The Study of the Effects of Vetiver Grass on Soil Properties Along Riverbanks in Chiang Mai

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Abstract

Soil erosion is a problem where soil is washed away, eroded, or degraded due to water currents, wind, or human activities. This leads to soil deterioration, loss of topsoil, and reduced fertility. It was found that a common solution to this issue is the use of ground cover plants, particularly vetiver grass. The grass has special properties that slow down water flow and trap sediments, allowing more water to seep into the lower soil layers, increasing soil moisture, preventing erosion, and enhancing soil nutrients. This study aimed to examine the effects of vetiver grass on soil properties along riverbanks in Chiang Mai. Three study sites were selected: the banks of the Ping River, the riverbanks in Mueang Chiang Mai district, and the riverbanks in Saraphi district. The study analyzed the physical and chemical properties of the soil, using soil from these sites to conduct an experiment growing Pang Kwang variety vetiver grass for two months. The results showed that vetiver grass can grow well along riverbanks in Chiang Mai, with the most suitable soil being the sandy loam of Mueang Chiang Mai district, followed by the sand of Saraphi district, and the sandy clay of the Ping River banks. Regarding sediment retention, vetiver grass was found to effectively slow water flow and trap sediments best in sandy clay, followed by sand and sandy loam. The study also found that vetiver grass improved soil structure by making it more porous, darkening soil color, lowering soil temperature, increasing moisture content, and enhancing phosphorus (P) and potassium (K) levels.

Key Words :vetiver grass, soil properties , riverbanks in Chiang Mai

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Researchers

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Chapter 1
Introduction

Rationale

Soil erosion is a problem in which soil is washed away, eroded, or degraded due to factors such as water currents, wind, or human activities. This leads to soil degradation, loss of topsoil, and decreased fertility. In October 2024, Chiang Mai experienced severe flooding, which significantly impacted soil resources along the Ping River in Mueang Chiang Mai and Saraphi districts. Prolonged flooding caused water saturation in the soil, leading to oxygen depletion, reduced fertility, and nutrient loss. Research findings indicate that a widely used solution to mitigate soil erosion is the use of ground cover plants, particularly vetiver grass. Vetiver grass has special properties that slow water flow and trap sediments, allowing more water to seep into lower soil layers. This process increases soil moisture, prevents erosion, and enhances soil nutrient content.

The research team was therefore interested in studying the effects of vetiver grass on soil properties along riverbanks in Chiang Mai. Soil samples were collected from three locations: the banks of the Ping River, the riverbanks in Mueang Chiang Mai district, and the riverbanks in Saraphi district. The study aimed to assess the impact of vetiver grass on soil properties as a guideline for improving soil quality and effectively preventing erosion along riverbanks in Chiang Mai in a sustainable manner.

Research Objective

To study the effects of vetiver grass on soil properties along riverbanks in Chiang Mai

Research Questions

Do different soil areas affect vetiver grass and soil properties, and if so, how?

Does soil texture variation impact vetiver grass and soil properties, and if so, how?

Hypothesis

Different soil areas affect vetiver grass and soil properties in varying ways.

Soil texture variations influence vetiver grass and soil properties differently.

Expected Benefits

1. Gain insights into the effects of vetiver grass on soil properties along riverbanks in Chiang Mai.
2. Utilize the study results as a valuable resource for disseminating information on the impact of vetiver grass on soil properties along riverbanks in Chiang Mai.

Research Scope

1. Content

The study focuses on the effects of vetiver grass on soil properties along riverbanks in Chiang Mai.

1.1 Factors related to vetiver grass growth to be measured:

- Height of vetiver grass (from soil surface to top of the plant)
- Root system characteristics at the end of the experiment
- Root length at the end of the experiment
- Dry biomass of vetiver grass at the end of the experiment (dry weight)

1.2 Factors related to physical soil properties to be measured:

- Soil structure
- Soil color
- Soil cohesion
- Soil texture
- Soil temperature
- Soil moisture content

1.3 Factors related to chemical soil properties to be measured:

- Soil pH (acidity-alkalinity)
- Nutrient content in the soil: Nitrogen (N), Phosphorus (P), and Potassium (K)

2. Location

Soil samples were collected from three sites: Site 1: Ping River bank; Site 2: Mueang Chiang Mai riverbank; and Site 3: Saraphi riverbank. The collected soil wase used in experimental setups at Varee Chiangmai School, Mueang, Chiang Mai.

3. Time

November 2024 – February 2025

Chapter 2
Literature Review

To complete the research "The Study of the Effects of Vetiver Grass on Soil Properties Along Riverbanks in Chiang Mai," the research team reviewed and examined the following theoretical documents and related research studies:

2.1 Vetiver Grass

2.2 Types of Soil

2.3 Soil Erosion

2.4 Related Research

2.1 Vetiver Grass

2.1.1 General Characteristics of Vetiver Grass

Vetiver grass is a tropical grass that grows naturally in various environments. In Thailand, it is commonly found in areas ranging from lowlands to higher grounds and can thrive in almost all types of soil. Its scientific name is *Vetiveria zizanoides*. It belongs to the grass family, growing in dense clumps, and spreads quickly through tillering. The clump diameter is approximately 30 centimeters, and its height ranges from 0.5 to 1.5 meters. The leaves are narrow, about 75 centimeters long, and 8 millimeters wide, with a rather stiff texture. When planted continuously in long rows along sloping areas, the clumps grow in contact with each other, forming a natural barrier similar to a fence. This can filter plant debris and soil particles carried by water, allowing sediment to accumulate and create natural embankments. Vetiver grass has a deep root system that grows more vertically than horizontally, with a large number of roots, making it highly drought-tolerant. The roots tightly connect to form a barrier or "wall" underground, capable of retaining water and moisture. The root system extends about 50 centimeters around the clump, without interfering with neighboring plants. It is considered a method of soil and water conservation, helping maintain soil moisture and preserve topsoil, which can be used for growing economic crops. The use of vetiver grass in soil and water conservation is a simple yet effective technique that contributes to sustainable agricultural development in rain-fed farming areas. This method can also be applied to other areas to protect the environment and conserve natural resources, such as along irrigation canals, reservoirs, ponds, forests, embankments, bridge approaches, and road shoulders.

2.1.2 Types of Vetiver Grass

Vetiver grass is a monocot plant belonging to the grass family, similar to corn, sorghum, and sugarcane. It is widely distributed in various areas and, according to surveys, approximately 12 species of vetiver are found worldwide, with 2 species identified in Thailand. These are:

1. Lowland Vetiver Grass: This species is believed to have originated in the central part of Asia, likely in India, and is typically found in lowland areas with high moisture or waterlogging. It grows in clumps and can reach a height of approximately 150 to 200 centimeters. The leaves are long and upright, with branches and tillers. The leaves are dark green, 45 to 100 centimeters long, and 0.6 to 1.2 centimeters wide. The upper side of the leaf is rounded to angular, while the underside is white with transverse lines visible when sunlight hits the leaf. The texture of the leaf is smooth, and the surface is coated with a waxy layer, making it shiny. The young leaves can be used as animal feed. The flower stalk reaches 150 to 200 centimeters in height, and the flowers are typically purple in color. The flowers do not have rigid branches. The roots are aromatic and extend deep into the soil, reaching depths of 100 to 300 centimeters. The varieties promoted by the Department of Land Development include those from Surat Thani, Songkhla 3, Kamphaeng Phet 2, Sri Lanka, and the Royal.

Figure 1: Lowland Vetiver Grass

2. Upland Vetiver Grass: This species originates from Southeast Asia, specifically in Thailand, Laos, Cambodia, and Vietnam. It is commonly found in relatively dry areas and grows in clumps, reaching a height of 100–150 centimeters. The tips of the leaves curve downward, resembling lemongrass clumps. It typically does not form tillers or branching stems. The leaves are pale green, measuring 35-80 centimeters in length and 0.4-0.8 centimeters in width. The back of the leaf folds into a triangular ridge, and the underside of the leaf is the same color as the back but paler. The leaf texture is rough and slightly prickly with minimal wax coating, making it

look coarse and not glossy. Locals use it as thatch for roofing. The flower spike reaches 100-150 centimeters in height, with flowers ranging in color from cream to purple. The flowers are small and have rigid bristles. Unlike the lowland variety, the roots are less fragrant and shorter, extending only 80 to 100 centimeters into the soil. The varieties promoted by the Department of Land Development include those from Ratchaburi, Prachuap Khiri Khan, Roi Et, Kamphaeng Phet 1, Nakhon Sawan, and Loei.

Figure 2: Upland Vetiver Grass

2.1.3 Special Characteristics of Vetiver Grass

Vetiver grass is used for soil and water conservation due to its several notable characteristics, as follows:

1. It forms dense clumps by producing shoots that grow tightly together without spreading sideways.
2. It produces new shoots and leaves without requiring much care.
3. Vetiver grass has closely spaced nodes on its stems, and it can be propagated through suckers year-round.
4. It primarily does not reproduce by seeds, allowing for better control over its spread.
5. The leaves are long, easy to cut, and regenerate quickly, while being strong and resistant to decomposition.
6. The root system is long, tightly woven, and helps retain water.
7. The roots provide a habitat for microorganisms.
8. It adapts well to various conditions and is resistant to common plant diseases.
9. Its growth below the soil surface allows it to survive well under different environmental conditions.

2.1.4 Growth of Vetiver Grass

1. Selection of Quality Seedlings: Quality vetiver grass seedlings typically have an age of 45 to 60 days. When strong seedlings are planted, they will form a fence-like barrier of vetiver grass that grows evenly and robustly.

2. Planting Time Selection: The best time to plant vetiver grass is during the early rainy season. The soil conditions at this time are moist for more than 15 days, which promotes better growth.

3. Leaf Pruning: At the beginning of the rainy season, it is advisable to trim the vetiver grass leaves to a height of 5 cm from the ground to encourage the growth of new shoots and to remove any dry, old shoots. In mid-rainy season, leaves should be trimmed to at least 45 cm to promote dense clumping that will resist water flow. At the end of the rainy season, the leaves should be trimmed to 5 cm again to stimulate new green growth during the dry season.

4. Proper Care and Maintenance: At the beginning of the rainy season, applying compost fertilizer along the vetiver grass rows will help improve its growth. Removing weeds along the rows will make the vetiver fence more visible and prevent it from being lost, ensuring the vetiver grass grows optimally.

5. Replanting and Separating Old Shoots: During the rainy season, replanting damaged or lost sections of the vetiver fence will strengthen the overall structure. It is also important to remove old, flowering, or dried shoots to allow new shoots to emerge and fill in gaps.

2.1.5 Benefits of Vetiver Grass

Soil and Water Conservation

1. Prevents soil erosion and degradation.
2. The vetiver grass rows help trap soil sediments.
3. Reduces the force of flowing water.
4. Helps retain water in the soil and upper areas.
5. Reduces the loss of plant nutrients from the area.

Soil Rehabilitation and Improvement

1. Increases organic matter in the soil.
2. Maintains moisture in the soil.
3. Improves soil drainage.
4. Makes the soil more porous and improves air circulation in the soil.

5. Boosts microbial activity in the soil.

Environmental Protection

1. Helps maintain water quality and water sources.
2. Absorbs heavy metals from the environment.
3. Aids in wastewater treatment and filtration.
4. Prevents erosion of road shoulders.

Other Versatile Benefits of Vetiver Grass

1. Planting vetiver grass along dikes to help maintain their stability.
2. Planting vetiver grass for roofing material. Vetiver grass roofing can be harvested and sold. The roots, which have a pleasant fragrance, were traditionally hung in wardrobes to impart a pleasant scent and repel moths that damage clothing.
3. Vetiver grass has medicinal properties to help expel gas from the intestines, relieve bloating, and reduce fever. The roots can also be extracted to make essential oils, which are valuable in commercial products. For example, France produces perfume from vetiver grass roots, known as Vetiver.

2.2 Types of Soil

2.2.1 Sandy Clay

Sandy clay contains at least 35% clay and 45% or more sand. When dry, it becomes very hard and cracks into clumps. When wet or moist, it can be flattened into thin sheets. The soil feels both sticky and gritty. A thin sheet of sandy clay, when lifted by its edge, will not break apart. It can also be easily rolled into a compact, spherical shape like a small pellet.

2.2.2 Sandy Loam

Sandy loam is composed of more than 50% sand but also contains enough silt and clay particles to bind together into clumps. The individual grains of sand are visible and can be felt. When dry, sandy loam forms clumps that easily crumble. When moist, it holds together in a clump and does not break apart when lightly tapped with a finger.

2.2.3 Sand

Sand is a soil type with no structure, consisting of more than 85% sand particles. It contains the largest soil particles of any plant-growing medium, making it visibly granular. Sand has a coarse, dry, and gritty texture, with large pore spaces. When dry, it feels rough to the touch; when moist, it loosely holds together but crumbles immediately upon contact. Sand has excellent drainage and aeration but retains very little water. Due to its poor nutrient-holding capacity, plants struggle to grow in sandy soil, and it is highly prone to erosion. Therefore, sandy soil must always be improved before use to maximize its potential benefits.

2.3 Soil Erosion

Soil erosion refers to the natural loss and degradation of topsoil due to factors such as water runoff, wind erosion, and human activities. Key human-induced causes include deforestation, slash-and-burn agriculture, and improper farming practices. These lead to a decline in soil fertility, reducing land productivity for agriculture and limiting land use potential. Soil erosion also causes sediment accumulation in rivers, canals, reservoirs, and dams, leading to shallower water bodies. This sediment buildup can cover aquatic habitats, disrupt fish spawning grounds, and block sunlight from reaching underwater ecosystems, negatively impacting aquatic life. In addition to erosion, soil degradation can result from naturally occurring toxic substances in the soil, such as heavy metals and harmful chemical compounds. This can lead to saline, alkaline, or acidic soil conditions. A significant example is the expansion of saline soil in northeastern Thailand. Improper land use and poor land management practices further worsen soil degradation. For instance, constructing reservoirs in areas with high underground salt deposits can lead to increased salinity as water dissolves these salts and brings them to the surface. Similarly, commercial salt production by extracting and evaporating groundwater increases soil salinity over a wider area. External pollutants such as household waste, industrial discharge, and chemical residues from fertilizers and pesticides also contribute to soil contamination. These issues not only harm the environment but also result in significant economic losses.

Soil erosion, which results in the formation of gullies or widespread excavation of land, is a type of surface soil transformation caused by two main factors:

1. Natural Erosion – This includes cracks in dry soil due to wind, riverbank erosion caused by flowing water, and the washing away of topsoil by rainfall.

2. Human and Animal Activities – Activities such as deforestation, road construction, mining, mountain blasting, and the excavation of animal habitats accelerate soil erosion.

Impacts of Soil Erosion on Living Organisms

1. The loss of nutrient-rich topsoil reduces soil fertility, negatively affecting agriculture.

2. Soil erosion creates gullies and channels, altering the landscape.

3. Displaced soil settles in rivers and reservoirs, causing sedimentation, shallowing water bodies, and obstructing waterway transportation.

4. Increased sedimentation can lead to severe flooding.

5. Eroded land dries out rapidly, increasing water demand for crops.

6. Lower soil moisture reduces microbial populations, disrupting soil ecosystems.

7. Continuous erosion depletes soil fertility, leading to declining agricultural productivity.

8. Farmers must rely more on chemical fertilizers each year, which further accelerates soil degradation.

9. The use of chemical fertilizers often goes hand in hand with pesticides, which eliminate all soil organisms, eventually leading to a complete loss of beneficial soil microbes.

2.4 Related Research

2.4.1 A study by the Research and Development Bureau of the Royal Irrigation Department on the suitability of ground cover plants for erosion control on slopes aimed to select appropriate plant species for planting on various sloped areas within irrigation systems. It also compared the effectiveness of different ground cover plants in preventing soil erosion at varying slopes. The study was conducted using test trays filled with compacted soil (at least 75% Standard Compaction Test). Three types of ground cover plants were tested: Wedelia (Creeping Daisy), Pennywort, and Bermuda Grass. These species were chosen for their shallow root systems, ease of planting, durability, horizontal growth, and low maintenance requirements. Once the plants had grown to cover the soil surface (after two months), erosion tests were conducted by comparing them with a control tray of bare soil. A simulated rainfall system was used to control 400 mm/day of rainfall, with three intensity levels: 50, 100, and 200 mm/hour, at three different slope gradients (vertical:horizontal): 1:1.5, 1:2, and 1:3. Data analysis showed that all three ground cover species were suitable for planting on sloped soil within irrigation systems and significantly reduced soil erosion ($p > .05$) at all slope gradients compared to bare soil. The effectiveness in preventing soil erosion ranked as follows: Bermuda Grass > Pennywort > Wedelia (Creeping Daisy). These plants reduced sediment loss by 87.08% to 98.82%, while rainfall intensity had no significant effect on the amount of soil erosion.

2.4.2 A study by the Faculty of Engineering at Rajamangala University of Technology Srivijaya aimed to develop a soil erosion model for roadside slopes by incorporating a surface runoff test system alongside a slope model. This allowed for the simulation of various surface runoff patterns and the analysis and comparison of erosion severity. The developed model was designed to adjust runoff rates through a test tray with a slope model, ranging from 20 to 70 liters per minute. The study examined erosion caused by surface runoff at a flow rate of 30 liters per minute, equivalent to rainfall exceeding 50 mm per hour (classified as violent rain). Tests were conducted at three slope gradients (vertical:horizontal): 1:1.5, 1:2.0, and 1:3.0, which align with the standard embankment slopes set by the Department of Highways. Each slope was tested at two soil compaction levels: 70% and 95% of the Standard Compaction Test. Additionally, the study evaluated the effectiveness of 1.16 cm-thick coir fiber mats as erosion control materials. A total of 12 tests were conducted, with sediment runoff data collected every 5 minutes for one hour. The results showed that the model successfully simulated both sheet erosion (shallow surface erosion) and rill erosion (deep channel erosion). The severity of erosion increased with steeper slopes. For the same slope gradient, 70% compacted soil experienced more erosion than 95% compacted soil, with rill erosion occurring in the less compacted soil and sheet erosion in the more compacted soil. The sediment runoff rates were 26.04 kg/m^2/hour for the 1:1.5 slope, 19.30 kg/m^2/hour for the 1:2.0 slope, and 13.19 kg/m^2/hour for the 1:3.0 slope at 70% compaction, whereas at 95% compaction, the rates were 1.03 kg/m²/hour for the 1:1.5 slope, 0.80 kg/m²/hour for the 1:2.0 slope, and 0.56 kg/m²/hour for the 1:3.0 slope. It was evident that gentler slopes and higher soil compaction significantly reduced erosion damage. Additionally, the use of coir fiber mats on the slopes effectively mitigated erosion, reducing sediment loss by an average of 96% compared to uncovered slopes.

Chapter 3
Methodology

Materials and Equipment

1. Upland vetiver seedlings, Pang Kwang variety, 1 month old.

2. Soil from three locations: along the Ping River, along the river in Mueang Chiang Mai District, and along the river in Saraphi District.

3. Experimental plots for planting vetiver grass, measuring 40 cm in width, 90 cm in length, and 15–40 cm in height, with a slope of 50% and a total of three plots.

4. Materials and equipment for studying and measuring the vetiver grass:

4.1 Vetiver grass height (measured from ground level to the tip at 2 months old)

4.1.1 Ruler

4.2 Root characteristics (at 2 months old)

4.2.1 Ruler 4.2.2 Basin

4.3 Vetiver grass biomass (dry weight at 2 months old)

4.3.1 Digital scale 4.3.2 Metal tray

5. Materials and equipment for studying and analyzing soil sediment:

5.1 Conical flask, 250 ml 5.2 Watering can

5.3 Digital scale 5.4 Beaker, 250 ml

5.5 Filter funnel 5.6 Filter paper, no.1

6. Materials and equipment for studying and measuring soil physical properties:

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

6.1.1 Soil samples 6.1.2 Pointed shovel

6.1.3 Ruler 6.1.4 Spray bottle

6.1.5 Field texture classification handbook 6.1.6 Soil structure handbook

6.1.7 Soil color chart 6.1.8 Plastic sample bags

6.2 Air temperature and soil moisture

6.2.1. ESP32 Board 6.2.2 Breadboard

6.2.3 Jumper wires 6.2.4 Rechargeable batteries

6.2.5 Soil Moisture Sensor Module 6.2.6 Soil Moisture Meter

6.2.7 Temperature and humidity sensor 6.2.8 Battery charging module

6.2.9 Micro USB to USB Cable
6.2.10 Computer

7. Materials and equipment for studying and measuring soil chemical properties:

7.1 Soil pH, and nutrient content (N, P, K)

7.1.1 Soil test kit for pH, N, P, K
7.1.2 Dried soil samples
7.1.3 Medium-sized test tubes
7.1.4 Pipette, 100 ml
7.1.5 Rubber pipette bulb
7.1.5 Beaker, 100 ml
7.1.6 Mortar and pestle for grinding soil
7.1.7 Digital scale
7.1.8 Droppers
7.1.9 Plastic sample bags

Methodology

1. The study area for soil sample collection along the riverbanks in Chiang Mai at three locations includes:

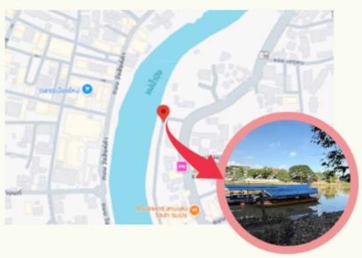

Figure 3: Sampling Site1 – Ping River Bank, Wat Ket, Mueang, Chiang Mai @ 60 kg

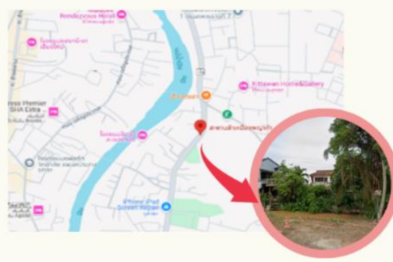

Figure 4: Sampling Site 2 – Mueang Chiang Mai Riverbank, Nong Hoi, Mueang, Chiang Mai @ 60 kg

Figure 5: Sampling Site 3 – Saraphi Riverbank, Tha Wang Tan, Saraphi, Chiang Mai @ 60 kg

2. Collect soil samples and measure the physical and chemical properties of the soil with the following details:

2.1 Soil structure
2.2 Soil color
2.3 Soil cohesion
2.4 Soil texture
2.5 Soil pH
2.6 Nutrient content in the soil (N, P, K)

Figure 6: Soil sampling and soil property measurements

3. Coordinate with the Land Development Study and Development Unit at the Huai Hong Khrai Royal Development Study Center, Doi Saket District, Chiang Mai, to receive 80 one-month-old Vetiver grass seedlings of the Pang Kwang variety.
4. Prepare the experimental plots for planting Vetiver grass, with dimensions of 40 cm wide, 90 cm long, and 15-40 cm high, with a slope of 50%. Drill holes in the base of all plots in the same size and number. A total of 3 plots will be prepared.
5. Students will fill the experimental plots with soil collected from the 3 selected areas as follows:

Experimental Plot 1: Soil from Site 1, along the Ping River bank

Experimental Plot 2: Soil from Site 2, along the riverbank in Mueang District

Experimental Plot 3: Soil from Site 3, along the riverbank in Saraphi District

6. Plant the one-month-old Vetiver grass seedlings of the Pang Kwang variety in the experimental plots in horizontal rows along the contour line, with a spacing of 5 cm. Each plot will have 24 seedlings planted equally.

Figure 7: Planting Pang Kwang variety vetiver seedlings in experimental plots

7. Water the plants equally in the morning and evening for a period of 2 months.
8. Construct a device to measure air temperature, air humidity, soil temperature, and soil moisture using the ESP32 NodeMCU Goouuu ESP32 DEVKIT Wi-Fi and Bluetooth board along with various sensors. Program the device to record data every hour to collect information for analyzing the differences in temperature and soil moisture changes across the three experimental plots.
9. Collect soil samples and measure the soil's physical and chemical properties as follows:

9.1 Soil structure	9.2 Soil color	9.3 Soil cohesion
9.4 Soil texture	9.5 Soil pH	9.6 Nutrient content in the soil (N, P, K)

10. Soil Sampling

Dig to a depth of 10 centimeters and place the soil in a ziplock bag. Collect 10 grams of soil per plot, with 3 replicates per plot, for a total of 9 samples.

11. Soil structure

11.1 Place an undisturbed soil sample in your hand and closely observe the soil's structure.

11.2 Measure and record the size and shape of the structure using a soil structure guidebook, and log the information in the soil characteristics record sheet.

12. Soil Color

12.1 Observe soil particles from each layer and record whether they are dry, moist, or wet. If dry, slightly moisten them with water from a prepared bottle.

12.2 Divide the soil into two parts.

12.3 Stand with sunlight coming over your shoulder, illuminating both the Munsell soil color chart and the soil sample.

12.4 Record the soil color in the data sheet.

13. Soil Cohesion

13.1 Take soil particles from the surface layer. If dry, moisten the soil with sprayed water, then pull apart the soil particles to observe cohesion.

13.2 Place the soil particle between your thumb and index finger, then gently press until the particle breaks apart.

13.3 Record the type of cohesion observed in the data sheet.

14. Soil Texture

14.1 Form a moist soil clump in hands.

14.2 Compare the texture with the field texture guide and record the results.

15. Soil pH Measurement

15.1 Take dried soil samples and grind them into fine particles.

15.2 Prepare a soil solution with a soil-to-water ratio of 1:1, using 2 spoons of soil and 2 ml of water.

15.3 Mix the soil solution with the pH test solution in a 1:1 ratio (2 ml soil solution to 2 ml pH solution), then compare the color to a pH color chart.

16. Measurement of N, P, K in Soil
    16.1 Take dried soil samples and grind them finely.
    16.2 Scoop 6 spoons of soil into a test tube, then use a pipette to add 7.5 ml of test solution to the soil. Shake the test tube and let it sit for 1 minute.
    16.3 Measure the soil fertility using a soil test kit for nitrogen (N).
    16.4 Measure the soil fertility using a soil test kit for phosphorus (P).
    16.5 Measure the soil fertility using a soil test kit for potassium (K).
    16.6 Record the test results in the data sheet for further analysis.
17. Sediment Collection
    17.1 Place clear plastic sheets under all three experimental plots.
    17.2 Use three identical 8-liter watering cans to evenly water all three plots. Observe the water flow.
    17.3 Collect water-mixed sediment and filter it to separate the soil.
    17.4 Weigh the sediment and record the results for comparison.
18. Vetiver Grass Data Collection
    18.1 Measure the height of the vetiver grass (from ground level to the tip) after 2 months using a ruler. Record the results and calculate the average height.
    18.2 Observe the root characteristics after 2 months.
        18.2.1 Uproot the vetiver grass.
        18.2.2 Clean the roots.
        18.2.3 Measure and record the width of the root system.
        18.2.4 Measure and compare the root length.
    18.3 Measure the dry biomass of the vetiver grass after 2 months. Uproot the plants, clean them, sun-dry for one day, then weigh them using an automatic scale. Record and compare the data.

19. Submit the collected data to the GLOBE Data Entry system and analyze the results for comparison.

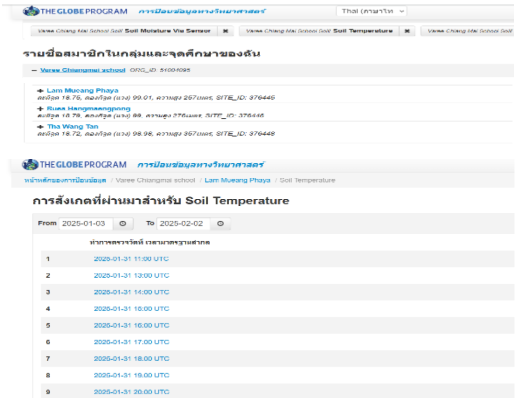

Figure 8: Data submitted to GLOBE Data Entry and analysis comparison

20. Organize and process the collected data for analysis and draw conclusions based on the findings. Use the knowledge gained from the study to create educational materials and share the information with others for further learning and awareness.

Chapter 4

Findings

The followings are the effects of vetiver grass on soil properties along the riverbanks in Chiang Mai.

1. Physical Characteristics of Vetiver Grass
2. Root System Characteristics at the End of the Experiment
3. Amount of Soil Sediment Collected from the Experiment
4. Physical and Chemical Properties of Soil (Before Planting Vetiver Grass)
5. Physical and Chemical Properties of Soil (After 2 Months of Vetiver Grass Growth)

Findings

1. Physical characteristics of vetiver grass: the height of the vetiver grass (measured from ground level to the tip), the root length (measured at the end of the experiment), and the dry biomass of the vetiver grass (at 2 months of age) are shown in the table below.

Experimental Plots	Site	Soil Texture	Average Height of Vetiver Grass Above Ground (cm) After 2 Months	Average Root Length of Vetiver Grass at the End of the Experiment (cm)	Biomass (g/plot)
Plot 1	Ping River bank	Sandy Clay (SC)	26.40	19.5	91.72
Plot 2	Riverbanks in Mueang Chiang Mai	Sandy Loam (SL)	32.90	20	118.02
Plot 3	Riverbanks in Saraphi	Sand (S)	27.40	19	97.80

Table 1: Height and root length of vetiver grass, and biomass of dry vetiver grass

2. Root System Characteristics at the End of the Experiment

Figure 9: Root system of Plot 1

Figure 10: Root system of Plot 2

Figure 11: Root system of Plot 3

3. Amount of Soil Sediment Collected from the Experiment

Experimental Plots	Site	Soil Texture	Amount of Sediment (g/plot)
Plot 1	Ping River Bank	Sandy Clay (SC)	3.52
Plot 2	Riverbanks in Mueang Chiang Mai	Sandy Loam (SL)	27.04
Plot 3	Riverbanks in Saraphi	Sand (S)	8.07

Table 2: Amount of Sediment from the Three Experimental Plots

4. Physical and Chemical Properties of Soil (Before Planting Vetiver Grass)

Plot	Soil Structure	Soil Color	Soil Cohesion	Soil Texture	Soil Temp (°C)	Soil Moisture (g/m^3)	pH	Nutrient Levels		
								N	P	K
Plot 1	Compact and dense	10 YR 3/2	Dense	Sandy Clay (SC)	30	7	6	Trace	low	Medium
Plot 2	Granular	2.5Y 3/2	Dense	Sandy Loam (SL)	29	8	6	Trace	Trace	low
Plot 3	Single grain	2.5 Y3/3	Loose (non-cohesive)	Sand (S)	31	8	6	Trace	Trace	low

Table 3: Physical and Chemical Properties of Soil before Planting Vetiver Grass

5. Physical and Chemical Properties of Soil (After 2 Months of Vetiver Grass Growth)

Plot	Soil Structure	Soil Color	Soil Cohesion	Soil Texture	Soil Temp (℃)	Soil Moisture (g/m³)	pH	Nutrient Levels		
								N	P	K
Plot 1	Granular	7.5 YR 4/3	Friable	Sandy Clay (SC)	17	9	6	Trace	Medium	Hight
Plot 2	Blocky	7.5 YR 4/3	Friable	Sandy Loam (SL)	17	10	6	Trace	Medium	Medium
Plot 3	Granular	10 YR 5/3	Friable	Sand (S)	19	10	6	Trace	Medium	Medium

Table 4: Physical and Chemical Properties of Soil after 2 Months of Vetiver Grass Growth

Chapter 5

Conclusion and Discussion

From the study of vetiver grass in the 3 experimental plots using soil from riverbanks in Chiang Mai with different types of soil, grown for a period of 2 months, it can be concluded that the growth of vetiver grass was best in Plot 2, located along the riverbank in Mueang District, with the soil type being sandy loam, and the biomass amounting to 118.02 grams. This was followed by Plot 3, located along the riverbank in Saraphi District, with sandy soil, and biomass amounting to 97.80 grams. Plot 1, located along the riverbank of the Ping River, with sandy clay soil, had a biomass of 91.72 grams, respectively. The sediment analysis results showed that vetiver grass was able to slow down water flow and effectively trap sediment, with the best performance in sandy clay, followed by sandy soil, and lastly sandy loam. Vetiver grass also affected the physical properties of the soil. In Plot 1 (sandy clay), the soil structure changed from massive compact to granular, with improved friability, and the soil color darkened to dark brown. In Plot 2 (sandy loam), the soil structure changed from granular to blocky, with denser aggregation, and the soil color darkened to dark brown. In Plot 3 (sandy soil), the soil structure changed from single-grain to granular, with improved friability, and the soil color changed to medium brown. Soil temperature decreased, with Plot 1 and Plot 2 at 17°C, and Plot 3 at 19°C. Soil moisture increased, with Plot 1 at 9 g/m³, and Plot 2 and Plot 3 at 10 g/m³. Regarding the chemical properties of the soil, the pH value remained at 6. The nutrient content in the soil showed that nitrogen (N) remained the same, while phosphorus (P) and potassium (K) increased.

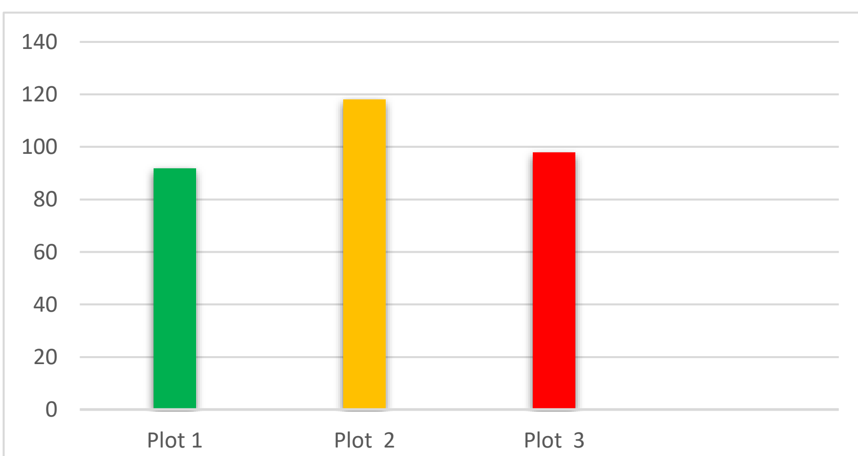

Figure 12: Graph 1 – Dry biomass of vetiver grass at 2 months of growth

Therefore, vetiver grass can grow well in riverbank soils in Chiang Mai, with the most suitable soil types being sandy loam, followed by sand, and sandy clay, respectively. Vetiver grass also improves both the physical and chemical properties of the soil, enhances soil fertility by increasing nutrient content, and effectively prevents soil erosion and degradation in a sustainable manner.

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Appendix

Table Showing the Results of Vetiver Grass Growth:

Height of Vetiver Grass from Ground Level to Tip (centimeters) After 2 Months of Planting

Vetiver grass	Plot 1	Plot 2	Plot 3
1	29.9	35.5	29.8
2	26.4	26.8	32.5
3	32.3	35	24.4
4	42.6	22.2	27
5	30.9	29.9	25.5
6	23.4	25.5	24.5
7	29.6	33.8	29.4
8	36.9	36	28.5
9	20.2	31.6	36
10	23.5	34.5	29.9
11	20.5	33.1	29.5
12	22.6	29	29
13	21.2	36	29.6
14	21	33.6	28.2
15	20.6	28.4	27.1
16	22.1	33	24.5
17	26.4	32.2	22.5
18	23.8	39	28.5
19	44.6	32.1	26.4
20	34.2	30.5	28.5
21	27.8	32	25.6
22	32.8	32.1	33.8
23	26.5	32	28.5
24	23.4	30	25.3
$\bar{x}$	26.40	32.90	27.40

Table Showing the Results of Vetiver Grass:

Root Length of Vetiver Grass at the End of the Experiment (centimeter)

Vetiver grass	Plot 1	Plot 2	Plot 3
1	19.2	19.8	19.1
2	19.5	20.0	19.2
3	19.4	19.9	18.9
4	19.2	19.8	18.8
5	19.6	20.1	18.9
6	19.7	19.5	19.0
7	19.2	20.0	19.1
8	19.5	20.1	19.2
9	19.4	19.5	19.0
10	19.2	19.7	18.8
11	19.5	19.9	18.9
12	19.4	19.8	19.2
13	19.2	20.0	19.1
14	19.5	20.3	19.0
15	19.4	20.3	18.9
16	19.2	19.7	18.9
17	19.4	19.9	19.2
18	19.3	19.8	19.1
19	19.5	20.0	19.0
20	19.4	20.2	18.9
21	19.6	20.2	19.2
22	19.5	20.1	19.2
23	19.4	20.3	19.0
24	19.4	20.0	19.1
$\bar{x}$	19.50	20.00	19.00

Table: Soil Chemical Properties Before Planting Vetiver Grass

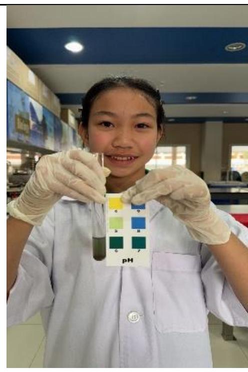
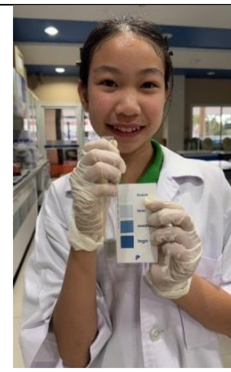
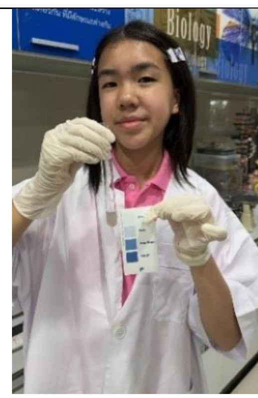
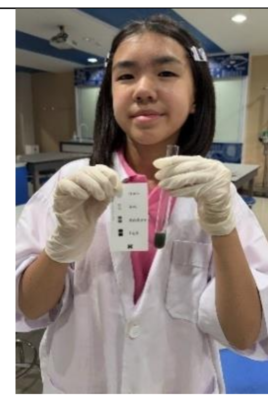
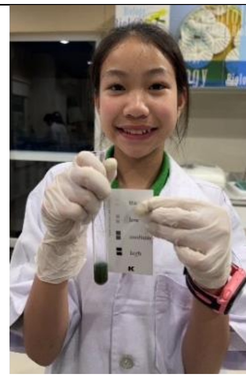
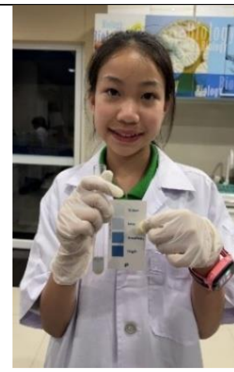
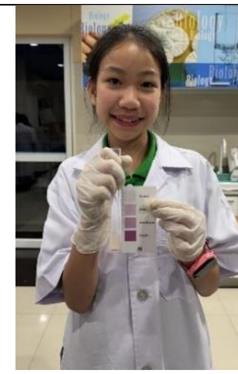
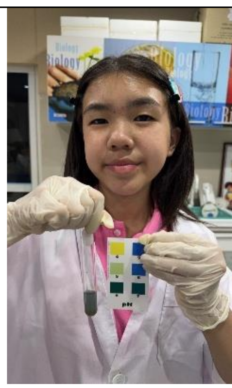
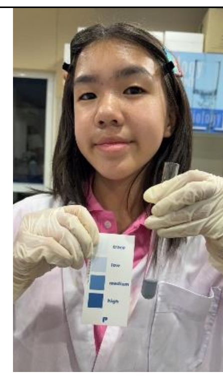
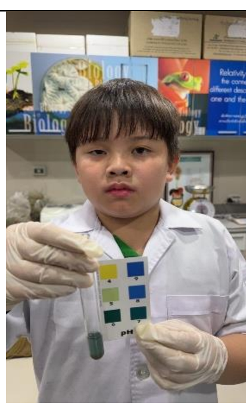
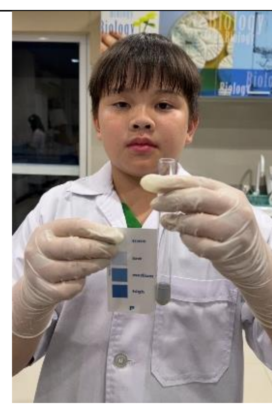
Experimental Plot	pH	N	P	K
Plot 1				
Result	6	Trace	low	Medium
Plot 2				
Result	6	Trace	Trace	low
Plot 3				
Result	6	Trace	Trace	low

Table: Soil Chemical Properties After Planting Vetiver Grass

Experimental Plot	pH	N	P	K
Plot 1				
Result	6	Trace	Medium	Hight
Plot 2				
Result	6	Trace	Medium	Medium
Plot 3				
Result	6	Trace	Medium	Medium