A Comparison of How Coffee Grounds and Biochar Affect Soil Fertility for Growing Chinese Convolvulus

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Abstract

As the use of organic materials in agriculture to improve soil fertility can be beneficial, most farmers rely on biochar for soil improvement before planting. Due to high consumption of coffee in their school, the researchers were interested in studying and comparing the effects of different proportions of coffee grounds and biochar on soil fertility and the growth of Chinese Convolvulus. The study was conducted in seven experimental plots within the school premises which had different amount of biochar and coffee grounds.The soil structure in all plots was similar, characterized by dark brown, loamy soil with high crumbliness. Temperature and soil moisture were inversely related; higher temperatures corresponded to lower moisture levels and vice versa. Plots with coffee grounds and biochar retained moisture better than those without.

Chemically, the soil pH was lowest in the soil-only plot (pH 4), indicating higher acidity compared to plots with coffee grounds and biochar (pH 5). Nutrient analysis revealed low nitrogen (N) content in soil-only plots, moderate levels of phosphorus (P) and potassium (K). Plots with coffee grounds had low N but high P and moderate K levels. Biochar plots had low N, moderate P, and high K levels. These nutrient levels affected the growth of Chinese Convolvulus. During weeks 1-4, Chinese Convolvulus plants grown in plots with 10% biochar exhibited the highest growth. The soil-only plot demonstrated the lowest growth after 4 weeks of cultivation.

Upon measuring the fresh weight of Chinese Convolvulus plants, it was found that plots with 10% biochar and 5% coffee grounds had the highest weight (0.40 kilograms) with the soil-only plot had

the lowest weight (0.32 kilograms). Overall, mixing coffee grounds and biochar in suitable proportions improved soil fertility, increased nutrient levels, and promoted plant growth.

Keywords : coffee grounds, biochar, Chinese Convolvulus, soil fertility , nutrients in soil, nitrogen (N), phosphorus (P), potassium (K)

Introduction

Soil is crucial for the growth of plants and agriculture. Plants rely on soil for root anchorage, water retention, air supply, and nutrients necessary for growth and productivity. If the soil is fertile, it positively impacts the growth of plants and increases yields for farmers.

The use of organic materials in agriculture to improve soil has physical and chemical implications for soil fertility. Plants can utilize these materials for growth. Typically, farmers use organic materials such as biochar to amend soil before planting. It is also often used as a planting medium mixed with soil for container gardening.

The researchers found that V Café, located within Varee Chiangmai School, serves beverages to the school's faculty and staff, with a significant consumption of fresh coffee. As a result, there is a large quantity of coffee grounds generated as waste from the coffee extraction process. Some of these grounds are disposed of through burying or incineration, which contributes to greenhouse gas emissions and global warming. The researchers were interested in utilizing coffee grounds as organic material in agriculture to improve soil before planting. They conducted a comparative study on the effects of different ratios of coffee grounds and biochar on soil fertility for the growth of Chinese Convolvulus in experimental plots within the school premises. It was expected that the comparative results obtained from this study will serve as a guideline for farmers to improve soil using organic materials as an alternative, promoting efficient and highly effective resource utilization and transforming waste into value. Additionally, this approach helps mitigate environmental issues and aligns with the concept of a circular economy, which is a sustainable agricultural practice.

Objectives

1. To study and compare the effects of different ratios of coffee grounds and biochar on soil fertility.
2. To study and compare the effects of different ratios of coffee grounds and biochar on the growth of Chinese Convolvulus.
3. To disseminate the comparative study findings as agricultural data for the school and community.

Question

Do different ratios of coffee grounds and biochar affect soil fertility and the growth of Chinese Convolvulus? If so, how?

Hypothesis

Different ratios of coffee grounds and biochar have varying effects on soil fertility and the growth of Chinese Convolvulus.

Materials and Equipment

1. Chinese Convolvulus seeds
2. Seven experimental plots, each 0.5 meters wide and 1 meter long
3. Materials and equipment for measuring physical properties

3.1 Soil structure, soil color, soil cohesion, and soil texture

3.1.1 Soil samples
3.1.2 Pointed trowel
3.1.3 Ruler
3.1.4 Spray bottle
3.1.5 Classification by touch field guide
3.1.6 Soil structure handbook
3.1.7 Soil color comparison book
3.1.8 Plastic bags for soil sample collection

3.2 Air temperature and soil moisture

3.2.1. ESP32 Board
3.2.2 Breadboard
3.2.3 Jumper Wire
3.2.4 Rechargeable batteries
3.2.5 Soil Moisture Sensor Module
3.2.6 DS18B20 Temperature Sensor
3.2.7 Battery Charging Module
3.2.8 Computer
3.2.9 Micro USB to USB Cable wire

4. Materials and equipment for chemical property testing

4.1 pH, Nitrogen, Phosphorus, and Potassium values in soil

4.1.1 Oven-dried soil sample

4.1.2 Soil testing kit for pH, Nitrogen, Phosphorus, and Potassium values

4.1.3 Small test tubes

4.1.4 100 ml pipette

4.1.5 Rubber stoppers for pipette

4.1.6 100 ml beaker

4.1.7 Soil grinder

4.1.8 Weighing scale

4.1.9 Dropper tubes

5. Materials and equipment for studying the growth of Chinese Convolvulus

5.1 The height, circumference of the stem, and biomass of Chinese Convolvulus

5.1.1 Ruler

5.1.2 Vernier caliper

5.1.3 Weighing scale

Methodologies

1. Prepared seven experimental plots measuring 0.5 meters x 1 meter which were located in the same area and had similar soil properties.

Plot 1: Control plot (soil)

Plot 2: 5 % Coffee ground

Plot 3: 10 % Coffee ground

Plot 4: 15 % Coffee ground

Plot 5: 5 % Biochar

Plot 6: 10 % Biochar

Plot 7: 15 % Biochar

2. The students prepared the first type of organic materials, which was coffee ground obtained from V Café in Varee Chiangmai School. They used the following ratios: 5%, 10%, and 15% coffee ground. The fresh coffee ground was dried by sun-drying for 2 days.

3. The students prepared the second type of organic materials, which were biochar. They used the following ratios: 5%, 10%, and 15%.

4. Put the coffee ground and biochar in experimental plots 2 – 7 with the ratios mentioned above for seven days to allow for decomposition and integration with the soil.

5. Collected soil data and measure the following physical and chemical properties:

5.1 Soil structure 5.2 Soil color

5.3 Soil cohesion 5.4 Soil texture

5.5 pH values 5.6 Levels of nitrogen, phosphorus, and potassium

6. Soil sample collection

6.1 Soil samples were collected by digging to a depth of 5 centimeters and placing them in ziplock bags, with a quantity of 10 grams from each of the 7 experimental plots.

7. Soil structure

7.1 The soil samples were placed undisturbed on the hand. The soil was observed in detail, paying close attention to its structure.

7.2 The size and shape were measured by comparing the data from the soil structure manual and recording the information in the soil characteristic data recording sheet.

8. Soil color

8.1 Soil particles were picked up from each soil sample layer and observed, then recorded in the data recording sheet whether the soil particles were dry or wet. If dry, they were moistened slightly with water from the prepared bottle.

8.2 The soil was divided into two parts.

8.3 Sunlight was stood to let pass through the shoulder to the soil color comparison book and the soil sample being examined for soil color.

8.4 The soil color values were recorded in the data recording sheet.

9. Soil cohesion

9.1 Took soil aggregates from the top layer. If the soil was dry, moisten the soil layer by spraying water and observed the soil cohesion.

9.2 Picked up soil aggregates between the thumb and index finger and gently squeezed the soil aggregates until they broke into parts.

9.3 Recorded the characteristics of soil cohesion in the data recording sheet.

10. Soil texture

10.1 Grabbed a handful of soil and make it moist.

10.2 Observed the characteristics of the soil texture compared to the field texture classification manual and record the results.

11. Soil pH (Acidity-Alkalinity)

11.1 Ground dried soil samples into fine powder.

11.2 Prepared a soil solution with a soil-to-water ratio of 1:1. Took 2 spatulas of soil and 2 ml of water to obtain the soil solution.

11.3 Mixed the soil solution with the pH testing solution in a 1:1 ratio. Took 2 ml of the soil solution and 2 ml of the pH testing solution, then compared the color with the pH color chart.

12. Soil nutrient (N, P, K)

12.1 Ground dried soil samples into fine powder.

12.2 Took 6 spatulas of soil samples and placed them in a test tube. Used a pipette to add 7.5 ml of the testing solution to the soil, shook the test tube, and left it for 1 minute.

12.3 Measured soil fertility using a soil testing kit (N in soil).

12.4 Measured soil fertility using a soil testing kit (P in soil).

12.5 Measured soil fertility using a soil testing kit (K in soil).

12.6 Recorded the experimental results in the data sheet for further analysis.

13. The equipment for measuring temperature, humidity in the air, and temperature and humidity inside the soil from the ESP32 NodeMCU Goouuu ESP32 DEVKIT Wi-Fi and Bluetooth board and various sensors was created by writing code to instruct the device to record data every 1 hour. This was done to collect data for analyzing the differences in temperature and humidity changes inside the soil of experimental plots 1-7.

14. Planted Chinese convolvulus seeds in the experimental plots, all 7 plots, with controlled variables including seed type, quantity of Chinese convolvulus seeds, water quantity, light quantity, etc. The growth period was set to 4 weeks, and data on plant growth was collected as follows:

14.1 Measured the growth of Chinese convolvulus by measuring the height of the plants and calculating the arithmetic mean.

14.2 Measured the circumference of the stem of Chinese convolvulus plants and calculated the arithmetic mean.

14.3 Biomass (fresh weight of Chinese convolvulus)

- Harvested Chinese convolvulus in the 7 experimental plots and measured the biomass from the fresh weight of Chinese convolvulus.

- Analyzed and compared the fresh weight of Chinese convolvulus in kilograms and recorded the results.

15. Submitted the collected data to the GLOBE Data Entry system and analyzed and compared it with the data on soil temperature and humidity obtained. Compared the effects of the coffee grounds and biochar on soil fertility using physical, chemical, and growth characteristics of Chinese convolvulus.

16. Organized the data for analysis, drew conclusions, and disseminated the knowledge gained from the study for further dissemination.

Findings

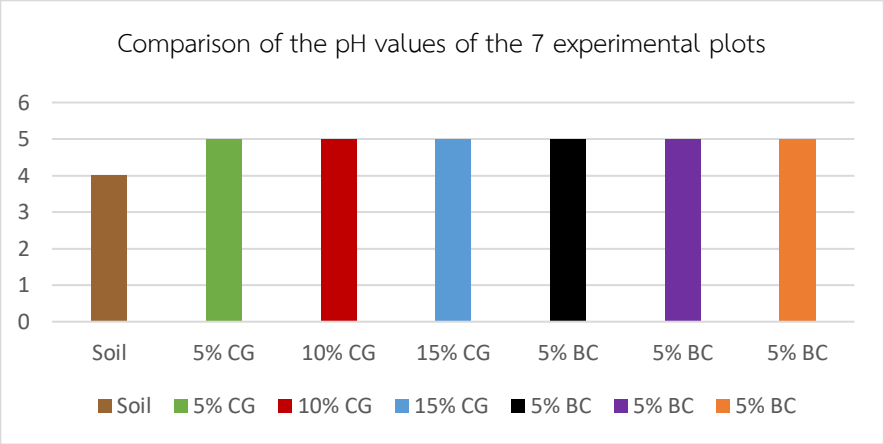
1. From the study of the physical characteristics of the soil using the GLOBE Protocols measurement principles, it was found that the soil structure was in the form of rounded aggregates, dark brown in color, with a loamy texture and high crumbliness. There were no significant differences observed among the samples.

2. Air temperature and soil moisture

Through the study using the ESP32 NodeMCU Goouuu ESP32 DEVKIT Wi-Fi and Bluetooth board and various sensors, data was collected as follows:

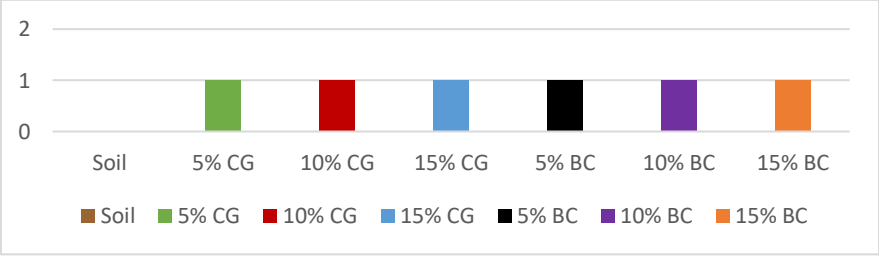
- The average soil temperature and moisture were found to be inversely related. When the temperature is high, the moisture content is low, and vice versa. The lowest average air temperature recorded was 25 degrees Celsius, observed in the 10% coffee grounds plot, while the highest average moisture content was 36 degrees Celsius, observed in the 15% coffee grounds plot. The plots mixed with coffee grounds and biochar retained soil moisture better than the plots without mixing.

3. Soil Acidity-Alkalinity (pH)

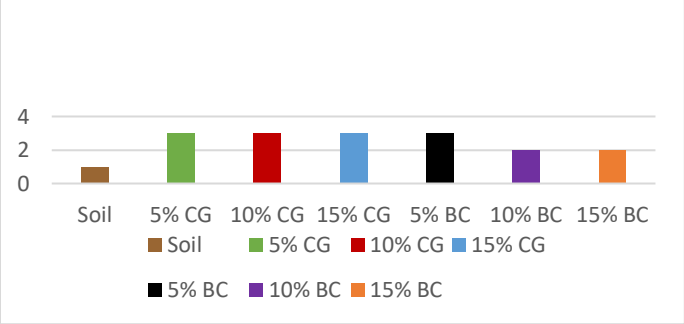


4. Soil nutrient (N, P, K)

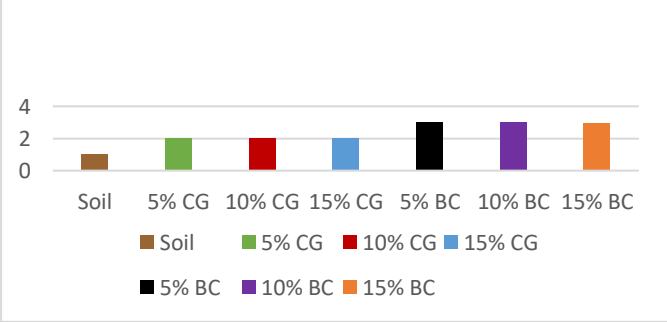
From the measuring the quantity of soil nutrient (N, P, K), in the 7 experimental plots, the following data was found:



Comparison of N levels of the 7 experimental plots



Comparison of P levels of the 7 experimental plots

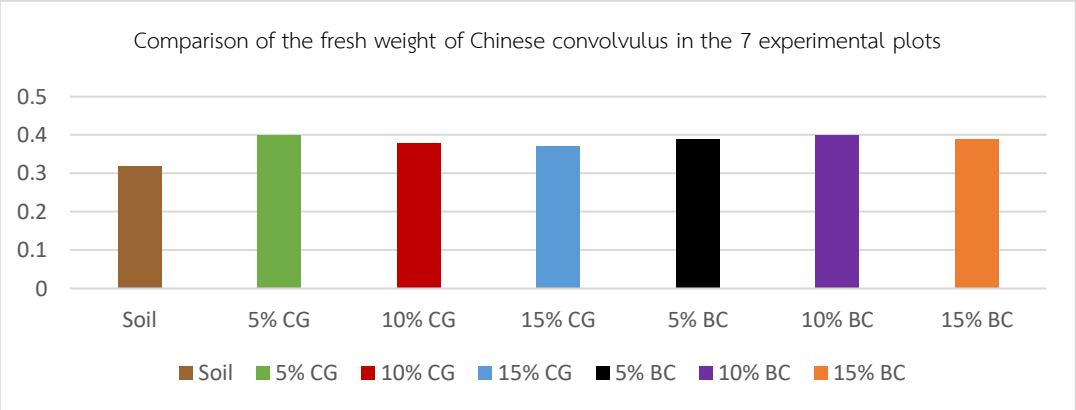


Comparison of K levels of the 7 experimental plots

5. From the study on the growth of Chinese convolvulus, it was found that the height and circumference of the stem in the first four weeks showed that Chinese convolvulus planted in plots with 10% biochar had the highest growth rate, while the plots with soil had the lowest growth rate.

Conclusion and Discussion

Based on the study comparing the ratio of coffee grounds and biochar on soil fertility concerning the growth of Chinese convolvulus, it can be concluded that the physical properties of the soil in plots with 5%, 10%, and 15% coffee grounds and 5%, 10%, and 15% biochar, respectively, exhibited similar characteristics. The soil structure was granular, dark brown in color, loamy, and highly friable, with no significant differences observed. Regarding soil temperature and moisture content, there was an inverse relationship between temperature and moisture; higher temperatures corresponded to lower moisture levels, and vice versa. The plots with a mixture of coffee grounds and biochar retained moisture better than the plots without a mixture. In terms of chemical properties, the soil pH was 4 in the plots without a mixture, indicating higher acidity compared to the plots with coffee grounds and biochar, which had a pH of 5. The nutrient content in the soil varied across plots. The plots without a mixture showed low levels of N, minimal P, and moderate K. In contrast, the plots with coffee grounds had low N, high P, and medium K levels, while the plots with biochar had low N, medium P, and high K levels. These variations in soil nutrients influenced the growth of Chinese convolvulus. Analyzing the growth of Chinese convolvulus based on height and stem circumference revealed that during the first four weeks, the plots with 10% biochar exhibited the highest growth rate. Conversely, the plots with 5% coffee grounds and 15% biochar showed the least growth, followed by the plots with 5% biochar, 10% coffee grounds, and 15% coffee grounds. The plots without a mixture exhibited the lowest growth rate after four weeks. Furthermore, measuring the fresh weight of Chinese convolvulus after four weeks of planting revealed that the plots with 10% biochar and 5% coffee grounds had the highest fresh weight at 0.40 kilograms. The plots with 5% biochar and 15% biochar had a fresh weight of 0.39 kilograms, while the plots with 10% coffee grounds had a fresh weight of 0.38 kilograms, and the plots with 15% coffee grounds had a fresh weight of 0.37 kilograms. The plots without a mixture had the lowest fresh weight at 0.32 kilograms.



From the results, it was found that the appropriate mixture of coffee grounds and biochar can significantly impact the chemical fertility of the soil, consequently increasing the nutrient content in the soil. This mixture could potentially serve as an alternative organic material for farmers to improve and maintain soil fertility before cultivation, promoting plant growth, enhancing agricultural productivity, and potentially reducing cultivation costs through the utilization of coffee grounds.

Acknowledgement

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On behalf of the research team, we would like to express our heartfelt gratitude to all authors of academic papers from books, journals, websites, as well as research data from everyone that the researchers have referenced in this study. We humbly extend our highest appreciation for the invaluable contributions made to our research.

Researchers

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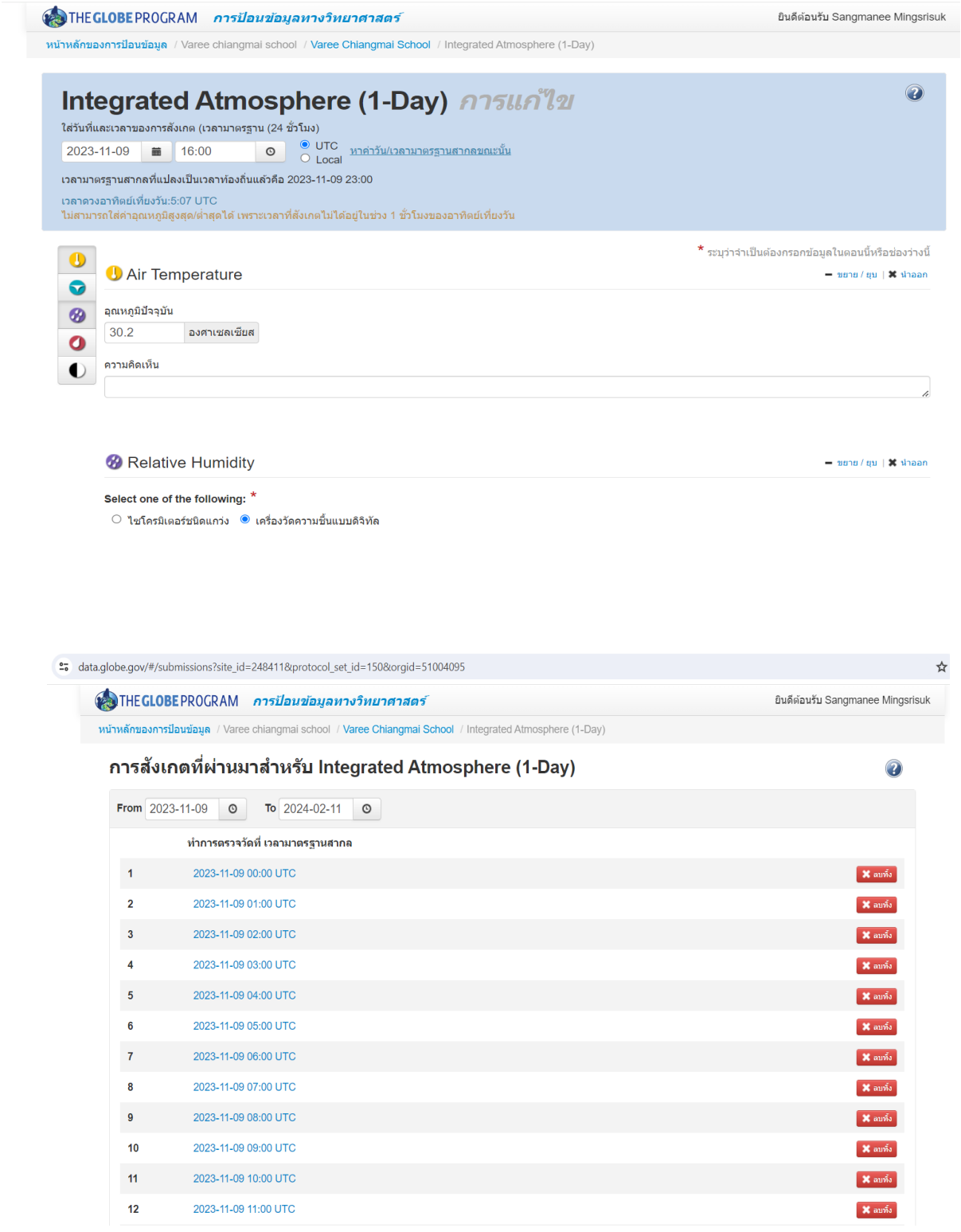
Submitting environmental measurement data to the GLOBE program database



A sample image of data submitted to the GLOBE Data Entry database