Planting System Modeling Of Chrysanthemum Seedling Plants Stock for Profit Optimization

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Abstract. Inventories of conventional agricultural cultivation products are closely related to available land area. Often the area of available land is not comparable to meet all demands and cause a profit loss. Appropriate planting management is needed to minimize the profit loss. This study aims to optimize the profit from Chrysanthemum seedling cultivation on Cianjur seedling plantation by developing a model of decision-making system through simulating the planting proportion between varieties. The method used in this research is by using hard method operational research (OR) approaches, while the simulation process is done using spread sheet excel with manual input. The results showed that in one planting period required four times planting with the particular planting proportion. The total profit generated from the best scenario simulation is IDR. 385,779,274.19 with 24.63% profit from first planting, 26.26% from second planting, 27.97% from third planting and 21.13% from fourth planting. The results of this study provide a basis for determining the decision of planting patterns compared with existing conditions that have not used the planning model at all.

Keywords: System modeling; Simulation; Profit optimization; Inventory

1. Introduction
The demands fulfillment to businesses engaged in conventional agricultural cultivation is closely related to land availability as a limitation. Farmers who are used to conventional agricultural technologies are generally not pursued the optimization of land use through application of advanced technologies. Based on that, the determination of the right planting pattern is needed to generate optimal profits; otherwise it will result in profit loss and increasing cost.

Chrysanthemum seedling plant is one of the agricultural commodities that are seeded at Gugenang, Cianjur district, West Java. Flower seeds used in seedling are obtained from Japan and the results of seedling are also exported to Japan, so the supply of raw materials (seeds) as well as the distribution of products (seedling plants) of this nursery business is an export-import process. Business that include import-export processes in material supply and product distribution require proper planning in production process as they generally have a relatively longer lead time than if supply and distribution only within the country, making it particularly vulnerable to profit loss.

The seedling plant produced by this nursery business consists of 16 Chrysanthemum varieties namely Aki, Hibiki, Kougen, Makoto, Hana, Kinka, Kirameki, Tsubasa, Izumi, Otome, Nana, Maiki, Angels, Sheltie, Urizun, and Mao. Each of these varieties has a different level of demand and tends to
fluctuate. Diverse types of products and fluctuating demand make nursery managers difficult to make a planting pattern planning. Previous research has formulated inventory planning for those chrysanthemum seedling businesses using the Q method [1]. The research shows that the amount of seedling plant inventory that must be met exceeds the capacity in one planting, so further research is needed to formulate a system for managing seed planting pattern based on the number of inventory that have been formulated by Q method. Based on the research background, the problems that can be formulated in this study include: (1) how to formulate a planting system model that is in accordance with the quantity of seedling plant inventory; (2) what is the planting proportion of each chrysanthemum seed variety that produces maximum sales profit. The purpose of this study are: (1) to find out the planting system modeling for the supply of chrysanthemum seedlings in accordance with the quantity of calculated inventory; (2) to obtain the planting proportion of each chrysanthemum seed variety which results in maximum sales profit.

This research was conducted with several limitations to simplify the process of mathematical modeling. The limitations of this study are:

a) This research is only focused on planting systems modeling of seedling plants, not discussing delivery systems
b) The quantity of inventory used in this study refers to the results of previous research [1] and no recalculation
c) The decision variables in this study is only the proportion of planting per variety, other factors are considered as parameters with a fixed value

Understanding of a system is a fundamental need to do a simulation or application of analytical methods, because the approach used to solve problems is a system approach, which is a holistic approach to a problem. A holistic approach is needed because the system (where problems arise) can exhibit behaviours or properties that none of its components individually may exhibit [2]. In general, the hard OR system modeling process consists of four stages including: (1) depict a problem situation summary (rich pictures, mind map, etc.); (2) analyse relevant systems; (3) create influence diagrams, and (4) formulate quantitative models or mathematical models [2].

Simulation is an experimental method to explain system behaviour, to construct theories or hypotheses based on the behaviour of the observed system, to predict future system behaviour that will be generated by changes in variables and system parameters or changes in operations [3]. So, simulation is the process of designing a model of an actual system, conducting experiments on the model and evaluating the results of the experiment.

2. Methods
As mention earlier, this study use hard OR system modeling approach and manual simulation to obtain the solution of problem. The following steps are:

1) Depiction of problem situation summary
This stage is a depiction of the problem situation faced, can include the description of the process flow and structure, the components involved, goals and desires, the relationship between components, data and information sources, and hierarchical structure [4]. An effective way to describe the situation perfectly is to draw it into a diagram. The problem situation summary diagram used in this study is a Mind Map diagram.

2) Determination of dominant seed varieties
Determination of dominant seed varieties is carried out to determine which seed varieties are prioritized to be handled based on the highest potential value. The proportion of dominant seed varieties will later become the decision variable to determine the proportion of seedling planting patterns, while other varieties (which are not dominant) will only fill the planting proportion up to 100%. Determination of these dominant varieties is done using the ABC classification. The steps of the ABC classification as described by [5] are as follows:
a. Calculate the potential value for each type of variety per year (Mi) by multiplying the number of usage or demand for each type of variety per year (Di) with the unit price of the variety (pi), mathematically can be expressed as in equation 1.

\[ M_i = D_i \times p_i \]  

(1)

b. Calculate the total potential value for all types of varieties with equation 2.

\[ M = \sum M_i \]  

(2)

c. Calculate the percentage of potential value for each of the varieties (Pi) with the equation 3.

\[ P_i = \frac{M_i}{M} \times 100\% \]  

(3)

d. Sort the percentage of potential value, starting from the largest percentage to the smallest.

e. Calculate the cumulative value of the percentage of potential value based on the sequence obtained in step (d).

3) Identification of relevant systems

The relevant system identification phase will show that all components and relationships between components are described as having relevance to the problem situation. This will be the basis for forming the right model to study and manipulate problem situations. The output generated from these phase is the Influence Diagram. Influence Diagram is a tool to describe the effect of system input with components in the system, between components in the system, and between components and system output.

4) Formulation of mathematical model

The mathematical model states (in quantitative terms) the relationship between various components, as defined in the relevant system [1]. To facilitate the formulation of mathematical models in this study, researchers used the following assumptions:

a. Chrysanthemum seedling plants produced are assumed to have no damage or failure in production, because the failure rate or defect of this plant is very small and almost non-existent.

b. The price of each chrysanthemum seed variety is assumed to be constant during this study and not affected by the size of the order and exchange rate changes.

c. The handling costs for all seed varieties are always the same.

d. Supplier always sends chrysanthemum seed on time with a lead time of 10 days.

e. Re-ordering all varieties of chrysanthemum seeds are carried out simultaneously when all the seeds supply is used up (after the last planting).

f. Chrysanthemum seedling plants are sent directly to Japan after 2 days storage.

5) Verification of mathematical model

Verification of mathematical model aims to ensure that there are no errors when formulating a mathematical model. The verification process needs to be carried out because it will verify that the mathematical model is logical, mathematically correct, and that the mathematical expression is correctly representing the relationship in the system. Verification is done by checking the suitability of all units in each equation.

6) Simulation

The simulation in this study is to conduct experiments on mathematical models that have been formulated, and then evaluate the results of these experiments so that solutions to problems are obtained. The simulation process was carried out in this study by using a spreadsheet with manual input on Microsoft Excel. The columns created in the spreadsheet correspond to the system components in the influence diagram.

7) Sensitivity and error analysis

Error analysis is done to find out the goodness of the model by looking at the difference between the total costs of the system modeling results using historical data with the total cost of the existing
data. A small difference shows that the model error is also small and the model is good. Sensitivity analysis is carried out to see how the solution will be affected if there are changes (both single and simultaneous changes) from parameter, and how much the changes will burden the solution. Sensitivity analysis in this study was carried out by making six changes in two parameters, namely inventory cost and handling cost.

3. Results and Discussion

3.1. Data Collection

Data collection in this study was carried out by direct observation and interviews with nursery management. There are several data needed as input in this study, which consists of:

1) Demand per variety per year (Di) and price per unit (Pi)
2) Number of seed stock based on Q method per one period
3) Handling cost (land preparation cost, planting cost, fertilizer cost, watering cost, harvesting cost, and seedling packaging cost) and inventory cost (electricity cost for cold storage, labour cost)

The input data are presented in tables 1, 2, and 3 below.

Table 1. Annual demand per varieties and price of seeds per unit

| No. | Varieties | Annual demand (Di) (pcs) | Price per unit (Pi) (IDR) | No. | Varieties | Annual demand (Di) (pcs) | Price per unit (Pi) (IDR) |
|-----|-----------|--------------------------|---------------------------|-----|-----------|--------------------------|---------------------------|
| 1   | Aki       | 693,000                  | 570                       | 9   | Izumi     | 299,000                  | 480                       |
| 2   | Hibiki    | 778,000                  | 570                       | 10  | Otome     | 251,000                  | 480                       |
| 3   | Kougen    | 316,000                  | 570                       | 11  | Nana      | 1,372,000                | 480                       |
| 4   | Makoto    | 2,238,000                | 570                       | 12  | Maiki     | 155,000                  | 480                       |
| 5   | Hana      | 536,000                  | 570                       | 13  | Malaikat  | 446,000                  | 480                       |
| 6   | Kinka     | 1,412,000                | 480                       | 14  | Sheltie   | 149,000                  | 480                       |
| 7   | Kirameki  | 924,000                  | 480                       | 15  | Urizun    | 123,000                  | 480                       |
| 8   | Tsubasa   | 979,000                  | 480                       | 16  | Mao       | 235,000                  | 480                       |
|     | Total     | 10,906,000               |                            |     |           |                           |                           |

Table 2. Number of seed stock based on Q method per one period

| No  | Varieties | Order qty (Q*) (pcs) | Safety Stock (Ss) (pcs) | Expected seedling plants qty (Q* + Ss) (pcs) | No  | Varieties | Order qty (Q*) (pcs) | Safety Stock (Ss) (pcs) | Expected seedling plants qty (Q* + Ss) (pcs) |
|-----|-----------|----------------------|-------------------------|-----------------------------------------------|-----|-----------|----------------------|-------------------------|-----------------------------------------------|
| 1   | Makoto    | 123,387              | 73,790                  | 197,178                                       | 9   | Malaikat  | 52,002               | 9,190                   | 61,193                                       |
| 2   | Kinka     | 98,812               | 48,859                  | 147,672                                       | 10  | Kougen    | 39,991               | 7,142                   | 47,133                                       |
| 3   | Nana      | 93,325               | 33,624                  | 126,949                                       | 11  | Izumi     | 42,293               | 5,924                   | 48,217                                       |
| 4   | Tsubasa   | 78,537               | 20,364                  | 98,901                                        | 12  | Otome     | 38,548               | 4,711                   | 43,259                                       |
| 5   | Kirameki  | 75,490               | 18,253                  | 93,743                                        | 13  | Mao       | 37,283               | 4,715                   | 41,998                                       |
| 6   | Hibiki    | 63,583               | 18,040                  | 81,623                                        | 14  | Maiki     | 30,951               | 4,046                   | 34,997                                       |
| 7   | Aki       | 146,862              | 7,195                   | 154,057                                       | 15  | Sheltie   | 29,736               | 3,069                   | 32,805                                       |
| 8   | Hana      | 52,760               | 13,316                  | 66,077                                        | 16  | Urizun    | 27,054               | 2,346                   | 29,423                                       |
|     | Total     |                     |                         | 1,305,225                                     |     |           |                      |                         |                                |
Table 3. Handling cost and inventory cost

| No. | Component                              | Cost (IDR) | Unit description |
|-----|----------------------------------------|------------|------------------|
| A. Handling Cost                      |            |              |
| 1   | Land preparation cost (LPC)            | 12,800,000 | per planting     |
| 2   | Planting cost (PPC)                    | 7,500,000  | per planting     |
| 3   | Fertilizer cost (FPC)                  | 16,900,000 | per planting     |
| 4   | Watering cost (SPC)                    | 24,000,000 | per planting     |
| 5   | Harvesting cost (HPC)                  | 3,750,000  | per planting     |
| 6   | Seedling packaging cost (PKC)          | 2,375,000  | per planting     |
|     | Handling cost (HC) = LPC+ PPC+ FPC+ SPC+ HPC+ PKC | 67,325,000 | per planting     |
|     | Unit handling cost (HC1) = HCA/350,000* pcs | 192.36  | per pcs per planting |

| B. Inventory Cost                     |            |              |
| 1   | Electricity cost for cold storage (CSC)| 20,000,000 | per month       |
| 2   | CSC1 = CSC/30 days                     | 666,667    | per day         |
| 3   | Labor cost (LSC)                       | 280,000    | per day         |
|     | Inventory cost (IC) = CSC1 + LSC       | 946,667    | per day         |
|     | Unit Inventory cost (IC1) = IC/600,000** pcs | 1.58 | per pcs per day |

*capacity per planting  
**storage capacity

3.2. Problem Situation Summary
This chrysanthemum nursery business is a business that requires an export-import process in the supply of raw materials and its distribution with relatively long lead times (approximately 10 days). Therefore, proper planning is needed in managing this nursery business, one of which is by calculating the inventory that must be met. The nursery with 35 Ha land area has a planting capacity of 350,000 seeds in one planting, while based on the inventory calculation with the Q method it is known that in one period, the seedling plants that must be provided are 1,305,224 pcs. Based on the gap between land capacity and required inventory, it is necessary to do several plantings in one period. Planting must be done several times and seed varieties (with different seed prices between varieties) make the nursery manager must be able to determine the right planting proportion. The proportion referred to is the proportion (%) of the number of each variety in each planting to produce the most optimal profit in one period. Figure 1 presents a summary of the problem situation of this study.

3.3. Dominant Seed Varieties
Determination of dominant seed varieties is based on the method previously explained. Based on these calculations, it can be known that the seed varieties that fall into the dominant category or category A (% total value ±80%) are 7 varieties, namely Makoto, Kinka, Nana, Tsubasa, Kirameki, Hibiki, and...
Aki, while other varieties besides that belong to category B (% total value ±15%) and category C (% total value ±5%). The simulation stage will use the results of this stage because in the simulation stage there will be 2% reduction or additional proportion from the initial proportion of varieties which fall into category A only. That step was carried out to get some combination of proportion options which will ultimately provide several choices that can generate the maximum profit.

3.4. Relevant System
The relevant system is described based on a summary of predetermined problem situations. Relevant system in this study is described in the influence diagram contained in Figure 2. Elements in circles are components of the system, with the output of the system is profit, uncontrollable inputs are costs, and controllable input or decision variable is planting proportions of dominant varieties.

3.5. Mathematical Model
To measure the modeling performance that has been designed, it can be done by formulating the mathematical model. Table 4 shows the result of the formulation of a mathematical model based on the influence diagram of the relevant system.

![Figure 2. Influence Diagram of Relevant System](image-url)
| No. | Role | Name of Elements | Notation | Equation | Unit |
|-----|------|------------------|----------|----------|------|
| 1   | Land capacity per planting | LC | (from data collection) | pcs |
| 2   | Required inventory qty. | Q*+Ss | (from data collection) | pcs |
| 3   | Unit handling cost | HC1 | (from data collection) | Rp/pcs/planting |
| 4   | Unit inventory cost | IC1 | (from data collection) | Rp/pcs/day |
| 5   | Seedling price per variety | Pi | (from data collection) | Rp/pcs |
| 6   | Controlable input | PLANTING PROPORTION PER VARIETY PER PLANTING | PF | (obtained from experiments on simulations) | % |
| 7   | The number of planting per period | NFP | (Q*+Ss) / LC | - |
| 8   | Planting pattern per period | PPF | (based on optimum PF) | - |
| 9   | Planted qty. per variety per planting | NVF | PF x LC | pcs |
| 10  | Remaining seeds qty. per variety per planting | RS | (Q*+Ss) - NVF | pcs |
| 11  | Handling cost per planting | HC | HC1 x ΣNVF | Rp |
| 12  | Inventory cost for seedling plants per planting | ICFa | ΣNVF x IC(1) x tp* | Rp |
| 13  | Inventory cost for remaining seeds per planting | ICFb | ΣRS x IC(1) x tp** | Rp |
| 14  | Total handling cost per period | THC | Σ HC | Rp |
| 15  | Total inventory cost per period | TIC | ΣICF | Rp |
| 16  | Total cost per period | TC | THC + TIC | Rp |
| 17  | Seedling sales per planting | PSF | ΣNVF x Pi | Rp |
| 18  | Total sales per period | TSS | Σ PSF | Rp |
| 19  | Output | P | TSS - TC | Rp |

\[ tp = \text{storage time required in days} \]
\[ tp^* = \text{storage time for planted seeds = 4 days} \]
\[ tp^{**} = \text{storage time for remaining seeds to next planting = 12 days} \]

3.6. Simulation

The simulation was carried out to determine some planting proportion options for each variety. The options for this proportion are different for the first, second, third and fourth planting, so the simulation must be done four times according to the number of plantings in one period. Seven varieties belonging to the dominant varieties will be used as a benchmark in determining the proportion option. Each proportion of dominant varieties is added and reduced up to 2% (-1%, -2%, +1%, and +2%) of the initial proportion. The initial proportion is the proportion of each variety obtained from the required inventory quantity per variety divided by the total required inventory quantity then multiplied by 100%. The total option of simulation per planting is 28 options of planting proportion (7 dominant varieties multiplied by 4 changes) plus the initial proportion. Table 5 shows the example of proportion for all varieties in each option. Each proportion option is simulated using an excel spreadsheet with columns according to system elements to obtain output in the form of profit per period.
3.7. Sensitivity and Error Analysis

In the error analysis, it can be seen the difference in profit generated by the initial conditions of the company with those generated by the pattern of cropping proportions based on the system modeling that has been made. Overall, the average difference between profit from existing conditions and profit from modeling is 2.43%. The difference can be said to be relatively small, so the model is concluded to have small error. In the sensitivity analysis, changes were made by increase and reduce IC1 value (+2%, +4%, +6%, -2%, -4%, -6%), and increase and reduce HC1 value (+2%, +4%, +6%, -2%, -4%, -6%). Based on the sensitivity analysis, it is known that the output of the model will change if the system parameters (IC1 and HC1) change, but the changes are relatively small which is below 6%.

3.8. Discussion

After the simulation calculation for all seed varieties in all options the proportion of planting in the first planting was obtained by the option that gave the highest profit in the first planting, namely the 4th option and the 28th option (as shown at Table 5). The proportion of planting for second, third and fourth planting uses the same calculation as the calculation for the first planting. Table 6 shows the simulation results of the most optimal planting proportions for all plantings.

| No. | Varieties | 1st | 2nd | 3rd | 4th | 25th | 26th | 27th | 28th |
|-----|-----------|-----|-----|-----|-----|------|------|------|------|
| 1   | Makoto    | 17.11% | 16.37% | 15.22% | 10.47% | 4.55% | 4.60% | 4.68% | 5.00% |
| 2   | Kinka     | 11.08% | 11.17% | 11.30% | 11.85% | 3.49% | 3.54% | 3.60% | 3.88% |
| 3   | Nana      | 9.51%  | 9.59%  | 9.71%  | 10.23% | 3.59% | 3.63% | 3.69% | 3.93% |
| 4   | Tsubasa   | 7.38%  | 7.45%  | 7.57%  | 8.04%  | 3.23% | 3.26% | 3.31% | 3.51% |
| 5   | Kirameki  | 7.00%  | 7.07%  | 7.17%  | 7.61%  | 3.15% | 3.18% | 3.21% | 3.37% |
| 6   | Hibiki    | 6.09%  | 6.15%  | 6.24%  | 6.64%  | 2.63% | 2.65% | 2.68% | 2.80% |
| 7   | Aki       | 11.55% | 11.64% | 11.79% | 12.38% | 2.48% | 2.49% | 2.51% | 2.59% |
| 8   | Hana      | 4.91%  | 4.97%  | 5.05%  | 5.41%  | 2.24% | 2.24% | 2.25% | 2.29% |
Based on the optimal planting proportion of the simulation results, it is known that the optimal proportion is not the same as the initial proportion that can be directly obtained by the formula of ordinary proportions. This shows that this research provides a better solution compared to the calculation of ordinary proportions. Nonetheless, modeling a system with a simpler calculation may make it easier to implement on a real system.

4. Conclusion
System modeling to determine the most appropriate proportion of planting to determine optimum profit can be done by designing a mathematical model and running simulations based on inputs: inventory quantity, costs, and planting capacity. The optimal planting proportion resulted from this study has found in the results section. The optimal proportion yields profit of IDR. 95,036,354.42 for the first planting, IDR. 101,520,387.46 for the second planting, IDR. 107,916,538.29 for the third planting, and IDR. 81,505,504.02 for the fourth planting, so the total profit is IDR. 385,779,274.19. The next research can be done by reducing some of the assumptions in this study, so that the model obtained is more representative of the real system.

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