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Development of a Compost Tea Brewer Machine

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Abstract *- The primary purpose of this research was to develop and evaluate the performance of a compost tea brewer machine. The specific goals were to solve the problem of the previous design of compost tea brewer machine with regards to the inability to maintain the aerobic condition of compost tea during the brewing process, inability to extract available nutrients and microorganisms available in compost, and design problems which result to difficulty in properly cleaning the machine. The developed machine was evaluated in terms of the quality of compost tea produced. Three settings of the rotational speed of the mixing vessel (1rpm, 3rpm, and 5rpm) were evaluated on brewing compost and its influence on the quality of compost tea produced. The data collected were analyzed using Random Complete Block Design, and the Least Significant Difference was utilized to compare treatment means. Blocking was done on each batch of produced vermicompost used in the study. Results showed that 5rpm setting of vessel mixing vermicompost gave a good quality of produced compost tea (dissolved oxygen of 6.43mg/L, electrical conductivity of 1.530mS-cm-1, pH level of 8.27, total bacterial count of 7.02log10 CFU/mL, total NPK content of 900mg/L, and seed germination index of 133.97%) which is above the minimum values set in this study. With a cost of PhP 43,033.00 for the compost tea brewer machine and a capacity of 100 Liters of compost tea for each brewing process, cost analysis revealed a breakeven of 45 brewing cycles per year and a payback period of 2.4 years.*

Keywords – *Aerobic Condition, Aerated Compost Tea, Aeration System, Compost Tea Brewer Machine*

I. INTRODUCTION

Composting, the decomposition of organic waste, is an essential step in the production of organic fertilizer. It is the natural process of microbes decaying or decomposing organic materials under controlled conditions. After composting, raw organic resources such as agricultural residues, animal manure, food waste, selected municipal trash, and suitable industrial wastes improve their suitability as a nutrient source in the soil [1].

Since compost is in solid form, it is difficult for plants to absorb it. To ensure faster absorption of nutrients by plants, it is necessary to make compost tea. By mixing compost and water, compost tea is produced. The method of producing compost tea is either aerated (ACT) or non-aerated (NCT) for a defined period. Other variation includes mixing additives to increase the bacteria present in the compost [2].

Compost tea has agricultural benefits such as generating and delivering soil microbes that live in symbiotic relationships with plants by dissolving soil nutrients and delivering them to plant root systems [3]. Regardless of how it's created, liquid compost tea can be sprayed on plants as a foliar spray to help them fight disease. When used in this manner, the tea provides an active approach to managing plant diseases by inhibiting spore germination, antagonism, and microbial competition with various plant pathogens.

When used as a spray, the tea supplies the plant with readily available nutritional elements. Compost tea is diluted at 1:4 or 1:6 with water for foliar spray. It has been suggested that maximum leaf surface area coverage may be required for beneficial bacteria in tea to outcompete plant pathogen colonization; however, regular and repeated applications are required [4].

Solid fertilizers like vermicompost or RM-CARES Organic Fertilizer performed best when paired with Effective Microorganisms + Vermitea or Effective Microorganisms + RM-CARES Organic Fertilizer tea in a study of rice production on organic and converted areas. Vermitea was applied weekly to rice fields using five knapsack sprayers (22.5 liter per knapsack sprayer) per hectare till vegetative growth. [5].

Using a volume adequate to reach the root region when applied to the soil [6]. The application of compost tea to the soil is considered to protect the roots against root pathogen invasion and produce healthier plants. It was found that a rate of 7 to 14 gallons per 1000 square feet produced the best results [7]. This rate permitted a little amount of root zone penetration. Vegetable crops should get weekly treatments for at least four weeks.

Both ACT and NCT entail steeping compost in water for a set amount of time at room temperature. Aeration is needed for ACT during the brewing process [8]. In the late 1980s

and 1990s, Weltzein, as a pioneer in this field, concentrated on the non-aerated method of compost tea brewing. However, in recent years, the ACT approach has gained popularity [9].

From the grower's standpoint, ACT has a significant benefit since it can be produced in 1 to 2 days and has fewer odor issues, whereas NCT requires 1 to 2 weeks of steeping time to produce. [4]. NTC, on the other hand, does not require any specific equipment other than steeping compost in a container and is associated with inexpensive inputs, whereas ACT necessitates a continual stirring and aeration of a huge quantity of liquids.

Aerated compost tea, a more modern technique used by compost tea brewers, is an active method that uses an aerator to aerate the compost and water mixture during the brewing process. The ACT can be produced with a shorter brewing period ranging from 12 to 72 hrs.

However, there are documented problems regarding the recent design of compost tea brewer machines available in the market. For instance, the inability of several machines to achieve aerobic conditions (6mg/L of dissolved oxygen level and above), inability to extract available nutrients and microorganisms from the compost, and design of the machine that leads to the inability to clean the machine properly.

The locally available design of an aerated compost tea brewer machine includes an air diffuser for increasing oxygen level and having a vessel to hold the compost during the brewing time. Aside from the attached air diffuser and several openings for the interaction of water and compost on the vessel, there are no other mechanisms that will cause the agitation of compost inside the vessel, which can lead to the inability of the machine to extract available nutrients and microorganisms, and it can lead to the anaerobic condition of the compost.

To overcome the constraints discussed above, it is necessary to develop a new compost tea brewer machine that will address the above problem using locally available materials.

II. OBJECTIVES OF THE STUDY

Generally, this study aimed to develop a compost tea brewer machine. Specifically, it aimed to design and fabricate a compost tea brewer machine, evaluate the quality of produced compost tea of the designed machine in terms of dissolved oxygen level, electrical conductivity, pH level, total bacterial count, and seed germination index, and NPK content and evaluate the cost of utilizing a compost tea brewer machine

III. MATERIALS AND METHODS

A. Design and Fabrication of the Machine

The machine was developed to address the problem in the current designs of available compost tea brewer machines. The design and dimensions of each component were based on the desired capacity and proportions of brewing materials (water and compost in terms of volume). The proportion of compost to the water of a machine used was 1:10 [7]. The duration of the brewing process using the designed machine is 24 hours [4]. The designed compost tea brewer made 100 liters of compost tea per 24 hours brewing process.

The primary components of the compost tea brewer machine are a brewing tank, a composting vessel, an aeration system, a transmission system, and a frame. The sizes of each machine component were calculated based on the expected loads and permissible stresses of the chosen materials. Solidworks software was used to create the design drawing. Further analyses of the major elements were also done using such features of SolidWorks shown in figure 1.

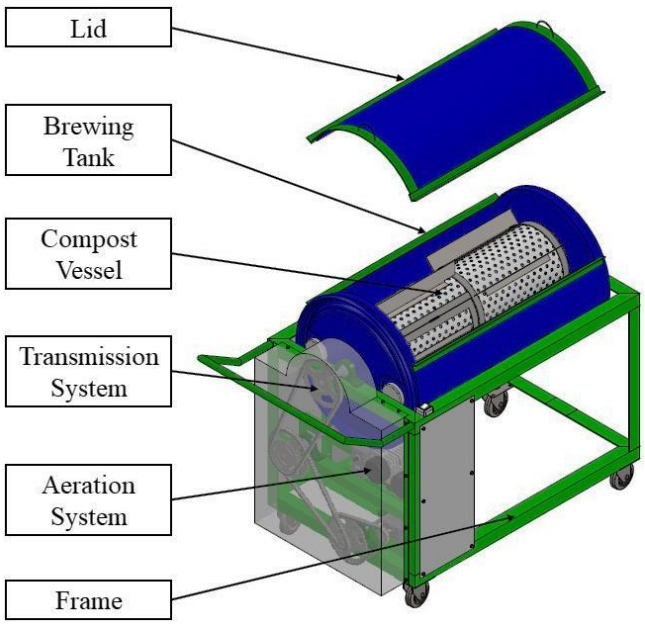

Fig. 1. Drawing plan of compost tea brewer machine

The machine was constructed by a certified local machinery fabricator utilizing basic and local manufacturing tools and equipment based on an approved design plan. In the components that come into contact with compost tea, stainless steel and HDPE plastics were used. The local machinery fabricator used simple production techniques such as measuring, cutting, connecting different pieces by welding, bolts, and nuts, assembling the various components, finishing, and painting.

B. Preliminary Testing of the Machine

Preliminary tests were carried out to assess the functioning conditions of the machine's various components. Necessary adjustments and/or minor modifications were made until the machine satisfied the required rpm and DO level to be maintained. Visual inspection was made on parts of the machine. This also allowed the familiarization of the researcher with the machine. A 24-hour test run was conducted to ensure that the machine would attain the required rotational speed and minimum level of dissolved oxygen during the performance evaluation.

C. Compost Preparation

Vermicomposting is the technique utilized to create the compost that will be used in the research. Vermicomposting is a simple biotechnological composting process that uses specific earthworm species to accelerate waste conversion and produce vermicompost. Earthworm excreta, also known as vermicompost, can help enhance soil health and nutrient concentrations. It is a nutritional organic fertilizer rich in humus, NPK, micronutrients, and beneficial soil organisms such as nitrogen-fixing bacteria, phosphate solubilizing bacteria, actinomycetes, and growth hormones auxins, gibberellins, and cytokinins. [8]. The method used in vermicompost production was recommended by Ramon Magsaysay Center for Agricultural Resources and Environment Studies (RM-CARES) at Central Luzon State University (CLSU). The materials were collected in the vicinity of CLSU. Table 1 shows the materials used in vermicomposting.

TABLE 1.
Test materials used in vermicomposting.

Item	Ratio	Quantity in kg
Carabao manure	6	60
Dried mango leaves	2	20
Rice straw	2	20
Chopped banana trunks	1	10
Fresh madre cacao	1	10

D. Compost Tea Production

One-week-old vermicompost (after harvest) was used to make compost tea using the designed compost tea brewing machine. The dilution ratio (in terms of volume) of vermicompost and water was 1:10 per brewing process [7]. The brewing materials used during the evaluation of the machine are listed in Table 2.

TABLE 2.
Brewing materials used during the performance evaluation of the machine.

Item	Quantity
Vermicompost	6.83kg* (0.01 m^3)
Tap Water	100 liters (0.10 m^3)

*Weight of vermicompost is based on the highest significant value of bulk density of vermicompost reported [12]

E. Compost Tea Brewing Procedure and Data Gathering

Compost tea brewer machine with all necessary instruments, apparatus, and brewing materials was placed in a covered area with an electrical power source. The brewing tank was filled with 100 liters of water. The power switch of the air pump was turned on. The water inside the brewing tank was aerated for 2 hours to raise the DO level from 4mg/L to 8 to 12mg/L and dissipate the water's chlorine. The vermicompost (6.83kg) was placed on a composting vessel and placed in the machine. The machine was allowed to brew compost tea for 24 hours. After 24 hours of the brewing process, the machine was switched off, and the gathering of samples of compost tea was done. The same procedure was done for each set of rotational speeds.

From the beginning to the completion of the brewing process, the DO level was measured at the surface liquid in the brewing tank every six (6) hours using the pen-type dissolved oxygen meter. Data gathered was used to determine the trend of DO level overtime of the brewing process. Electrical conductivity and pH levels were recorded using an electrical conductivity meter and pH meter at the brewing process's end at the brewing tank's surface liquid. One (1) sample of 350 mL compost tea was collected after the brewing process and placed on an unused distilled water container. Each sample taken was subjected to laboratory testing to determine the total percentage of NPK in compost tea.

For the total bacterial count, one (1) sample of 350 mL of compost tea was collected every six (6) hours from the start-up to the end of the brewing process at the surface liquid inside the brewing tank and was placed on unused distilled water container. One milliliter of the well-stirred sample was taken, the dilution series prepared, and microorganisms were cultured using the pour plate technique with three replicates. Nutrient agar was used as the culture media. Then cultured samples were kept in an incubator at 37°C for 24 hr. All microbial colonies were counted separately, and the total bacterial count (CFU/mL) was calculated. One (1) sample of 350 mL compost tea was collected after the brewing process and placed on an unused distilled water container for the seed germination index.

Each sample taken was subjected to seed germination bioassay to determine the seed germination index of tomato (Lycopersicon esculentum cultivar Diamante Max F1) applied with compost tea. A sterile Petri plate lined with filter paper was pipetted with five (5) milliliters of compost tea. On the filter paper, ten tomato seeds were uniformly dispersed and placed in a dark room. Five (5) milliliters of distilled water were pipetted into a sterile petri dish lined with filter paper for control. Each sample was run in triplicate. Sterile Petri dishes were left in a dark room, and after five days, all the tomato seeds successfully germinated, and the total length of each tomato root was recorded.

The power consumption by the machine was recorded using a digital power meter. Power consumption was calculated by multiplying the power recorded by the time consumed by the machine to brew the compost tea. For the NPK of compost as test material, a 500 g of sample was collected from compost before subjecting to the brewing process. Samples were placed in an individual plastic container. Each sample taken was subjected to laboratory testing to determine the total percentage of NPK in compost.

F. Performance Evaluation of the Machine

The machine was evaluated based on the quality of produced compost tea as affected by the rotational speed of the composting vessel. Data were gathered and recorded on a prepared datasheet. The performance parameter that was used as a reference in the evaluation is shown in Table 3.

TABLE 3.
Minimum compost tea quality requirements.

Item	Unit	Values
Dissolved Oxygen Level, [4]	mg/L	6 or higher,
pH Level, [11]	-	6.5 – 8.4
Electrical Conductivity, [7] & [12]	$mS\text{-}cm^{-1}$	1.1 or higher
NPK Content, [13]	mg/L	257mg/L or higher
Population of Bacteria, [14]	Log_{10} CFU/ml	5.00 – 9.00
Germination Index, [15]	%	60 or higher

G. Experimental Design

The statistical analysis used was a single factor experiment, and it was laid out in randomized complete block design (RCBD). The analysis of variance was done to see if the difference between the treatment means were significant. Blocking was done to eliminate the variance in the time of production of each batch of vermicompost. The least significant difference (LSD) was used for the comparison of means of different treatments. There were three (3) settings of continuous rotational speed (1, 3, and 5 rpm) of mixing compost in the composting vessel that served as the treatments in this study.

IV. RESULTS AND DISCUSSION

A. Description of the Machine

The compost tea brewer machine was fabricated using locally available materials. The major components of the device were the brewing tank, transmission system, aeration system, compost vessel, and frame. The fabricated compost tea brewer machine, as shown in Figure 2 in a batch-type manner, where the compost was loaded in a composting vessel. One operator was required during the loading of materials, brewing process, and cleaning of the machine after brewing. Table 4 shows the specification of the compost tea brewer machine.

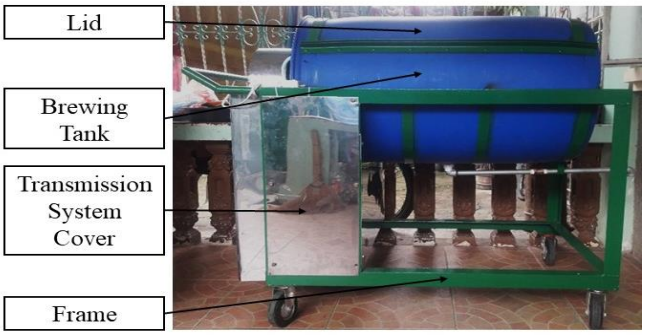

Fig. 2. Parts of the compost tea brewer machine

TABLE 4
Specification of the compost tea brewer machine

Item	Specification
A. Capacity, Liters/brewing process	100
B. Main Structure	
Dimensions and Weight	
L * W * H, mm	1,590 x 690 x 1,080
Weight, Kg	105
C. Brewing Tank	
Materials	HDPE Plastic
Length, mm	970
Diameter, mm	550
D. Compost Vessel	
Materials	HDPE Plastic
Length, mm	800
Diameter, mm	260
E. Prime mover	
Manufacturer	SPG Co., Ltd.
Type & Rated power, W	Induction Motor, 25W
Rated speed, rpm	1,700
Gear Head Ratio	1:36
Weight, kg	4.2
F. Air Pump	
Manufacturer	Resun
Air Flow Rate, L/min	75 x 2
Power Rating, W	58
Type	Electro-magnetic Air Pump
Weight, kg	2.5 kg

B. Principle of Operation

The main function of the compost tea brewer machine was to extract microorganisms, nutrients, and organic compounds available on compost into a water solution. The compost vessel held compost, and the lower portion of the composting vessel was suspended into the tank with water throughout the brewing process. A motor caused the composting vessel to rotate through chain and sprocket connection to mix the compost inside the vessel and allow extraction of microorganisms, nutrients, and organic compounds present in the compost. The air pump directed the air through PVC pipes into the tank, which stirred its contents and kept the consistency of the compost tea relatively uniform. It provided oxygen to support the growth of microorganisms in compost tea. The brewing tank held the compost tea throughout the brewing process.

C. Characteristics of Compost as Test Materials

The chemical characteristics of the compost used to make compost tea with the developed machine are shown in Table 5. With values of 3,000-15,000 mg/kg, 1,000-10,000 mg/kg, and 1,500-5,600 mg/kg, respectively, total nitrogen, total phosphorus, and total potassium of compost in all batches were within the optimum range of excellent compost [1].

TABLE 5.
Chemical characteristics of compost used in the brewing process (mg/Kg)

Batch of Compost	Mean Values (mg/Kg)			Total NPK (mg/Kg)
	Nitrogen	Phosphorus	Potassium	
Batch 1	5,700	4,900	2,200	12,700
Batch 2	5,500	4,800	2,500	12,900
Batch 3	5,200	4,200	2,700	12,100

D. Results of Preliminary Testing

After the fabrication of the machine, the first preliminary testing was done to check if the machine worked according to its purpose. During the first preliminary testing, the rotational speed of the composting vessel was established through a series of different numbers of the tooth of the sprocket and using a motor controller that regulated the rotational speed of the motor. A power switch was also provided on the right side of the device for safety purposes and ease of operation.

The second preliminary testing was done to test the capability of the aeration system of the machine to maintain the aerobic conditions (a minimum of 6mg/L of dissolved oxygen) of compost tea and the transmission system of the machine to mix agitate the compost inside the vessel continuously. It was tested using the rotational speed of a compost vessel's 5rpm (highest rpm setting of the machine). Test materials used were vermicompost produced by RM-CARES and water with a ratio of 1:10. The dissolved oxygen level was recorded every three (3) hours using a DO meter to observe its trend over time. After 24 hours of the brewing process, the machine maintained the dissolved oxygen level above 6mg/L Figure 3. A downward trend was also observed in DO levels over 24 hours of the brewing process. It was a normal condition due to the growth of the microorganism population present in the compost tea.

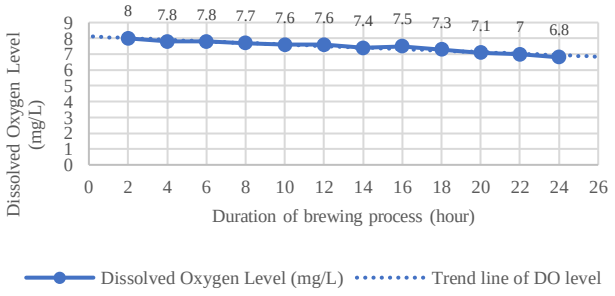

Fig. 3. A trend line of the dissolved oxygen level of compost tea during 2nd preliminary testing of the machine

E. Machine Performance Characteristics

The machine's performance was determined by monitoring the various parameters included in the research. Data on the compost tea quality in terms of dissolved oxygen level, NPK Content, electrical conductivity, pH level, the population of microorganisms, and seed germination index of the compost tea brewer machine were gathered and analyzed.

a) Dissolved Oxygen Level: The dissolved oxygen level of the compost tea as affected by the varying rotational speed of the composting vessel is shown in Table 6. The highest mean of DO level was at 5rpm setting with 6.43mg/L, while the lowest mean at 1rpm setting with 6.20mg/L. The values recorded at three (3) rotational speeds were above the minimum value of 6.00mg/L in which the aerobic

TABLE 6.
Dissolved oxygen level (mg/L) of compost tea as affected by the rotational speed of a composting vessel.

Rotational speed, RPM	Block			Mean
	I	II	III	
1	6.3	6.2	6.1	6.20
3	6.4	6.5	6.3	6.40
5	6.3	6.6	6.4	6.43

Analysis of variance revealed an insignificant effect of the rotational speed of the composting vessel on the dissolved oxygen level of the compost tea during the brewing process. The dissolved oxygen of compost tea produced was 6.20mg/L, 6.40mg/L, and 6.43mg/L for 1rpm, 3rpm, and 5rpm, respectively. Therefore, the DO level of compost tea was the same whether it was produced using 1rpm, 3rpm, or a 5rpm setting of the rotational speed of the composting vessel. The aeration system of the machine affects the DO level of the compost tea produced.

b) Electrical Conductivity: Table 7 shows the effect of varying the rotating speed of the composting vessel on the electrical conductivity of the compost tea obtained. The highest mean of electrical conductivity was 1.530 mS-cm^{-1} at 5rpm, while the lowest mean of electrical conductivity was 1.470 mS-cm^{-1} at 1rpm. The values recorded at three (3) rotational speeds were above the minimum value of 1.100 mS-cm^{-1}, which had a greater plant growth response [12].

TABLE 7.
Compost tea's electrical conductivity (mS-cm–1) is affected by the rotational speed of a composting vessel.

Rotational speed, RPM	Block			Mean
	I	II	III	
1	1.490	1.467	1.448	1.470^{b}
3	1.544	1.500	1.500	1.510^{a}
5	1.550	1.540	1.510	1.530^{a}

Means not sharing the same letter in a column differ significantly at 1% by Least Significant Difference (LSD).

Analysis of variance revealed a statistically significant indication at α=0.01 to show a highly significant difference in electrical conductivity among the three (3) rotational speeds of compost vessels to mix the compost. The comparison of among means of the electrical conductivity as influenced by the rotational speed of a composting vessel revealed that the electrical conductivity of compost tea produced at 1rpm setting was significantly lower compared to the electrical conductivity of compost tea produced at 3rpm and 5rpm settings. The electrical conductivity of compost tea produced at 3rpm and 5rpm did not differ significantly. It could be concluded that 3rpm and 5rpm settings produced compost tea with higher electrical conductivity than the 1rpm setting.

The higher rotational speed of vessel mixing compost helped the extraction of available soluble salts in the compost. The Source of soluble salts in compost such as carabao manure consists of ammonium, nitrate, phosphate, and other major soluble salts such as sodium, magnesium, calcium, and sulfate. According to reference [17], the electrical conductivity of compost tea should not exceed 2.00 $mS\text{-}cm^{-1;}$ otherwise, plant damage, such as a decrease in germination rates and leaf burning, as well as mortality, may occur.

c) pH Level: The pH levels of compost tea as influenced by varying rotational speed of the composting vessel are shown in Table 8. The highest-recorded mean pH level of compost tea was produced at 1 RPM setting with 8.4, while the lowest-recorded mean pH level was produced at 3 RPM setting. The values of pH level of compost tea produced at three rotational speed settings were within the recommended range of pH level (6.50 – 8.40).

TABLE 8.
the pH level of compost tea is affected by the rotational speed of the composting vessel.

Rotational speed, RPM	Block			Mean
	I	II	III	
1	8.4	8.4	8.4	8.40
3	8.3	8.1	8.1	8.13
5	8.2	8.2	8.4	8.27

Analysis of variance showed no significant effect of varying rotational speed of compost vessel in the pH levels of compost tea produced. The pH levels of compost tea were 8.40, 8.13, and 8.27 for 1rpm, 3rpm, and 5rpm, respectively. Therefore, it can be concluded that the pH level of the produced compost tea is the same whether it was produced at 1rpm, 3rpm, and 5rpm settings.

The pH level across the experimental unit did not vary greatly due to the same compost materials used in each study's experimental unit. In reference [13], the pH level of aerated compost tea did not vary greatly (5.07 – 5.16) as affected by the duration of the brewing process.

d) Total Bacterial Count: The total bacterial count ($\log_{10}$ CFU/mL) of compost tea as influenced by the varying rotational speed of a composting vessel is shown in Table 9. The highest mean of a total bacterial count of compost tea with 7.13$\log_{10}$ CFU/mL was recorded at 3rpm setting, while the lowest mean total bacterial count was recorded at 1rpm with 6.99$\log_{10}$ CFU/mL. The values of the total bacterial count of compost tea produced at three different settings were within the ideal range of the total bacterial count of compost tea (5.00 to 9.00$\log_{10}$ CFU/mL). The values of the total bacterial count were also in agreement with the range of results (6.43 to 8.62$\log_{10}$ CFU/mL) of other studies of compost tea [13].

TABLE 9
Total bacterial count ($\log_{10}$ CFU/mL) of compost tea as affected by the rotational speed of the composting vessel.

Rotational speed, RPM	Block			Mean
	I	II	III	
1	7.091	7.15	6.73	6.99
3	7.180	6.92	7.29	7.13
5	7.120	6.96	6.98	7.02

Analysis of variance revealed no significant difference in the total bacterial count of compost tea produced among the three rotational speeds of compost vessels. The mean total bacterial counts of compost tea were 6.99$\log_{10}$ CFU/mL, 7.13$\log_{10}$ CFU/mL and 7.02$\log_{10}$ CFU/mL for 1rpm, 3rpm and 5rpm respectively. Therefore, the total bacterial count of compost tea produced at 1rpm, 3rpm, and 5rpm was the same.

This could also be attributed to the compost used in the study and the DO level in which the airflow rate given the aeration system was constant. Reference [4] suggested that if mixing of compost were not adequate, the compost would compact and eventually go to an anaerobic condition because it did not have aerated water moving through the compost. The brewing process in all experimental units was above the minimum aerobic range of DO level of about 6mg/L and above.

e) Total NPK Content: The total NPK content (%) of compost tea as influenced by the varying rotational speed of the composting vessel is shown in Table 10. The highest mean of the total NPK content of compost tea was produced at a 5rpm setting, while the lowest of compost tea was produced at a 1rpm setting. The values in the experimental unit were above the baseline set in the minimum total NPK (257mg/L) content based on other published studies of compost tea [7] & [10].

Analysis of variance revealed no significant difference in the total NPK content of compost tea produced at three (3) different rotational speed settings. The mean values of compost tea were 613.33mg/L, 866.67mg/L, and 900mg/L for 1rpm, 3rpm, and 5rpm settings, respectively. Therefore, it could be concluded that the total NPK content of the produced compost tea was the same whether it was produced at 1rpm, 3rpm, or 5rpm setting.

TABLE 10
Total NPK content (mg/L) of compost tea as affected by the rotational speed of compost vessel

Rotational speed, RPM	Block			Mean
	I	II	III	
1	800	640	400	613.33
3	800	900	900	866.67
5	700	800	1200	900.00

Despite the insignificant result of analysis of variance, it could be observed that the higher rpm would have a higher NPK content compared to lower rpm, but several authors suggested that solubility of nutrients could also be attributed to the quality of compost and different levels of concentration of nutrients present in compost to water [18]. In addition, it was observed that the highest and lowest total NPK content and the electrical conductivity of produced compost tea were at 5rpm and 1rpm, respectively. It only indicated that the higher the rotational speed of the composting vessel, the more nutrients would be present in compost tea due to agitation and mixing of compost.

f) Seed Germination Index: The seed germination index of tomato (sn. Solanum Lycopersicum cv. Diamante Max F1) applied with compost tea produced at three (3) different settings of the rotational speed of the composting vessel was shown in Table 11. The highest mean of seed germination index was at 5 RPM setting with 133.97%, while the lowest of seed germination index was at 1 RPM setting with 92.18%. All data of seed germination index recorded in each experimental unit at three (3) rotational speeds were above the minimum threshold of 60.00% as suggested for safe soil application [15].

TABLE 11.
Germination index (%) of tomato (sn. Solanum Lycopersicum cv. Diamante Max F1) applied with compost tea produced at three (3) different rotational speeds of compost vessel.

Rotational speed, RPM	Block			Mean
	I	II	III	
1	107.26	99.26	70.03	92.18[b]
3	128.73	116.33	131.58	125.55[a]
5	133.26	128.60	140.06	133.97[a]

Means not sharing the same letter in a column differ significantly at 1% by Least Significant Difference (LSD).

Analysis of variance shown in Appendix Table 6 reveals a statistically significant indication at α=0.05 to show a difference in the germination index of tomato applied with compost tea produced at three (3) different rotational speed settings. The comparison of among means of the seed germination index as influenced by the rotational speed of compost vessel revealed that the seed germination index of compost tea produced at 1 RPM was significantly lower than the seed germination index compost tea produced at 3 RPM and 5 RPM setting. The seed germination index of compost tea produced at 3 RPM and 5 RPM settings does not differ significantly. Therefore, 3 RPM and 5 RPM settings produced compost tea with a higher seed germination index than the 1 RPM setting.

g) Interaction between Dissolved Oxygen and Total Bacterial Count of Compost Tea over Time of Brewing Process: The desirable level of dissolved oxygen (DO) for the brewing process of compost tea is 6 mg/L [4]. The machine was able to maintain the desired level of the dissolved oxygen level (6.20 to 7.50mg/L) throughout the brewing process; however, a downward trend line (as shown in Figure 4) was observed on the dissolved oxygen level of compost tea in all three (3) rpm settings of the machine. It observed an upward trend line on compost tea's total bacterial count (TBC) in all three (3) rpm settings. The downward trend of DO level and the upward trend of TBC could be attributed to the growth of a population of bacteria in the compost tea. As the population of bacteria increased, the oxygen demand increased, and as a result, the DO level decreased in the compost tea. The critical part of the brewing process is when the DO level of compost tea reaches below 5mg/L. The anaerobic conditions ensued, and toxic materials to plant growth were produced in the compost tea.

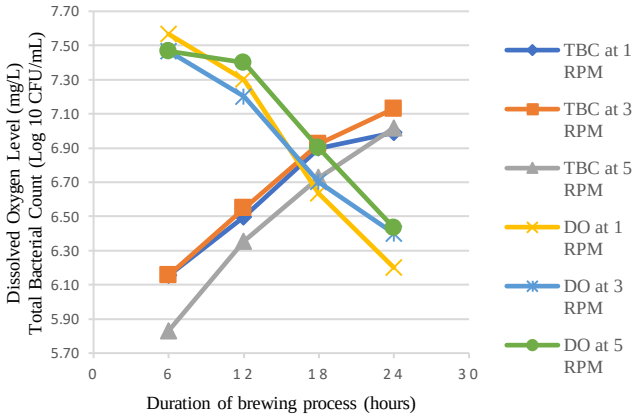

Fig. 4. The average dissolved oxygen level (mg/L) and the total bacterial count (Log_{10} CFU/mL) of compost tea as affected by varying speed of compost vessel during 24 hours of the brewing process

h) Power Consumption: The power consumption of the machine was determined using a digital power meter. The power consumption of the compost tea brewer machine as affected by the rotational speed of the composting vessel was shown in Figure 5. It could be seen that the power consumption ranged from 2.522 to 3.072kW. The highest power consumption was recorded at 1rpm, while the lowest power consumption was recorded at 5rpm. Power consumption was lower on the compost vessel's highest rotational speed setting than the lowest rotational speed. It was due to the use of an AC motor speed controller that regulated the current flow to the motor, and as a result, it was able to control the desired speed at a given current flow output by the controller. The AC motor speed controller was a closed-loop speed controller used for controlling the motor speed in response to the varying current supply. The electric motor decreased its efficiency as the current flow increased caused by the AC motor speed controller. Using a lower setting speed setting in the AC motor speed controller, the current flow in the electric motor increased, and as a result, the power consumption increased.

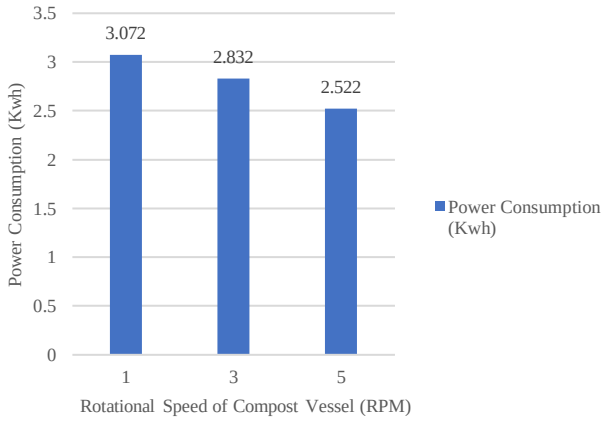

Fig. 5. Power consumption of machine as affected by varying the speed of a composting vessel during 24 hours of the brewing process

F. Cost Analysis of the Machine

The cost of materials and fabrication of the compost tea brewer machine was Php 45,033.00 with an expected life span of 5 years. Considering all the assumptions made, including the annual use of machine per year of 98 brewing cycles per year and price per liter of 8.00 Php/Liter, cost analysis indicated a breakeven of 45 brewing cycles per year and a payback period of 2.4 years. Figure 6 shows the breakeven graph analysis of using a compost tea brewing machine. It is revealed that the compost tea brewer machine could earn a net income when the machine operates more than 45 brewing cycles per year.

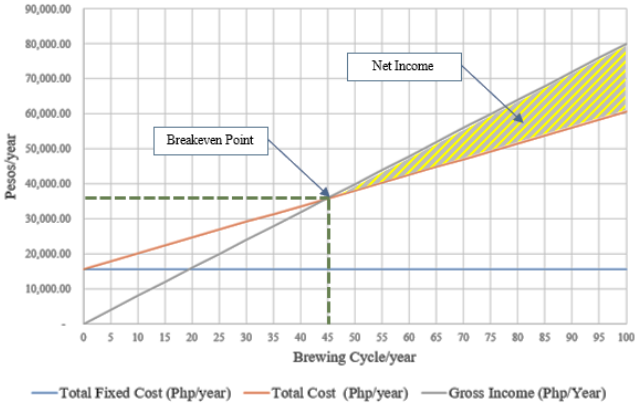

Fig. 6. Breakeven graph analysis of using a compost tea brewer machine.

V. CONCLUSIONS

The following conclusions were drawn based on the study findings: A compost tea brewer machine with five (5) major components, namely: a composting vessel, brewing tank, aeration system, transmission system, and mainframe, was successfully fabricated following the design calculations and considerations. It operated on the extraction principle of beneficial organisms and nutrients through the rotational motion of vessels containing compost. The machine with an overall dimension of 1,365mm x 665mm x 1,370mm was completely fabricated using available materials from a local manufacturing shop.

The machine performed satisfactorily based on its performance parameters regarding the quality of the produced compost tea (dissolved oxygen level, electrical conductivity, pH level, total bacterial count, and total NPK content). Generally, the compost tea brewer machine is best operated at an operating speed of 5rpm with a dissolved oxygen level of 6.43mg/L, the electrical conductivity of 1.530mS-cm^{-1}, pH level of 8.27, total bacterial count of 7.02 $\log_{10}$ CFU/mL, total NPK content of 900mg/L and seed germination index of 133.97%. The cost analysis on the use of the machine revealed that it is financially viable if used for selling produced compost tea to the farmer. The cost of fabricating the device was Php 45,033.00. The average annual net income was 18,739.78Php/year, with a computed breakeven brewing cycle per year and a payback period of 45 brewing cycles/year and 2.4 years, respectively.

VI. RECOMMENDATIONS

The following recommendations were made based on the result of the research; The compost tea brewer machine should be used at an operating speed of 5rpm and brewing time of 24 hours. The machine could be evaluated using other types of compost. The machine could be evaluated using a shorter duration of the brewing process.

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