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# Organic Fertilizer Application using Leaf Waste According to Maejo Engineering Method 1

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## Abstract

This study aimed to find a solution for leaf waste management in area of Valaya Alongkorn Rajabhat University which has a lot of perennials by applying Maejo Engineering Method 1. The experimental design of making organic fertilizer from leaf waste consisted of the proportion of leaves in 3 piles. This work used different ratios between leaf waste and cow dung by ratio 3:1, 4:1 and 5:1, respectively. We analyzed the results and checked the quality according to the organic fertilizer standard method using criteria of the Department of Agriculture. The result found that organic fertilizers from leaf waste in different ratios, can be decomposed into high quality organic fertilizer within 60 days. Using mixed cow dung that is 1 to 5% less than the Mae Jo Engineering method 1 can save a lot of cost of cattle. The results of the comparison of the t-test between the organic fertilizers obtained from the three experiments revealed that there was a statistically insignificant difference at the 0.05 level of significant. The results of the analysis of fertilizer quality standards found that the organic fertilizers from leaf waste in this study have been high quality more than the Department of Agriculture's organic fertilizer standards. The ratio between the carbon to nitrogen value is 14.25. This means very good degradation conditions. Furthermore, the organic fertilizers contain heavy metal impurities at a level not exceeding the standard value. The net present value valuation and payback period found that the resulting organic fertilizer has a net present value of 1,130 Baht/unit of production when 400 kg. of leaf waste, 100 kg of cow dung, yielded fertilizer in the study equal to 200 kg. The results of this study can be developed to determine concrete waste management guidelines in the study area and lead to the formulation of waste management policies to meet the needs of the organization towards becoming a green university.

**Keywords :** leaf waste; organic fertilizer; cost-effective

## Introduction

The current situation of global resource use intensified in the management of waste pollution in various countries around the world, both in developed countries and developing countries. The problem of increasing amounts of solid waste from consumption, especially in large urban areas in various countries, reflects that there is still a large proportion of unmanaged organic waste in many countries, especially in countries where agriculture is the main income. For example, in Hanoi, where the proportion of organic waste is as high as 71%, it takes more than one technology to make organic fertilizer and it takes more than 6 weeks to get rid of Most of them come from educational institutions of different levels with a variety of activities [1]. In Thailand, there was 49% organic waste in Bangkok in 2014 [2]. Data on the amount of solid waste in Thailand by the Pollution Control Department in 2019 shows that the total amount of solid waste in the country is up to 28.71 million tons. The amount of solid waste that was disposed of properly was 9.81 million tons (34.20%), the amount of solid waste that could be used for 12.52 million tons (46.60%), and the amount of solid waste that was not properly disposed of was up to 6.38 million tons. (22.20%). The Master Plan under the National Strategy in 2019, issue, 18 addresses the actions to achieve the goal of effective waste management in the country according to international standards by reducing waste at source by campaigning to raise awareness for people and related sectors to jointly reduce the amount of waste from residential, schools or educational institutions, government offices Establishments, service establishments and hospitality activities. There often the source of large amounts of organic waste together with methods of supporting the use of products and services that promote production, including products that are environmentally friendly and can be reused many times [3]. In addition, there should be support and promotion of local groups or networks to manage the local solid waste with the capability and potential to manage waste in limited areas this corresponds to the concept of the circular economy system, which has the capacity and potential to manage waste problems in limited areas which is in line with the concept of the circular economy system. This research was conducted to create the value of leaf waste of Valaya Alongkorn Rajabhat University and economic valuation. The results of the study can be developed into the creation of the university's waste management policy in order to become a green university.

## Methodology

**Organic fertilizer production from leaf waste**

**1. The production of organic compost by Maejo 1**, engineering method is a convenient method for the maintenance of the fertilizer pile and using a fast fertilizer production period. In this study, the conversion efficiency of digestion at different conditions was studied by dividing the experiment according to the ratio of fertilizers in different proportions. Design and define the area of the base frame of the manure pile, size 2 x 2 square meters, bring the pile of leaf waste together to a height of about 10 centimeters, alternating with cow dung from fattening cattle according to the ratio given in Table 1. Leave it for 60 days without turning over the fertilizer pile. Water and humidify daily and fertilize piles once a week to create an air circulation system. In this study, the name In tree Fertilizer derived from the use of leaf waste in the study area was used as VRU Fertilizer (Valaya Alongkorn Rajabhat University : VRU). The experiment was designed by specifying the ratio of 3 ratios as shown in Table 1. The experimental site was located in the university area for the convenience of conducting the study.

**Table 1** Leaf waste cow dung ratio in experiment

| experiment | Amount of leaf waste (kg) | Cow dung (kg.) | Total (kg) | Ratio |
|---|---|---|---|---|
| 1 | 375 | 125 | 500 | 3:1 |
| 2 | 400 | 100 | 500 | 4:1 |
| 3 | 416 | 84 | 500 | 5:1 |

**Figure 1** Three piles of experimental fertilizers

**2. Preparing the Fertilizer Pile for the experiment (VRU Fertilizer).** Determination of the moisture level of the fertilizer pile is carried out in accordance with the procedure in the fertilizer production manual with a non-reversible method of the fertilizer pile. Use the method of observing and recording the results of the experiment every 7 days, watering every day, once a day to keep the fertilizer pile always moist. From the study by observation method of watering each fertilizer pile, it was found that the outer layer of the fertilizer pile was moist but the inside was still dry. Therefore, the organic fertilizer pile must be stabbed to add water to humidify the organic fertilizer pile so that the fertilizer pile has sufficient moisture for the decomposition process of Mix Culture microorganisms that exist in nature and in the experimental material [4]. In this experiment, the moisture content was about 60-70% and the air circulation was combined with the humidity for the microorganisms to be used in the fermentation process of more than 50% or more [5] which is a diverse group of microorganisms that come from fattened cow dung and from leaf litter. It was found that the most common groups were Gammaproteo bacteria, Pseudomonas and Enterobacteria, Bacillales and Actinobacteria. These are the most common groups in the process of making organic fertilizers [6]. The process of making organic fertilizer VRU consists of 2 main steps, first Step is humidification in the experimental fertilizer pile and the second step is to create a ventilation system in the experimental fertilizer pile. By the method of stabbing the fertilizer pile every 7 days with a stick or iron bar into a small hole to have a depth of the base of the fertilizer pile. Measure the distance between the air inlets about 40 centimeters, then add water to increase the humidity inside the fertilizer pile [7].

**3. Data analysis.** Quality inspection of fertilizers produced in all 3 piles and compared according to the standards of the Department of Agriculture. Use the submission of samples for laboratory analysis and compare the results with the organic fertilizer standards of the Department of Agriculture which consists of the physical and chemical properties of the fertilizer as shown in Table 2.

**Table 2** Physical properties and chemical properties according to organic fertilizer standards

| Numb | Attribute | Criteria |
|---|---|---|
| 1 | Fertilizer size | Not more than 12.5x12.5 mm. |
| 2 | Moisture content and volatile matter | not more than 35% by weight |
| 3 | Stone and gravel quantity | Larger than 5 mm, not more than 5% by weight |
| 4 | Plastics, glass, sharp materials and other metals | Set to none |
| 5 | organic matter | Not less than 30% by weight |
| 6 | pH value (pH) | 5.5 - 8.5 |
| 7 | Carbon to Nitrogen Ratio (C-N) | Not more than 20:1 |
| 8 | Conductivity (EC: Electrical Conductivity) | Not more than 6 dB/m |
| 9 | macronutrient content | - Nitrogen (Total N) not less than 1.0 percent by weight<br>- Phosphorus (Total $P_2O_5$) not less than 0.5 percent by weight<br>- Potassium (Total $K_2O$) not less than 0.5 percent by weight |
| 10 | complete degradation | more than 80 percent |
| 11 | heavy metal | - Arsenic, not more than 50 mg/kg<br>- Cadmium not more than 5 mg/kg<br>- Chromium not more than 300 mg/kg<br>- Copper not more than 500 mg/kg<br>- Lead not more than 500 mg/kg<br>- Mercury not more than 2 mg/kg |

Reference source: Government Gazette (2007)

**Economic cost analysis**

**1. Cost.** For this study refers to the cost of various activities, including the cost of experimental materials in a production activity, divided into two categories: fixed costs and variable costs. Fixed costs are costs with constant behavior, meaning total costs that do not change according to the level of production during a certain stage of production but the fixed cost per unit will change in a decreasing way if the production volume increases. In addition, fixed costs can be divided into 2 types: Committed fixed cost, which is fixed cost that cannot be changed in the short term, such as long-term lease depreciation and short-term fixed costs. Discretionary fixed costs are fixed costs that arise from time to time from meetings or decisions of the management such as public relations or research expenses. (2) Variable costs are costs that will have a total cost that changes in proportion to the change in activity level or production volume while the cost per unit will remain the same for every unit. Generally, variable costs can be controlled by the department or entity that caused the variable cost. In this study, referring to an agency affiliated with the university that conducts experimental activities.

**2. Net present value (NPV).** It is the sum of the adjusted net returns for the project time taking into account ongoing projects or starting to work, will it be worth it or not. That is, if the resulting NPV is greater than zero or positive. Shows that it is worth the investment, and in case the NPV value is negative or below zero, it means that the investment under the project is not worth it. It can be written as a formula for calculating as follows:

$$NPV = \sum_{t=1}^{n} \frac{B_t - C_t}{(1+i)^t}$$

NPV is Net present value of the project
$B_t$ is The return as of the year of computation
$C_t$ is The cost as of the year of computation
i is The discount rate
t is The age of the project

**3. Payback Period (PBP).** The duration of the investment in which the net cash inflows from the project are exactly the same as the net cash outflows or the investment has no profit and no loss, it is based on the cumulative net present value that changes from negative to positive [8].

**Statistics used for testing**

In this study Descriptive statistic was used which consisted of frequency, mean, percentage and standard deviation. Analyze and compare the results of the study with the quality level of fertilizers determined from various chemical properties according to the criteria with t-test independent for economic calculations [9].

The experimental and analysis process can be summarized as follows, as shown in Figure 2.

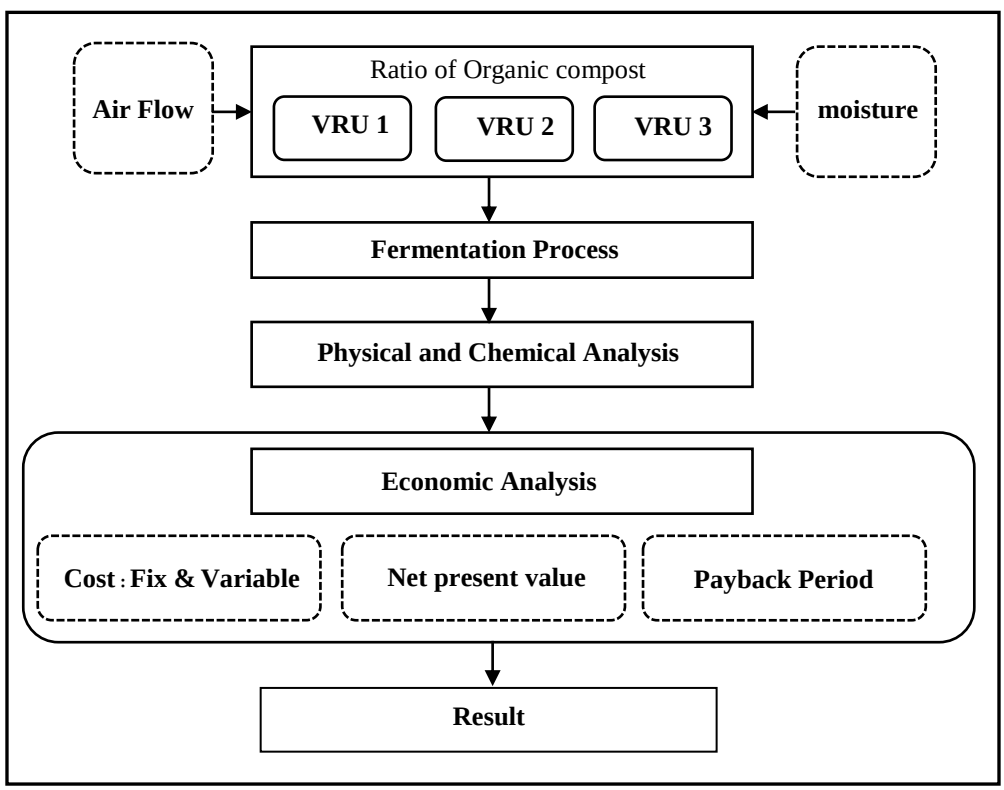


**Figure 2** Educational procedures and method

## Results and Discussion

### Quality Analysis of Organic Fertilizer (VRU Fertilizer)

Fertilizer analysis was based on formulas or ratios designed for each experiment. After 60 days of microbial decomposition process, stop watering, humidify the compost pile and reduce humidity by drying the organic fertilizer in sunlight and in a well-ventilated area for microorganisms to enter the resting process. Spread the fertilizer layer to a thickness of about 20-30 cm. After that, leave the time for the organic fertilizer to dry for 3-4 days. Then reduce the size to make it easier and more convenient to use by using a coarse grinder. Fertilizer samples were analyzed in the laboratory by standard methods to compare the quality of the 3 piles with the standard criteria and the method of analyzing organic fertilizer according to the standards of the Department of Agriculture [10]. The results of the analysis are shown in Table 3.

**Table 3** The results of organic fertilizer analysis were compared with organic fertilizer standards

| Analytical parameters | VRU 1 | VRU 2 | VRU 3 | Organic fertilizer standard |
|---|---|---|---|---|
| total nitrogen content (%) | 1.61 | 1.56 | 1.12 | not less than 1 |
| Phosphorus content (%) | 2.13 | 1.88 | 1.47 | not less than 0.5 |
| potassium content (%) | 1.02 | 0.89 | 0.71 | not less than 0.5 |
| Carbon to Nitrogen Ratio (C/N Ratio) | 13.24 | 14.25 | 15.77 | no more than 20 |
| Certified organic material (%) | 36.72 | 38.4 | 30.47 | no more than 30 |
| (pH) | 8.01 | 7.8 | 7.93 | 5.5 - 8.5 |
| Conductivity (dS/m) | 4.235 | 4.62 | 2.315 | no more than 6 |
| Arsenic (mg/kg) | 2.05 | 2.51 | 3.7 | not more than 50 mg/kg |
| Cadmium (mg/kg) | 0.59 | 0.71 | 0.92 | not more than 5 mg/kg. |
| Chromium (mg/kg) | 9.17 | 9.46 | 14.84 | not more than 300 mg/kg |
| Copper (mg/kg) | 50.32 | 46.99 | 32.81 | not more than 500 mg/kg |
| Lead (mg/kg) | 7.99 | 8.3 | 12.06 | not more than 500 mg/kg |
| Mercury (mg/kg) | ND | ND | ND | not more than 2 mg/kg |

From Table 3, the results of organic fertilizer analysis were compared with the 13 parameters of organic fertilizer standards. The results showed that the quality of VRU fertilizer passed the standards of the Department of Agriculture and there is also a trend of high quality especially in the three main nutrient groups, including the total amount of nitrogen, phosphorus content and potassium content. From the experiment, it was found that the nutrient content was very high, indicating that VRU organic fertilizer can be used in agriculture as efficiently as organic fertilizer or bio-fertilizer that has passed the same standard test. In addition, the results of other comparative analyzes also indicated that It is higher than the specified organic fertilizer standards as well. The results of the percentage analysis of macronutrients Shown in Figure 3.

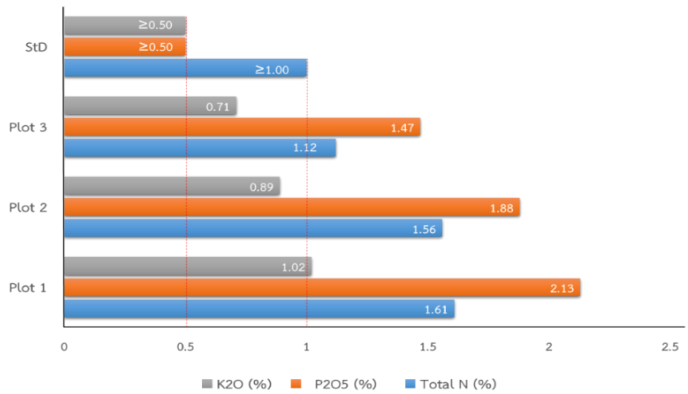


**Figure 3** Comparison of macronutrients of VRU organic fertilizers and organic fertilizer standards

**Note :** The red dotted line shows Reference point for organic fertilizer standards of the Department of Agriculture (2007)

From Figure 2, all 3 stacks of VRU organic fertilizers meet the standards of the Department of Agriculture according to the Government Gazette Fertilizer Act (No. 2 B.E. 2550). The results of checking the relationship by independent t-test to compare the differences of the three fertilizer piles found that the three fertilizer piles. It was found that the three fertilizer stacks were related in terms of chemical and physical properties for all 13 parameters. The significance level of 0.05 is shown in Table 4.

**Economic evaluation and presentation as a policy**

The economic valuation in this study was calculated in two parts: Payback Period (PBP) and Net Present Value (NPV). The results of the payback period calculation revealed that the payback period of biofertilizer production is very short. The payback period is only 1 month and 11 days to produce 600 kg of organic fertilizer (which comes from 300 kilograms of leaf waste and 300 kilograms of fattening cow dung). Total cost of VRU organic fertilizer production is 1,410 baht (It is the cost that comes from fattening cow dung and packaging only). In the production of organic fertilizer VRU from 3 piles of experiments, each experimental pile will yield a quantity of 600 kg of fertilizer per pile, a total of 1800 kg which can be packed in bags of 120 bags, size 15 kg per bag. When selling all fertilizers at a price of 40 baht per bag, a total return of 4,800 baht will be obtained.

**Table 4** Statistical correlation test of all 13 parameters analyzed per fertilizer pile

| The relationship of the 3 piles of VRU fertilizer | t | Sig. |
|---|---|---|
| VRU 1 – VRU 2 | 0.0037 | 0.9970 |
| VRU 1 – VRU 3 | 0.1987 | 0.8490 |
| VRU 2 – VRU 3 | 0.2009 | 0.8426 |

## Conclusion

In this study, there were 3 preliminary experiments in the test fertilizer piles to find the average to determine the most suitable ratio of fertilizer pile representatives. Starting from a total of 5 ratio to only 3 ratios are left for use as a representative study. Although the results showed consistent with the study report on composting piles by Maejo Engineering

Method 1 but the results of this study show that the amount of cow dung used did not show a statistically significant difference. Therefore, if conducting studies or composting in this way in areas where there is a shortage of cow manure or the need to reduce production costs as much as possible. Using cow manure at a lower rate than the Maejo Engineering Method 1 stipulates, it is possible to shred twigs and leaves without affecting the quality of organic fertilizers were also statistically significant. When considering the Carbon to Nitrogen Ratio (C/N Ratio), which represents the degradation rate of tree and leaf litter, it was found that VRU Organic Fertilizer Stacks 1, 2 and 3 had these values at 13.24, 14.25 and 15.77, respectively. It can be seen that when the amount of cow manure is different the degradation rates are similar and are still within acceptable levels according to the Department of Agriculture's organic fertilizer standard, which states that the C/N Ratio must not exceed 20. Economic value analysis shows great value for money in action. It also encourages the cost-effective utilization of leaf waste in line with the circular economy concept to focusing on Circular Supplies, which is the use of recycled materials and bio-based materials. The materials that can be reused entirely to be used as the main raw material in production to reduce the use of resources in production reduce waste. And more importantly, it is the use of renewable energy in the production process to the maximum benefit.

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