Study of mulch base from freshwater algae mixed with natural materials to retain moisture and increase minerals in the soil.

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Abstract

This study aims to develop Study of mulch base from freshwater algae mixed with natural materials to retain moisture and increase minerals in the soil. The primary materials used are freshwater algae and rice straw in three ratio formulations: 10:0, 9:1, and 8:2, respectively, and supplemented with agricultural by-products such as crushed eggshells for calcium and fungal prevention, earthworm castings to increase NPK, and starch paste as a binder to form the soil cover material. The experiments were divided into 10 sets: Sets 1-5 used loamy soil (planting soil) and sets 6-10 used clayey sandy soil (low in minerals) to test various soil properties, including pH, temperature, NPK content, moisture, and organic matter content, as well as to study the water used for irrigating plants and the decomposition of the soil cover materials. The results showed that the soil cover material with an 8:2 ratio provided the best moisture retention due to the freshwater algae's high water-holding capacity and the rice straw's role in reducing water evaporation. Using soil cover materials from freshwater algae mixed with natural materials not only helped retain moisture in the soil but also increased soil fertility through decomposition, which released important minerals for plant growth. Thus, this material is suitable for organic farming and soil and water conservation.

Keywords: soil cover materials, algae, natural materials

1. Introduction

At present, people are paying more attention to health care, especially the consumption of vegetables, due to their awareness of the nutritional value and health benefits of consuming safe food. This increasing demand has led farmers to accelerate production to meet consumer needs. As a result, farmers need to find methods and technologies that make farming more convenient, reduce maintenance time, and not

only improve production efficiency but also lower costs and labor in the agricultural process. Farmers use various methods to control weeds, maintain soil moisture, and improve cultivation efficiency. One traditional method commonly used is covering the soil with plastic sheets, which helps reduce weed growth and retain moisture effectively. However, it also creates problems with microplastic residues in the soil, which may have long-term environmental impacts. An alternative is using fabric soil covers, which are effective in controlling weeds and can be reused multiple times, but they are very expensive, making them inaccessible to small-scale farmers or those with limited budgets. Additionally, rice straw is used as a natural and biodegradable soil cover, but excessive moisture accumulation can lead to fungal growth and fermentation, producing methane gas, which is a greenhouse gas that contributes to global warming.

Due to the limitations and impacts of these methods, this project focuses on developing a new alternative soil cover material by combining algae with natural materials, which effectively helps retain moisture and improve soil minerals. Algae is a material that is easily found in nature, decomposes naturally, and does not produce harmful residues in the soil or environment. Additionally, algae help reduce weed growth and can improve soil structure, making it more loamy and increasing soil minerals.

Based on this information, our project is interested in studying soil cover materials made from algae mixed with natural materials that affect moisture retention and the enhancement of soil minerals. The materials we have chosen to use are agricultural by-products from nature, which, when decomposed, can add essential nutrients to the soil for plant growth. These materials include algae, which helps add organic matter to the soil and releases nitrogen (N) and phosphorus (P) when decomposed important nutrients for plant growth. Algae also improve soil structure by enhancing aeration and moisture retention. Rice straw, when decomposed, adds potassium (K) to the soil. Crushed eggshells add calcium (Ca) and magnesium (Mg) to the soil, help prevent fungal infections, and balance the soil. Tapioca starch acts as a natural binder that helps the materials adhere together, making the soil cover cohesive and durable. Earthworm castings contain natural hormones that stimulate plant growth and accelerate seed germination. This approach not only helps reduce production costs for farmers but also promotes sustainable and environmentally friendly agriculture by reducing reliance on

chemicals and synthetic materials. Additionally, it helps reduce the impact of greenhouse gases produced by traditional soil-covering methods.

Thus, this project provides a new approach to enhancing cultivation efficiency and soil maintenance in the long term.

Research Question

Does mulch base from freshwater algae mixed with natural materials affect moisture retention and mineral enhancement in the soil?

Objective

To develop mulch base from freshwater algae mixed with natural materials that help retain moisture and enhance soil minerals.

Research Hypothesis

Soil cover material made from algae mixed with natural materials can effectively retain moisture and enhance soil minerals.

2. Materials, Equipment, and Research Methodology

Materials and Chemicals

1. Algae
2. Rice straw
3. Earthworm castings
4. Crushed eggshells
5. Tapioca starch

Equipment

6. Soil NPK testing kit
7. Hot Air Oven
8. Muffle furnace
9. Universal indicator paper
10. Micrometer
11. Thermometer
12. Hygrometer
13. Moisture meter
14. Digital scale
15. Vernier caliper

Research Methodology

Section 1: Defining the Study Area

1. This research is conducted in the garden area of Miss Jitpattra Kaewtan's home in Kantang District, Trang Province, located at latitude 7.4630 and longitude 99.6011

Image 1 shows the study area.

Section 2: Steps to Create Soil Cover Sheets

2.1 Preparing the Equipment for Making Soil Cover Sheets

- **Algae:** Clean off any mud or dirt from the algae to reduce odor.
- **Eggshells:** Wash thoroughly, dry them, and grind them finely.
- **Rice Straw:** Cut into small pieces, dry them, grind them finely, and sift the powder through a mesh sieve.
- **Tapioca Starch:** Dissolve in water (1:2 ratio), then heat and stir until clear. This will be used as a binder for forming the sheets.

Image 2 shows the materials and equipment.

2.2 Study of Mixing Proportions

To create a soil cover material, it is necessary to study and experiment with the appropriate proportions to obtain a sheet that is effective, easy to shape, and can maintain its form over time. The algae-to-rice straw mixture will have three different ratios:

- Formula 1 (10:0)
- Formula 2 (9:1)
- Formula 3 (8:2)
- In all formulas, natural materials are added equally:
- 15 grams of earthworm castings

- 5 grams of crushed eggshells
- 5 grams of tapioca starch

2.3 Shaping the Material

After combining and grinding all ingredients finely, pour the mixture into a mold or on a mesh sheet. Apply pressure or compression to spread the mixture into a flat sheet. Roll the sheet to a consistent thickness of about 2–5 millimeters, and then dry the formed sheet in an oven at a low temperature (50-60°C) or use soft natural sunlight until completely dry. This process increases durability and prevents mold growth, preparing the material for use.

Image 3 shows the formation of soil covering material.

Section 3: Soil Cover Material Test

Trim the soil cover material to the desired size and punch a hole in the center for fitting around the base of the plant stem, or shape it to suit the planting area.

3.1 Define Experimental Groups

Divide the experiments into 10 groups with 3 repetitions each as follows:

- **Group 1:** Plant in pots with potting soil, no soil cover
- **Group 2:** Plant in pots with potting soil, covered with plastic soil cover
- **Group 3:** Plant in pots with potting soil, covered with soil cover formula 1
- **Group 4:** Plant in pots with potting soil, covered with soil cover formula 2
- **Group 5:** Plant in pots with potting soil, covered with soil cover formula 3
- **Group 6:** Plant in pots with sandy-clay soil lacking nutrients, and no soil cover
- **Group 7:** Plant in pots with sandy-clay soil lacking nutrients, covered with plastic soil cover
- **Group 8:** Plant in pots with sandy-clay soil lacking nutrients, covered with soil cover formula 1
- **Group 9:** Plant in pots with sandy-clay soil lacking nutrients, covered with soil cover formula 2
- **Group 10:** Plant in pots with sandy-clay soil lacking nutrients, covered with soil cover formula 3

3.2 Water Conservation Test

Monitor soil moisture levels daily, morning and evening, using a Moist Meter. Water the plants based on the moisture level criteria: if the soil moisture falls below 50%, water each pot with 200 mL of water. Record the amount of water used each time and accumulate the total water used throughout the one-week experimental period.

Image 4 shows the experimental setup and water-saving test.

Section 4: Soil Quality Inspection

Soil Quality Measurement According to GLOBE Methodology

1. **Soil Sample Collection:**

   Collect soil samples from plants that have undergone an experiment with soil cover for 4 weeks. A total of 10 experimental sets with 3 repetitions (30 samples in total) should be collected from the soil surface down to a depth of 15 cm. Mix all the soil together to obtain 400 grams and place it in separate bags.

2. **Study of Soil Properties in the Laboratory:**

   Study the soil properties based on various indices in the laboratory before and after the use of soil cover materials. These properties include:

   - Soil temperature, measured using a thermometer.
   - Soil texture, determined using a soil texture triangle chart.
   - pH value of the soil, measured using a pH Meter.
   - Nitrogen, Phosphorus, and Potassium values, measured using an NPK soil test kit.
   - The remaining soil sample should be weighed before drying. Afterward, dry the soil at 60°C for 24 hours and weigh it again. Then, measure organic matter by heating the soil (which has been dried to remove moisture) at 450°C for 4 hours, then weigh it again and calculate the percentage of organic carbon (%OC) in the soil.

3. **Data Entry:**

   Submit the collected data into the GLOBE Data Entry system.

Image 5 shows soil quality measurement.

Image 6 shows soil quality measurement.

Section 5: Decomposition Analysis

1. **Decomposition Rate:**

   The decomposition rate is determined by comparing the weight before and after the test to measure the weight loss of the material caused by decomposition. Observe the physical changes, such as changes in color and weight, during the decomposition process.

$$(\%\ \text{weight loss}) = \left[\frac{W_0 - W_t}{W_0}\right] x\ 100$$

W_0 = Initial weight of the soil cover material before burial (grams)

W_t = Weight of the soil cover material after burial (grams)

t = Duration of the test

Image 7 shows the biodegradation test.

Soil Quality Analysis

1. The soil quality parameters, such as temperature, pH, moisture percentage, and organic matter content, will be analyzed. The results will be evaluated using statistical methods, including the calculation of averages and standard deviations.

Comparison of Experimental Groups

2. Statistical comparison will be conducted using One-Way ANOVA at a confidence level of 0.05.

Results of the Study

The research project titled " Study of mulch base from freshwater algae mixed with natural materials to retain moisture and increase minerals in the soil." is divided into three sections:

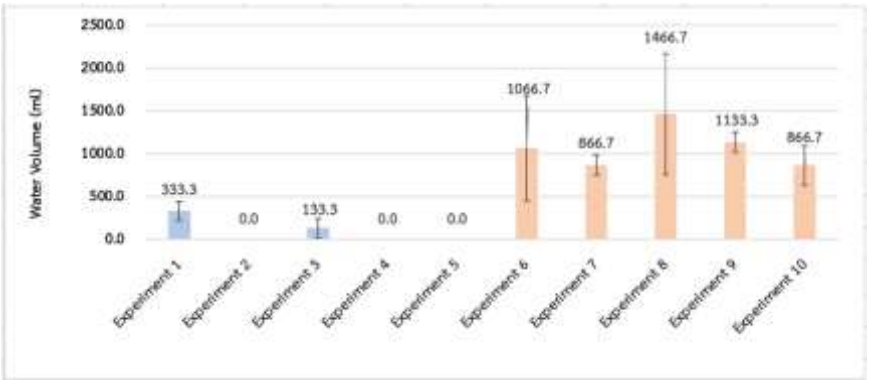
- **Section 1: Study of mulch base from freshwater algae mixed with natural materials to retain moisture and increase minerals in the soil.**

  Table 1 presents the results of the study on how • mulch base from freshwater algae mixed with natural materials to impacts soil moisture retention.

Experiment	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Experiment Set 1	90.0±0.0	60.0±0.0^{A}	66.7±1.2	60.0±0.0	60.0±0.0	67.0±0.0	55.7±0.6
Experiment Set 2	100.0±0.0	65.7±0.0^{B}	87.7±1.2	67.7±0.6	76.7±1.2	64.7±0.6	59.3±1.2
Experiment Set 3	100.0±0.0	55.3±0.6^{C}	85.3±1.0	67.7±0.6	64.0±1.0	65.3±0.6	57.7±1.0
Experiment Set 4	100.0±0.0	73.3±0.6^{D}	90.3±0.6	72.3±1.2	64.7±0.6	73.3±1.2	54.3±0.6
Experiment Set 5	100.0±0.0	80.3±0.6^{E}	89.3±0.6	86.0±0.6	63.3±0.6	64.3±0.6	57.0±0.6
Experiment Set 6	62.0±0.0	60.7±0.6^{F}	39.0±1.2	47.3±0.0	52.7±1.2	54.0±0.0	52.7±1.2
Experiment Set 7	67.7±0.6	59.7±0.6^{G}	47.0±0.6	45.0±0.6	49.0±0.6	54.3±0.6	53.3±0.6
Experiment Set 8	63.0±0.6	57.7±1.2^{H}	55.0±0.0	45.0±1.2	51.7±0.0	56.7±1.2	57.3±0.0
Experiment Set 9	60.7±0.6	61.7±1.2^{I}	52.7±0.6	60.0±0.6	52.3±0.6	49.7±0.6	53.0±0.6
Experiment Set 10	69.7±0.6	75.0±0.0^{J}	47.7±1.2	55.3±0.6	60.7±1.2	56.7±0.6	52.7±1.2

From the study results, when comparing the average soil moisture values across the 10 experimental groups over a 7-day period, it was found that there were statistically significant differences at the 0.05 level. This indicates that the mulch made from freshwater algae mixed with natural materials has an impact on soil moisture retention**.**

Image 8: Bar Chart Showing Watering Volume Over 1 Week When Using Mulch Made from Freshwater Algae Mixed with Natural Materials



The study results show that when comparing the volume of water applied in the 10 experimental groups based on the set criteria over a 7-day period, significant statistical differences were found at the 0.05 level. This indicates that mulch made from freshwater algae mixed with natural materials has an impact on moisture retention in the soil.

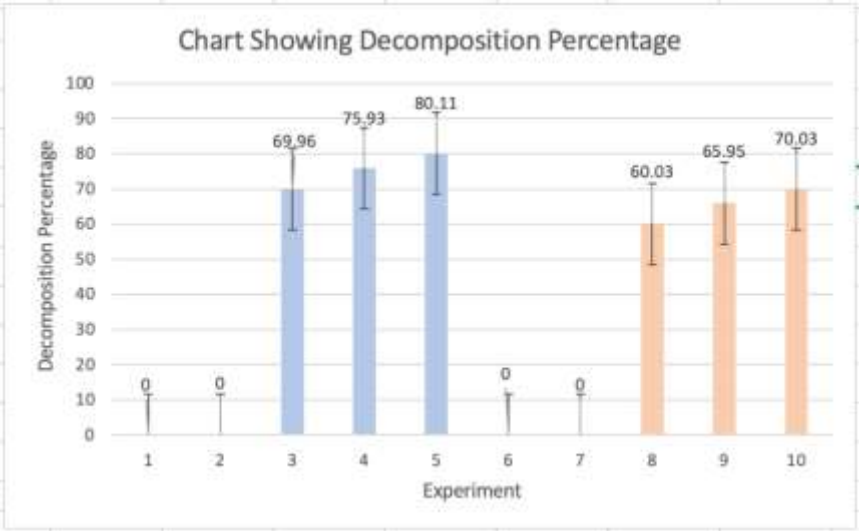
- **Section 2: Results of Studying mulch base from freshwater algae mixed with natural materials to retain moisture and increase minerals in the soil.**
  Table 2 presents the results of the study on how mulch base from freshwater algae mixed with natural materials to retain moisture and increase minerals in the soil.

Soil Properties	Experiment									
	1	2	3	4	5	6	7	8	9	10
Soil pH	8	8	8	8	8	8	8	8	8	8
% Moisture	65.63	70.54	70.76	75.46	77.17	52.91	53.71	55.2	55.73	59.69
Soil Temperature	32	32	31	31	31	30	31	30	30	30
Soil Texture			Loam Soil			Clay Loam Soil				
N before	trace	trace	trace	trace	trace	trace	trace	trace	trace	trace
N after	trace	trace	high	high	high	trace	trace	medium	medium	medium
P before	low	low	low	low	low	trace	trace	trace	trace	trace
P after	low	low	high	high	high	trace	trace	low	low	low
K before	trace	trace	trace	trace	trace	trace	trace	trace	trace	trace
K after	trace	trace	high	high	high	trace	trace	medium	medium	medium
Organic Matter (Before)	45.15	45.16	45	45.06	45.1	5.07	5.13	5.6	5.23	5.1
Organic Matter (After)	45.15	45.16	95.55	93.5	90.55	5.07	5.13	26.23	25.1	24.13

From the study results, when comparing the levels of minerals (NPK) in the soil over the course of one month, it was found that the experimental groups using mulch made from freshwater algae mixed with natural materials significantly increased the mineral content in the soil. Each experimental group showed an increase in the amount of minerals present.

Section 3: Results of Studying the Degradation of Mulch Made from Freshwater Algae Mixed with Natural Materials

Image 9: Bar Chart Showing the Degradation of Mulch Made from Freshwater Algae Mixed with Natural Materials



The study results revealed that when comparing the degradation of mulch made from freshwater algae mixed with natural materials across the 10 experimental groups over a 4-week period, it was found that the mulch could naturally decompose as expected.

Summary and Discussion of Research Results

The study on mulch made from freshwater algae mixed with natural materials shows that this material positively affects soil moisture retention. The experimental group with an 8:2 ratio (algae to rice straw) was the most effective at retaining moisture in the soil, followed by the group with a 9:1 ratio. This is freshwater algae have a high water retention capacity. Their structure allows them to absorb and retain water effectively while balancing water retention with aeration. Using only algae (10:0) may result in excessive water retention, which could reduce soil aeration and harm plant roots that need oxygen.

The rice straw, when mixed in a 20% ratio in the 8:2 formula, increases soil aeration, improving water drainage while still maintaining good moisture retention. Rice straw also helps reduce water evaporation by preventing direct sunlight and wind exposure to the soil surface, keeping moisture near the surface and enhancing its retention. Additionally, crushed eggshells and earthworm castings help improve mineral content, especially nitrogen, phosphorus, potassium, and calcium in the soil. The study shows that the mulch mixture can retain moisture as effectively as plastic mulch.

Watering Volume Comparison

When comparing the watering volumes in the 10 experimental groups over a one-week period, statistically significant differences were observed. Experimental groups 2 (soil with plastic mulch), 4 (soil with formula 2 mulch), and 5 (soil with formula 3 mulch) required no additional watering because their soil moisture levels stayed above 50%. These results demonstrate that the mulch reduces the frequency of watering significantly, which aids in water conservation and lowers the maintenance cost for plants. This is particularly beneficial in areas with limited water resources or during drought periods. Compared to plastic mulch, the algae-natural material mulch demonstrated equivalent or superior moisture retention.

Mineral Content (NPK) in Soil

After one month of planting, the experimental groups that used the algae-natural material mulch showed increased levels of minerals in the soil. Groups 3 to 5 showed high increases in NPK content, while groups 8 to 10 showed moderate increases. This indicates that the algae-natural material mulch contributes to higher levels of essential minerals like NPK, calcium, and magnesium, supporting both short-term and long-term plant growth.

Compared to plastic mulch, the algae-natural mulch increases mineral content more effectively and is more environmentally friendly, as it does not leave microplastic residues.

Degradation of Mulch

After four weeks, the algae-natural material mulch showed natural decomposition. The ratio of algae to rice straw significantly affected the rate of degradation. The 100:0 ratio (pure algae) showed the slowest degradation due to the algae's robust cell wall, which resists rapid breakdown. The 90:10 ratio (algae and a small amount of rice straw) degraded faster due to better aeration, which allowed microorganisms to break it down more quickly. The 80:20 ratio (algae and more rice straw) had the fastest degradation, suitable for areas needing rapid organic matter and mineral addition. The choice of ratio depends on the specific needs of the area, such as moisture retention or rapid soil enrichment.

Conclusion

The study demonstrates that selecting the right natural materials and appropriate ratios can effectively conserve water and enhance soil fertility. The algae-natural material mulch has a positive impact on moisture retention and nutrient content in the soil, comparable to plastic mulch, but is more sustainable and environmentally friendly. The findings offer practical insights for improving soil management in agricultural practices, particularly in areas with water scarcity, and contribute to organic farming strategies aimed at preserving natural resources and maintaining soil health.

Acknowledgments

The study on mulch made from freshwater algae mixed with natural materials that affects moisture retention and increases minerals in the soil has been successfully completed. I would like to express my gratitude to the administration and teachers of Chulabhorn Royal Academy School, Trang, for their continuous support. I also thank the Freshwater Fisheries Research and Development Center for providing algae for the experiment. My heartfelt thanks go to Khun Sirikwan Nuphuthi and Khun Patchara Phongmanawut, as well as Assoc. Prof. Dr. Mallika Charoensuthasinee from Walailak University for their valuable advice, guidance, and constructive suggestions that greatly contributed to the success of this project. Their support has been essential in bringing this project to fruition.

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Badge descriptions

1. I AM A DATA SCIENTIST

We are a leader in various tools, both technical and statistical. We collect data for analysisfrom raw data. We are good communicators with management and pay attention to every detail in operations. We have problem-solving skills, including presentation skills, and the ability to explaincomplex ideas in an easy-to-understand format.

2. I MAKE AN IMPACT

This study aims to develop Study of mulch base from freshwater algae mixed with natural materials to retain moisture and increase minerals in the soil. We create mulch base to replace plastic mulching sheets. To reduce weed problems Maintain soil moisture and reduce the amount of plastic residue in the soil. The materials we choose to use They are agricultural waste materials that come from nature. When decomposed, these materials can add important nutrients to the soil for use in plant growth. The highlight of this project is the material is more breathable than plastic mulch. Maintain humidity Can be decomposed into fertilizer to add minerals to the soil. Importantly, the price is 10 times cheaper than plastic mulching sheets and can increase cultivation efficiency for farmers as well.

3. I AM A COLLABORATOR

Step 1: Topic thinking and event planning, there is collaboration between members within the team. There is a collaboration with the Inland Fisheries Research Center, Trang.

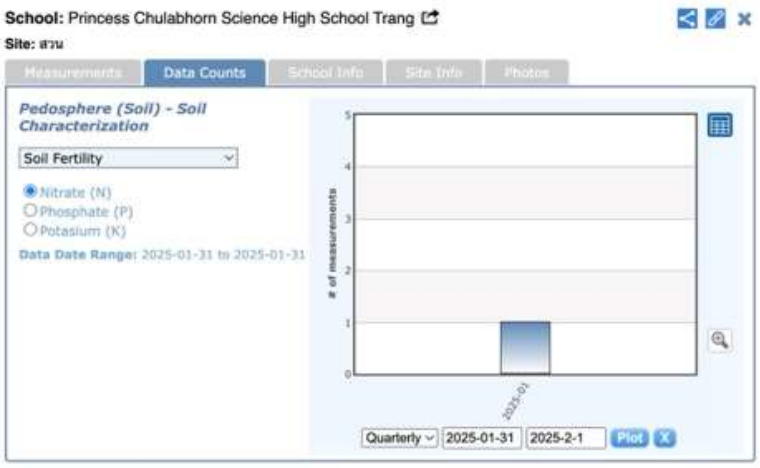
Step 2: Ms. Natchawadee Seephom is the person who collects and collects weather data in Kantang districts, Trang province, and Ms. Jittapat Keawtan is the soil measurement and soil sampler for quality analysis according to the principles of the GLOBE protocol. By measuring throughout the experiment. Both before and after trying to use mulching sheets.

Step 3: Ms. Natchawadee Seephom Prepare materials and formulas for making mulch base from freshwater algae mixed with natural materials. Along with keeping records of watering plants according to conditions

Step 4: Team members work together to analyze weather data. Soil quality and the ability to retain moisture of each mulch formula

Step 5: Ms. Natchawadee Seephom is the author of the research report. Ms. Jittapat Keawtan prepared the presentation and team members together to create a video presentation of the research, throughout this research, teachers and scientists were advised throughout the work.

Enter data in data entry



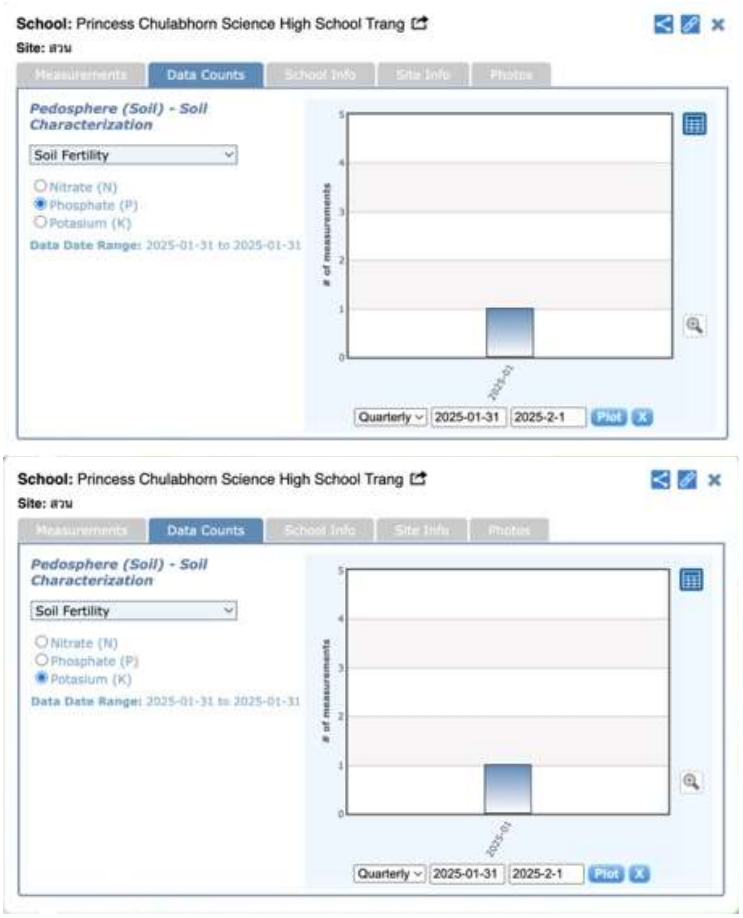


Image 18: Soil mineral data entry

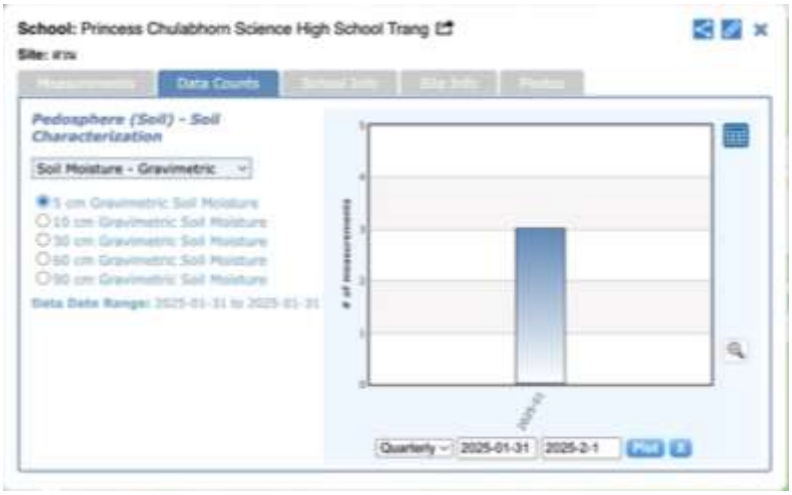


Image 18: Soil Moisture data entry

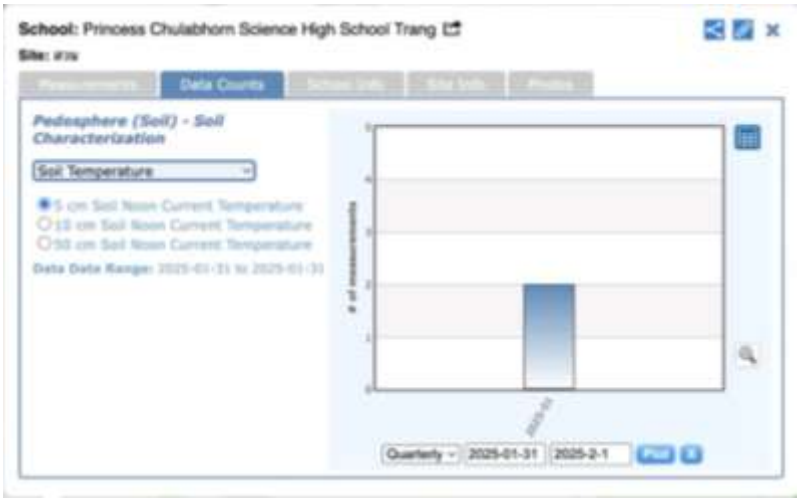


Image 19: Soil Temperature data entry

Appendix with raw data

Soil moisture

Average

Experiment	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Experiment 1	90.0	60.0	66.7	60.0	60.0	67.0	55.7
Experiment 2	100.0	65.7	87.7	67.7	76.7	64.7	59.3
Experiment 3	100.0	55.3	85.3	67.7	64.0	65.3	57.7
Experiment 4	100.0	73.3	90.3	72.3	64.7	73.3	54.3
Experiment 5	100.0	80.3	89.3	86.0	63.3	64.3	57.0
Experiment 6	62.0	60.7	39.0	47.3	52.7	54.0	54.7
Experiment 7	67.7	59.7	47.0	45.0	49.0	54.3	53.3
Experiment 8	63.0	57.7	55.0	45.0	51.7	56.7	57.3
Experiment 9	60.7	61.7	52.7	60.0	52.3	49.7	53.0
Experiment 10	69.7	75.0	47.7	55.3	60.7	56.7	52.7

Image 10: Showing the average soil moisture

SD

Experiment	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Experiment 1	0.0	0.0	1.2	0.0	0.0	0.0	0.6
Experiment 2	0.0	0.0	1.2	0.6	1.2	0.6	1.2
Experiment 3	0.0	0.6	1.0	0.6	1.0	0.6	1.0
Experiment 4	0.0	0.6	0.6	1.2	0.6	1.2	0.6
Experiment 5	0.0	0.6	0.6	0.6	0.6	0.6	0.6
Experiment 6	0.0	0.6	1.2	0.0	1.2	0.0	1.2
Experiment 7	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Experiment 8	0.6	1.2	0.0	1.2	0.0	1.2	0.0
Experiment 9	0.6	1.2	0.6	0.6	0.6	0.6	0.6
Experiment 10	0.6	0.0	1.2	0.6	1.2	0.6	1.2

Image 11: Showing the SD value of soil moisture

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	6001.172	9	666.79689	4.8816687	6.534E-05	2.0400981
Within Groups	8195.52	60	136.592			
Total	14196.692	69				

Image 11: Showing the summary of soil moisture results

Soil temperature

Average

Experiment	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Experiment 1	27	28	25	24	26	26	23
Experiment 2	28	32	35	26	28	28	25
Experiment 3	32	31	31	29	27	28	28
Experiment 4	30	28	28	29	28	30	28
Experiment 5	32	31	27	30	29	30	28
Experiment 6	27	27	27	24	26	29	24
Experiment 7	30	32	33	26	30	29	27
Experiment 8	32	30	31	30	30	28	27
Experiment 9	30	28	29	29	29	30	30
Experiment 10	33	29	29	32	31	29	30

Image 12: Showing the average soil temperature value

SD

Experiment	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Experiment 1	1	1	1	1	1	1	1
Experiment 2	1	1	1	1	1	1	1
Experiment 3	1	1	1	1	1	1	1
Experiment 4	1	1	1	1	1	1	1
Experiment 5	1	1	1	1	1	1	1
Experiment 6	1	1	1	1	1	1	1
Experiment 7	1	1	1	1	1	1	1
Experiment 8	1	1	1	1	1	1	1
Experiment 9	1	1	1	1	1	1	1
Experiment 10	1	1	1	1	1	1	1

Image 13: Showing the SD (Standard Deviation) of soil temperature

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	154.229	9	17.1365	4.48712	0.00016	2.0401
Within Groups	229.143	60	3.81905			
Total	383.371	69				

Image 14: Summary of Soil Temperature Results

Amount of water applied

Experiment	Water Volume (ml)	SD
Experiment 1	333.3	115.5
Experiment 2	0.0	0
Experiment 3	133.3	115.5
Experiment 4	0.0	0
Experiment 5	0.0	0
Experiment 6	1066.7	611
Experiment 7	866.7	115.5
Experiment 8	1466.7	702.4
Experiment 9	1133.3	115.5
Experiment 10	866.7	230.9

Image 15: showing the average value and SD (Standard Deviation) in water irrigation

ANOVA						
Source of Variatio	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	8288000	9	920889	9.46119	1.7473E-05	2.39281
Within Groups	1946667	20	97333.3			
Total	1E+07	29				

Image 16: Show the summary of the irrigation results**.**

Air Humidity

Average soil moisture (Percentage): Growing soil

วันที่	ไม่คลุม (เช้า/เย็น)			คลุมพลาสติก(เช้า/เย็น)			แผ่นคลุม 10 : 0 (เช้า/เย็น)			แผ่นคลุม 9 : 1(เช้า/เย็น)			แผ่นคลุม 8 : 2 (เช้า/เย็น)	
28 ม.ค.	An	90.0	90.0	Bn	100.0	100.0	Cn	100.0	100.0	Dn	100.0	100.0	En	100.0	100.0
29 ม.ค.	An	90.0	80.0	Bn	100.0	96.7	Cn	98.3	100.0	Dn	100.0	98.3	En	100.0	100.0
30 ม.ค.	An	66.7	79.3	Bn	87.0	90.0	Cn	85.3	70.3	Dn	90.3	91.0	En	89.3	88.7
31 ม.ค.	An	60.0	70.3	Bn	67.7	85.7	Cn	67.7	92.7	Dn	72.3	86.3	En	89.0	89.7
1 ก.พ. 68	An	60.0	67.3	Bn	76.7	76.0	Cn	64.0	67.7	Dn	64.0	68.7	En	63.3	66.3
2 ก.พ. 68	An	56.7	58.7	Bn	62.0	83.3	Cn	67.7	66.0	Dn	62.3	69.7	En	61.3	76.7
3 ก.พ. 68	An	60.0	74.0	Bn	65.7	59.7	Cn	55.3	84.0	Dn	73.3	75.3	En	80.3	81.7
4 ก.พ. 68	An	76.0	73.3	Bn	74.0	75.3	Cn	76.3	80.3	Dn	72.0	75.0	En	84.3	90.3
5 ก.พ. 68	An	67.0	52.7	Bn	64.7	69.3	Cn	65.3	73.7	Dn	73.3	73.0	En	64.3	83.7
6 ก.พ. 68	An	55.7	84.0	Bn	59.3	59.7	Cn	57.7	74.7	Dn	54.3	74.0	En	57.0	79.3
7 ก.พ. 68	An	66.2	70.0	Bn	66.0	68.1	Cn	66.4	76.2	Dn	66.5	74.0	En	68.5	84.4
8 ก.พ. 68	An	63.0	68.9	Bn	63.3	65.7	Cn	63.1	74.9	Dn	64.7	73.7	En	63.3	82.5
9 ก.พ. 68	An	61.6	74.3	Bn	62.9	64.5	Cn	62.4	75.3	Dn	61.8	73.9	En	62.9	82.1
10 ก.พ. 68	An	63.6	71.1	Bn	64.1	66.1	Cn	64.0	75.5	Dn	64.4	73.9	En	64.9	83.0
11 ก.พ. 68	An	62.7	71.4	Bn	63.4	65.4	Cn	63.2	75.2	Dn	63.6	73.8	En	63.7	82.5
12 ก.พ. 68	An	62.7	72.3	Bn	63.5	65.3	Cn	63.2	75.3	Dn	63.3	73.8	En	63.9	82.5
13 ก.พ. 68	An	63.0	71.6	Bn	63.7	65.6	Cn	63.5	75.3	Dn	63.8	73.8	En	64.2	82.7

Average soil moisture (Percentage):Clay loam soil

วันที่	ไม่คลุม (เช้า/เย็น)			คลุมพลาสติก(เช้า/เย็น)			แผ่นคลุม 10 : 0 (เช้า/เย็น)			แผ่นคลุม 9 : 1(เช้า/เย็น)			แผ่นคลุม 8 : 2 (เช้า/เย็น)	
28 ม.ค.	Aช	62.0	55.0	Bช	68.0	62.0	Cช	63.0	54.0	Dช	61.0	54.0	Eช	70.0	60.0
29 ม.ค.	Aช	61.0	57.0	Bช	60.0	57.0	Cช	58.0	44.0	Dช	62.0	50.0	Eช	75.0	63.0
30 ม.ค.	Aช	39.0	47.0	Bช	47.0	50.7	Cช	55.0	45.7	Dช	52.7	46.0	Eช	47.7	50.3
31 ม.ค.	Aช	47.3	49.0	Bช	45.0	57.0	Cช	45.0	48.7	Dช	60.0	63.3	Eช	55.3	53.3
1 ก.พ.	Aช	52.7	50.3	Bช	49.0	52.3	Cช	51.7	45.0	Dช	52.3	57.7	Eช	60.7	55.0
2 ก.พ.	Aช	58.3	50.3	Bช	58.0	49.7	Cช	59.0	53.3	Dช	47.3	63.0	Eช	48.0	63.0
3 ก.พ.	Aช	41.0	40.3	Bช	49.7	51.3	Cช	51.3	55.7	Dช	51.0	57.0	Eช	58.0	49.7
4 ก.พ.	Aช	56.3	46.7	Bช	74.0	43.4	Cช	51.3	47.3	Dช	60.0	52.3	Eช	56.3	50.3
5 ก.พ.	Aช	54.0	47.3	Bช	54.3	43.3	Cช	56.7	45.0	Dช	49.7	51.0	Eช	56.7	53.3
6 ก.พ.	Aช	54.7	53.3	Bช	53.3	52.3	Cช	57.3	48.7	Dช	53.0	55.3	Eช	52.7	49.0
7 ก.พ.	Aช	55.0	49.1	Bช	60.5	46.3	Cช	55.1	47.0	Dช	54.2	52.9	Eช	55.2	50.9
8 ก.พ.	Aช	54.6	49.9	Bช	56.0	47.3	Cช	56.4	46.9	Dช	52.3	53.1	Eช	54.9	51.1
9 ก.พ.	Aช	54.8	50.8	Bช	56.6	48.7	Cช	56.3	47.5	Dช	53.2	53.7	Eช	54.3	50.3
10 ก.พ.	Aช	54.8	49.9	Bช	57.7	47.4	Cช	55.9	47.1	Dช	53.2	53.2	Eช	54.8	50.7
11 ก.พ.	Aช	54.7	50.2	Bช	56.8	47.8	Cช	56.2	47.2	Dช	52.9	53.3	Eช	54.6	50.7
12 ก.พ.	Aช	54.7	50.3	Bช	57.1	48.0	Cช	56.1	47.3	Dช	53.1	53.4	Eช	54.6	50.6
13 ก.พ.	Aช	54.7	50.1	Bช	57.2	47.7	Cช	56.1	47.2	Dช	53.1	53.3	Eช	54.7	50.7

Image 16**:** Showing the average humidity value.

Air temperature

วันที่	ไม่คลุม (เช้า/เย็น)			คลุมพลาสติก(เช้า/เย็น)			แผ่นคลุม 10 : 0 (เช้า/เย็น)			แผ่นคลุม 9 : 1(เช้า/เย็น)			แผ่นคลุม 8 : 2 (เช้า/เย็น)		
28 ม.ค.	An	27	31	Bn	28	31	Cn	32	30	Dn	30	29	En	32	29
29 ม.ค.	An	28	31	Bn	32	30	Cn	31	29	Dn	28	29	En	31	30
30 ม.ค.	An	25	32	Bn	35	30	Cn	31	29	Dn	28	30	En	27	30
31 ม.ค.	An	24	31	Bn	26	31	Cn	29	30	Dn	29	31	En	30	30
1 ก.พ.	An	26	34	Bn	28	33	Cn	27	32	Dn	28	32	En	29	31
2 ก.พ.	An	26	33	Bn	28	33	Cn	28	33	Dn	30	32	En	30	32
3 ก.พ.	An	23	33	Bn	25	33	Cn	28	33	Dn	28	32	En	28	32
4 ก.พ.	An	29	34	Bn	30	33	Cn	28	33	Dn	30	32	En	30	32
5 ก.พ.	An	28	34	Bn	28	32	Cn	28	33	Dn	29	33	En	29	32
6 ก.พ.	An	27	31	Bn	27	31	Cn	28	31	Dn	29	33	En	29	32
7 ก.พ.	An	28	32	Bn	28	33	Cn	28	32	Dn	28	32	En	29	32
8 ก.พ.	An	32	34	Bn	32	34	Cn	30	34	Dn	30	34	En	30	34
9 ก.พ.	An	32	33	Bn	32	32	Cn	31	32	Dn	30	32	En	30	32
10 ก.พ.	An	29	33	Bn	28	33	Cn	27	33	Dn	27	33	En	27	33
11 ก.พ.	An	32	33	Bn	32	33	Cn	32	33	Dn	31	32	En	32	33
12 ก.พ.	An	29	33	Bn	29	33	Cn	28	33	Dn	28	33	En	28	33
13 ก.พ.	An	28	35	Bn	28	35	Cn	28	35	Dn	28	34	En	29	34

Average soil moisture (Percentage):Clay loam soil

วันที่	ไม่คลุม (เช้า/เย็น)			คลุมพลาสติก(เช้า/เย็น)			แผ่นคลุม 10 : 0 (เช้า/เย็น)			แผ่นคลุม 9 : 1(เช้า/เย็น)			แผ่นคลุม 8 : 2 (เช้า/เย็น)		
28 ม.ค.	Aช	27	31	Bช	30	31	Cช	32	30	Dช	30	29	Eช	33	29
29 ม.ค.	Aช	27	28	Bช	32	30	Cช	30	29	Dช	28	29	Eช	29	30
30 ม.ค.	Aช	27	29	Bช	33	29	Cช	31	28	Dช	29	29	Eช	29	30
31 ม.ค.	Aช	24	29	Bช	26	30	Cช	30	30	Dช	29	30	Eช	32	30
1 ก.พ.	Aช	26	32	Bช	30	32	Cช	30	29	Dช	29	30	Eช	31	30
2 ก.พ.	Aช	29	31	Bช	29	31	Cช	28	30	Dช	29	30	Eช	29	30
3 ก.พ.	Aช	24	31	Bช	27	32	Cช	27	31	Dช	30	31	Eช	30	31
4 ก.พ.	Aช	31	32	Bช	32	33	Cช	28	31	Dช	30	31	Eช	31	31
5 ก.พ.	Aช	28	32	Bช	30	32	Cช	30	31	Dช	30	31	Eช	29	31
6 ก.พ.	Aช	31	29	Bช	31	30	Cช	31	29	Dช	30	29	Eช	30	30
7 ก.พ.	Aช	29	33	Bช	28	32	Cช	28	32	Dช	29	32	Eช	28	32
8 ก.พ.	Aช	33	34	Bช	31	34	Cช	30	34	Dช	31	34	Eช	30	34
9 ก.พ.	Aช	33	30	Bช	32	31	Cช	31	31	Dช	30	31	Eช	30	32
10 ก.พ.	Aช	29	33	Bช	29	33	Cช	27	33	Dช	28	32	Eช	28	33
11 ก.พ.	Aช	33	34	Bช	32	34	Cช	30	33	Dช	30	33	Eช	31	33
12 ก.พ.	Aช	30	33	Bช	29	34	Cช	28	33	Dช	28	33	Eช	29	33
13 ก.พ.	Aช	30	34	Bช	30	34	Cช	28	34	Dช	29	34	Eช	29	34

Image 17**:** Showing the average Air Temperature value.