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EFFECTIVENESS OF FOOD WASTE BIO-COMPOSTED FERTILIZERS ON PLANTATIONS

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Abstract

This research studied the production of organic fertilizer from food wastes through composting in view of its easy availability in Malaysia. In methodology, food wastes such as banana peels, Chinese kale and eggshells in different proportions will be stacked up layer by layer in a compost bin prepared with the inclusion of bulking agents such as dry leaves and soil to produce matured compost to supply useful microorganisms to the decomposition process. Results from the application of the biofertilizers produced on the growth of water spinach and green onion plants had revealed the potential of banana peels in supporting the growth of the plants, while for the ones produced from the combinations of eggshells and Chinese kale, nitrogen loss could be observed, thereby suppressing their growth and resulting in a much slower growth rate. Meanwhile, from the statistical analysis conducted, the findings obtained were proven to be significant, indicating the positive influence of fertilizers type on the growth of plants. Hence, it could be concluded that this research would certainly provide an insight to the potential management of organic waste in our country by converting organic wastes from food into biofertilizer.

Keywords: Biofertilizer, Composting, Organic waste, Statistical analysis.

1. Introduction

Generally, a total of approximately 38 billion metric tons of biodegradable wastes are produced all over the world every year [1]. This dramatic increment of waste production is due to increased consumption rate, population explosion and human behaviour. Apparently, as the wastes are regarded as disposable and unusable, deposition and burning have always been some of the primary treatment methods. Unfortunately, numerous adverse environmental effects occur due to the dumping of the wastes such as atmospheric pollution as well as the alteration in the status of heavy metal present in the soil [2]. To deal with this challenging issue, several practices and methods in treating the organic wastes as aforementioned have been formulated and applied all over the world, of which one of it is food waste composting. Primarily, food waste refers to all unconsumed food substances produced from markets, hawker centres, households, food courts, supermarkets and other eating establishments which are to be recycled and disposed of [3]. Meanwhile, composting can be viewed as an easy, natural and economical biodegradation process, converting the components present in the organic waste into relatively stable humus-like substances to be used as soil amendment and organic fertilizer afterwards [4]. Obviously, through composting, the number of wastes can be drastically reduced and at the same time, useful nutrients can be returned to soil to increase its fertility.

In general, it is common that fertilizers are important in supplying essential nutrients such as potassium, nitrogen and phosphorus to plants for the sake of crop yield increment [5]. However, over the past few years, the needs to replace those traditional chemical fertilizers with so-called biofertilizers have been receiving widespread attention and have also aroused a growing interest in the public in view of the adverse impacts brought about using chemical soil amendment, whereby one of the most significant effects caused by it is carbon dioxide emissions during its production process, which have certainly worsened the condition of global warming [6]. In fact, the production of chemical fertilizers, with a relatively high energy consumption, has been widely regarded as one of the most environmentally harmful production and distribution activities around the world. Hence, there is a need to look for more economical and environmental viable technology as any untimely application of artificial fertilizers will negatively affect not only the natural balance of the soil crop ecosystems, but it also affects the microbial ecology which will then lead to a sharp decline in crop yield.

The continuous dependence on chemical fertilizers for future agricultural growth reflected that there would have further loss in soil quantity with the possibilities of water contamination as well as an unsustainable burden on the fiscal system [7]. Apparently, the abundance of raw materials in Malaysia has in turn give assurance on the feasibility of turning to biofertilizer for enhancement of crop yield. In Malaysia, an increase in this plantation area has indicated a rise in the production of potential raw materials for organic fertilizer production. Another organic material which is one of the focuses in this study is food waste, with a total production amount of 15,000 tonnes in Malaysia in the year 2016 as reported [8].

Food waste composts consisted of tea leaves, coffee grounds, banana peels, lemongrass leaves and eggshells in different ratio was proven to help in plant growth and managed to substitute chemical fertilizer [9]. According to Wazir et al. [10], household waste such as banana peel improved the height of the plant in both potato and pea while adding the wastes such as eggshell increased the number of leaves and leaf area.

Reaction engineering approach had been utilized on the onion drying into thin layer at different temperature. It was shown that the approach was effective in investigating the drying parameters accurately [11]. A further extensive approach using reaction engineering approach on composting was reliable as one of the simulation tools on operating conditions and geometry configurations [12].

Therefore, the aim of this research is to study the production of biofertilizer from food wastes especially from household wastes (dry banana peels, Chine kale and eggshells) owing to its easy availability compared to other sources of organic wastes. This is to reduce our dependence upon the expensive petroleum sources of chemical fertilizers and most importantly, to reduce the pressure of the overloaded municipal solid waste transportation system and landfill sites. In addition, different combination of household wastes would provide different enhancement towards plantation. There was no research with the combination of Chinese kale as part of the compost. Besides, the effectiveness of the biofertilizer produced will be investigated by applying it to the growth of water spinach and green onion plants. All the significance of the findings obtained will be determined via Analysis of Variance (ANOVA), followed by Fisher's Least Significance Difference (LSD) test.

2. Experimental Procedure

2.1. Preparation of materials

Compost bin and composting medium were prepared beforehand. 50cm x 50 cm x 80cm plastic flowerpot was used as the compost bin. Holes were pierced on every side of the pot to prevent the mixture in the bin from getting compacted which would then hinder ventilation and aeration. At the same time, the bottom of the container was also drilled with holes for the draining of leachate out of the compost bin. In addition, these holes were made for the pricking of the mixtures with thin stick to prevent compaction.

Food wastes from home and markets namely banana peels, vegetable wastes and eggshells with their characteristics stated in Table 1 were taken as composting medium for this composting process. In this research, three different samples comprised of food wastes in different proportions as presented in Table 2. Reactor A was acting as the research control which contained only banana peel. For Reactor B, Chinese kale was added to banana peel while for Reactor C, eggshells were successively added Chinese kale and banana peel. The constructed compost bins were shown in Figs. 1 and 2, correspondingly showing its top view and side view.

As indicated in Table 2, dry leaves functioned as bulking agent were also included in the three reactors to absorb the excess moisture, while soil and matured compost were added to supply microorganisms useful in the decomposition process to the mixture. Furthermore, C/N value of 27.0, 25.1 and 25.4 were corresponded to Reactors A, B and C respectively. Typically, the values were obtained by applying Eq. (1), whereby the total carbon value of the food wastes was divided by its total nitrogen value.

$$C/N = \frac{\text{Total Carbon Value}}{\text{Total Nitrogen Value}} \quad (1)$$

where

Carbon Value (kg C) = Mass of Food Waste (kg) × Carbon Content (wt.%)

Nitrogen Value (kg N) = Mass of Food Waste (kg) × Nitrogen Content (wt.%)

Table 1. Characteristics of raw organic wastes.

Raw Waste	Carbon content (wt.%)	Nitrogen content (wt.%)	Carbon to Nitrogen Ratio (C/N)	References
Banana peel (dry)	37.800	1.400	26	[13]
Chinese kale (vegetable)	41.570	1.820	21.65	[14]
Eggshells	12.601	0.398	2.29	[15, 16]

Table 2. Preparation of compost medium.

Reactor	Content		Packing	C/N	Bulking Agent
	Food Waste	Amount (kg)			
A (Control)	Banana peel	1.00	0.03 [17]	27.0	Dry leaves
B	Banana peel	0.60		25.1	Soil
	Chinese kale	0.40	0 [17]		Matured compost
C	Banana peel	0.33			
	Chinese kale	0.33		25.4	
	Eggshell	0.34	0.017 [18]		

Fig. 1. Top view of the compost bin.

Fig. 2. Side view of the compost bin.

2.2. Composting procedure

The kitchen wastes were shredded into smaller particles of 3-50 mm to provide larger surface area per unit volume for the degradation process, as shown in Fig. 3. The compost bin was layered with 1 inch of garden soil followed by 1 inch of compost to help in the introduction the required bacteria for the breakdown process.

The prepared vegetable wastes (Chinese kale) and fruit peels (banana peels) which have high nitrogen content were added to activate the heat process in the compost, while crushed eggshells were included to add calcium and other minerals to the compost layer in developing a strong cellular structure [19]. The layering of the first layer of soil, compost as well as food wastes are respectively shown in Figs. 4-6. Eventually, this process was repeated by adding layers of wastes and soils based on Figs. 4-6.

Basically, all the wastes and agents were added by pressing the mixture with pestle. To avoid any spillage, a shallow tray was placed underneath the compost bin and kept at a place with direct sunlight for hastening the composting process. Meanwhile, frequent watering of the compost was done to ensure a satisfactory moisture level. In this case, the collected drain water was reused as it contained useful bacteria and essential nutrients for the breakdown of the organic waste materials. Furthermore, regular physical mixing of the compost mixture was also performed with the help of a stick or shovel to ensure the growth of the bacteria which would help the compost to decompose faster, and most importantly, to aerate the pile.

Throughout this composting process, the pH value and temperature of the compost mixture were taken at a daily basis by using a 4 in 1 digital soil meter. Typically, once the temperature reached ambient air, a matured compost to be used as biofertilizer was successfully produced and this process normally took two to three months.

Fig. 3. Shredded pieces of banana peels.

Fig. 4. Layering of approximately 1 inch of garden soil.

Fig. 5. Layering of approximately 1 inch of matured compost.

Fig. 6. Layering of the prepared food wastes.

Figures 7-9 represent the types of raw wastes prepared for Reactor A, Reactor B and Reactor C.

Fig. 7. Types of raw waste in Reactor A.

Fig. 8. Types of raw waste in Reactor B.

Fig. 9. Types of raw waste in Reactor C.

2.3. Characterizations of compost produced

After the successful generation of the biofertilizer, the trends of the changes in temperature and pH value of the compost pile throughout the degradation process was analysed.

2.4. Determination on the effectiveness of the biofertilizer produced

The effectiveness of the three sets of biofertilizer produced was determined by applying it to the growth of water spinach and green onion whereby the growth curves were assessed over the entire cultivation period of exactly 25 days.

Basically, the polyvinyl chloride (PVC) pots used for the cultivation of the plants with measurement of 13.5cm in height and 15.5cm in diameter. Three different pots of the same size were filled with treatment soils consisting of the mixture of normal garden soil together with the three different sets of composts obtained in a proportion of 1:1 to about three quarters full in preparation for the water spinach plant, and this step was repeated for green onion plant.

The effects of different sets of organic fertilizers obtained on the growth of the plant were investigated by measuring their shoot and root lengths coupled with the number of days taken to germinate, as well was the measurement of growth rate by taking the average of the shoot extension over a period of 5 days.

2.5. Statistical analysis

This research analysed the findings obtained by a detailed statistical analysis via analysis of variance (ANOVA) with the aid of Microsoft Excel regarding the physical parameters of the cultivated plants upon the application of the organic soil amendments on the relationship between the independent variable (fertilizers type produced by compost bin A, B and C) and dependent variable (recorded physical parameters of cultivated plant).

A post hoc test via Fisher's least significant difference test was conducted to determine which pair of fertilizers were different in terms of their means. The first step taken in this Fisher's LSD test was to calculate the LSD value using Eq. (2). A table was then to calculate the difference in the average value obtained from the ANOVA conducted concerning the independent variable, namely between Reactor A, Reactor B and Reactor C.

Once the absolute value of the difference in the average value calculated was greater or equal to the previously determined LSD value, null hypothesis was rejected, and it could therefore be concluded that the results were significant. Conversely, results were proven to be insignificant if the condition was the other way around.

$$LSD = T_{critical}\sqrt{MSE\left(\frac{1}{n_i}+\frac{1}{n_j}\right)} \tag{2}$$

where $T_{critical}$ =Critical value, calculated from *Microsoft Excel* using *T.INV.2T* (Significance level, Degrees of freedom within), MSE = Mean square within, obtained from the results of the ANOVA test, and n =Number of samples regarding each fertilizer type used to calculate the means

3. Results and Discussion

3.1. Production of biofertilizers

Biofertilizers were successfully obtained after the degradation of the prepared organic wastes in the different compost bins as shown in Figs. 10, 11 and 12, respectively, which presented the matured compost produced by Reactor A, Reactor B as well as Reactor C. The composting process had been carried out for a total period of 50 days, right after the required types of food wastes and compost bins were prepared.

Fig. 10. Matured compost produced by Reactor A.

Fig. 11. Matured compost produced by Reactor B.

Fig. 12. Matured compost produced by Reactor C.

3.2. Characterizations on the obtained biofertilizers

3.2.1. Trends of changes in temperature

The evolution in temperature concerning all the three reactors were analysed as presented in Fig. 13, whereby the ambient temperature represented with a blue dotted line was also included to understand the variation in accordance with environmental condition.

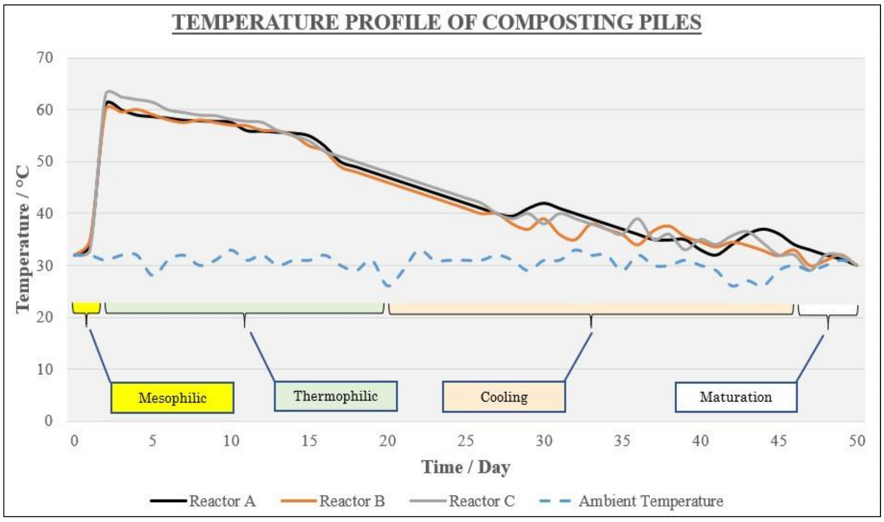

Fig. 13. Changes in temperature of compost piles against time.

From Fig. 13, it could be seen that the entire composting stage was a four-phase process which comprised of the first stage as mesophilic with a temperature range of 25-45℃, second stage as thermophilic ranging from 45-65℃, and then followed by cooling phase and lastly maturation phase [13]. The different stages of the processes as aforesaid were clearly labelled to have a clearer idea on the entire course of temperature evolution and changes.

Typically, both the three compost piles began at the mesophilic state with a temperature of 32℃, similar to those of the ambient temperature represented with a blue dotted line. The compost temperature of Reactor A, Reactor B and Reactor C increased sharply until a high temperature of 62℃, 61℃ and 64℃, respectively were attained within 72 hours of pile formation, signifying the commencement of thermophilic phase. As such, the entire thermophilic phase had lasted for around 16 days during the composting process.

At approximately twentieth day of the degradation process, cooling phase took place in all the three reactors whereby the compost temperatures started declining until it approached ambient temperature ranging from 31-33℃. Eventually, maturation phase occurred and decomposition of the organic materials into matured and finished compost which are biologically stable in nature happened.

Regarding the evolution in temperature of all the three compost piles, the maximum recorded temperature during the composting process were around 60-64℃ (on day 3). The high thermophilic temperatures attained could be accounted to the added dry leaves functioning as bulking agent, which had delivered the appropriate aeration essential for biological activity [13]. These dry leaves had also helped in ensuring that the thermophilic phase lasted for more than five days during the composting process, whereby in this study, the stated phase had managed to stay for a total period of approximately 16 days in all the three reactors [14].

The sharp temperature rose during the early stage of the degradation process, owing to the heat energy generated by the thermophilic microorganisms present via respiration activities as well as through the degradation of organic materials [15]. Conversely, the downtrend of temperature at twentieth day of the composting process as aforementioned had indicated a decline in microbial activity as well as a slowed-down degradation rate due to the decreased amount of available organic material, thereby stopping the breakdown activities of microorganisms and leading to the commencement of cooling phases [20].

To conclude, Reactor A, B and C undergone four phases. At mesophilic phase, all reactors required temperature roughly the same. For second phase, Reactor C required higher temperature compared to Reactors A and B. Under cooling phase, Reactor A showed more stable temperature changes. Last phase which was maturation phase showed that Reactor A had stable temperature changes compared to Reactors A and B. Therefore, Reactor A showed stable temperature changes compared to Reactors A and B which proved that it was more consistent to be utilized as compost.

3.2.2. Trends of changes in pH value

The trends of the changes in pH value concerning all the three reactors were shown in Fig. 14. The pH value during the degradation process varied within the value of 3.9-8.3, of which all the composts were initially in the acidic states. However, this acidity level started increasing steadily from the first week until the third week. Specifically, the value increased from day 1 until day 19 for Reactor A, while for Reactor B and Reactor C, was from the first day until day 17. From day 20, the pH values for Reactor A started turning to neutral but later, rose and declined to the neutral condition again of around 7.2 on day 15 of the composting process. Conversely, for Reactor B and Reactor C, starting from day 17, the pH values began turning to acidic before finalised at the slightly neutral state on the fiftieth day.

For pH changes, the acidic condition of the compost at the start of the degradation process was owing to the formation of organic acids but will later, rose above neutral as the acids are being consumed. Likewise, in another study stated that pH would always drop at the start of the aerobic decomposition process in view of the formation of fatty acids and nitrification process, it would later increase again with the degradation of organic matter by microorganisms [21]. Apart from organic matter decomposition, the increment in the pH value could also be accounted to the formation of ammonium [22].

To conclude, fluctuations in the pH values of the compost mixtures might be caused by the release of proteins originating from the mixtures of food waste remaining along the degradation process, as suggested by [20]. Reactor A and B showed more to neutral pH while Reactor C showed more to acidic pH. All reactors were proven to be suitable to be utilized in plantation as all of the pH was in the range of 5.5-8.0, which was the best plant growth pH range [23].

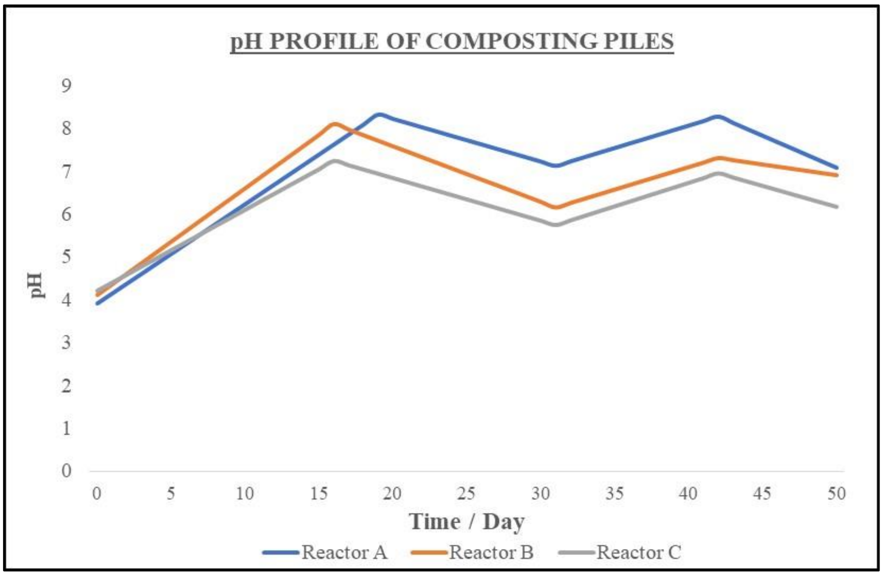

Fig. 14. Changes in pH of composting piles against time.

3.2.3. Growth response of plants towards biofertilizer application

Table 3 presented on the respective growth rates of the cultivated plants, featuring the number of days taken to germinate as well as the corresponding final shoot length and final root length, whereby the superscripts (a and b) attached with each figure in Table 3 represented the significance of results indicated by the least significant difference test performed. From Table 3, fertilizer A only used 3 days for germination process while fertilizer B and C showed roughly the same amount of period. Therefore, fertilizer A was significantly different from fertilizer B and C in terms of germination period. Fertilizer A had taken much lesser period to germinate compared to Fertilizers B and C. Specifically, 3 days were required for germination in both the selected plants cultivated under Fertilizer A, which had thus proved its capability in supporting their growth. Meanwhile, a total period of 6 days and 7 days were correspondingly taken by water spinach and green onion to sprout in Fertilizers B and C.

Figures 15(a) to 15(c) while Fig. 16 depict the water spinach plants obtained at the end of the cultivation period. Figure 17(a) to 17(c) showed the germinated green onion plants grown under Fertilisers A, B and C whereas Fig. 18 depicted the plants obtained at the end of the cultivation period. Fertilizer A had shown the greatest height in both the planted vegetations, which were 31.9 cm (Fig. 16) and 31.2 cm (Fig. 18), respectively, while for Fertilizer B and Fertilizer C, the value ranged from 27.0cm to 29.0cm. The root length of Fertilizer A was the greatest for water spinach plants, and then followed by Fertilizer C and lastly, Fertilizer B, whereas in green onion plant, the growth rate of Fertilizer B slightly surpassed that of Fertilizer C and came in second. Apparently, the influence of tryptophan (amino acids) presented in banana peels in regulating plant growth, improving the metabolism of plants, and increasing the physiological availability of water and nutrients. Furthermore, division and enlargement of cells are stimulated which then lead to plant growth [24, 25].

Table 3. Effects of different organic fertilizers application on the physical parameters of water spinach and green onion plants.

Fertilizer	Number of Days Taken to Germinate		Final Shoot Length/cm (After planted for 25 days)		Final Root Length/cm (After planted for 25 days)	
	Water Spinach	Green Onion	Water Spinach	Green Onion	Water Spinach	Green Onion
A	3 [b]	3 [b]	31.9 [a]	31.2 [a]	7.2 [a]	7.3 [a]
B	7 [a]	6 [a]	27.7 [b]	28.5 [b]	6.6 [b]	6.8 [b]
C	6 [a]	7 [a]	29.5 [b]	27.9 [b]	6.8 [b]	6.6 [b]

Note. Different letters with each value in a column are significantly different at P≤0.05.

Fig. 15(a). Early germination of water spinach plant cultivated in Fertiliser A.

Fig. 15(b). Early germination of water spinach plant cultivated in Fertiliser B.

Fig. 15(c). Early germination of water spinach plant cultivated in Fertiliser C.

Fig. 16. Growth of water spinach plants after being planted for 25 days.

Fig. 17(a). Early germination of green onion plant cultivated in Fertiliser A.

Fig. 17(b). Early germination of green onion plant cultivated in Fertiliser B.

Fig. 17(c). Early germination of green onion plant cultivated in Fertiliser C.

Fig. 18. Growth of green onion plant after being planted for 25 days.

3.2.4. Comparison in the growth rates of plants

The rates of the shoot growth were determined to assess the respective growth rates of the planted vegetations as shown in Table 4. The rates were calculated by dividing the changes in length with the amount of time the plants had grown, whereby in this study, a total period of five days was taken, featuring water spinach and green onion plants respectively for ease of comparison.

From Figs. 19 and 20, the set of plants cultivated under Fertilizer A had shown the fastest growth rate during the early stage. Nevertheless, as time progresses (nearing to 15 days of plantation), plants in Fertilizer B and Fertilizer C started growing fast and eventually, resulting in a comparatively similar plant height as the ones grown under Fertilizer A for both the different vegetations. These results agree with the findings who had reported that the combination of eggshell with biowaste, when applied to money plant and wheat grass, would bring about remarkable growth [26]. The possible reasons for this might be due to the fact that eggshell is a great source of calcium whereby according to [10], a single eggshell consists of approximately 2.07 ± 0.18 gram (g) of calcium, together with other macro and micronutrients whereby all are important nutrient elements essential to the plant not only aids in neutralising soil acidity, but is also required for nitrate uptake, enzyme formation as well as root development [25, 27, 28]. For Chinese kale, which can also be known as Chinese broccoli, Gai-lan or Kailan, is a type of vegetation rich in vitamin C, vitamin A, vitamin K, calcium, folic acid as well as dietary fiber [29].

Table 4. Comparison in the average growth rate of water spinach and green onion plants.

Days of Growth	Average Growth Rates					
	Fertilizer A		Fertilizer B		Fertilizer C	
	Water Spinach	Green Onion	Water Spinach	Green Onion	Water Spinach	Green Onion
0	0	0	0	0	0	0
5	0.50	1.00	0	0	0	0
10	1.20	1.86	0.80	1.36	1.12	1.12
15	1.60	0.74	0.88	1.48	1.23	1.70
20	1.50	1.74	2.02	1.06	1.80	1.88
25	1.58	0.90	1.84	1.80	2.00	0.88

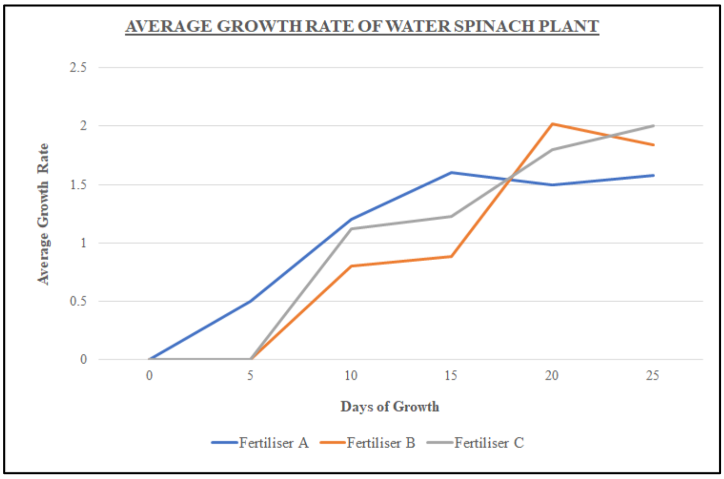

Fig. 19. The rate of growth of water spinach plant.

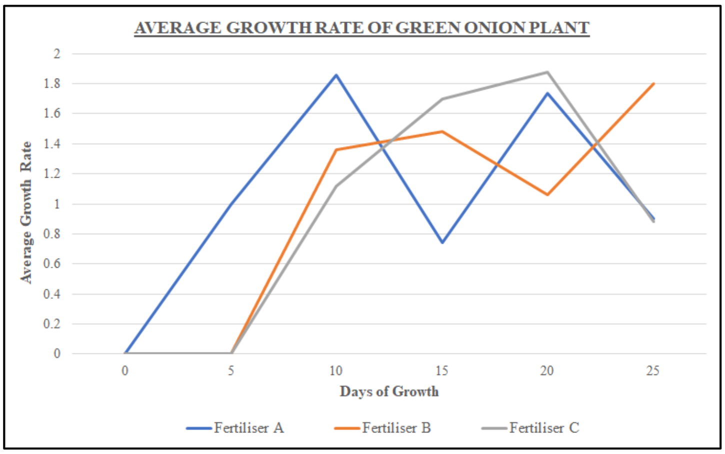

Fig. 20. The rate of growth of green onion plant.

Hence, with all the parameters put into consideration, it could be concluded that the compost produced by Reactor A had induced a faster germination and growth rates during the early stage while at the later stage, plants grown in Fertilizers B and C turned out to be faster.

3.2.5. ANOVA on the number of days to germinate

Figure 21 shows the calculated F value of 24.5, was found to have significantly exceeded the critical F value of 9.55 and therefore it could now be concluded that the variance between the means of the different sets of fertilizers were significantly different. The P value (0.01) had in turn depicted a comparatively lesser amount than the significance level of 0.05, thus this signified that the differences between the means among the different fertilizers were marginally significant. All in all, upon combining the results of F statistics with the P value, a decision of rejecting the null hypothesis was made, thereby concluding that fertilizers type did influence the required number of days to germinate.

Number of Days to Germinate (ANOVA)

Null Hypothesis (Ho) = Fertiliser type has no effect on the required number of days to germinate

Alternate Hypothesis (H') = Fertiliser type has an effect on the required number of days to germinate

DATA

PLANT TYPE	*NUMBER OF DAYS TO GERMINATE*		
	Fertiliser A	*Fertiliser B*	*Fertiliser C*
Water Spinach	3	7	6
Green Onion	3	6	7

annova: single factor

Significance level = 0.05

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Fertiliser A	2	6	3	0
Fertiliser B	2	13	6.5	0.5
Fertiliser C	2	13	6.5	0.5

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F critical*
Between Groups	16.33	2	8.17	24.5	0.01	9.55
Within Groups	1	3	0.33			
Total	17.33	5				

Fig. 21. Single factor ANOVA performed via Microsoft Excel regarding the number of days taken to germinate.

Subsequently, to determine which pair of fertilizers were different in terms of their means, a post hoc test via Fisher's least significant difference was conducted, as shown in Fig. 22. The calculated LSD value was 1.84, which showed that Fertilizer A was found to have significantly differed from both Fertilizers B and C. Nevertheless, this wasn't the case for Fertilizer B with Fertilizer C since LSD greatly exceeded their absolute value of difference in mean. these results had suggested that the application of organic soil amendment produced from banana peels alone (Fertilizer A) really did influence the total amount of days required for gemination by plants, for which the plants being cultivated under the said fertilizer had managed to germinate on average 3.5 days faster compared to the other two fertilizers. Yet, Fertilizers B and C did not appear to significantly decrease the days taken to germinate. It was proven that banana peels used the shortest duration compared to other types of household wastes such as eggshells, wood ash and tea waste [10].

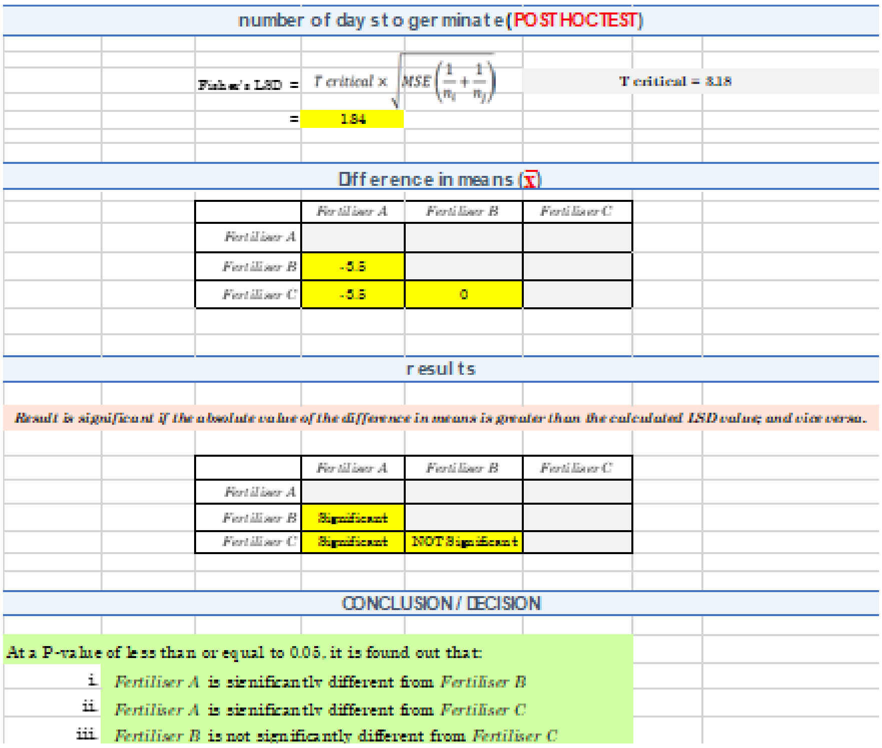

Fig. 22. Fisher's LSD performed via Microsoft Excel regarding the number of days taken to germinate.

3.2.6. ANOVA on the shoot length of plants

From Fig. 23, the calculated F value was 11.05, which was significantly exceeded the critical F value of 9.55 and therefore it could now be concluded that the variance between the means of the different sets of fertilizers were significantly different. The P value (0.04), had in turn depicted a slightly lesser amount than the significance level of 0.05, and this therefore signified that the differences between the means among the different fertilizers were marginally significant. All in all, upon combining the results of F statistics with the P value, a decision of rejecting the null hypothesis was made as enough evidence were available to conclude that fertilizers type did influence the growth rate of plants as indicated by their corresponding shoot length. Subsequently, to determine which pair of fertilizers were different in terms of their means, a post hoc test via Fisher's least significant difference was conducted, as shown in Fig. 24.

annova: single factor

Significance level = 0.05

SUMMARY

Groups	Count	Sum	Average	Variance
Fertiliser A	2	63.10	31.55	0.24
Fertiliser B	2	56.20	28.10	0.32
Fertiliser C	2	57.40	28.70	1.28

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	13.59	2	6.80	11.05	0.04	9.55
Within Groups	1.845	3	0.62			
Total	15.435	5				

Fig. 23. Single factor ANOVA performed via Microsoft Excel regarding the final shoot length of the plants after planted for 25 days.

From Fig. 24, the calculated LSD value was 2.50, results similar to the number of days taken to germinate were obtained. Fertilizer A had been found to significantly differ from both Fertilizers B and C, but this wasn't the case for Fertilizer B with Fertilizer C since LSD greatly exceeded their absolute value of the difference in means. According to Halpatrao et al. [30], fruit peels such as banana peels improved the nutrient of the soil and enhanced plant growth.

SHOOT LENGTH (POST HOC TEST)

$$\text{Fisher's LSD} = T\ critical \times \sqrt{MSE\left(\frac{1}{n_i}+\frac{1}{n_j}\right)}$$

T critical = 3.18

= 2.50

Difference in means ($\bar{x}$)

	Fertiliser A	Fertiliser B	Fertiliser C
Fertiliser A			
Fertiliser B	3.45		
Fertiliser C	2.85	-0.60	

results

Result is significant if the absolute value of the difference in means is greater than the calculated LSD value; and vice versa.

	Fertiliser A	Fertiliser B	Fertiliser C
Fertiliser A			
Fertiliser B	Significant		
Fertiliser C	Significant	NOT Significant	

CONCLUSION / DECISION

At a P-value of less than or equal to 0.05, it is found out that:

i. *Fertiliser A* is significantly different from *Fertiliser B*

ii. *Fertiliser A* is significantly different from *Fertiliser C*

iii. *Fertiliser B* is not significantly different from *Fertiliser C*

Fig. 24. Fisher's LSD performed via Microsoft Excel regarding the final shoot length of the plants after planted for 25 days.

3.2.7. ANOVA on the root length of plants

One-way ANOVA analysis was also applied to the length of the roots obtained during day 25 after they were successfully planted, as shown in Fig. 25. The calculated F value was 13.444, was found to have significantly exceeded the critical F value of 9.552 and therefore it could now be concluded that the variance between the means of the different sets of fertilizers were significantly different. The P value (0.032) was slightly lesser amount than the significance level of 0.05 was obtained, signifying that the differences between the means among the different fertilizers were marginally significant. All in all, upon combining the results of F statistics with the P value, a decision of rejecting the null hypothesis was made as enough evidence were available to conclude that fertilizers type influenced the growth rate of the plants as indicated by their corresponding root lengths. Subsequently, to determine which pair of fertilizers were different in terms of their means, a post hoc test via Fisher's least significant difference was conducted, as shown in Fig. 26.

annova: single factor

Significance level = 0.05

SUMMARY

Groups	Count	Sum	Average	Variance
Fertiliser A	2	14.5	7.25	0.005
Fertiliser B	2	13.4	6.70	0.020
Fertiliser C	2	13.4	6.70	0.020

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.403	2	0.202	13.444	0.032	9.552
Within Groups	0.045	3	0.015			
Total	0.448	5				

Fig. 25. Single factor ANOVA performed via Microsoft Excel regarding the root length of the plants after planted for 25 days.

ROOT LENGTH (POST HOC TEST)

$$\text{Fisher's LSD} = T\,critical \times \sqrt{MSE\left(\frac{1}{n_i}+\frac{1}{n_j}\right)}$$

T critical = 3.18

= 0.39

DIFFERENCE IN MEANS ($\bar{X}$)

	Fertiliser A	Fertiliser B	Fertiliser C
Fertiliser A			
Fertiliser B	0.55		
Fertiliser C	0.55	0.00	

RESULTS

Result is significant if the absolute value of the difference in means is greater than the calculated LSD value; and vice versa.

	Fertiliser A	Fertiliser B	Fertiliser C
Fertiliser A			
Fertiliser B	Significant		
Fertiliser C	Significant	NOT Significant	

CONCLUSION / DECISION

At a P-value of less than or equal to 0.05, it is found out that:

i. *Fertiliser A* is significantly different from *Fertiliser B*

ii. *Fertiliser A* is significantly different from *Fertiliser C*

iii. *Fertiliser B* is not significantly different from *Fertiliser C*

Fig. 26. Fisher's LSD performed via Microsoft Excel regarding the final root length of the plants after planted for 25 days.

It was noted that Fertilizer A was statistically different from both Fertilizers B and C. The result was aligned with the previous researcher's data that that application of fruit peel powder had significant differences ($P<0.05$) on root length [31]. Thus, it could be deduced that the organic soil amendment produced from banana peels via composting was effective in supporting the growth of both the water spinach and green onion plants. This was particularly true since by comparing their respective shoot length, the ones cultivated in Fertilizer A had managed to grow on average 3.45cm and 2.85cm taller than the ones grown in Fertilizer B and Fertilizer C, while regarding their root's length, plants grown in Fertilizer A managed to penetrate on average 0.55cm deeper than the ones cultivated in Fertilizers B and C.

4. Conclusions

Organic fertilizers with the combination of various ratio of food wastes namely banana peels, Chinese kale and eggshells in the presence of dry leaves functioning as bulking agent is one of the successful ways to reduce waste dumping to landfill. Effectiveness of the organic fertilizers were undergone investigations on both water spinach and green onion plantation through analyses. Fertilizer A which consisted of solely banana peels itself improved the growth of the plants, whereas Fertilizers B and C suppressed the growth of the plants. This was aligned with the analytic work performed mentioning that null hypothesis was rejected as there was enough evidence to conclude that fertilizers type did influence the number of days taken to germinate as well as on the recorded plant's physical parameters during day 25 after the seedlings were planted. In addition, the post hoc test performed aiming in identifying which pairs of means were significant, revealed the capability of banana peels in supporting the growth of plants.

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