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Optimization of Organic Rice Production using Linear Programming Analysis in Lampung Province

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ABSTRACT

This research aims to determine the optimization model of production and maximum profit of farming and determine the optimal allocation of production resources. The research was conducted in Pringsewu and Lampung Selatan Districts. The respondents are 20 organic rice farmers. The research method used is a quantitative method using the Linear Programming analysis method using POM-QM for windows 3.0 helper software. The result shows that Linear Function for Z max objective = 30,573X1 + 16,906X2 + 1,500X3 where X1, X2, and X3 are organic rice, non-organic rice, and soybean. The optimal farming production only produces organic rice with a planting area of 19.2713 hectares, and the maximum profit obtained is Rp.589,181,300,-. The optimization model of organic rice farming production is Max Z = 30573X1. The use of resources of land, labor, and seeds is not optimal yet or unutilized. The availability is at the farmers' level of excess so that under optimal conditions, labor and seeds need to be added to the existing stock. The allocation of used capital resources shows that its use has been optimal, and if the farmers increase the capital utilization by 1 unit, it will increase the business profit by Rp 2.282,-.

Keywords: Linear Programming, Organic Rice, Production Optimization.

INTRODUCTION

Food security is one of the development goals in Indonesia. Food security is described as how many available foods can cover every household's needs (Cotula, Djire, Tenga, 2008). Additionally, the National Food Security Framework is based on food availability, supply stability, and food access (Hariyadi, 2010). Thus, the need for food is always increasing as the population is also growing. Handayani (2016) said that the major food in Indonesia is rice, cassava, and maize. Rice has a strategic role in economic policy as it is one of the primary ingredients in Indonesia. Therefore, the indicator can be seen from how much rice is available and how good the quality and quantity of it is. Therefore, modern agricultural techniques began to be applied with the use of chemical fertilizers and pesticides to increase the number of rice products. The negative impact of the use of chemical pesticides such as the occurrence of environmental pollution, agricultural land becoming increasingly barren, pests becoming resistant, pesticide residue in plants by 30%, water, soil, and negative impacts on human safety and health (Handayani, Anggraini, & Yolandika, 2019). Problems concerning food safety, environmental condition, health, micro farmer's welfare, physical and chemical degradation of paddy fields, and concerns about food security are behind the development of organic farming.

Public awareness to consume safe and healthy foods, about 80% of the population aged 18-24 years and 75% of the population aged 35-49 years consume organic products (Handayani, Affandi, & Astuti, 2018; Duram, 2010). The sales data of organic products showed a fairly high growth, reaching 17-25%, much higher than the conventional product sales growth of only 2-3%. Organic agriculture has different concepts from conventional farming in terms of soil fertility, seed use, pest management, plant diseases, product quality, and production stability (Siahaan, 2009).

Organic farming is becoming popular in Southeast Asia as part of a sustainable agriculture system (Affandi & Handayani, 2020). In Indonesia, organic farming has been re-socialized since 2010 with the Go Organic 2010 government program. Organic rice business development efforts are still being improved by the government, including the government budgeting organic fertilizer subsidy of 11.75 million tons with a budget of Rp. 11,86 trillion and the Strategic Plan of 2015-2019 concerning the organic village of food crops and organic fertilizer processing unit (Ministry of Agriculture, 2018). Long-Term Agricultural Development Plan Policy 2002-2025 Ministry of Agriculture, its content seeks to realize a high-value farming system through intensifying and zoning superior commodity development. Optimizing land use, such as intercropping, is one of the efforts to increase the productivity of the unified land area, which is expected to increase farmers' income (Handayani et al., 2019). Farmers' income strongly influences the success of farming, and the amount of income depends on the productivity of the farm, the use of cropping patterns, and the allocation of resources such as labor, land, and capital optimally. Lampung Provincial began cultivating organic rice in 2010 with a planting area of 65.78 hectares and spread in Pringsewu Regency, South Lampung Regency, Centre Lampung Regency, and Tanggamus Regency (Lampung Province Agriculture Office, 2014). The development of organic rice production can still be improved with priority areas of development in the Pringsewu and South Lampung Districts. It can be seen from 23,611 hectares of rice planting area and 88,129 hectares in each regency, which can be expanded with various agriculture extensification programs. According to that data, there is a huge potential to develop organic rice.

The number of farmers who grow organic rice does not develop as expected, the extent of organic rice planting can explain this is not large, and some are still used for the cultivation of non-organic rice and other commodities. The results of Minh, Ranamukhaarachchi, and Jayasuriya (2007) explain that the reason for the lack of development of agriculture with the organic system is the lack of human resources and the time required to make compost as inventory and the transition from chemical to organic takes a long time. Farmers have not dared to plant fully organic rice because the market does not absorb the risk of organic products. The cropping pattern applied by farmers in Lampung Province (organic, non-organic, and *gadu* plant) is a double cultivation pattern that plants these three commodities during the same planting season but on a separate plot (Handayani, Affandi, & Astuti, 2018). The varying income level of the cropping pattern makes it difficult to know the maximum benefits achieved from the combined farming of these three commodities. Thus, the opportunity to increase productivity can be done by optimizing land use with a diversification system and minimizing the use of resources such as seeds, labor, and capital without changing the optimal value of income which is the main goal in every farming. Information on the organic rice production optimization model is needed so that farmers can determine organic rice planting patterns for profit maximization of farming.

Organic rice cultivation in Lampung Province is less developed because most farmers use a double cropping system on adjacent land to plant various plants to anticipate the lower organic price. The management cropping system is becoming a major issue for most farmers, especially in maximizing revenue gains from managing resources. This time, farmers experienced break-even income and did not get any ideal profit. According to the above description, it is necessary to examine the optimization of organic rice farming in Lampung Province. Operational research is developing very heavily and is widely used for planning, financial planning and control, supply chain management, agricultural resource modeling, forestry planning, expansion planning of dairy farming, macroeconomic modeling and planning, and past cross-management. This study aims to examine the optimization model of production and maximum profit of farming and determine the allocation of production resources (land, labor, capital, and seed cost) for organic, non-organic rice, and soybean farming.

LITERATURE REVIEW

Organic farming is the management of agricultural production in which the cultivation technique relies on natural ingredients without synthetic chemicals to maintain soil fertility and production (IFOAM, 2005; FAO, 2007). The business development of organic rice is different from non-organic rice because of several things, such as the use of seeds, fertilizer, application of cultivation, the amount of production, and the selling price of products in the modern market (Nirmagustina & Handayani, 2020). The organic rice's position is outstanding, as anticipated before (Handayani & Affandi, 2019). Furthermore, organic rice farming reveals to be more effective than non-organic farming (Handayani, Anggraini, & Yolandika, 2019).

Linear Programming (LP) is the method with linear characteristics to determine an optimal solution by minimizing or maximizing the objective function against a set of constraints resources (Siswanto, 2007). In their research, Minh, Ranamukhaarachchi, and Jayasuriya (2007), LP was selected to formulate the appropriate resources by example composition of pig, buffalo, and green manures for fertilizer organic, which has optimum production because of the increasing fertility of the soil. Thus, they were intentionally created to optimize the livestock capacity of farmers following the availability of manure production for organic fertilizer. The research results show that the farmers can increase the sugarcane yield and improve soil fertility and productivity with the heat-compost prepared by using buffalo and green manures at a ratio of 3:7.

RESEARCH METHOD

The research was conducted from January to May 2019 (MT1). Data collection was in the Pringsewu Regency and South of Lampung Regency Lampung Province. The method of determining the location is using a purposive method to consider that the area has a large area of organic rice planting. Therefore, the selection of these locations is quite representative of the conditions for planting organic rice in Lampung Province.

The determination of respondents was done using a simple random sampling technique. The samples in this study were 20 organic rice farmers. The research uses survey methods, whose data is collected from a sample of the population to represent the entire population (Singarimbun, 2008). The data used are data from interviews and direct observations of organic rice farming activities, non-organic rice, and soybeans. The problem is then formulated in a linear program method and solved by the simplex method with the help of POM-QM software for Windows 3.0.

The LP is used as the quantitative mathematical analysis to examine and support agricultural research and systems decision-making. LP is a mathematical analysis technique aiming to optimize production that is limited to certain resource constraints for optimal solutions. The analysis step for determining the optimization of organic rice production using the LP equation model can be explained by identifying the problem by calculating total production costs, including fixed costs and variable costs.

Formulation of Linear Programming Model

The formulation of the Linear Programming Model consists of the formulation of decision variables, the formulation of function objectives of organic rice farming, and the formulation of resource constraints functions. Determine the decision variable. The decision variable used in this research is the number of farming systems for organic rice, non-organic rice, and soybean (Xi).

The LP models can maximize or minimize functions (Hillier & Lieberman, 2001). The maximizing model used in this study is explained below:

Determination of objectives function

Maximize $Z = \sum_{i=1}^{j} C_i X_i$

$Z = C_1X_1 + C_2X_2 + ... + C_nX_n$ ………………………………………… (1)

Determination of constraints

Resources in the form of land, labor, capital, and seed cost for each farming function are determined by the formula:

Eligible Constraints :

$b_{11}X_1 + b_{12}X_2 + ... + b_{1n}X_n$ (=, ≤, ≥) a_1 …………………………(2)

$b_{21}X_1 + b_{22}X_2 + … + b_{2n}X_n$ (=, ≤, ≥) a_2 …………………………(3)

$b_{m1}X_1 + b_{m2}X_2 + … + b_{mn}X_n$ (=, ≤, ≥) a_m ………………………(4)

$x_1, x_2, …, x_n \geq 0$

The limiting function can be either (=) or in equality (≤ or ≥). The limiting function is namely b constraint. Constants (both as coefficients and right values) in the constraint function and on the destination are said to be function parameters. The last inequality ($x_1, x_2, ..., x_n \geq 0$) shows non-negative limits (Nasendi & Anwar, 2010).

Variables:

- organic rice planting area	X1
- non-organic rice planting area	X2
- soybean planting area	X3

Constraints:

- land	a1
- labor	a2
- capital	a3
- seed cost	a4

Acceptance

- Organic profit	C1
- Non organic profit	C2
- Soybean profit	C3

Information:

b1 = availability of land b2 = availability of labor b3 = availability of capital
b4 = availability of seed cost

RESULTS

Model Formulation

The model formulation obtains the objective function model and the constraint function to maximize profits. The cost power used is fixed costs and variable costs. Revenue, production costs, and profit of each variable are shown in Table 1.

Table 1. Revenue, Production Cost, and Profit Farming

No	Variable	Revenue (Rp/ha)	Total Cost (Rp/ha)	Profit (Rp/ha)
1	Organic rice	43,756,343	13,183,343	30,573,000
2	Non-organic rice	28,751,612	11,845,612	16,906,000
3	Soybean	9,600,000	8,100,000	1,500,000

Table 1 shows the profit for each farm. Furthermore, The maximum profit function can be formulated as follows:

Maximize Z = 30,573X1 + 16,906X2 + 1,500X3 (Rp1,000/ha)………… (5)

Formulation of Constraints Function

Based on data obtained, the respondent farmers carried out 3 types of farming on their land. The use of production factors to produce products in one production cycle can be seen in Table 2.

Table 2. Farming Resources

No	Variable	Land (ha)	Labor (HOK)	Capital (Rp)	Seed cost (Rp)
1.	Organic rice	1	57	13,395,000	509,000
2.	Non-organic rice	1	35	11,846,000	625,000
3.	Soybean	1	40	7,500.000	300,000
	Resources	21.25	1,100	259,302,000	10,500,000

Several constraints that limit farming activities can be seen in the following constraint functions:

1. Land = a11X1 + a12X2 + a13X3 ≤ b1
= X1 + X2 + X3 ≤ 21.25 (Ha)

2. Labor = a21X1 + a22X2 + a23X3 ≤ b2
= 57X1 + 35X2 + 40X3 ≤ 1,100 (HOK)

3. Capital = a31X1 + a32X2 + a33X3 ≤ b3
= 13,395X1 + 11,846X2 + 7,500X3 ≤ 258,139…(Rp x 1,000)

4. Seed Cost = a41X1 + a42X2 + a43X3 ≤ b4
= 509X1 + 625X2 + 300X3 ≤ 10,500…... (Rp x 1,000)

The last inequality (X1 > 0, X2 ≥ 0, dan X3 ≥ 0) shows non-negative limits.

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DISCUSSION

Optimal Combination Products

According to data processing with the program POM version 3 for windows, then the results of an optimal analysis can be known (Matthews & Marzec, 2012). Optimal solutions consist of optimal combinations of products, resources, and sensitivity analysis (see table 3).

Table 3. The Optimal Combination of Products

Var	Value	Reduce Cost	Original Val	Lower Bound	Upper Bound
X1	19.2713	0	30573	19116.65	Infinity
X2	-	10131.53	16906	Infinity	27037.53
X3	-	15618.14	1500	Infinity	17118.14
			58		

Table 3 above explains that the maximum profit that can be obtained in farming is Rp589,181,300,- by planting only 1 type of product, organic rice (X1), planted on 19,2713 hectares. Non-organic rice products (X2) and soybeans (X3) should not be planted because they will increase operating costs equal to the value of reducing costs Rp10,131,530,- and Rp15,618,140,-. The production optimization model obtained on farming is: Maximize Z = 30573 X1. Based on Handayani, Noer, and Desfaryani's (2022) research, rice farming is more profitable than other farms on land because organic rice plants have a higher economic value. Prihtanti, Hartono, and Irham (2013) state that rice cultivation with organic systems tends to be better than an organic system, such as togetherness between farmers, soil quality maintenance function, biodiversity, reduction of environmental pollution, and farming profits. Subsequent research by Sari (2011) stated that more organic rice should be planted. This refers to the long-term impact on food security.

Sensitivity Analysis

Sensitivity analysis is needed to analyze the impact of changes in parameter values that include variable values and constraints on linear programs, such as changes in production costs or increasing profits.

Sensitivity of Profit Parameters on Base Variables (Cj)

After analyzing the profit parameters on the base variable (Cj) in one planting period, that to remain optimal is as follows:

1. Organic rice: 19,116,650 ≤ profit ≤ infinity
2. non organic rice: profit ≤ 27,037,530
3. Soybean: profit ≤ 17,118,140

The maximum benefit can be obtained if the respondent farmer is planting organic rice (X1); there is no limit (infinity). This means that the more land planted by organic rice, the greater the profits, and there is no maximum limit to profits to be gained. The lowest profit that the respondent farmers will obtain is Rp19,116,650,-. The maximum profit that can be obtained if farmers keep planting organic rice (X2) of Rp27,037,053,- and the lowest profit that can be obtained is no limit (infinity negative/loss). The maximum profit that can be obtained if farmers keep planting soybeans (X3) of Rp17,118,140,- and the lowest profit that can be obtained is no limit (infinity negative/loss).

Capacity Sensitivity Parameter (bi)

Capacity parameter sensitivity analysis (bi) is done to discover the minimum limit of resource availability which is the constraint, and the maximum limit of its availability to get the most optimal solution. Analysis of the status of farming resources can be seen in Table 4.

Table 4. Analysis of Resources Status

Constraint	Dual Value	Slack/Surplus	Original Val	Lower Bound	Upper Bound
Land	0	1.9787	21.25	19.2713	Infinity
Labor	0	1.5361	1100	1098.464	Infinity
Capital	-2.2824	0	258139	0	278500
Seed cost	0	690.9111	10500	9809.089	Infinity

Land (b1)

Land available for agriculture is becoming limited by industrialization, urbanization, and expansion of residential areas, so the need arises to maximize land productivity (Najim, Lee, Haque, & Esham, 2007). The condition of organic, non-organic rice farming and soybeans carried out by farmers in Lampung Province in the 2018 planting season shows optimal conditions if they can be planted within an area of 19.2713 hectares (1.9787 hectares have not been used). The minimum capacity of the land area that can be planted with organic rice is 19,2713 hectares and can be increased again without infinity. Land resources do not have dual values; this means that land resources do not have an opportunity cost, so adding land capacity will not result in the addition of optimal benefits. The research results of Nurani (2014) show that the amount of land used for non-organic rice farming is significant to profit. Therefore, the addition of land area will increase production and directly impact the sale of organic rice products.

Labor (b2)

Labor is the main resource of farming. The optimization of labor resources in farming shows the value of slack/surplus of 1.5361. It means that the labor resources at the level of the respondent farmers have excess status but have not been fully utilized in order to achieve optimal income from organic rice farming. The use of labor is at least 1,098 HOK and can be increased again without limit (infinity). Labor resources do not have dual values; this means that labor resources do not have an opportunity cost, so the addition of labor capacity will not result in the addition of optimal benefits. Similar research conducted by Prasetyani, Rafsanjani, and Rimantho (2017), shows that capital resources are not used up because the production capacity is not optimal. The results show that labor significantly affects the benefits of organic rice farming. However, the problem often is limited labor availability in agriculture. In-depth research to provide answers to labor issues conducted by Prayoga (2016), the large number of rural residents who continue to higher education, then choose comfortable jobs in cities. This has caused labor shortages in the agricultural sector which is considered less attractive and this has become a problem of sustainability for rice production in Malaysia.

Capital
Capital availability is important because capital is a factor in sustainable rice production. Most farmers are subsistence farmers, they are limited availability of capital. Capital will determine the success of the business because it involves purchasing inputs, labor costs, machine rental, and other high input costs. In this study, the use of capital is optimal (capital resources are used up). Capital has a dual value of 2.2824, it shows that this resource has an opportunity cost so that if the amount of capital is added to Rp.1 then the profit will increase by Rp. 2.282 which is Rp. 589,181,300 + Rp. 2,282= Rp. 589,183,582. Based on this, the respondent farmer should be increasing the use of capital so that the maximum business profit with a record of the use of other resources remains (ceteris paribus). Research by Najim et al. (2007) shows that the amount of capital has a significant effect on farming profits.

Seed Cost (b4)
The seeds used in this farming are converted into rupiah value considering the three seeds are obtained by farmers in different units. In optimal conditions, the costs incurred for procuring seedlings amounted to Rp. 9,809,089. The availability of rice seeds is excess and has a residual amount of Rp. 690,911. Labor resources do not have dual values, this means that labor resources do not have an opportunity cost so the addition of labor capacity or inventory will not result in the addition of optimal benefits. Research by Handayani et al (2019), that the use of seed costs can increase business profits and increase the number of seed costs by Rp. 1, - will increase profits by Rp. 24.8574, -.

Based on the description, it is appropriate for the farmers more attention to the type of plant being cultivated. If farmers want to get maximum profits, the step taken is to plant all the land owned by organic rice plants. The double planting system that is currently being carried out causes profits not to be maximized. If farmers start implementing a single planting system (organic rice), the use of resources will be efficient and directly impact the minimization of production costs. In addition, the use of production factors, especially capital, should be added because additional capital will increase optimum benefits for food security.

CONCLUSION

The results of the study show that the maximum profit that can be obtained in farming is Rp. 589,181,300,- by planting only organic rice on 19,2713 hectares. Non-organic rice products (X2) and soybeans (X3) should not be planted because they will increase operating costs equal to the value of reducing costs Rp. 10,131,530,- and Rp. 15,618,140,-. The production optimization model obtained on farming is: Maximize Z = 30573 X1. The allocation of resources for organic rice farming in the form of land, labor, and seeds is still not optimal or has not been fully utilized while the availability is at the level of excess farmers. In order for conditions of optimal use of resources, land use, labor, and seedlings need to be increased from the available inventory. Furthermore, the use of capital resources is used up, this shows that their use has been optimal and if the farmer increases the use of capital by 1 unit, it will increase the business profit by Rp. 2.282,-.

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DECLARATION OF CONFLICTING INTERESTS
The authors declared no potential conflicts of interest.

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