Research Title

The effect of coffee grounds on soil properties in a demonstration rice paddy plot, Somdetpittayakom School, Somdet District, Kalasin Province.

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Junior High School

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Abstract

The objective of this research was to study 1) the properties of potting soil mixed with coffee grounds. The research aimed to: 1) compare the properties of potting soil mixed with coffee grounds with potting soil not mixed with coffee grounds; and 2) compare the properties of potting soil mixed with coffee grounds with potting soil not mixed with coffee grounds. The research area was the demonstration rice field at Somdetpittayakom School, Somdet District, Kalasin Province. The study used the GLOBE Protocol to examine soil color, texture, temperature, moisture, pH, and fertility, and recorded the data in a data entry system. The research results showed that the soil in all three plots was clay soil without coffee grounds mixed in. It was yellowish-red in color, hard to the touch, not soft, and could not be molded into a round ball. The soil temperature in plots without coffee grounds mixed in is as high as 35 degrees Celsius. The soil moisture content in plots with coffee grounds mixed in is higher than in plots without coffee grounds. When the soil's pH was tested from the three plots, it was found to be slightly acidic, with values between 5.0 and 6.0, which is suitable for rice cultivation. And when soil fertility was measured, it was found that soil without coffee grounds mixed in had low levels of nitrogen and phosphorus, and moderate levels of potassium.

Keywords: Soil, Coffee grounds, Soil properties

Introduction

Soil is a vital resource for plants and all living organisms on Earth, serving as a primary source of water, air, and essential nutrients required for plant growth
If soil lacks fertility or possesses unsuitable physical and chemical properties, plants cannot grow normally. Generally, high-quality soil consists of 45% inorganic matter, 5% organic matter, 25% water, and 25% air

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However, soil degradation has become a critical issue, primarily caused by the shift from subsistence farming to commercial agriculture, improper land management, and long-term land use without soil quality improvement

In Thailand, out of the total 320.69 million rai, approximately 131.59 million rai (30%) is used for agriculture. Data from the Land Development Department indicates that **about 70.13% of the country faces soil degradation issues**, with a significant portion of the land having organic matter levels below 1.5–2%. Furthermore, soil erosion has reached a critical stage, increasing significantly over the past decades due to deforestation, urbanization, and the intensive use of chemical fertilizers and monocropping

To address these issues, **improving soil quality** can be achieved through various methods, such as integrated farming, organic practices, and biological soil amendments **Spent coffee grounds**, a byproduct of the increasing global coffee consumption, have emerged as a valuable material for this purpose. Research shows that coffee grounds contain essential nutrients, particularly **high levels of nitrogen, as well as potassium and phosphorus**, which are crucial for plant development. Additionally, coffee grounds can help suppress certain pests and adjust soil acidity to levels suitable for various plants. **Somdetpittayakom School**, located in Kalasin Province, established a demonstration rice field using soil dredged from the "Ang Waree" public reservoir in 2022

However, the rice yield was significantly lower than expected, producing only 450 kilograms per rai compared to the potential yield of 1,000 kilograms. Facing this challenge, the researchers became interested in studying the properties of the soil in the demonstration field and exploring **soil quality improvement using coffee grounds** to create a more suitable environment for rice cultivation and to serve as a sustainable learning resource for the school and community

Research question:

What are the properties of the soil in the demonstration rice fields that are mixed with coffee grounds and those that are not mixed with coffee grounds?

Research Hypothesis:

Soil mixed with coffee grounds will have better properties for rice cultivation than soil not mixed with coffee grounds.

Research Objectives:

1. To study the properties of potting soil mixed with coffee grounds and potting soil without coffee grounds.
2. To compare the properties of potting soil mixed with coffee grounds and potting soil without coffee grounds.

Materials and Research Methodology

Materials and Equipment

The materials and equipment used for studying soil properties consist of the following

- **Soil Samples:** Soil from three experimental plots
- **Spent Coffee Grounds:** Used as a soil amendment
- **Soil Temperature Measurement:** Includes a needle or digital soil thermometer, a lead nail (at least 12 cm long), a hammer, a 12-cm plastic tube for the thermometer, a standard thermometer for calibration, a wrench, a clock, and data recording sheets
- **Soil Moisture Measurement:** Includes a hoe or shovel, a soil auger, measuring tape, metal cans with lids (for samples at 0-5 cm and 10 cm depths), plastic bags with rubber bands, and identification labels
- **Soil Fertility Measurement (N, P, K):** Dried and sieved soil samples, an NPK soil test kit, distilled water, teaspoons, a test tube rack, and data recording sheets
- **Soil pH Measurement:** pH paper, a pH pen or meter, distilled water, and glassware

Research Methodology

The research followed the **GLOBE Protocol** standards, conducted through these steps:

1. **Site Survey and Preparation:** The research was conducted at the demonstration rice field of Somdet Pittayakom School

Three soil plots, each 90 square centimeters, were prepared

- **Plot 1:** Soil mixed with 2 kg of coffee grounds that had been sun-dried for 3 days
- **Plot 2:** Soil mixed with 2 kg of moist coffee grounds
- **Plot 3:** Soil without any coffee grounds (Control)
- All plots were left to rest for **7 days** before measurements

2. **Soil Color Analysis:** Soil samples were observed for moisture levels (dry, moist, or wet) and compared against a soil color chart under natural sunlight
3. **Soil Texture Analysis:** Samples were moistened and felt by hand to determine their ability to be molded into shapes, then compared with a field soil texture manual
4. **Soil Temperature Measurement:** A lead hole was created using a 12-cm nail

A thermometer was inserted into the hole for at least 2 minutes until the reading stabilized (varying by no more than 0.5 - 1°C) at a depth of 5 cm. Thermometers were calibrated using room-temperature water before use

5. **Soil Moisture Measurement:** Soil samples were collected from depths of 0-5 cm and 10 cm The samples were weighed, then baked at **95-105°C for 24 hours** to calculate the moisture content based on the mass difference between wet and dry soil

6. **Soil pH Measurement:** 20 grams of dried, sieved soil were mixed with distilled water in a **1:1 ratio**

The mixture was stirred and allowed to settle before the pH of the clear liquid was measured using pH paper or a pH pen

7. **Soil Fertility Measurement (NPK):** Soil solutions were tested using specific reagents (HI 3895-N, P, and K)

. The results for Nitrate-Nitrogen and Phosphorus were determined by color comparison, while Potassium was determined by the level of turbidity in the solution

Research Results

The study on the properties of soil mixed with spent coffee grounds compared to unmixed soil yielded the following results:

1. Properties of Soil Without Spent Coffee Grounds (Control Plot)

Based on the analysis of Plot 3 (control), the soil properties after 7 days were as follows:

• **Soil Color and Texture:** The soil was **yellow-red**, with a **hard, clayey texture** that was not soft to the touch and could not be molded into spheres

• **Temperature:** The soil temperature was high at **35°C**

. • **Moisture Content:** Moisture levels were **0.87 g/g** at a depth of 5 cm and **0.95 g/g** at 10 cm

• **pH and Fertility:** The soil pH was **6.0**. Nutrient analysis showed **low levels of Nitrogen (N) and Phosphorus (P)**, while Potassium (K) was at a moderate level

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2. Properties of Soil Mixed with Dried Spent Coffee Grounds

The analysis of Plot 1, which was mixed with 2 kg of dried coffee grounds, showed:

• **Soil Color and Texture:** The soil turned **brown** and became a **soft clay** with large aggregates that could be molded into spheres

• **Temperature:** The temperature was lower than the control plot at **30°C**

. • **Moisture Content:** Moisture levels increased to **1 g/g** at 5 cm and **1.06 g/g** at 10 cm

. • **pH and Fertility:** The pH was **5.0**. The levels of **Nitrogen (N), Phosphorus (P), and Potassium (K) were all moderate**

3. Properties of Soil Mixed with Moist Spent Coffee Grounds

The analysis of Plot 2, mixed with 2 kg of moist coffee grounds, showed:

• **Soil Color and Texture:** The soil was **brown** and had a **fine, soft, clayey texture** that could be molded into spheres

• **Temperature:** Similar to the dried coffee plot, the temperature was **30°C**

• **Moisture Content:** Moisture was **1 g/g** at 5 cm and reached its highest point of **1.24 g/g** at 10 cm

• **pH and Fertility:** The pH was **5.0**, with **moderate levels of N, P, and K**

4. Comparative Summary

When comparing all three plots, the researchers found that **soil mixed with spent coffee grounds (both dry and moist) had significantly improved properties** compared to the unmixed soil:

• **Physical Changes:** The coffee grounds changed the soil color from yellow-red to brown and turned hard soil into a softer, moldable texture

• **Environmental Factors:** Mixed soil maintained a **lower temperature (30°C vs 35°C)** and **higher moisture content** because the porous nature of coffee grounds allows for better air and water retention

• **Nutrient Enhancement:** Adding coffee grounds increased the availability of essential nutrients, specifically raising **Nitrogen and Phosphorus levels from "low" to "moderate"**

Conclusion and Discussion

Conclusion

Based on the research findings after a 7-day soil resting period, the results are as follows:

1. **Plot 1 (Soil mixed with dried spent coffee grounds):** The soil turned **brown** with a **soft, clayey texture** and large soil aggregates that could be molded into spheres . The soil temperature was **30°C**, and moisture levels were 1 g/g at a 5-cm depth and 1.06 g/g at a 10-cm depth. The pH was **5.0**, and nutrient levels for **Nitrogen (N), Phosphorus (P), and Potassium (K) were all at moderate levels**

. 2. **Plot 2 (Soil mixed with moist spent coffee grounds):** The soil was **brown** with a **fine, soft, clayey texture** that could be molded into spheres

. The soil temperature was **30°C**, and moisture levels were 1 g/g at a 5-cm depth and 1.24 g/g at a 10-cm depth. The pH was **5.0**, with **moderate levels of N, P, and K**

. 3. **Plot 3 (Control - Soil without coffee grounds):** The soil remained **yellow-red** with a **hard, clayey texture** that was not soft to the touch and could not be molded

. The temperature was higher at **35°C**, and moisture levels were lower (0.87 g/g at 5 cm and 0.95 g/g at 10 cm). The pH was **6.0**, with **low levels of Nitrogen and Phosphorus**, and a moderate level of Potassium

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Discussion

1. **Physical Properties:** Soil mixed with coffee grounds turned brown and became softer compared to the hard, yellow-red control soil

. This color change is attributed to the **roasting process** of coffee beans and the **high organic matter** in coffee grounds, which aligns with previous research indicating that coffee grounds increase organic matter more than other soil amendments

2. **Temperature and Moisture:** The soil mixed with coffee grounds had **lower temperatures and higher moisture** than the control plot

. This is because coffee grounds are **highly porous**, allowing air and moisture to move through and be trapped within the soil structure

3. **Soil Fertility:** Adding coffee grounds improved nutrient levels from "low" to **"moderate" for Nitrogen and Phosphorus** . Chemical analysis (ICP-AES) confirms that coffee grounds contain essential minerals such as **K, P, Mg, Ca, and Fe**, with Potassium being the most abundant. This supports the use of coffee grounds as a viable alternative for promoting plant growth

4. **Dry vs. Moist Grounds:** There was **no significant difference** between soil mixed with dry versus moist coffee grounds

. This may be due to the short drying period (3 days) and overcast weather during the preparation, which prevented the grounds from drying completely

Cautions: While coffee grounds improve soil quality, they contain compounds like **caffeine, tannins, and chlorogenic acid**, which can be **toxic to plants**

. A short mixing period may not be sufficient to neutralize these substances entirely

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References

Soil Survey and Classification Division. (2000). *Manual for Soil Suitability Classification for Economic Crops of Thailand*. Technical Document No. 453. Land Development Department, Ministry of Agriculture and Cooperatives, Bangkok

Faculty members of the Department of Soil Science. (1998). *Introduction to Soil Science*. Department of Soil Science, Kasetsart University, Bangkok

Jaruporn Sriprasert. (1997). *Analysis of Caffeine Content in Ready-to-Drink Canned Coffee*. In Research Training Project. Phetchaburi: Phetchaburi Rajabhat Institute

Jeeraporn Inthasan et al. (2020). *Effect of Soil Amendments on Changes in Some Soil Chemical Properties in Saraburi Soil Series*. Journal of Agri. Research & Extension 38(2): 25-35

Erb Kheoruenromne. (1999). *Soil Survey Laboratory Manual*. Bangkok: Department of Science, Faculty of Agriculture, Kasetsart University

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