieties of alternative crops consisting of turnips, muskmelons, kailan, peanuts, cantaloupes and water mimosas. These six plant varieties are popularly cultivated in the central region with low water use according to the recommendations from the Department of Agricultural Extension (Thailand).

Table 1 illustrates data on cost, water volume, harvest period and productivity of each plant consisting of \( X_1 = \text{Hom Pathum Rice}, X_2 = \text{Turnips}, X_3 = \text{Muskmelon}, X_4 = \text{Kailan}, X_5 = \text{Peanut}, X_6 = \text{Cantaloupe}, X_7 = \text{Water Mimosa} \).

<table>
<thead>
<tr>
<th>Data</th>
<th>Plants</th>
<th>X1</th>
<th>X2</th>
<th>X3</th>
<th>X4</th>
<th>X5</th>
<th>X6</th>
<th>X7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Cost (Baht/rai)</td>
<td></td>
<td>5,520</td>
<td>6,860</td>
<td>10,800</td>
<td>5,920</td>
<td>6,470</td>
<td>26,000</td>
<td>71,000</td>
</tr>
<tr>
<td>Water Volume (m³/rai)</td>
<td></td>
<td>1,2000</td>
<td>750</td>
<td>655</td>
<td>300</td>
<td>700</td>
<td>750</td>
<td>1,200</td>
</tr>
<tr>
<td>Harvest Period (days)</td>
<td></td>
<td>120</td>
<td>60</td>
<td>60</td>
<td>55</td>
<td>120</td>
<td>55</td>
<td>45</td>
</tr>
<tr>
<td>Productivity (kg/rai)</td>
<td></td>
<td>900</td>
<td>6,000</td>
<td>8,000</td>
<td>2,500</td>
<td>520</td>
<td>3,400</td>
<td>12,000</td>
</tr>
</tbody>
</table>

Source: Department of Agricultural Extension (Thailand)

Table 2 compares the efficiency of prediction methods for rice and six rotation crops. Lowest AE is a criterion used to determine a choice of prediction method. Moving Average for 3 Months method was a suitable approach to forecast selling price for X1, X2, X3, X5, and X7.
while Moving Average for 5 Months was for X4 and X6. The chosen methods for each type of plant were subsequently used to predict their selling prices as shown in Table 3.

<table>
<thead>
<tr>
<th>Linear</th>
<th>X1</th>
<th>X2</th>
<th>X3</th>
<th>X4</th>
<th>X5</th>
<th>X6</th>
<th>X7</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAPE</td>
<td>11.856</td>
<td>30.496</td>
<td>4.648</td>
<td>40.979</td>
<td>7.966</td>
<td>8.278</td>
<td>21.092</td>
</tr>
<tr>
<td>MAD</td>
<td>2.338</td>
<td>3.878</td>
<td>0.663</td>
<td>6.124</td>
<td>1.121</td>
<td>2.447</td>
<td>3.695</td>
</tr>
<tr>
<td>MSD</td>
<td>7.96</td>
<td>23.799</td>
<td>0.637</td>
<td>56.791</td>
<td>2.258</td>
<td>8.342</td>
<td>23.791</td>
</tr>
<tr>
<td>Moving Average for 3 Months</td>
<td>X1</td>
<td>X2</td>
<td>X3</td>
<td>X4</td>
<td>X5</td>
<td>X6</td>
<td>X7</td>
</tr>
<tr>
<td>MAPE</td>
<td>4.289</td>
<td>27.447</td>
<td>2.982</td>
<td>34.48</td>
<td>5.378</td>
<td>6.17</td>
<td>15.328</td>
</tr>
<tr>
<td>MAD</td>
<td>0.806</td>
<td>3.529</td>
<td>0.423</td>
<td>5.495</td>
<td>0.764</td>
<td>1.831</td>
<td>2.65</td>
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<tr>
<td>MSD</td>
<td>1.09</td>
<td>18.879</td>
<td>0.312</td>
<td>43.235</td>
<td>1.234</td>
<td>4.846</td>
<td>12.628</td>
</tr>
<tr>
<td>Moving Average for 5 Months</td>
<td>X1</td>
<td>X2</td>
<td>X3</td>
<td>X4</td>
<td>X5</td>
<td>X6</td>
<td>X7</td>
</tr>
<tr>
<td>MAD</td>
<td>0.817</td>
<td>3.657</td>
<td>0.451</td>
<td>5.176</td>
<td>0.846</td>
<td>1.829</td>
<td>2.845</td>
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<tr>
<td>MSD</td>
<td>1.164</td>
<td>20.28</td>
<td>0.347</td>
<td>44.58</td>
<td>1.4</td>
<td>4.886</td>
<td>14.32</td>
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<tr>
<td>AE</td>
<td>2.119</td>
<td>17.386</td>
<td>1.326</td>
<td>27.404</td>
<td>2.753</td>
<td>4.282</td>
<td>11.156</td>
</tr>
<tr>
<td>Moving Average for 7 Months</td>
<td>X1</td>
<td>X2</td>
<td>X3</td>
<td>X4</td>
<td>X5</td>
<td>X6</td>
<td>X7</td>
</tr>
<tr>
<td>MAD</td>
<td>0.92</td>
<td>3.93</td>
<td>0.496</td>
<td>5.782</td>
<td>0.977</td>
<td>2.024</td>
<td>3.161</td>
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<tr>
<td>MSD</td>
<td>1.493</td>
<td>24.899</td>
<td>0.433</td>
<td>54.361</td>
<td>1.754</td>
<td>5.662</td>
<td>17.553</td>
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<tr>
<td>AE</td>
<td>2.442</td>
<td>19.682</td>
<td>1.478</td>
<td>32.358</td>
<td>3.236</td>
<td>4.819</td>
<td>12.859</td>
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</table>

<table>
<thead>
<tr>
<th>Single Exponential Method</th>
<th>X1</th>
<th>X2</th>
<th>X3</th>
<th>X4</th>
<th>X5</th>
<th>X6</th>
<th>X7</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAD</td>
<td>0.902</td>
<td>3.814</td>
<td>0.499</td>
<td>6.026</td>
<td>0.921</td>
<td>2.427</td>
<td>3.76</td>
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<tr>
<td>MSD</td>
<td>1.573</td>
<td>25.877</td>
<td>0.549</td>
<td>59.075</td>
<td>2.233</td>
<td>8.953</td>
<td>25.081</td>
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<tr>
<td>Double Exponential Method</td>
<td>X1</td>
<td>X2</td>
<td>X3</td>
<td>X4</td>
<td>X5</td>
<td>X6</td>
<td>X7</td>
</tr>
<tr>
<td>MAPE</td>
<td>4.952</td>
<td>34.533</td>
<td>3.695</td>
<td>47.234</td>
<td>6.391</td>
<td>8.912</td>
<td>20.834</td>
</tr>
<tr>
<td>MAD</td>
<td>0.932</td>
<td>4.437</td>
<td>0.527</td>
<td>7.539</td>
<td>0.898</td>
<td>2.614</td>
<td>3.711</td>
</tr>
<tr>
<td>MSD</td>
<td>1.652</td>
<td>36.633</td>
<td>0.572</td>
<td>90.528</td>
<td>2.335</td>
<td>11.847</td>
<td>26.525</td>
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<tr>
<td>AE</td>
<td>2.512</td>
<td>25.201</td>
<td>1.598</td>
<td>48.434</td>
<td>3.208</td>
<td>7.791</td>
<td>17.023</td>
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<td>Winters’ Method</td>
<td>X1</td>
<td>X2</td>
<td>X3</td>
<td>X4</td>
<td>X5</td>
<td>X6</td>
<td>X7</td>
</tr>
<tr>
<td>MAPE</td>
<td>9.244</td>
<td>39.454</td>
<td>5.059</td>
<td>47.624</td>
<td>8.7038</td>
<td>9.369</td>
<td>26.914</td>
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<tr>
<td>MAD</td>
<td>1.752</td>
<td>4.939</td>
<td>0.7253</td>
<td>7.3299</td>
<td>1.2199</td>
<td>2.79</td>
<td>4.74</td>
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<tr>
<td>MSD</td>
<td>5.044</td>
<td>35.148</td>
<td>0.8676</td>
<td>85.403</td>
<td>3.1145</td>
<td>12.407</td>
<td>39.301</td>
</tr>
</tbody>
</table>

Table 2 Comparative the efficiency of prediction methods for rice and six rotation crops.
After obtaining sale prices for each crop, the data were used to create the following three main scenarios.

1. **Cultivation for Maximum Profit**

Most of the area in Pathumthani province is near the Chao Phraya River (Thailand’s primary river) with irrigation system coverage. Therefore irrigation system was not a constraint in this scenario. This scenario simulated five cases as shown in Figure 2. Case 1 involved original cultivation by farmers growing only Hom Pathum rice twice a year at two months apart. The first crop was planted in January and harvested in April, while the second crop was planted in July and harvested in October. Cases 2 – 5 are scenarios where the following six types of alternative crops were cultivated: turnips, muskmelon, kailan, peanut, cantaloupe and water mimosa.

![Figure 2 The scenarios cultivation for maximum profit](image)

2. **Cultivation with the Shortest Harvesting Cycle**

This scenarios is a guideline for cultivation for producing as quickly as possible. This situation can be simulated to provide examinations in the three cases shown in Figure 3.
3. Cultivation with the Least Water Use

Although Pathumthani is near the Chao Phraya River with coverage from irrigation canal systems, Thailand encounters periodic droughts in some years with salinity from rising seawater levels. Therefore, there is a need to plant crops with low water requirements. Examples were simulated in the four cases shown in Figure 4.

6. RESULTS

This study considers the profit and amount of water used for one year in the cultivation area of ten rai. Table 4 illustrates the profit and amount of water in each scenario.

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Profit (Baht)</th>
<th>Water Volume (m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cultivation for maximum profit</td>
<td></td>
<td></td>
</tr>
<tr>
<td>case 1</td>
<td>246,810</td>
<td>24,000</td>
</tr>
<tr>
<td>case 2</td>
<td>250,140</td>
<td>24,000</td>
</tr>
<tr>
<td>case 3</td>
<td>1,046,600</td>
<td>38,050</td>
</tr>
<tr>
<td>case 4</td>
<td>5,071,370</td>
<td>45,550</td>
</tr>
<tr>
<td>case 5</td>
<td>3,494,720</td>
<td>36,550</td>
</tr>
<tr>
<td>Cultivation with the shortest harvesting cycle</td>
<td></td>
<td></td>
</tr>
<tr>
<td>case 6</td>
<td>5,225,570</td>
<td>45,550</td>
</tr>
<tr>
<td>case 7</td>
<td>4,608,310</td>
<td>41,050</td>
</tr>
<tr>
<td>case 8</td>
<td>5,013,770</td>
<td>45,550</td>
</tr>
<tr>
<td>Cultivation with the least water use</td>
<td></td>
<td></td>
</tr>
<tr>
<td>case 9</td>
<td>2,241,998</td>
<td>32,100</td>
</tr>
<tr>
<td>case 10</td>
<td>1,055,428</td>
<td>29,500</td>
</tr>
<tr>
<td>case 11</td>
<td>169,826</td>
<td>26,000</td>
</tr>
<tr>
<td>case 12</td>
<td>1,651,058</td>
<td>28,550</td>
</tr>
</tbody>
</table>

From the table, it can be seen that case study 6 provided the highest total profits of 5,225,570 baht. In case study 6, the following plan was suggested: 2 months of turnips
(December-January), 2 months of water mimosa (February-March), 2 months of cantaloupe (April-May), 4 months of Hom Pathum rice (June-September), and 2 months of muskmelon (October-November). In comparison with the traditional method in case study 1, the profit was only 246,810 baht. By contrast, case study 11 gave the lowest total profits, and required more water volume than the traditional method.

7. CONCLUSION

The findings of this research can be very useful for the general farmers, who have limited access to information technology system. The prediction methods are simple and can be analyzed by farmers and agricultural communities without the need for state-of-the-art technology or governmental supports. Under this innovative research, Thai farmers will be able to utilize smart farming and gain higher profit.

ACKNOWLEDGEMENTS

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REFERENCES

Lakkana Ruekkasaem and Montalee Sasananan


Appendix: Graphical results of the best forecasting method

![Moving Average Plot for Hom Pathum Rice](image)

**Figure 5** Graphical result of moving average (3 months) method for Hom Pathum Rice
Figure 6 Graphical result of moving average (3 months) method for turnips

Figure 7 Graphical result of moving average (3 months) method for muskmelon
Figure 8 Graphical result of moving average (5 months) method for kailan

Figure 9 Graphical result of moving average (3 months) method for peanut
Forecasting Agricultural Products Prices Using Time Series Methods For Crop Planning

**Figure 10** Graphical result of moving average (5 months) method for Cantaloupe

**Figure 11** Graphical result of moving average (3 months) method for water mimosa