P. ISSN 2527-9629, E. ISSN 2548-6675
JOURNAL OF ENVIRONMENTAL ENGINEERING AND WASTE MANAGEMENT
In Collaboration With:
Managed by Environmental Engineering Undergraduate Program, School of Engineering, President University, Jl. Ki Hajar Dewantara, Kota Jababeka, Cikarang Baru, Bekasi 17550 – Indonesia.

The Study of Composting from Spent Coffee Grounds in Making Process Liquid Fertilizer

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Manuscript History

Received
10-05-2021
Revised
27-05-2021
Accepted
28-05-2021
Available online
28-10-2022

Keywords

spent coffee grounds;
Liquid Fertilizer;
Composting;
NPK

Abstract. Nowadays, coffee is one of needs among metropolitan people. This lifestyle impact to increasing waste along coffee production, one of them is spent coffee grounds. Spent coffee grounds has toxic properties to the environment such as caffeine, tannins, and polyphenols. While other chemicals contain on spent coffee grounds are 2.28% nitrogen, 0.06% phosphorus, 0.6% potassium, which means has a good impact to the soil. In existing condition, spent coffee grounds is commonly used to, biodiesel and bioethanol or by direct used to the soil. The processing of spent coffee grounds to be liquid organic fertilizer by using bio-activator are considered to substitute the direct used, it will improve the quality of soil. **Objectives:** The objective of this research is to study of liquid fertilizer from spent coffee grounds, whether comply or not to the standard regulation Ministerial Decree of Agriculture of the Republic of Indonesia Number 261/2019. **Method and results:** This research use a spent coffee grounds from *arabica* and *robusta* coffee and applied 2(two) different dilution by repeated 2x2 on one time by using EM4 as bio-activator. The pH and temperature for 4 experiments measured daily and has an average on 4.8 and 31-degree celcius for 10 days. Nitrogen, Phosphorus, and phosphor measured in the end of experiment has average results on 0.18, 0.17, 0.04, sequentially. **Conclusion:** The result for chemical parameter; Nitrogen, Phosphorus, and phosphor has not comply to the standard of liquid organic fertilizer by Indonesia Government.

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1 Introduction

1 Backgrounds

Currently coffee is a lifestyle among young people, this trend then moves linearly with the number of coffee shops. This phenomenon gives an impact to the growth of coffee bean production in Indonesia. Data from the Indonesian Minister of Agriculture stated that coffee ore production increased by 5.31% in 2018 [1]. According to data from the Central Statistics Agency in 2019, the amount of coffee production in Indonesia reached 742 tons with a total of 98.6% coming from smallholder plantations [2]. The founder and chief executive officer 'Kopi Kenangan' Edward Tritanata said the company saw a more than 50 percent increase in online sales during the Covid-19 period [3]. The increasing demand for coffee has triggered the emergence of processed coffee waste, in the form of spent coffee grounds. Generally, one regular cup of coffee results in 20 grams spent coffee grounds. In the case of 'Kopi Kenangan' who sales in average 500 cups per day per store, means that one store produces approximately 10.000 grams spent coffee grounds per day [4]. The spent coffee grounds has toxic properties to the environment such as caffeine, tannins, and polyphenols, additionally the large amount oxygen is needed to degrade it [5]. As an alternative purpose of spent coffee grounds are widely used for recycling to be biodiesel, bioethanol, and carbon active [6,7,8]. In the agricultural sector spent coffee grounds is used to improve agricultural quality yields. This is done because spent coffee grounds contain 2.28% nitrogen, 0.06% phosphorus, 0.6% potassium, and other compounds such as magnesium, sulphur, and calcium which are nutrient to the soil [9]. Considering the waste condition in the form of organic waste, the spent coffee grounds mainly discarded to the trash and ended up in landfill. This shows spent coffee grounds contribute to organic waste amount that reached 4552.6 tons/ day in Jakarta [28]. One of solution to upgrading the spent coffee grounds quality is by doing composting and make it as liquid fertilizer.

Liquid fertilizer is used to increase nitrogen in the soil. Nitrogen is the main constituent of protein for plants, although most of the nitrogen elements in nature are 'inert' so they cannot be used directly by plants [27]. In fact, nitrogen has an important role in encouraging rapid plant growth, improving crop yields and quality of plant [27]. Study in Bekasi, Indonesia showed the use of a liquid organic fertilizer from fermented oil palm fruit fiber increased nitrogen absorption by mustard plants by up to 24 percent while also improving soil chemical properties such as pH, organic C, and total N [10].

Liquid fertilizers are usually insoluble in water, and nutrients are released slowly as microorganisms transform them to soluble form. Liquid organic fertilizer has been widely used in hydroponic plants due to its abundance of macro- and micronutrients for plant growth [20]. There are two types of liquid fertilizer if distinguished from the base material; an-organic and organic. The liquid organic fertilizer is generally used municipal waste and livestock waste as their based ingredient while liquid an-organic fertilizer has chemical content as based material [11].

Composting is a process of decomposing compounds contained in the remaining organic matter with a special treatment. Composting also a form of biodegradable that has grown in popularity over time. This is one method of processing spent coffee grounds that can be done by utilizing microorganisms. The method includes a variety of microorganisms and is based on natural biological decomposition of organic components. EM4 is an addition substance to optimize the utilization of food substances because the bacteria contained in EM4 can digest cellulose, starch, sugar, protein, fat [13]. EM4 contains 90% of Lactobacillus sp. (lactic acid producing bacteria) phosphate solvent, photosynthetic bacteria, Streptomyces sp, cellulose-decomposing fungi and yeast [13]. EM4 mixed with molasses or sugar as raw materials to utilized the plasmolysis process to ferment liquid organic fertilizer. Plasmolysis process is situation, the plant cell autolyzed, releasing organic matter such as amino acids and carbohydrates inside the cell.

Microorganisms weakened these compounds in the presence of natural contaminants in the substrate, producing amino acids, hormones, and enzymes [20].

1.2 Problem Statement

The problem statement of this paper is the liquid fertilizer from spent coffee grounds comply with standard regulation for liquid fertilizer; Ministerial Decree of Agriculture of the Republic of Indonesia Number 261/2019?

1.3 Objectives

The objectives of this paper to determine whether liquid fertilizer from spent coffee grounds comply with the Ministerial Decree of Agriculture of the Republic of Indonesia Number 261/2019

1.4 Scope and Limitation

This final project has been conducted under the following scopes:

(1) Independent variable for this research is the amount of water volume on EM4 Bio-activator,
(2) Dependent variable of this research is the liquid fertilizer contents; Physical parameter (pH, temperature, and color) and chemical parameter (N - Total, Phosphorus, and Potassium),
(3) Control variable are the 220 grams spent coffee grounds.

In conducting this research, there are several limitations to be considered:

(1) This experimental was done on March 2021
(2) Composting process is done 10 days by using plastic jar
(3) Effective Micro-organism 4 from PT Songgolangit Persada is used in this process
(4) Used 2(two) differences volume of water

(5) Quality analysis is done by 'Balai Pengujian Mutu Produk Tanaman, South Jakarta'

(6) The experimental research done 2x2 at the same time.

2 Method

2.1 Research Framework

The stage had to be done in this experimental research shows in Fig. 1

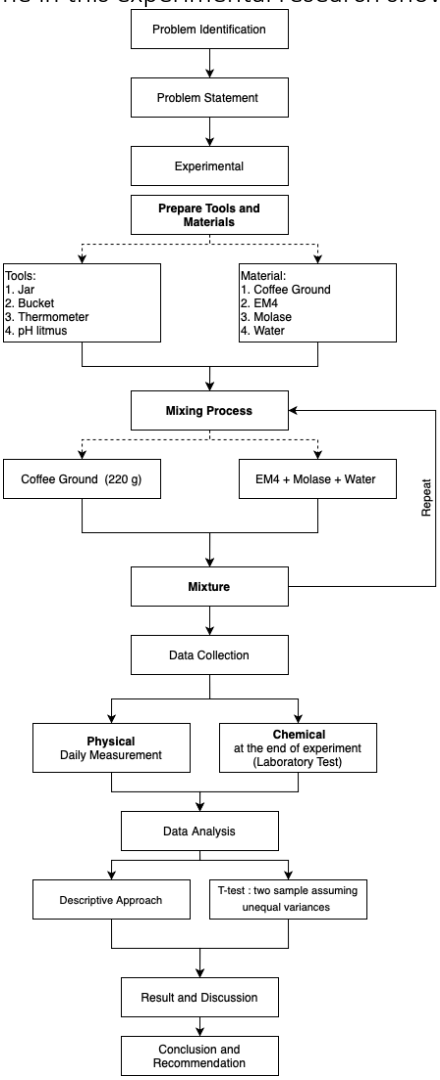

Fig. 1. Research Framework.

The population of this research is liquid organic fertilizer from spent coffee grounds and EM4 Bio-activator, whereas the sample are taken with random sampling that through quality test for both physical and chemical quality test.

2.2 Data Collection Method

2.2.1 Environmental Primary Data Collection

The data was collected using observation method. This research was done from March to April 2021. Firstly, the spent coffee grounds are collected from 'Kopi Kenangan' which contain Arabica coffee and Robusta coffee. Whereas in this research, the experimental design used is Completely Randomized Design (CRD). CRD means the experiment container used on this research is same or homogeneous. The experiment had done twice on the same time (2x2). The physical and chemical parameter would be measured on this experiment. There are 4 physical parameters; temperature, pH, color, and odor which was checked every day [12]. Whereas the three chemical parameters were Nitrogen, Phosphorus, and Potassium, which would be measured at the end of composting process [12].

2.2.2 Experimental Method

The experimental for composting process had done by following steps [23]:

(1) The base ingredients (spent coffee grounds) are divided equally by 220 grams in each container
(2) Put the EM4 Bio-activator had been process by the step on the instructions use with the ratio 1 : 1 : 50, which are 100 ml EM4 : 100 ml molasses : 5 L water and 1 : 1 : 60, which are 100 ml EM4 : 100 ml molasses : 6 L water.
(3) Keep it on the closed container
(4) Open the container once a day to give off fermentation gas and measure the pH

(5) Leave it for 10 days [23] and filter the result of fermentation from base ingredients.

Table 1. Experimental Dosage

Formula	Based Ingredient			EM4	
	Amount	Unit	Dose	Amount	Unit
Formula A	220	g	1 : 1 : 50	1500	ml
Formula B	220	g	1 : 1 : 60	1500	ml

2.2.3 Composting Process and Quality Test

Composting has been done for 10 days, along pH, temperature, color, and odor is checked on daily at 14.00. The pH is measured by litmus paper and temperature is measured by mercury temperature. This is done to determine the composting is still processing. While the chemical parameter is measured after ten days and done by Balai Pengujian Mutu Produk Tanaman, East Jakarta.

2.3 Data Analysis Method

The result of temperature, color, and odor will used descriptive research to explain the condition of liquid fertilizer. Processing primary data in the form of experimental with a laboratory measurement, then analyzed using statistics by using t-test analysis. The t-test determines the difference in the population mean value with the significant level is 0.05 (5% error rate and 95% confidence level) [16]. P one-tailed will be used on this study to determine the difference between groups in a specific direction [26]. The hypothesis to be tested in this research by using the t test is the minimum standard of pH, nitrogen, phosphorus, and kalium for liquid organic fertilizers in Ministerial Decree of Agriculture of the Republic of Indonesia Number 261 of 2019. It can be conclude the standard of pH is 4, means the hypotheses are:

H_O: μ pH ≥ 4, pH comply to the standards significantly against the Ministerial Decree of Agriculture of the Republic of Indonesia Number 261 of 2019.

H_a: μ pH < 4, pH do not comply to the standards significantly against the Ministerial Decree of Agriculture of the Republic of Indonesia Number 261 of 2019.

Meanwhile, the minimum standard of nitrogen, phosphorus, and potassium onMinisterial Decree of Agriculture of the Republic of Indonesia Number 261 of 2019 is 2%, means the hypotheses are:

H_O: μ x ≥ 2%, chemical parameters comply to the standards significantly against the Ministerial Decree of Agriculture of the Republic of Indonesia Number 261 of 2019.

H_a: μ x < 2%, chemical parameters do not comply the standards significantly against the Ministerial Decree of Agriculture of the Republic of Indonesia Number 261 of 2019.

Table. 2. Liquid Fertilizer Specification

(Ministerial Decree of Agriculture of the Republic of Indonesia Number 261/2019)

No.	Parameter	Unit	Type	
			Soil	Liquid
1.	C-organic	%	minimum of 15	minimum of 10
2.	Macronutrient $N + P_2O_5 + K_2O$	%	≤ 25	2 – 6
3.	N-organic	% (w/v)		minimum of 0.5
4.	Micro nutrient			
	Fe total	ppm	maximum of 15000	90 – 900
	Mn total	ppm	–	25 – 500
	Cu total	ppm	–	25 – 500
	Zn total	ppm	maximum of 5000	25 – 500
	B total	ppm	–	12 – 250
	Mo total	ppm	–	2 – 10
5.	pH	–	4 – 9	4 – 9
6.	E.coli	cfu/ml MPN/ml	$< 1 \times 10^2$	$< 1 \times 10^2$
	Salmonella sp	cfu/ml MPN/ml	$< 1 \times 10^2$	$< 1 \times 10^2$

No.	Parameter	Unit	Type	
			Soil	Liquid
7.	Heavy metal			
	As	ppm	maximum of 10	maximum of 5.0
	Hg	ppm	maximum of 1	maximum of 0.2
	Pb	ppm	maximum of 50	maximum of 5.0
	Cd	ppm	maximum of 2	maximum of 1.0
	Cr	ppm	maximum of 180	maximum of 40
	Ni	ppm	maximum of 50	maximum of 10
8.	Other elements/compounds			
	Na	ppm	maximum of 2000	maximum of 2000
	Cl	ppm	maximum of 2000	maximum of 2000

3 Results and Discussion

3.1 Physical Parameter

3.1.1 Temperature

Measurement of temperature has done daily for 10 days. Along composting process, all treatment has same initial temperature with 31.5-degree celcius and decrease to 31-degree celcius on second day. Almost all treatment has stagnant temperature for along 10 days. Almost other treatments are close to 30°C, that is considered to be close to the soil temperature [18]. Keep the soil temperature was important to has balance of energy input (short wave) and output (long wave), which varies continuously on a daily and seasonal basis. Soil temperature affects plant nutrient absorption in the short term through effects on soil water, chemical reaction rates, and nutrient transport [21].

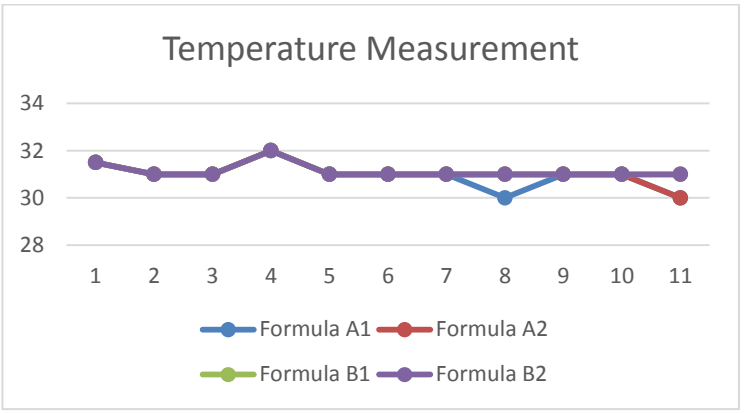

Fig. 2. Temperature Measurement

3.1.2 Color and Odor

Color and odor were checked daily. There is no odor from first until third day, whereas the fourth day the odor changed into acid for treatment A1 and rotten or soil smell for other treatment. While the color from first until forth day are dark brown, this happened because of the color of EM4 and the mixing with spent coffee grounds.

(a)

(b)

(c) (d)

Fig. 3. Color of Liquid Organic Fertilizer:
(a) Treatment A Trial 1 (b) Treatment A Trial 2 (c) Treatment B Trial 1 (d) Treatment B Trial 2

3.1.3 pH

pH measurement done with litmus paper. The EM4 has an initial pH 6 before mixing with spent coffee grounds. After mixing process, the pH is decrease to 5 and going to 4 on 4^{th} days. It may be due to the acidic nature of the spent coffee grounds. The graphic of pH value during the decomposition process of organic matter can be seen in **Figure 4.** In general, for all treatments, at the beginning of the decomposition process of organic matter, the pH value decreases and then the pH value going stable until the last day. The pH value drops at the beginning of the process of decomposing organic matter due to the activity of bacteria that produce organic acids such as lactic acid, acetic acid or pyruvic acid. The formation of these organic acids is the result of the breakdown of organic material into lactic acid by the bacteria Lactobacillus sp [19]. The final pH value of the decomposition process of organic matter is acidic at a pH value of 5, whereas in the A1 treatment the pH value decreases from day 9 and 10, pH value 4 and 3, respectively.

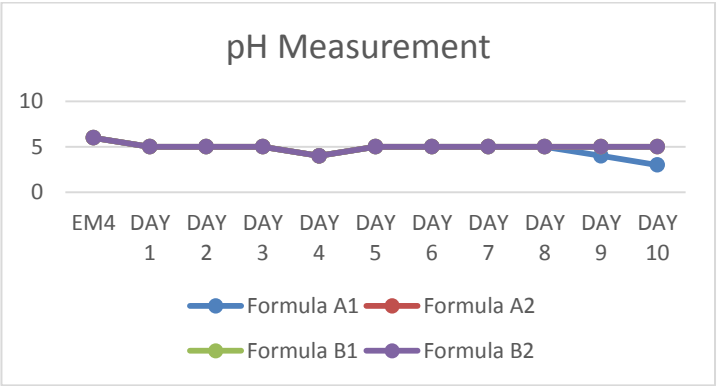

Fig. 4. pH Measurement

The t-test result on **table 3** shows the P(T<=t) one-tail value is more than alpha (α = 0.05). So, it can be conclude the H_o is accepted and H_a is rejected. According to Ministerial Decree of Agriculture of the Republic of Indonesia Number 261/2019 for liquid organic fertilizer the number of pH is normally has good quality, which comply to standard on range 4 - 9.

Table 3. pH Result

	Formula A1	Formula A2	Formula B1	Formula B2
Mean	4,72727273	5	5	5
Variance	0,61818182	0,2	0,2	0,2
Observations	11	11	11	11
Pooled Variance	0,61818182	0,1	0,1	0,1
Hypothesized Mean Difference	0	0	0	0
df	10	20	20	20
t Stat	0,88561489	7,41619849	7,41619849	7,41619849
P(T<=t) one-tail	**0,19831071**	**1,8411E-07**	**1,8411E-07**	**1,8411E-07**
t Critical one-tail	1,81246112	1,72471824	1,72471824	1,72471824
P(T<=t) two-tail	0,39662142	3,6822E-07	3,6822E-07	3,6822E-07
t Critical two-tail	2,22813885	2,08596345	2,08596345	2,08596345

3.2 Chemical Parameter

3.2.1 Nitrogen Total

Table 4 shows the result of treatment on Formula A which contain 50 ml of water and Formula B contain 60 ml of water. The treatment on trial A and B shown the range of Nitrogen are 0.16 - 0.25%.

Table 4. Nitrogen Result

	Unit	Formula A	Formula B	Regulation of Nitrogen
Trial 1	%	0,25	0,16	2 - 6
Trial 2	%	0,16	0,159	2 - 6

Data analysis by using t-test: two sample assuming equal variances shown the P(T<=t) one-tail value is less than alpha (α = 0.05). It can be concluded the H_a is accepted.

Table 5. T-test for Nitrogen

	Formula A	Formula B
Mean	0,205	0,1595
Variance	0,00405	5E-07
Observations	2	2
Pooled Variance	0,00405	5E-07
Hypothesized Mean Difference	0	0
df	1	1
t Stat	-23,0298607	-2125,2263
P(T<=t) one-tail	**0,01381294**	**0,00014978**
t Critical one-tail	6,31375151	6,31375151
P(T<=t) two-tail	0,02762588	0,00029955
t Critical two-tail	12,7062047	12,7062047

It can be caused by the composting process and raw material. There are possibility of nitrogen evaporating due to poor compost packaging or cover along composting process that affect the lower number of Nitrogen [23]. Besides, the research conducted in Denpasar, shown the composting with the basic ingredients of spent coffee grounds mixing with EM4 also did not meet the standards, with an average nitrogen yield of 0.08% [22]. Number of nitrogen content can be higher by adding inorganic fertilizers or by adding organic materials with high nitrogen content such as animal urine, legume plants and *azola pinata* [23].

3.2.2 Phosphorus

The laboratory findings are shown in the table alongside the national norm criterion on minimum phosphorus number is 2%, while the Formula A and B show the result 0,07 - 0,40% as shown in **table 6.**

Table 6. Phosphorus Result

	Unit	Formula A	Formula B	Regulation of Phosphorus
Trial 1	%	0,40	0,07	2 - 6
Trial 2	%	0,11	0,10	2 - 6

The minimum national norm for Phosphorus is 2 percent. The t-test result is shown on **table 7** show P(T<=t) one-tail value is less than alpha ($\alpha = 0.05$).

Table 7. Phosphorus Result

	Formula A	Formula B
Mean	0,255	0,085
Variance	0,04205	0,00045
Observations	2	2
Pooled Variance	0,04205	0,00045
Hypothesized Mean Difference	0	0
df	1	1
t Stat	-6,9481119	-73,708384
P(T<=t) one-tail	**0,04549998**	**0,00431824**
t Critical one-tail	6,31375151	6,31375151
P(T<=t) two-tail	0,09099997	0,00863648
t Critical two-tail	12,7062047	12,7062047

This demonstrates that each treatment's phosphorus content not met the regulation Ministerial Decree of Agriculture of the Republic of Indonesia No. 261/2019. The lower of Phosphorus content may triggered from the time of composting process. Based on previous research the results of the analysis of variance in total phosphorus content, it is known that the composting time significantly affects the total phosphorus content [23]. One of the factors that can

support the existence of significant differences in total phosphorus content with different composting times is due to the microbial activity of Lactobacillus sp., Streptomyces sp., As cellulose and yeast decomposing fungi that can change phosphorus thereby affecting the increase in total P content. The longer of composting time, the more nutrients or food used for the activity of microorganisms and affect the availability of nutrients will run out and lead to death in micro-organisms, so that in this phase the activity of microorganisms in breaking down organic compounds will decrease and the result will be a lower phosphorus content than before [24].

3.2.3 Potassium

According to the Ministerial Decree of Agriculture of the Republic of Indonesia No. 261/2019 shown that potassium does not meet the standard. The treatment on formula A and B shown the range of Nitrogen are 0.03 - 0.05%, while the minimum number is 2%. The result of treatment is shown on **Table 8.**

Table 8. Potassium Result

	Unit	Formula A	Formula B	Regulation of Potassium
Trial 1	%	0,04	0,05	2
Trial 2	%	0,03	0,04	2

The t-test: two sample assuming equal variances is done by using $\alpha = 0.05$. The result on **table 8** shown the P(T<=t) one-tail value is less than alpha, it can be concluded the H_0 is rejected and H_a is accepted means the potassium has not complied the regulation which is Ministerial Decree of Agriculture of the Republic of Indonesia No. 261/2019 as shown in **fig 2.**

Table 9. T-test Potassium Result

	Formula A	Formula B
Mean	0,035	0,045
Variance	5E-05	5E-05
Observations	2	2
Pooled Variance	5E-05	5E-05
Hypothesized Mean Difference	0	0

	Formula A	Formula B
df	1	1
t Stat	-226,8986558	-225,74396
P(T<=t) one-tail	**0,001402863**	**0,00141004**
t Critical one-tail	6,313751515	6,31375151
P(T<=t) two-tail	0,002805727	0,00282008
t Critical two-tail	12,70620474	12,7062047

The low number of potassium may triggered from the potassium number of spent coffee grounds itself, which contain 0.6% value. Study on 2017 proved that the treatment with the addition of the dose of raw material with the highest potassium value resulted in liquid organic fertilizer with a higher potassium content than the treatment with raw material with a small potassium value [25]. One of raw material that has highest potassium value is straw with value 1.4% - 2% [25].

4 Conclusions

This research shows the pH number is comply to the Ministerial Decree of Agriculture of the Republic of Indonesia Number 261 of 2019 on range 4 - 9. Meanwhile the total Nitrogen, Phosphorus, and Potassium content in liquid fertilizer from Arabica and Robusta spent coffee grounds using EM4 after composting process is the lower than alpha. This shows the number of contents does not comply to the standard regulation who has standard minimum for liquid organic fertilizer 2% for Nitrogen, Phosphorus, and Potassium. It is recommended for this treatment can be optimize by do the time variances of composting process and added another based material to increase the result of Nitrogen, Phosphorus, and Potassium.

5 Acknowledgement

Thanks to most valuable lecturer Ms. Yunita Ismail and Ms. Temmy Wikaningrum for advice and patience.

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