An Effect of Different Types of Ground Cover Plants on Soil Temperature and Moisture

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Abstract

Continuous climate change over the years has impacted various aspects of the Earth, including soil quality, leading to its degradation. To address this issue, one widely adopted solution is the use of ground cover plants, which help preserve topsoil, retain moisture, and regulate soil temperature, preventing excessive heat. A survey of the school revealed that several types of ground cover plants were cultivated around large trees, prompting the researchers to study how different types of ground cover plants affect changes in soil temperature and moisture. The study aims to provide insights into selecting the most suitable ground cover plants for effective soil management.

A comparative study of four types of ground cover plants—Manila grass, Kyoto dwarf, Ceylon myrtle, and Spanish shawl—was conducted to assess their effects on changes in soil temperature and moisture during the day using custom-built equipment. The findings revealed that Spanish shawl was the most effective at maintaining stable soil temperature, followed by Ceylon myrtle, Kyoto dwarf, and Manila grass, respectively. Conversely, Manila grass was the best at retaining soil moisture, followed by Ceylon myrtle, Spanish shawl and Kyoto dwarf. Overall, Ceylon myrtle demonstrated the highest ability to maintain both soil temperature and moisture, followed by Spanish shawl, Manila grass, and Kyoto dwarf. These differences are likely influenced by factors such as stomatal structure and stomatal density. In conclusion, different ground cover plants have varying capacities to regulate soil temperature and moisture, depending on their leaf structures

and plant characteristics. Selecting appropriate ground cover plants can significantly enhance soil preservation and management.

Keywords: ground cover plant, soil temperature, soil moisture, air temperature, air humidity

Introduction

It is well known that the ongoing climate change over the past several years has impacted various components of the Earth in multiple ways. For instance, average temperatures in different regions have risen, rainfall patterns and distribution have shifted, extreme weather events have become more frequent, and droughts have posed significant challenges to water management. Soil quality has also been directly affected. One key factor contributing to soil degradation is the widespread alteration of land cover, including urban expansion, deforestation for housing development, and the cultivation of cash crops. These activities have led to severe soil deterioration. Experts from the UN have warned that if soil degradation is not addressed, topsoil could be entirely depleted within 60 years. By 2050, usable soil is projected to decrease to only one-quarter of what was available in 1960 (Climate Change Adaptation Information Center of Thailand, 2022)

Soil quality improvement and maintenance can generally be achieved through various methods, with one of the most popular being the cultivation of ground cover plants. This method helps protect topsoil, retain soil moisture, and regulate soil temperature, preventing it from becoming excessively high. Additionally, many ground cover plants contribute to enriching the soil with nutrients. A survey of the school revealed that several types of ground cover plants are planted around large trees. This prompted the research group to study the effects of different ground cover plant species on soil temperature and moisture changes, aiming to provide guidelines for selecting suitable ground cover plants (Palintu Wutichatiwanich, 2015).

Research Question

How do different types of ground cover plants affect changes in soil temperature and moisture?

Hypothesis

The soil temperature and moisture under different types of ground cover plants will exhibit varying changes throughout the day.

Variables

Independent Variable: Types of ground cover plants

Dependent Variable Soil temperature and moisture

Controlled Variables Time period for data collection and the equipment used to measure soil temperature and moisture

Objectives

1. To measure the changes in the air temperature and humidity, as well as soil temperature and moisture, over a 24-hour period.
2. To compare the effects of different types of ground cover plants on changes in soil temperature and moisture.

Expected Benefits

1. Understanding the changes in soil moisture and temperature under different of ground cover plants.
2. Providing valuable data to support the selection of suitable ground cover plants for practical applications.

Scopes

Scope of Study

1. Compare the changes in soil temperature and moisture under different types of ground cover plants.
2. Study the leaf surface structure of each ground cover plant species.
3. Analyze the relationship between changes in soil temperature and moisture and the leaf surface structure of each ground cover plant species.

Scope of Time

November 2024 – January 2025

Materials and Equipment

Equipment for Measuring Temperature and Humidity

1. Arduino UNO R3 Board
2. Breadboard
3. Air Temperature and Humidity Sensor (DHT22 ASAIR AM2302)
4. Waterproof Soil Temperature Sensor (DS18B20)
5. Resistive Soil Moisture Sensor
6. Micro SD Card Module and Micro SD Card – For data storage and logging
7. Jumper Wires
8. Power Bank

Equipment for Studying Leaf Structure

1. Microscope
2. Plastic Petri Dishes
3. Glass slides and cover slips
4. Forceps
5. Droppers
6. Measuring Cylinder
7. 200-ml Preserves Jar
8. Tissue Paper
9. Paintbrush
10. Distilled Water
11. 6% Sodium Hypochlorite Solution
12. Safranin O stain

Research Methodology

1. Identify four research sites under large trees with different ground cover plants, including two monocots (Manila grass and Kyoto dwarf) and two dicots (Spanish shawl and Ceylon myrtle).

Figure 1: Research sites and the four types of ground cover plants

2. Assemble equipment using the Arduino Uno R3 board and sensors to measure air temperature around leaves, as well as soil temperature and moisture. Program the devices to record data every 10 minutes and test the system before installation at the designated study sites.
3. Test the code before installing it to collect data at the designated study sites, ensuring that the device records data at each site continuously for at least 24 hours.

Figure 2: Making and installing of data measurement equipment at the study sites.

4. Retrieve recorded data from the devices and create graphs to examine the relationships between air temperature, air temperature around leaves, soil temperature, and soil moisture at each site and for each type of ground cover plant.
5. Examine the leaf structures of each type of ground cover plant under a light microscope. Use this information to analyze correlations with air temperature, soil temperature, and soil moisture data collected.

Figure 3: Study of leaf structures of the four ground cover plants

6. Analyze the data to compare the effects of each ground cover plant on changes in soil temperature and moisture, and the relationship between the leaf structure of each plant and the changes in soil temperature and moisture.
7. Discussion and Conclusion

Results

The results from measuring changes in air temperature, soil temperature, and soil moisture using the custom-made Arduino board and various sensors at the research sites with four different ground cover plant species (two monocots and two dicots) are shown in the graph below. It was found that the temperature and humidity of the air fluctuate more easily throughout the day, while the temperature and humidity within the soil remain relatively stable. This can be observed in the graph showing the standard deviation data of temperature and humidity changes in the soil during the daytime period (6:00 AM - 6:00 PM), with the degree of variation increasing as follows.

- Changes in Soil Temperature
  Spanish shawl < Ceylon myrtle < Kyoto dwarf < Manila grass
- Changes in Soil Moisture
  Manila grass < Ceylon myrtle < Spanish shawl < Kyoto dwarf

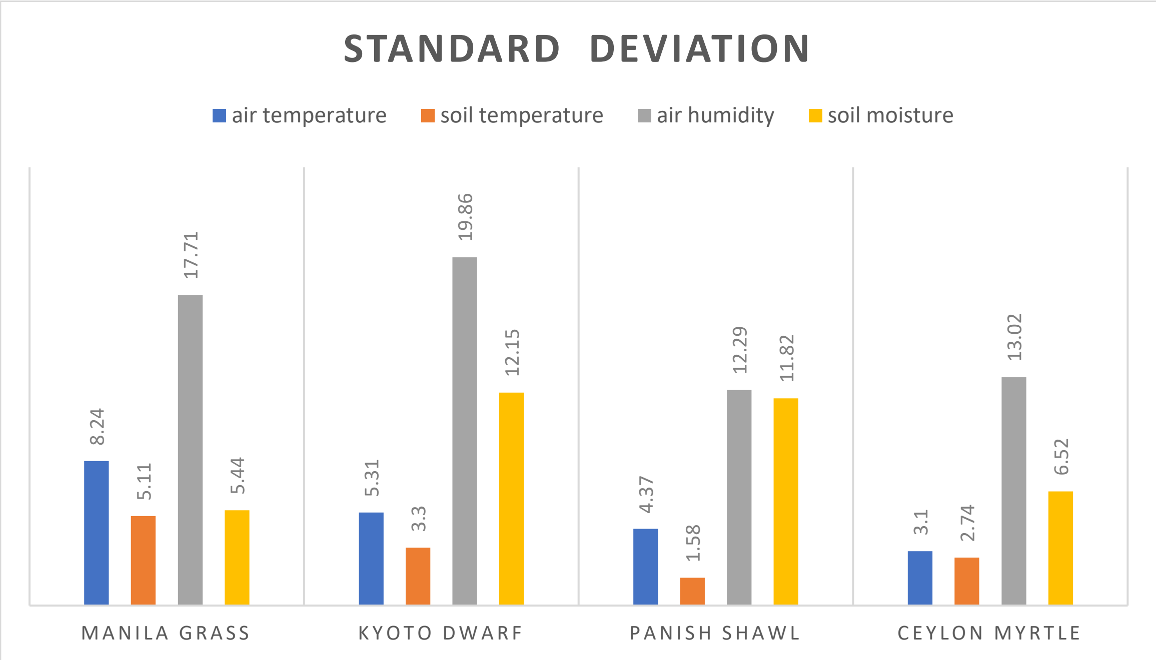

Figure 4: Graph showing the standard deviation of soil temperature and moisture changes during the daytime at the four study sites with different ground cover plants

Conclusion and Discussion

Due to limitations with only two sets of the custom-made equipment, we were unable to collect data from all four research sites at the same time. Therefore, data comparisons were made by calculating the coefficient of variation, and the analysis results are shown in the graph below:

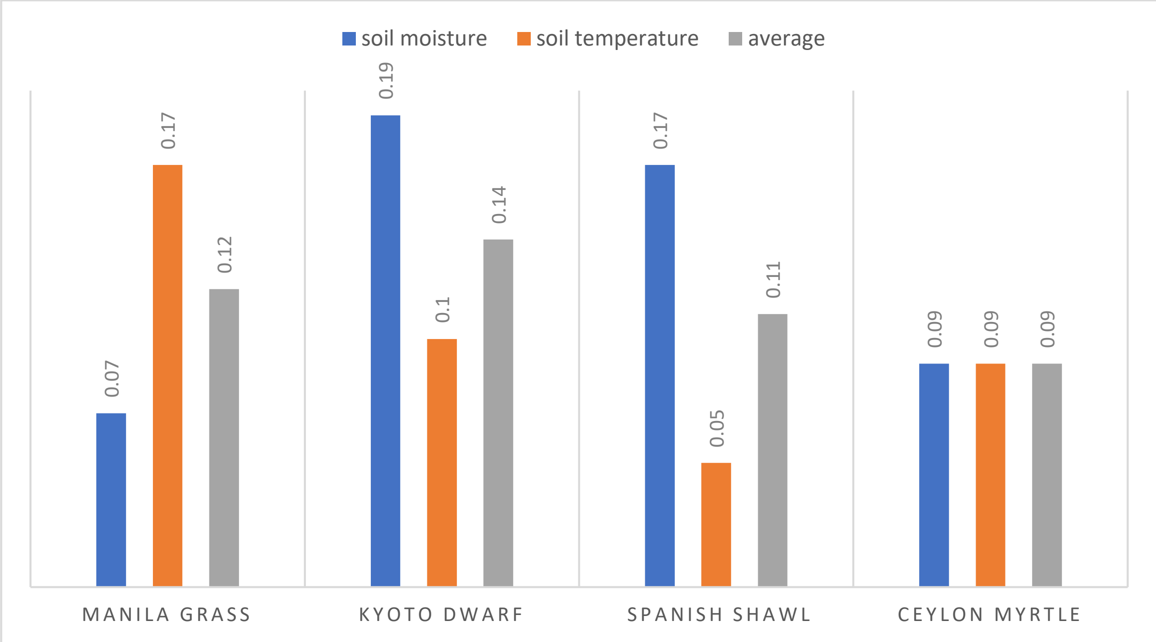

Figure 5: Graph showing the coefficient of variation for soil temperature and moisture changes at the four study sites with different ground cover plants

From the graph, it can be observed that the effects of ground cover plants on the changes in soil temperature and moisture align with the analysis based on the standard deviation of the previously analyzed data. Specifically, in terms of soil temperature, Spanish shawl has the greatest ability to maintain stable soil temperature, followed by Ceylon myrtle, Kyoto dwarf, and Manila grass, respectively.

Regarding changes in soil moisture, Manila grass demonstrates the highest ability to retain soil moisture, followed by Ceylon myrtle, Spanish shawl, and Kyoto dwarf, respectively. When considering overall performance, Ceylon myrtle has the best capability to maintain both soil temperature and moisture, followed by Spanish shawl, Manila grass, and Kyoto dwarf, respectively. This may result from the structure and density of stomata, as the dicotyledonous plants, Ceylon myrtle and Spanish shawl, tend to have higher stomatal density, as illustrated in the image.

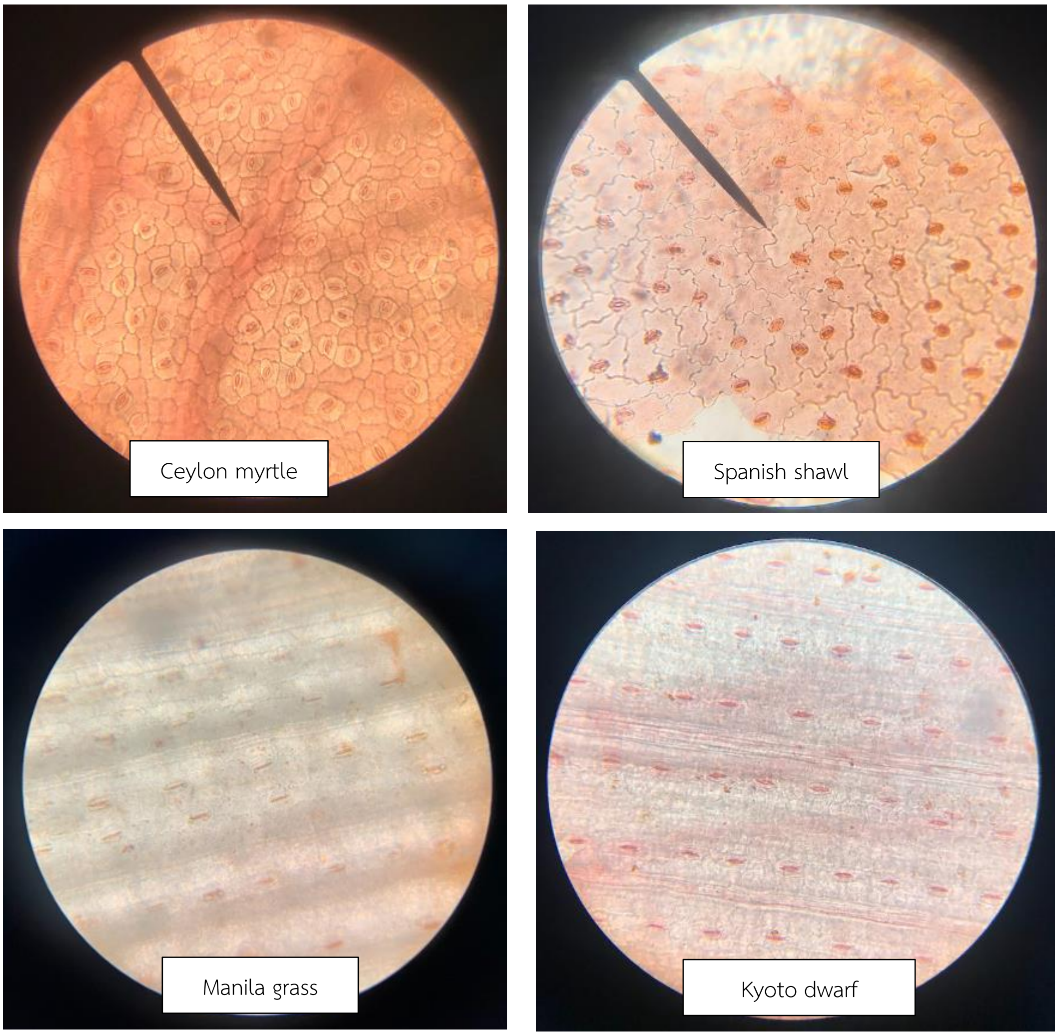

Figure 6: Stomatal structure of the four ground cover plants

Moreover, factors such as the arrangement of leaf blades and the branch structures of ground cover plants, which differ in density of soil coverage, may also play a role. This can be observed when comparing Manila grass and Kyoto dwarf, both monocotyledonous plants with similar stomatal structures. Manila grass, which has denser coverage, exhibits lower coefficients of variation in soil temperature and moisture changes compared to Kyoto dwarf. Similarly, when comparing Ceylon myrtle and Spanish shawl, both dicotyledonous plants, Ceylon myrtle demonstrates denser branch and leaf coverage than Spanish shawl.

Based on the discussion above, it can be concluded that each ground cover plant has varying capacities to maintain soil temperature and moisture, depending on factors such as leaf structure and plant characteristics. Therefore, selecting the appropriate ground cover plant can effectively enhance soil conservation.

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