Developing Flowerpot from Coffee Grounds Using the Design of Experimental Technique

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Abstract. This research aims to utilize coffee grounds as flowerpot by using the design of experimental techniquein order to reduce the use of plastic bagsand add value to coffee grounds in a way that is environmentally friendly. Three-level full factorial design method was emphasized in designing step. The amount of coffee grounds, the amount of bonding chemical, and the compressive force were three main factors of the experiment in this research. The result found that the highest efficiency of tested flowerpot in this experiment was the flowerpot with ingredients of 275:45:2000 (the amount of coffee grounds: the amount of bonding chemical: the compressive force). Moreover, the longest duration of degradation in the soil of tested flowerpots was 17 days.

Keywords: Design of Experimental, DOE, Factorial Designs, Coffee Grounds, Flowerpot

1. Introduction

In only a few years, a coffee shop business in Thailand has rapidly and continuously grown. This can be observed from the increasingnumber of coffee shops and the fact that they can now be found almost everywhere such as in department stores, gas stations, and educational institutes. In the process of making coffee, the waste from this process is the coffee grounds. Normally, the coffee grounds are disposed as garbage. However, in recent research, the coffee grounds have been used in various products such as fertilizer and soap. For the same reason, this research is aimedat utilizing coffee grounds as flowerpot. Normally, farmers prefer to use the plastic bag in planting because it is easily purchased and cheap. However, the disadvantage of planting in plastic bag is that it can cause damage to the root of the plant when the plastic bag is torn or pulled down. Moreover, the plastic bag is commonly reused and its decomposing time is at least a decade. And so, this research will attempt to utilize coffee grounds as flowerpot in order to reduce the use of plastic bagsand add value to coffee grounds in a way that is environmentally friendly.

2. Literature Review

Tontabtimthong*et al.* (2007) had researched the possibility of creating flowerpot from agricultural residues. The ingredientsfor this flowerpot consisted of 100 grams of coconut husk, 150 grams of coconut fiber, and 50 grams of glue. Then, these ingredients were mixed together. Next, they were compressed using hydraulic with 10 tons of compressive force. This ingredient can produce a flowerpot of six inches in diameter. After that, this flowerpot was left to dryfor about ten minutes. Once the flowerpot is dried, it can be used immediately.[1]

Dansai Industrial and Community Education College (2009) had also carried out research on creating flowerpot from leavings. Leavings such as a piece of paper were immersed into water for about four hours. Then, they were blended and mixed with water and glue. Next, chalk powder was added to easily set the shape. After that, the mixture was brought into the mold of flowerpot and then left to dry out. Finally, the flowerpot was taken out from the mold and painted with oil coloraccording to the desired pattern.[3]

Kialek (2010) had also developed a flowerpot using natural material. Kialek's research aimed to create a flowerpot from the natural material instead of using plastic bagsas a way to reducing global warming. The natural materials used in this research consisted of sawdust, coconut husk, and fertilizer. The ingredients

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consisted of 1000 grams of dung mixed with soil and 500 ml of glue, and then allowed to mix well together. Next, this mixture was compressed to the desired flowerpot shape. After that, this flowerpot was left to dryfor about two to three days. Then, this flowerpot was decorated in the desired shape. After the flowerpot had dried, the tree can be planted immediately. From the experiment, the results found that the flowerpot from natural materials had the ability to absorb water and disperse the heat from the flowerpot. Moreover, it can be biodegradable and help create an unpolluted environment.[4]

3. Basic Information

Coffee grounds are the waste from the coffee making process. They are easily obtained from various places such as household kitchens, coffee shops, and offices. First step before using them is to dry out the coffee grounds to prevent fungi. Then, the size of coffee grounds is selected by using a fine sieveMethodology.

3.1. Factorial Designs[2], [5]

Factorial design is commonly used to study the influence of factors on a process that occurs simultaneously. All factors can be changed simultaneously during the experiment rather than changing only one factor. It can provide more efficiency, as well as time and cost savings. Moreover, the interaction between factors can be analyzed as well. In this study, the interaction is the results of factors in many processes. If the experiment is not tested using factorial design, the interaction factors cannot be clearly observed.

3.2. Three-Level Full Factorial Design

Three-Level Full factorial design is an experiment using full factorial for each factor and can be changed into three levels of testing. This is equal to 3k,for in the experiment with three factors, each factor can be changed to three levels. In this study, the experiment has three levels of factors as shown in Table1.

TABLE 1: The controlled factors of this study

Factors	No. of Factors	Symbols	Levels
1.The amount of coffee grounds	3	A	250 grams 275 grams 300 grams
2.The amount of bonding chemical	3	B	35grams 40grams 35grams
3. Compressive force	3	C	1000 pound/inch^2 1500pound/inch^2 2000 pound/inch^2

3.3. Design of Experiment

In this study, the experiment was designed by specifying three main factors for making flowerpot which included the amount of coffee grounds, the amount of bonding chemical, and the compressive force in the forming process. Each factor was allocated into three levels which consisted of 250, 275, 300 grams of the amount of coffee grounds; 30, 35, 40 grams of the amount of bonding chemical; and 1000, 1500, and 2000 pound/inch2 of compressive force as shown in Table 1.

From Table 1, in the design step of flowerpot, it found that the treatment was 3 x 3 x 3 =27 trials and three replications of testing. Therefore, the data to be collected in each experiment equal 27 x 3 = 81,and the number of conditions in each experiment is called a Run. In Table 1, A refers to the amount of coffee grounds, B refers to the amount of bonding chemical, and C refers to the compressive force. An example of flowerpot from coffee grounds is shown in Fig.1.

Fig. 1. Example of flowerpots from coffee grounds

3.4. Design of Degradation Testing in Soil

For the design of degradation testing in soil, the first step was to take the flowerpot from coffee grounds and have it buried in the soil at the proper depth. The next step was to observe the duration of degradation in the flowerpot soil. The performance of degradation for each Run was tested in two stages. In the first stage, the flowerpots were tested every three days, one time a day at 3 p.m. to 4 p.m. for nine days. At this earlier stage, the flowerpots were hardly degraded. Next, nine days after the burial, the testing had changed into one time a day at the same period. When the decomposition was completed, the coffee grounds will have decomposed into a homogeneous soil. The example of degradation in soil is shown in Fig.2.

Fig. 2. Example of degradation in soil

3.5. Hypothesis of Testing

This study has replicated the testing three times. The factors, which were expected to affect the degradation in soil, included the amount of coffee grounds, the amount of bonding chemical, and the compressive force.

Hypothesis 1: Does the amount of coffee grounds affect the degradation in the soil of flowerpot?

H_o: The amount of coffee grounds does not affect the degradation in the soil of flowerpot.

H_1: The amount of coffee grounds affects the degradation in the soil of flowerpot.

Hypothesis 2: Does the amount of bonding chemical affect the degradation in the soil of flowerpot?

H_o: The amount of bonding chemical does not affect the degradation in the soil of flowerpot.

H_1: The amount of bonding chemical affects the degradation in the soil of flowerpot

Hypothesis 3: Does the compressive force affect the degradation in the soil of flowerpot?

H_o: The compressive force does not affect the degradation in the soil of flowerpot.

H_1: The compressive force affects the degradation in the soil of flowerpot.

Hypothesis 4: Does the interaction between the amount of coffee grounds and the amount of bonding chemical affect the degradation in the soil of flowerpot?

H_o: The interaction between the amount of coffee grounds and the amount of bonding chemical does not affect the degradation in the soil of flowerpot.

H_1: The interaction between the amount of coffee grounds and the amount of bonding chemical affects the degradation in the soil of flowerpot.

Hypothesis 5: Does the interaction between the amount of coffee grounds and compressive force affect the degradation in the soil of flowerpot?

H_o: The interaction between the amount of coffee grounds and compressive force does not affect the degradation in the soil of flowerpot.

H_1: The interaction between the amount of coffee grounds and compressive force affects the degradation in the soil of flowerpot.

Hypothesis 6: Does the interaction between the amount of bonding chemical and compressive force affect the degradation in the soil of flowerpot?

H_o: The interaction between the amount of bonding chemical and compressive force does not affect the degradation in the soil of flowerpot.

H_1: The interaction between the amount of bonding chemical and compressive force affects the degradation in the soil of flowerpot.

Hypothesis 7: Does the interaction between the amount of coffee grounds and compressive force affect the degradation in the soil of flowerpot?

H_o: The interaction between the amount of coffee grounds and compressive force does not affect the degradation in the soil of flowerpot.

H_1: The interaction between the amount of coffee grounds and compressive force affects the degradation in the soil of flowerpot.

In testing the hypothesis of this experiment, the MINITAB software was used to test the analysis of variance (ANOVA) on the effects of degradation in soil. Moreover, in analyzing the result, the significance level is set at 0.05. If the P-value is less than the significant level (P-value<α), it can be concluded that H_1 is accepted. Conversely, if the P-value is greater than the significant level (P-value>α), it can be concluded that H_o is accepted. Hence, the results of the analysis of variance are shown in Table 2.

TABLE 2: ANOVA of the degradation test in soil of flowerpot from coffee grounds

Source	DF	Seq SS	Add SS	Adj MS	F	P
A	2	155.556	155.556	77.778	65.84	0.000
B	2	89.556	89.556	44.778	38.46	0.000
C	2	3.556	3.556	1.778	0.24	0.000
A*B	4	15.778	15.778	3.944	2.67	0.987
A*C	4	1.778	1.778	0.444	0.31	0.13
B*C	4	1.778	1.778	0.444	0.32	0.13
A*B*C	8	4.889	4.889	0.611	0.2	0.07

From Table 2, the results can be summarized as follows:

- *Hypothesis 1:* Accept H_1, the amount of coffee grounds affects the degradation in soil of flowerpot.
- *Hypothesis 2:* Accept H_1, the bonding chemical affects the degradation in soil of flowerpot.
- *Hypothesis 3:* Accept H_1, the compressive force affects the degradation in soil of flowerpot.
- *Hypothesis 4:* Accept H_o, the interaction between the amount of coffee grounds and the amount of bonding chemical does not affect the degradation in the soil of flowerpot.
- *Hypothesis 5:* Accept H_o, the interaction between the amount of coffee grounds and the compressive force does not affect the degradation in the soil of flowerpot.
- *Hypothesis 6:* Accept H_o, the interaction between the amount of bonding chemical and the compressive force does not affect the degradation in the soil of flowerpot.
- *Hypothesis 7:* Accept H_o, the interaction between the amount of coffee grounds and the compressive force does not affect the degradation in the soil of the flowerpot.

4. Summary

From the analysis of variance using the MINITAB software and hypothesis testing, the results can be summarized as follows:

The testing of degradation in soil: the important factors that effect this testing included the amount of coffee grounds, the amount of bonding chemical and the compressive force. Examples of degradation time in soil are shown in Table 3.

From Table 3, it can be observed that the shortest duration for the degradation in soil of flowerpot from coffee grounds was 11 days, while the longest duration was 17 days. Moreover, there were only four experiments which had similar results, 17 days. These consisted of flowerpots Nos. 26, 5, 54, and 79. First, flowerpot No. 26 had ingredients which consisted of 300:45:1500 (the amount of coffee grounds: the amount of bonding chemical: the compressive force). Second, flowerpot No.51 had ingredients which consisted of 275:45:2000. Third, flowerpot No.54 had ingredients which consisted of 300:45:2000. Finally, flowerpot No.79 had ingredients which consisted of 300:45:2000. These indicated that all four flowerpots had similar efficiency, even though differed in the amounts of coffee grounds which were 275 and 300 grams. To sum up, flowerpot No.51 had the highest efficiency in this experiment with ingredients of 275:45:2000.

TABLE 3: Examples of degradation time in soil

Flowerpot No.	A	B	C	Degradation time in soil (Day)
26	300	45	1500	17
27	300	45	2000	11
51	275	45	2000	17
54	300	45	2000	17
57	250	35	2000	11
79	300	45	1000	17

5. Further Study

This research had only focused on three main factors, namely, the amount of coffee grounds, the amount of bonding chemical, and the compressive force. These three factors were controlled in this study. However, other remaining factors were not controlled such as the weather, the humidity, and the moisture inside the flowerpot. These factors could be controlled during degradation testing in future studies.

6. References

[1] P. Tontabtimthong, M. Jinadith, S. Boonpung, and J. Kinboon. *Research on creating flowerpot from agricultural residues.* Thesis, Rajamangala University of Technology, Bangkok, 2007.

[2] P. Chutima. *Design of Experiment in Engineering.*Chulalongkorn University Publisher, 2002.

[3] Dansai Industrial and Community Education College. *Leavings flowerpot.*Dansai Industrial and Community Education College Publisher, 2009.

[4] W. Kialek. *Flowerpot from natural materials.*Bangkaew Industrial and Community College Publisher, 2010.

[5] C. Sikaewseiw, *Full Factorial Design.* [online: 03/03/12]: http://www.statistics.ob.tc/Full_DOE.htm