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Development of Organic Fertilizer from Banana Peel, Egg Shell and Yeast for The Effective Growth of Chili Plant

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Abstract: In Malaysia, food waste is the most common type of waste. Organic fertilizer made from food waste can assist Malaysia to minimize its food waste production. Banana peel and egg shell were utilised to generate an organic fertiliser in this study. Banana peel is high in biomass fiber, nitrogen, potassium, and phosphorus, all of which are essential components of organic fertilizer. Phosphate and calcium, which become essential for plant growth, are found in egg shells. While yeast contains nutritional, efficient and able to improve soil in plants. In this study, the performance of organic fertilizer was determined using chilli plant in this study. The efficiency of organic fertilizer and pH value were measured by the growth parameters of chilli plants such as height and total number of leaves were. Fourier-Transform Infrared Spectroscopy (FTIR) was used to determine the composition of the soil while the soil while pH meters was used to measure the acidity or alkalinity of soil. It was observed that the optimum amount of banana peel, egg shell and yeast is 1.6g, 6g and 1g at pH value 7.1.

Keywords: Organic Fertilizer, Banana Peel, Egg Shell, Yeast, Plant Growth.

1. Introduction

Chemical fertilizer is now widely used as a fertilizer on farms the worldwide. When fertilizer is misused and the farm's drainage system is not properly distributed, water pollution might arise. The water from the farm, which contains ammonia nitrogen, will run into the river, contaminating it [1]. The most major concern in agriculture is the excessive use of chemical fertilizers [2].

Organic fertilizer can be used from food waste can be used to replace chemical fertilizers. Statistically, humans create 1.3 billion tonnes of food waste in worldwide. Food waste has an impact on the environment during the stages of food production, storage, transportation, and waste treatment. Soil degradation, deforestation, water and air pollution, and greenhouse gas emissions are all examples of these [3].

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Food waste is a worldwide issue that results in financial losses, has a harmful influence on the environment across the food chain, and will have an impact on individual health [4]. It can be reused as fertilizer to avoid financial losses and the negative impact of food waste on the environment. The production of organic fertiliser from food waste benefits the environment while reducing the use of chemical fertilisers. Organic fertiliser also supports in the management of soil pH and the production of soil microbes, which helps to preserve soil structure [5]. Furthermore, organic fertiliser derived from food waste can aid in the growth of microbial biomass carbon in the soil [6].

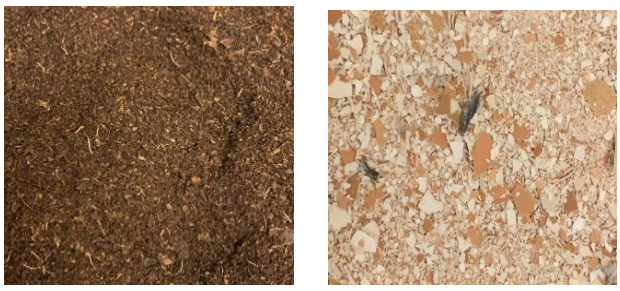
The objectives of project are to produce organic fertilizer from banana peel and egg shell, to measure the pH of soil that suitable for planting chili trees and to examine the effect of different amount of compost used on chili plant. All of the raw materials for this project come from organic waste, such as banana peels and egg shells. These items will be gathered from domestic garbage. The chilli plant is being used as an experimental research to see how effective fertilisers are. In addition, different amounts of compost will be added to the chilli plant to determine the optimum amount of fertilizer.

2. Materials and Methods

In this topic, the material and method that used to making an organic fertilizer will be discussed.

2.1 Organic Fertilizer Preparation

In this study, organic fertilizer was made from banana peel and egg shell. Banana peels and egg shells were collected from household waste. At first, banana peels and egg shells were rinsed using a distilled water to ensure banana peels and egg shells were clean. After that, banana peel and egg shell were cut into small pieces. Next, banana peel and egg shell were dried in the air fryer with the temperature 200℃ in 15 minutes. After drying process, blender was used to grind the banana peel and egg shell into powder as shown in **Figure 1**.



(a) (b)

Figure 1: (a) Banana peel powder and (b) egg shell powder

Then banana peels and egg shells were mixed together at different amount based on experimental design. The amount of banana peels, egg shell and yeast that used are 1.6g, 6g, and 1g respectively. After mixing process, the fertilizer was applied to the chili plants with different amount of organic fertilizer as shown in **Table 1**.

Table 1: Amount of fertilizer in every chili plant

Sample	A Control	B Amount banana peel, egg shell, yeast (g)	C Amount of banana peel, egg shell (g)	D Amount of banana peel (g)
1	No fertilizer	1.6, 6.0, 1.0	1.6	1.6
2		3.2, 12.0, 2.0	3.2, 12.0	3.2
3		4.8, 18.0, 3.0	4.8, 18.0	4.8
4		6.4, 24.0, 4.0	6.4, 24.0	6.4

2.2 Physiochemical

pH value of the soil was determined by using soil pH meter. There were 13 sample including control were used to determined the ph value of the soil. Based on previous research, the pH value for chili plant is 5.5-6.8 [5]. The pH meter probe was placed into the soil vertically and the pH value was recorded. pH meter probe cannot be insert too deep in the soil to avoid the root damage. During pH test, the texture of soil cannot be dried because the pH value will not accurate. Next, the composition inside the soil was determined by using Fourier-Transform Infrared Spectroscopy (FTIR) Analysis. The crystal for sample placement was cleaned with the alcohol to remove the dirty. After cleaning the crystal, soil sample was placed on sample accessory using a spatula. The absorbance data was collected in the range 4000 cm^{-1}- 650 cm^{-1} with resolution 4.0 cm^{-1}.

2.3 Plant Growth

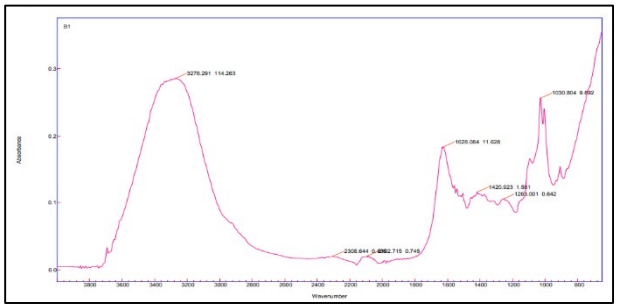
Plant growth analysis is used to know the effectiveness of organic fertilizer. The chili plant was divided to 4 parts where each of chili plant was fertilized with a different type and amount of fertilizer. Sample A is the control while sample B contains banana peel, egg shell, and yeast, sample C contain banana peel and egg shell, and sample D cotains banana peel only. The chili plants was placed at the place that has sunlight and all of the chili plants were watered with the same amount of water, 40 ml. Fertilizer was applied for four times in eight weeks duration. The height of chili plant and amount of leave were recorded every two weeks.

3. Results and Discussion

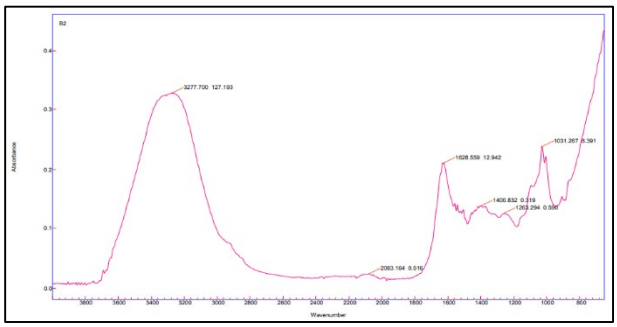
The result of the FTIR spectrum reveal the soil's general chemical composition as well as information on its organic and mineral components. The pH of the soil can determine whether a plant does extraordinarily well, barely makes it, or succumbs to death. Viability of plant is dependent on the pH of the soil.

3.1 FTIR analysis

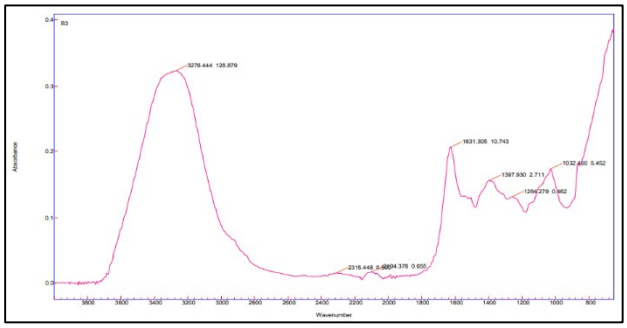
FTIR analysis is performed to measure the amount of nitrogen in the soil to determine the best fertilizer ratio. The FTIR spectra of soil samples was recorded using absorbance data. The soil parameters is important to observe optimum for the fertilization application. The result of the FTIR analysis of Sample B, C and D as shown in **Figure 2, 3** and **4**.



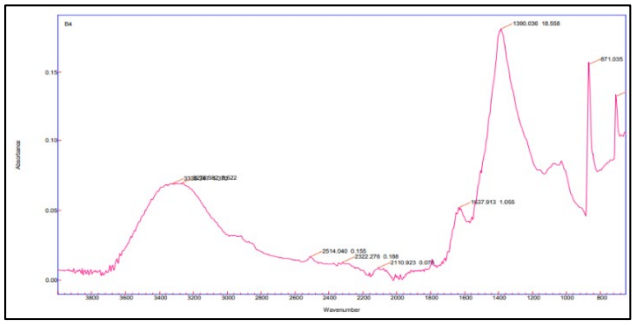
(a) Sample B1



(b) Sample B2



(c) Sample B3

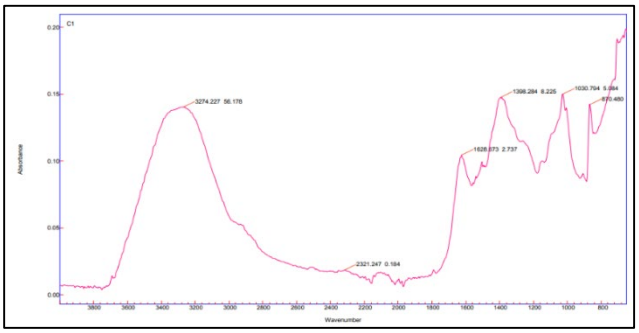


(d) Sample B4

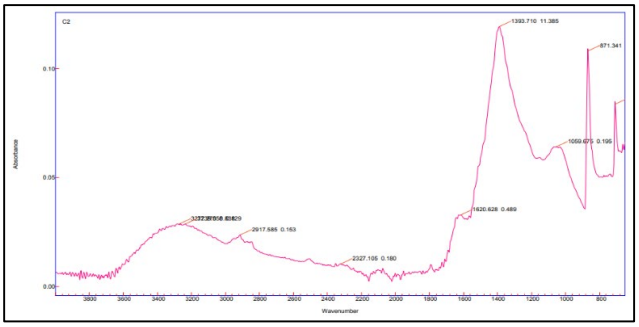
Figure 2 : (a), (b), (c) and (d) the FTIR spectra of Sample B

Based on **Figure 2**, it showed that Sample B has the compounds that displayed clear peaks in the spectrum. In the FTIR spectrum of Sample B, the sharp peak at 1030.804 cm^{-1} appeared responding to phosphate molecules in medium intensity. The small peak at 1420.923 cm^{-1} exposing a carbonyl group (C=O) with low intensity band. The medium absorption peak at 1628.084 cm^{-1} corresponding to the amine group (N-H) with medium intensity. For the final peak is at 3276.291 cm^{-1} exposing a wide

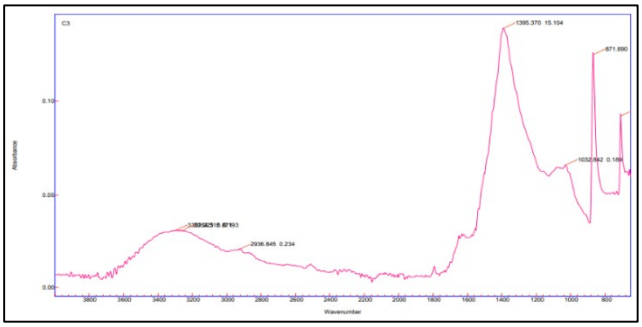
and strong absorption band that can related with the carboxylic acid group (O-H) and amine group (N-H). These peaks in the FTIR spectrum of Sample B appeared that the carboxyl, nitrogen, phosphate compounds are presented in banana peel, egg shells and yeast.



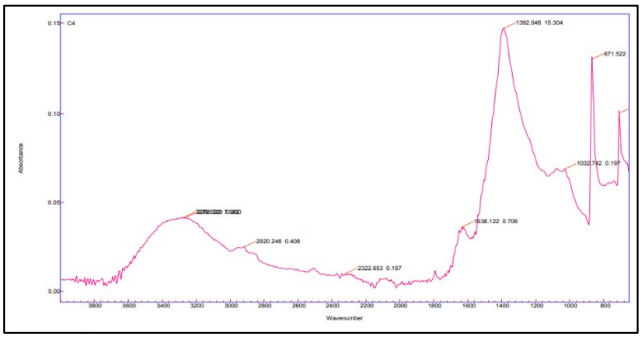
(a) Sample C1



(b) Sample C2



(c) Sample C3

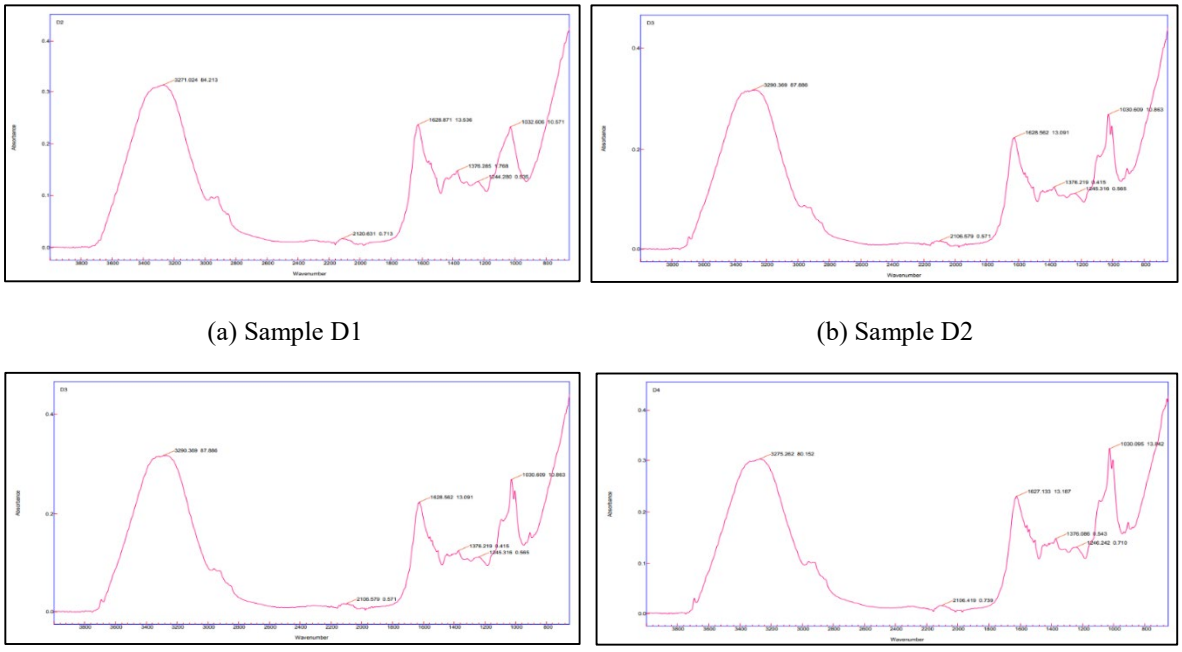


(d) Sample C4

Figure 3: (a), (b), (c) and (d) the FTIR spectra of Sample C

The above **Figure 3** represents the FTIR spectrum of constructed Sample C1, C2, C3 and C4. The peak range at 3274.227 cm^{-1} to 3279.532 cm^{-1} reveals a broad and strong absorption band, which

can be attributed to the hydroxyl (OH) and amine group (NH) groups. The small peak with a low intensity band range at 2321.247 cm^{-1} to 2322.653 cm^{-1} corresponds to an amine group's N-H stretching. The signal range at 1628.673 cm^{-1} to 1638.122 cm^{-1}, which corresponds to the C=O bond of carboxylic acid, and the band range at 1398.284 cm^{-1} to 1392.048 cm^{-1}, which reveals a deep and long peak corresponding to the CH and NH amide groups, are related to the presence of proteins in the peak which organic fertilizer. A sharp intensity peak at range 870.480 cm^{-1} to 871.690 cm^{-1} is associated with the carbonate (CO_3^{-2}) group. The height peak of graph for each Sample C1, C2, C3 and C4 was different because of the amount of banana peels and egg shells only were different for each plant. These all peaks that showed in the FTIR spectra are related presence of the amino acid, nitrogen in banana peels and egg shells only



(a) Sample D1 (b) Sample D2

(c) Sample D3 (d) Sample D4

Figure 4: (a), (b), (c) and (d) the FTIR spectra of Sample D

Figure 4 represents the FTIR spectrum of constructed Sample D1, D2, D3 and D4. The peak range at 3269.629 cm^{-1} to 3275.262 cm^{-1} reveals a broad and strong absorption band, which can be attributed to the hydroxyl (OH) and amine group (NH) groups. The small peak with a low intensity band range at 2106.419 cm^{-1} to 2113.663 cm^{-1} corresponds to an amine group's N-H stretching. The signal range at 1625.730 cm^{-1} to 1628.871 cm^{-1}, which corresponds to the C=O bond of carboxylic acid, and the band range at 1376.086 cm^{-1} to 1421.326 cm^{-1}, which reveals a deep and long peak corresponding to the CH and NH amide groups, are related to the presence of proteins in the peak which organic fertilizer. A sharp intensity peak at range 1030.095 cm^{-1} to 1032.606 cm^{-1} is associated with the carbonate (CO_3^{-2}) group. The height peak of graph for each Sample D1, D2, D3 and D4 was different because of the amount of banana peels only received were different for each plant. These all peaks that showed in the FTIR spectra are related presence of the amino acid, nitrogen in banana peels only.

Based on the observation from the FTIR spectrum in Figure 2 (a), it has the low value all peaks of nitrogen, amino acids and carboxylic acids in the FTIR spectrum between the Sample B2, B3 and B4. It is due to the amount ratio of banana peel, egg shells and yeast that was given to these sample of plants. Sample B1 receives the least amount ratio of banana peels, egg shells and yeasts. Besides, the Sample B has the all peaks that responded to the nitrogen, amino acids and carboxylic acid compounds

that contain in banana peels, egg shells and yeasts in FTIR spectrum result compared to remaining samples. Since Sample A is a control, it was not received any organic fertilizer. For Figure 3, all peaks that showed in the FTIR spectra are related of the amino acid, nitrogen that presented in banana peels and egg shells. The FTIR spectrum of formulated organic fertilizer for Sample D was reported in Figure 4, all peaks are related presence in banana peels only.

3.2 pH analysis

The changes in soil pH have a significant impact on plant growth.The ideal range for bacterial development in the soil to facilitate decomposition is in the centre of the pH scale. The breakdown process releases nutrients and minerals into the soil, allowing plants and shrubs to use them. The pH of the soil determines its fertility. Microorganisms that transform nitrogen in the air into a form that plants can use thrive in the mid range. When the pH falls beyond the middle range, both of these vital activities become increasingly impeded, locking up nutrients in the soil and preventing the plant from fully utilising them [6].

The pH value was determined by a soil pH meter. All the plant shows the different value of pH because of different composition and amount of the organic fertilizer. **Table 2** shows average the soil pH analysis for sample A, B, C and D in the end of observation week. The sample was taken thrice and the sample B shows in the middle of the range which 7 as the neutral mark.

Table 2: Evaluation of pH value of Sample A, B, C and D

Sample	Trial 1	Trial 2	Trial 3	Average
A	7.0	7.0	6.6	6.9
B	7.0	7.0	7.4	7.1
C	7.5	7.8	7.5	7.6
D	6.1	6.4	5.8	6.1

Based on **Table 2**, the difference of average of Sample A, B, C and D due to the difference of organic waste tput in each sample in fertilization process. Sample A as a control, Sample B make up with three elements which are banana peel, egg shell and yeast, Sample C without yeast and Sample D only banana peel. Sample B provides the optimum pH value for chili growth. It reach the neutral mark that shows the best range for bacterial growth to promote decomposition and will locking up the nutrients in the soil. Banana peel is the main component in produced organic fertilizer and as a waste product that release carbon source and contains nitrogen, phosphorus and amino acid while egg shell rich of phosphate and calcium that very effective for plant growth. The level of nitrogen and phosphorus will affect the pH value of soil. The pH value that reach high alkalinity or acidic, it will poisonous and produce a toxic amount that can have an effect on a certain nutrient.

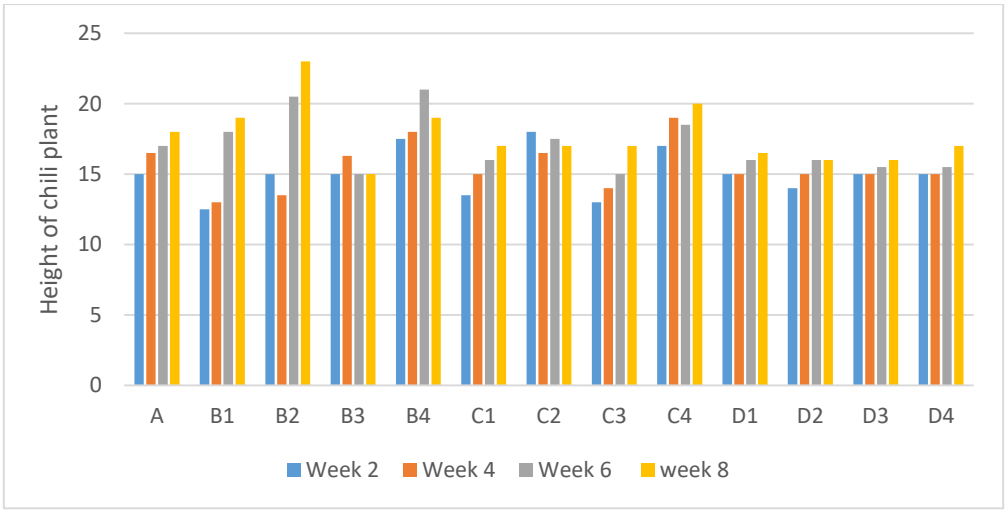
3.3 Chili Plant Growth

Chili plant growth such as the height of chili plant and the number of leave per chili plant were measured. The result was recorded every two weeks after the fertilization. Thirteen chili plant were potted with organic fertilizer. **Figure 5** shows the progress of chili plant B1 in week 1 and week 8.

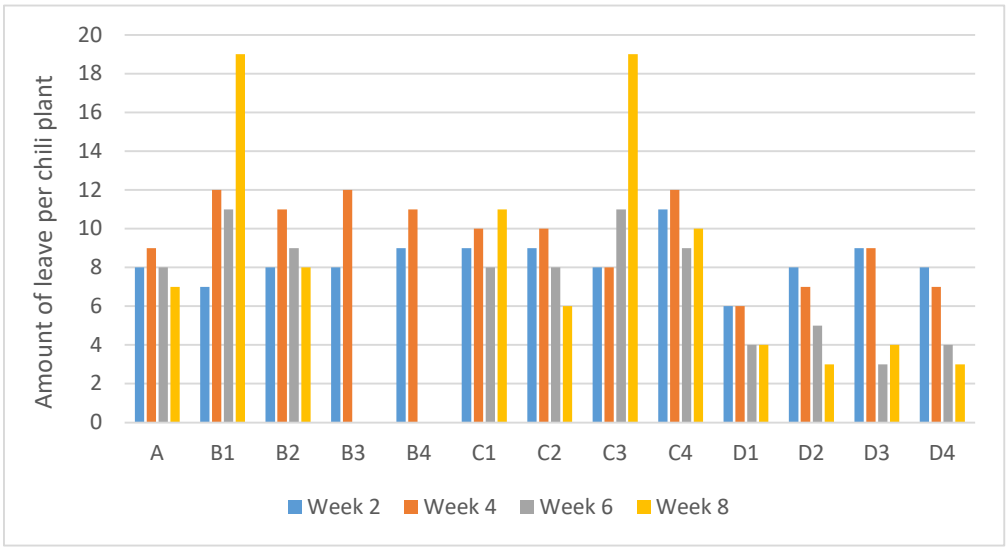
(a) (b)

Figure 5: Picture of chili plant B1 in (a) week 1 and (b) after week 8

Figure 6(a) shows the graph of height of chili plant and Figure 6(b) is the graph of the number of leave per chili plant.



(a)



(b)

Figure 6: (a) Height and (b) amount of leave per chili plant

From **Figure 6**, the highest chili plant was observed in the sample B1 which increase around 1-5 cm every two weeks. The maximum number of leaves were observed in sample is B1 which the increase of amount of leave is around 5-8. This is because chili plant sample B1 has a suitable amount of nitrogen and phosphorus compared to other chili plant.

From the result, chili plant sample B1 with amount of organic fertilizer 1.6g, 6g and 1g yeast depicted the significant growth in term of height and amount leaves. The sample B2, B3 and B4 shows the decreases in amount of leave and also the height of chili plant. This is because chili plant sample B1 has an optimum level of nitrogen compared to chili plant sample B2, B3 and B4. The total amount of nitrogen of chili plant sample B2, B3 and B4 is greater than sample B1. So, it shows that sample B2, B3 and B4 have excessive amount of nitrogen. Excessive amount of nitrogen in soil will reduce or loss the nutrient in the soil [7][8].

4. Conclusion

In conclusion, the application of organic waste with readily available nitrogen, phosphorus, sodium, calcium and amino acid in banana peel, egg shell and yeast has effectively increased the growth of chili plant. Using the organic waste as a fertilizer will save cost, environmentally friendly product and minimize the food waste production. The chemical fertilizer that contain ammonia nitrogen will give a bad impact to environment and cause water pollution. In this study the organic fertilizer made of banana peel, egg shell and yeast provide the best result to the growth of chili plant as in Sample B1 with the amount of organic fertilizer 1.6g, 6g and 1g. The compost has a good long term effect as it slowly decomposes all the components, so during the decomposition the nutrients can be accessed by the chili plant. It can be concluded that banana peel, egg shell and yeast has a great potential as support for agricultural applications.

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