Carbon Sequestration and Carbon Dioxide Emission in Vetiver Grass Cultivation Areas in Thailand

The Fifth International Conference on Vetiver,
Lucnow, India, Oct 28-30, 2011

Prapa Taranet, Kamalapa Wattanaprapat,
Isariya Meesing and Pornpat Nopmalai

Land Development Department ,
Ministry of Agriculture and Cooperatives, THAILAND

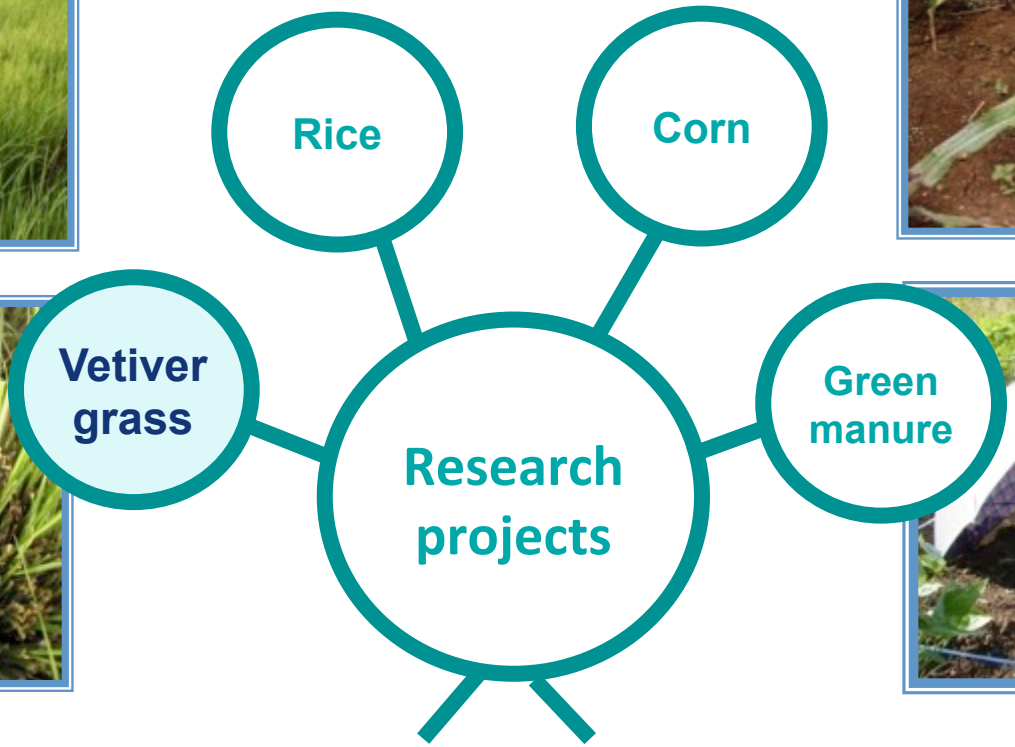
:: Presentation Outline

- Introduction
- Objectives
- Materials and Methods
- Results and Discussion
- Conclusion

Introduction

Research activity:

Soil carbon dynamics research of LDD



- **Carbon sequestration**
- **CO_2 emission**
- **Vetiver grass**

  - high biomass, long massive roots
  - used for soil conservation
  - sequestering carbon into the soil

- Soil organic carbon stock increased about 10 times (from 24 to 229 tons C ha^{-1}) in soil at 1.2 m within 7 years of vetiver plantation (**Khanema and Thammathaworn,** 2010)

- CO_2 emission rates in corn cultivation rates were ranged between 63 to 1006 mg CO_2 m^{-2} h^{-1} (**Jaiarree,** 2008)

- After 4 years of wheat straw application (0, 8, 16 tons ha^{-1}), Soil organic carbon stock in 0-10 cm; 19.6, 25.6 and 26.5 tons ha^{-1}, respectively, and CO_2 fluxes ranged from 13 to 1229.2 mg CO_2 m^{-2} h^{-1} (**Jacinthe et al,** 2002)

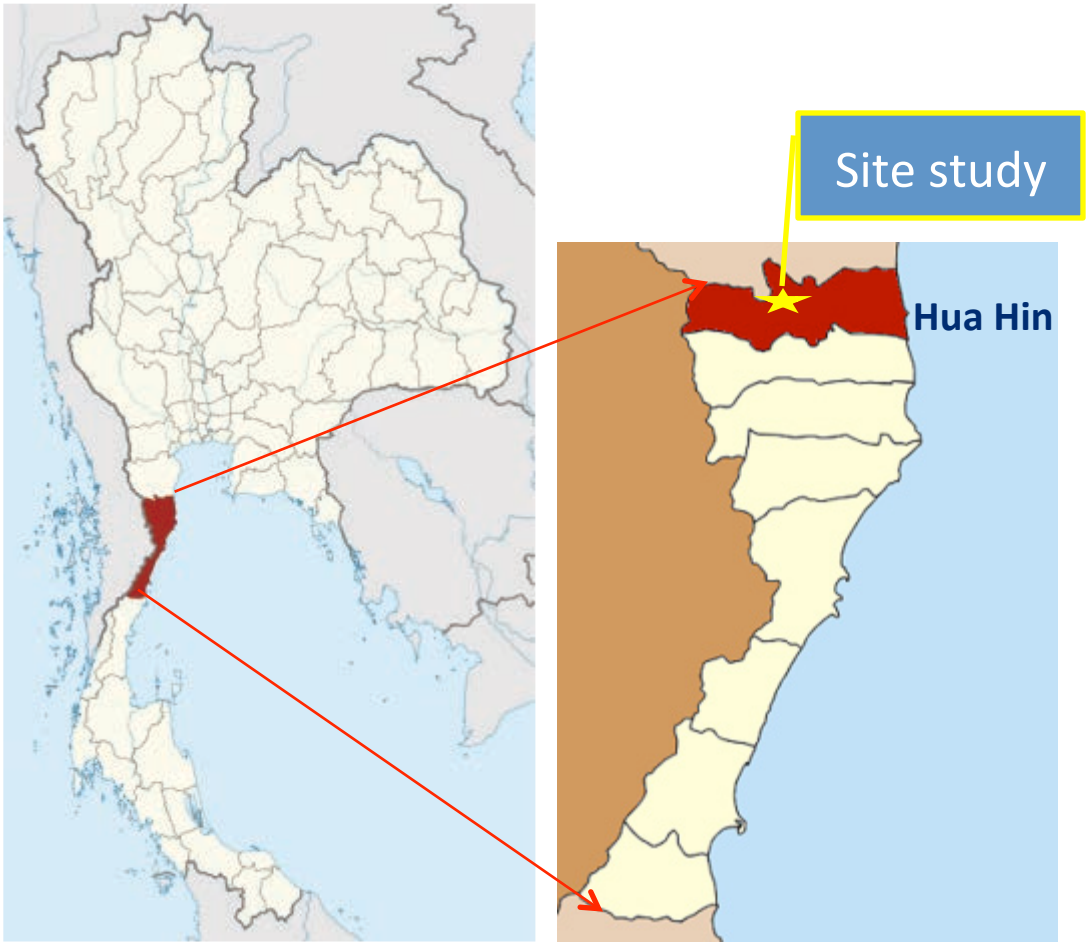
Objectives

- To determine the amount of carbon sequestration and CO_2 emission from soil in vetiver grass cultivation areas comparing to non-vetiver grass cultivation area.

- To introduce the obtained data for soil quality improvement and soil and water conservation program.

Materials and Methods

Study site: The Chai Patthana-Mae Fa Luang Re-forestation Project Prachuap Khiri Khan Province:



N: 581584
E: 1394964
Sea Level = 126 M.
Air Temp = 22.6-33.4 °C
Rainfall = 937 mm/year
Study period: 2008-2010

Study area before preparation

- Soil name: Pran buri
  (Classification : Coarse-loamy, mixed, active, isohyperthermic Typic Haplustalfs)
- Pineapple is the primary crop cultivated

Treatments

- Non-vetiver grass (Bare soil)
- Sri Lanka ecotype
- Surat Thani ecotype

Chrysopogon zizanioides

- Prachuap Khiri Khan ecotype
- Roi Et ecotype

Chrysopogon nemoralis

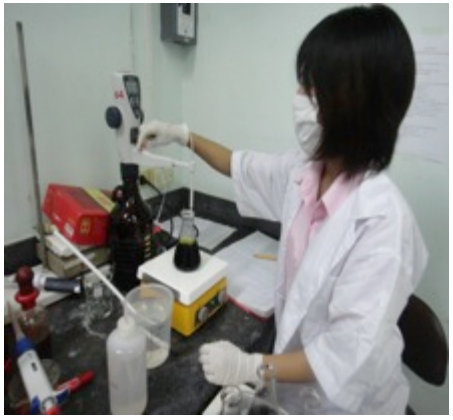
Preparation of stock

Maintainance of vetiver grass

Land preparation

Planting of vetiver grass

Vetiver grass sampling and measuring



Vetiver grasses were cut 5 times after planting; 8 , 12, 16, 20 and 24 months after planting (MAP)

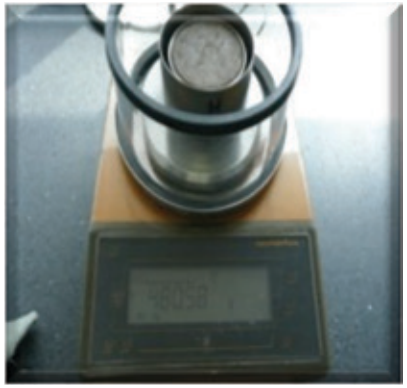
In laboratory, biomass were dried at 80 degrees C and weighed as dry weight

The samples were analyzed to estimate organic carbon

In farm practice, biomass was weighed as fresh weight

Biomass was added into the soil

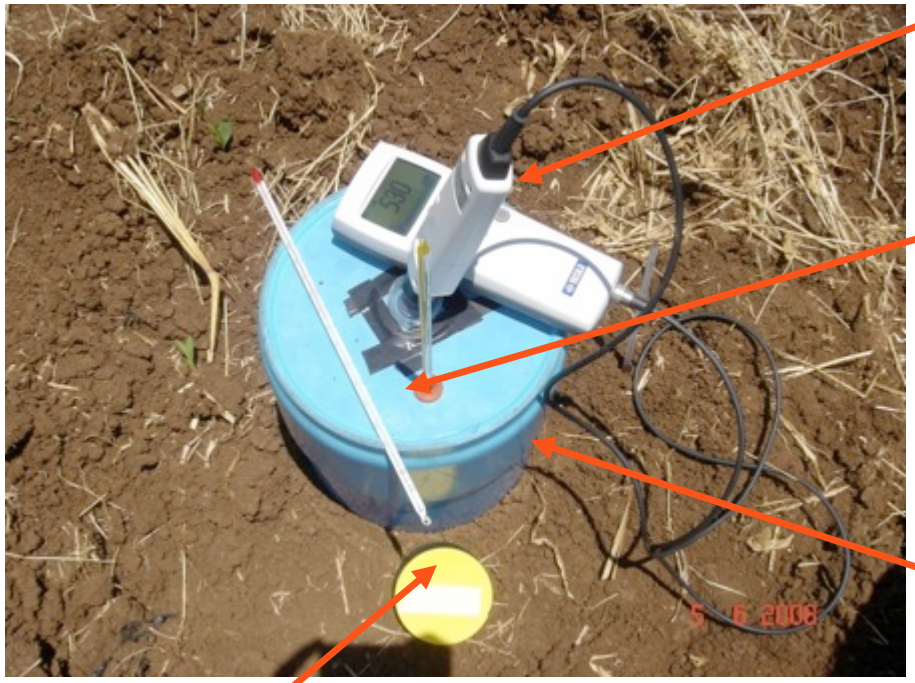
Soil sampling and measuring



Soil samples were collected 3 times
at 3 levels of depth: 0-18, 18-40 and 40-70 cm

- The undisturbed soil was taken by using core method to determine bulk density
- The disturbed soil was taken to estimate soil organic carbon and other chemical properties

Closed chamber measurement



1. Measuring CO_2 emission by Hand-Held CO_2 Meter

2. Measuring soil, air and chamber temperature by a thermometer

3. The chamber was made from PVC with an inner diameter of 20 cm and height of 25 cm

4. Collecting the soil samples (soil moisture:SM)

Gas Sampling

Hand-Held CO_2 Meter fitted with the cover and placed on the chamber base which inserted into the soil

Measuring the volume of the chamber

Measuring CO_2 emissions within 15 minutes

- **Soil organic carbon (SOC) stock calculation:**

$$\text{SOC stock} = \text{SOC} \times \text{Db} \times \text{V}$$

SOC stock	soil organic carbon stock (g C m^{-2})
SOC	soil organic carbon content (g C g^{-1}soil)
Db	bulk density (g m^{-3})
V	soil volume per area (m^3 m^{-2})

- **CO_2 flux (F) calculation:** **(Hutchinson and Mosier, 1981)**

$$\mathrm{Ci} = \frac{qiMP}{RT} \quad (1) \qquad :: \quad F = \frac{V}{A}\frac{\partial Ci}{\partial t} \quad (2)$$

Ci = mass/volume concentration (mg CO_2 m^{-3})

qi = volume/volume of CO_2 concentration (m^3 m^{-3})

M = molecular weight of CO_2 (44 g mol^{-1})

P = the atmospheric pressure (1 atm)

R = the gas constant (0.082 m^3 .atm K^{-1} mol^{-1})

T = average temperature inside the chamber (K)

F = flux on the aerial basis (mg CO_2 m^{-3} sec^{-1})

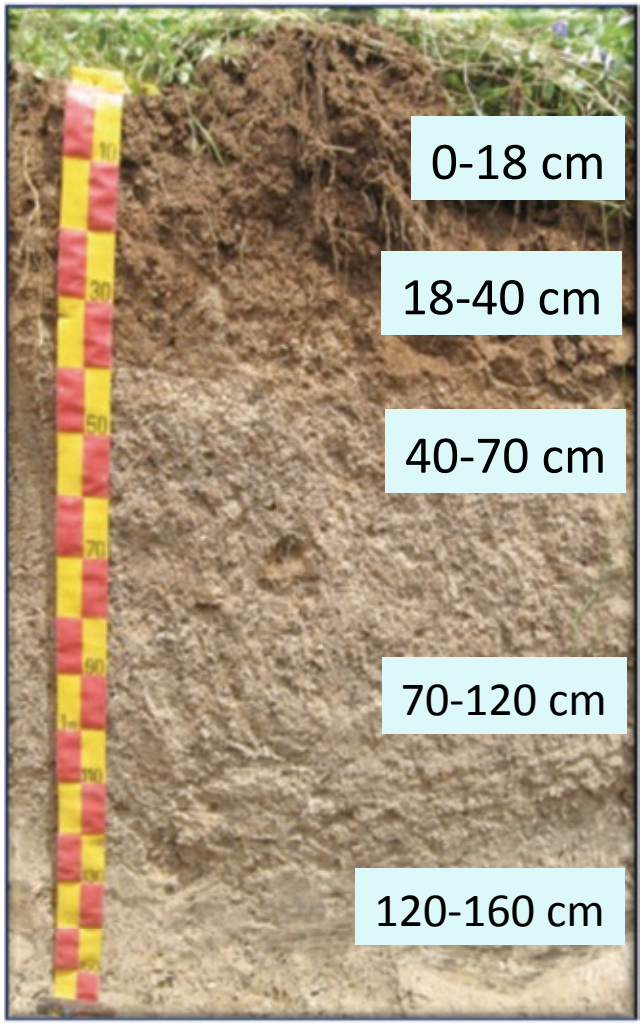
V = the volume of chamber (m3)

A = area of soil enclosed by the chamber (m^2)

$\frac{\partial Ci}{\partial t}$ = the increase of CO_2 concentration in the chamber as the function of time (mg CO_2 m^{-3} sec^{-1})

Results and Discussion

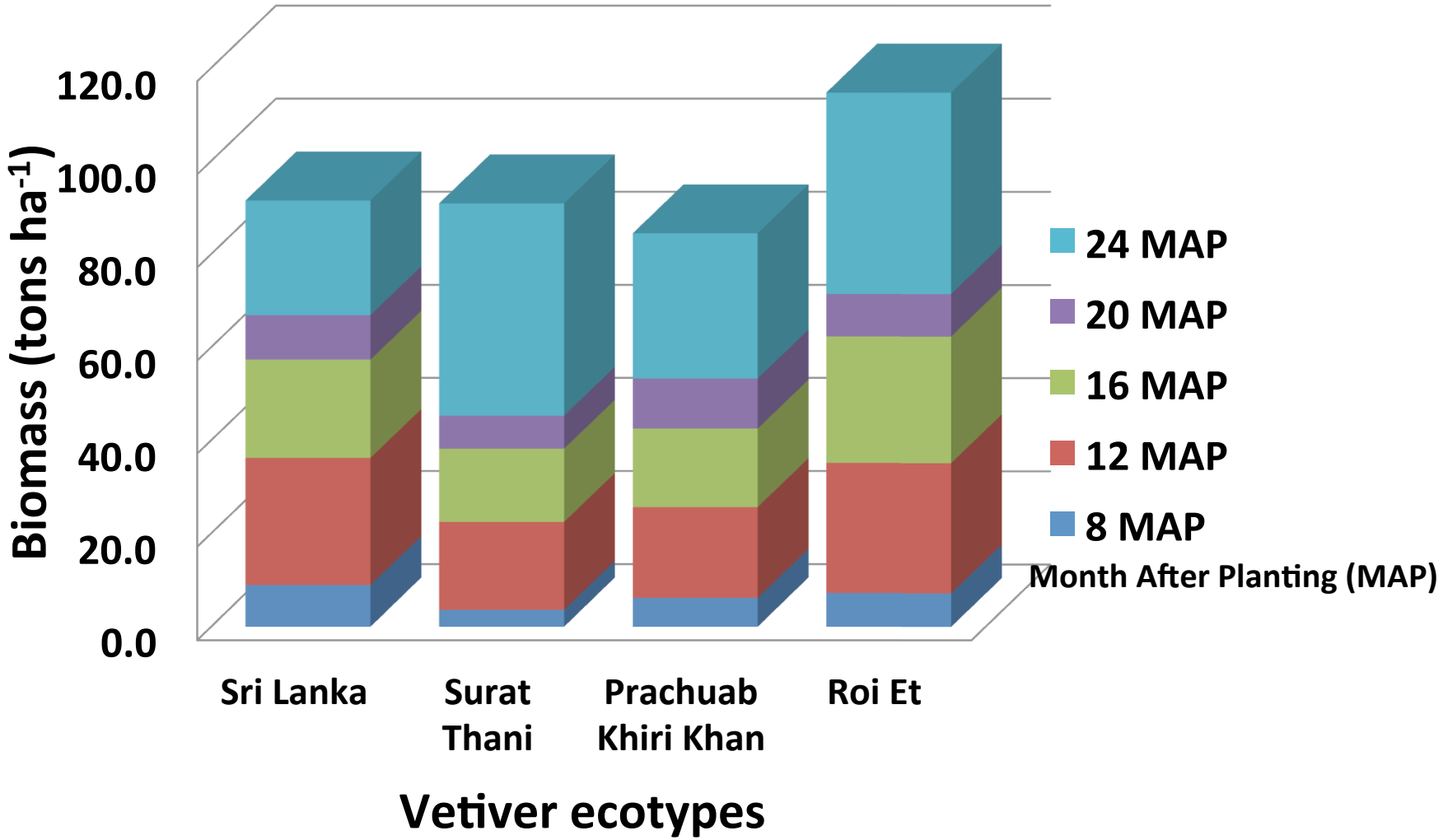
1. Soil characteristics



Soil profile

Text.	Db (g cm^{-3})	SM (%)	pH (H_2O)	OM (%)	P (mg kg^{-1})	K
loam	1.6	15.8	7.7	1.24	35	145
gravelly loam	1.6	15.8	7.6	1.07	15	155
gravelly loam	1.4	15.7	8.0	0.71	6	61
gravelly loam	1.5	12.4	8.3	0.76	7	89
gravelly loam	1.5	7.7	5.2	0.34	4	42

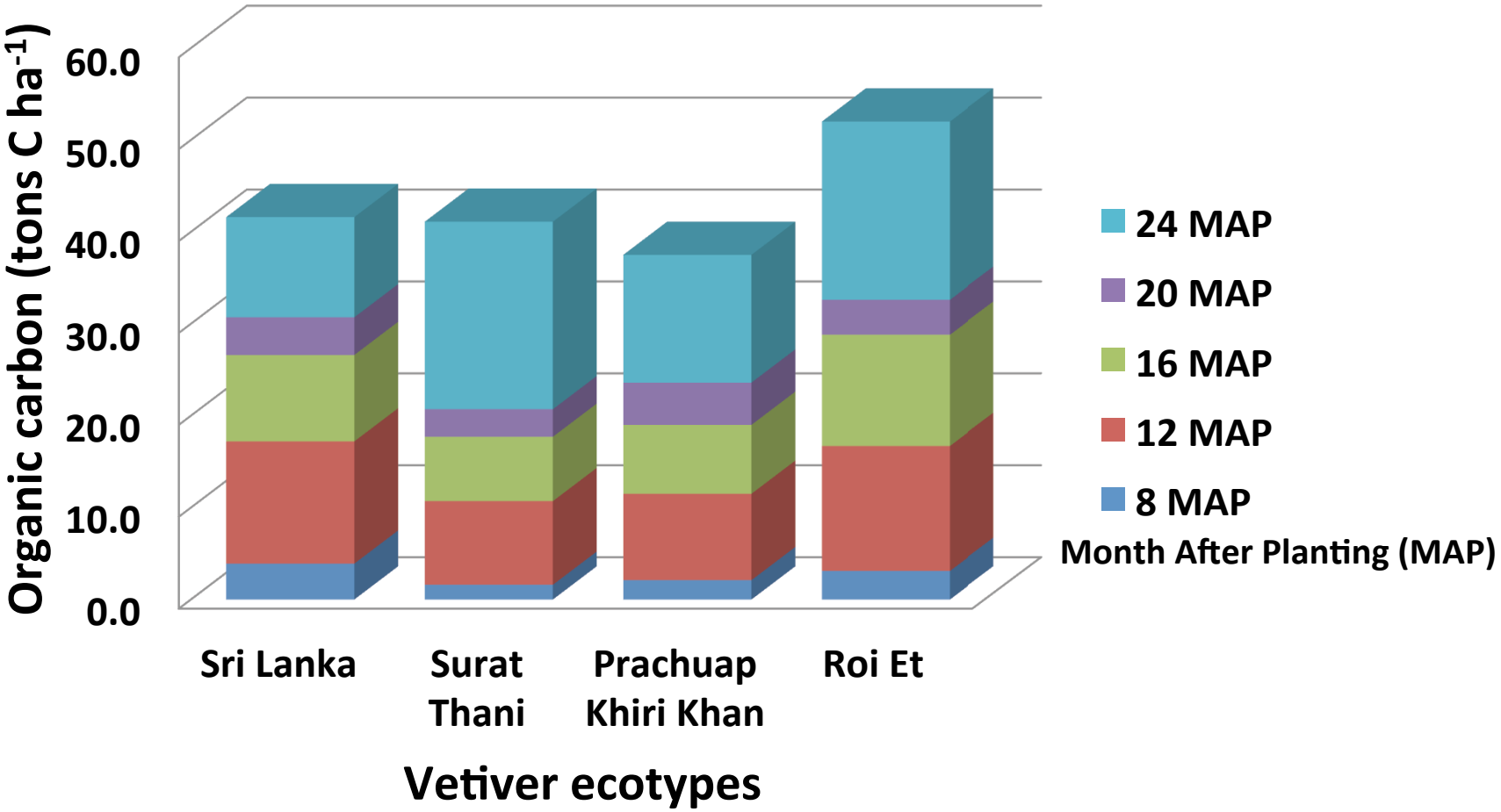
2. Biomass of 4 ecotypes of vetiver grass in 5 times cutting



The highest yield = the Roi Et (114.7 tons ha^{-1})

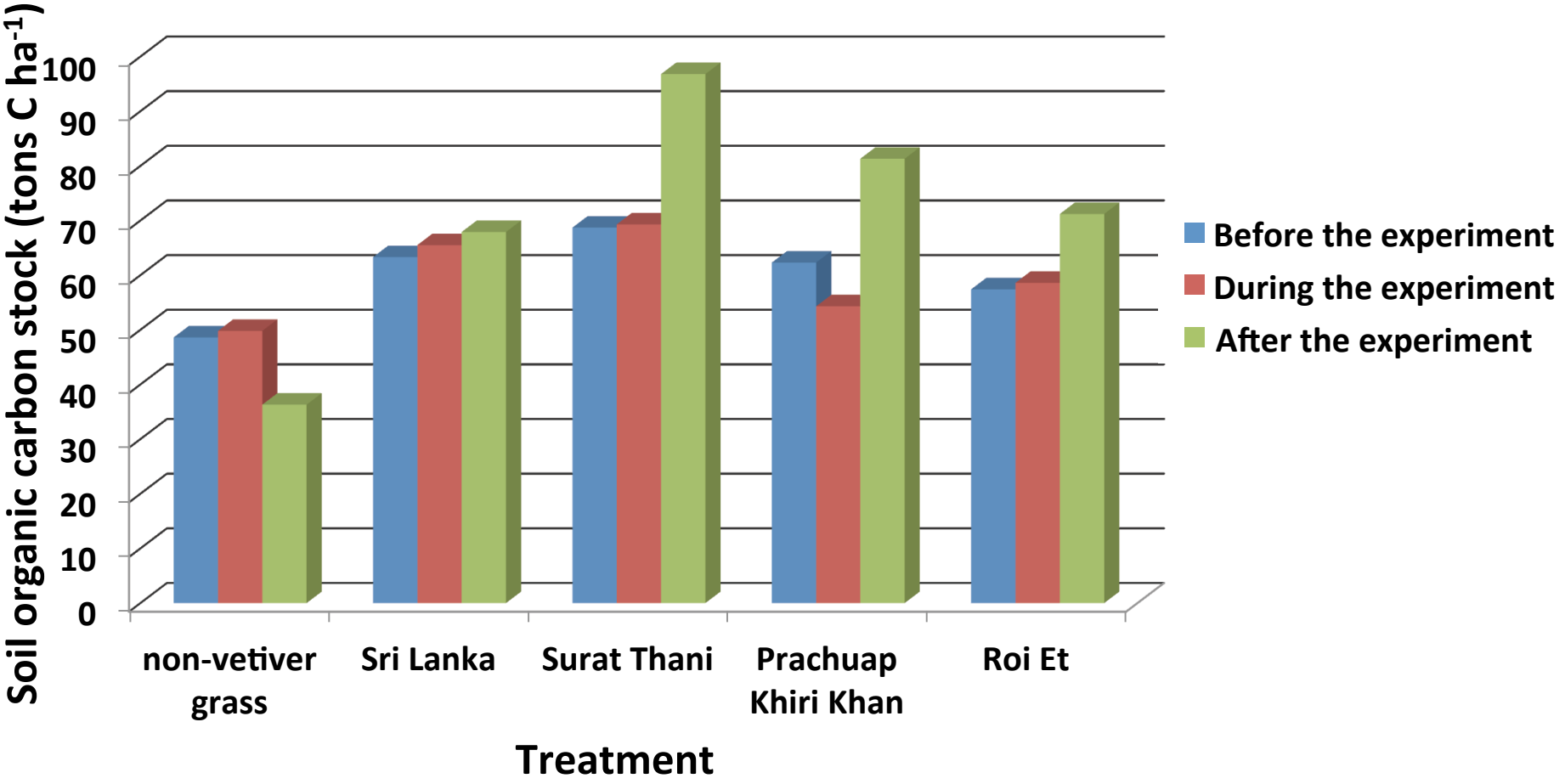
The lowest yield = the Prachuap Khiri Khan (84.4 tons ha^{-1})

3.Organic carbon content in 4 ecotypes of vetiver grass



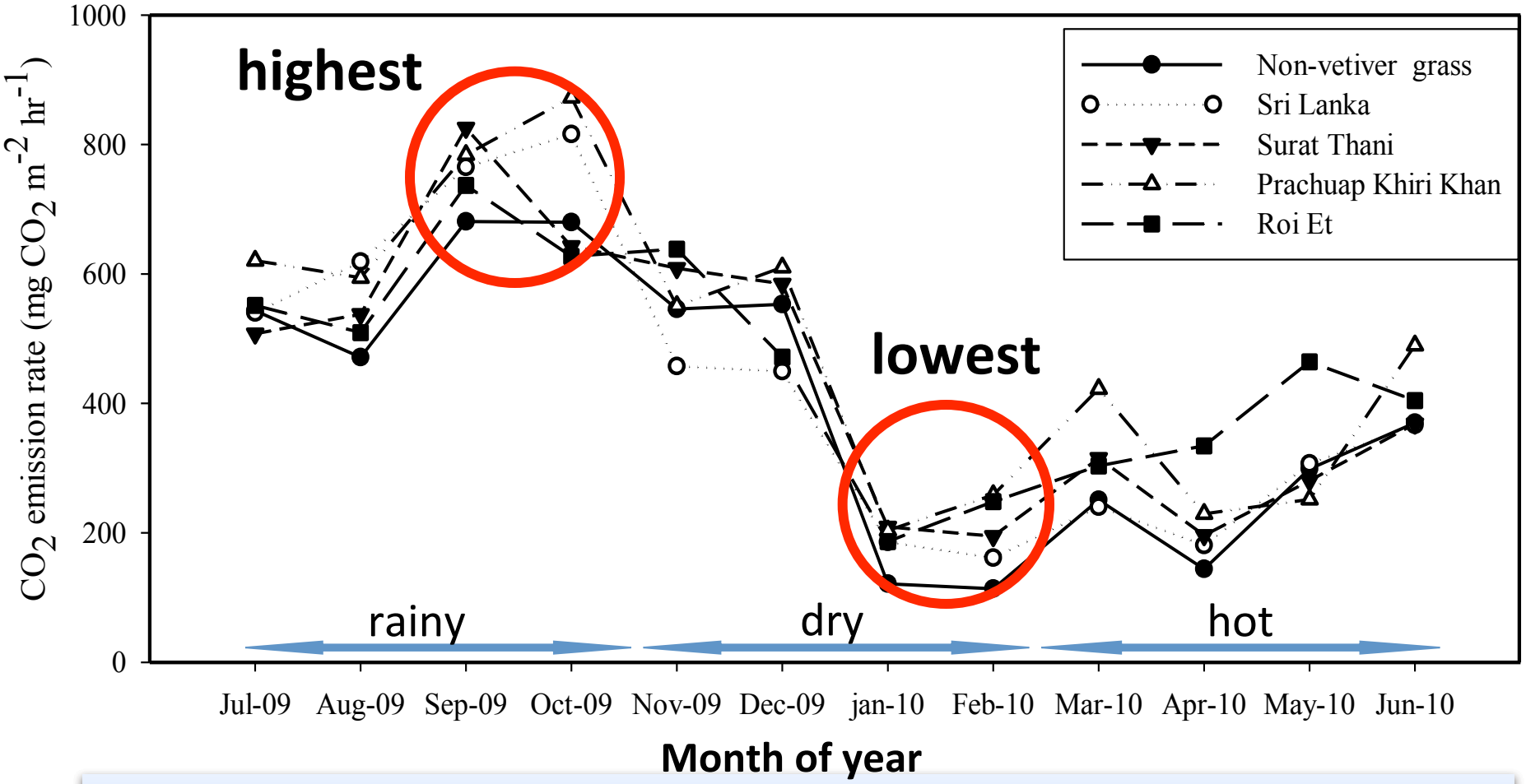
The highest OC content = the Roi Et ecotype (51.9 tons C ha^{-1})
The lowest = the Prachuap Khiri Khan ecotype (37.6 tons C ha^{-1})

4. Change in soil organic carbon stock



Soil organic carbon stock, in vetiver grass cultivation areas, carbon stocks increased but in non-vetiver grass cultivation area decreased

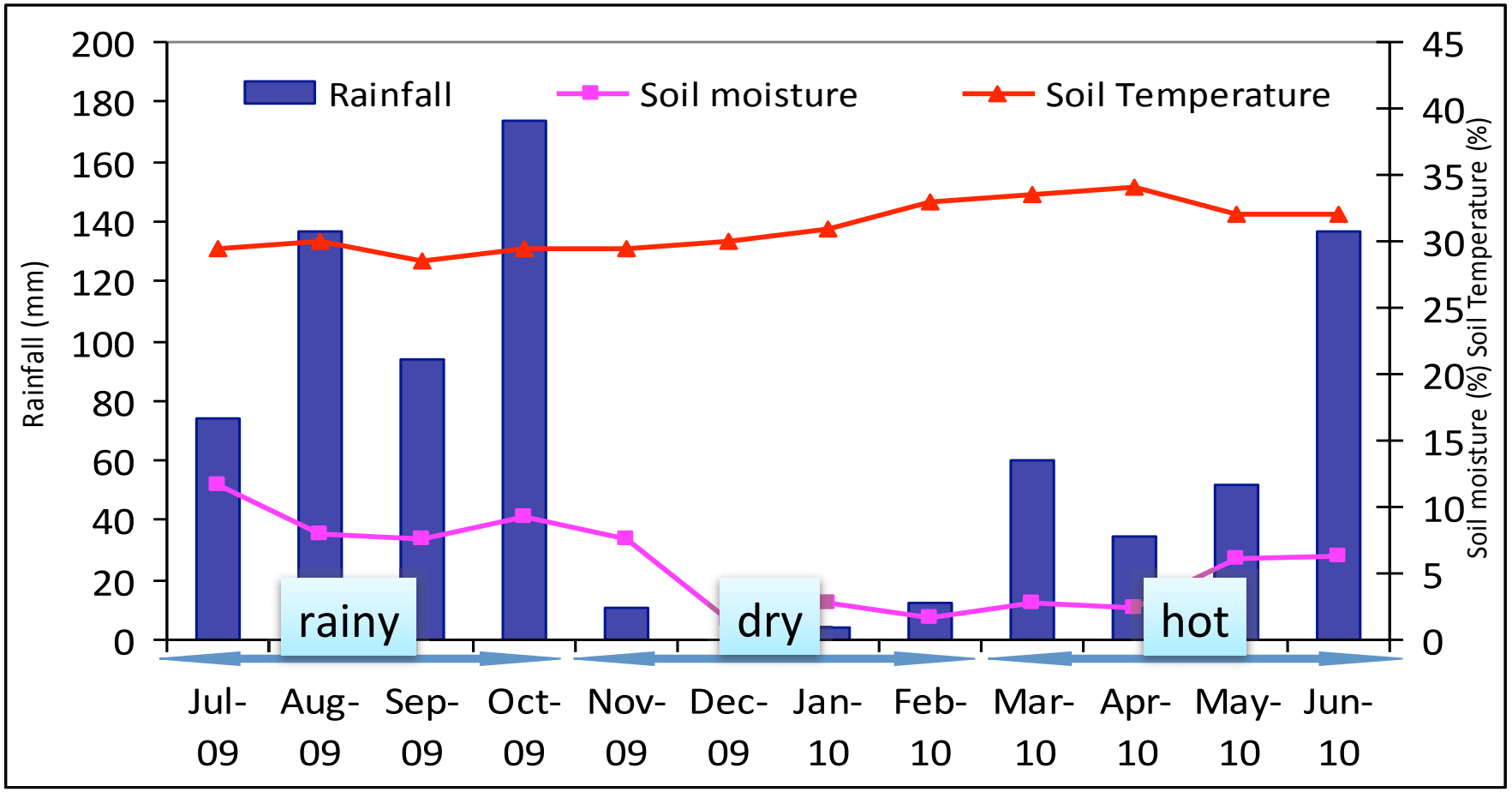
5. CO_2 emission from soil



Average CO_2 emission from vetiver grass cultivation areas and non-vetiver grass cultivation area from July 2009 to June 2010.

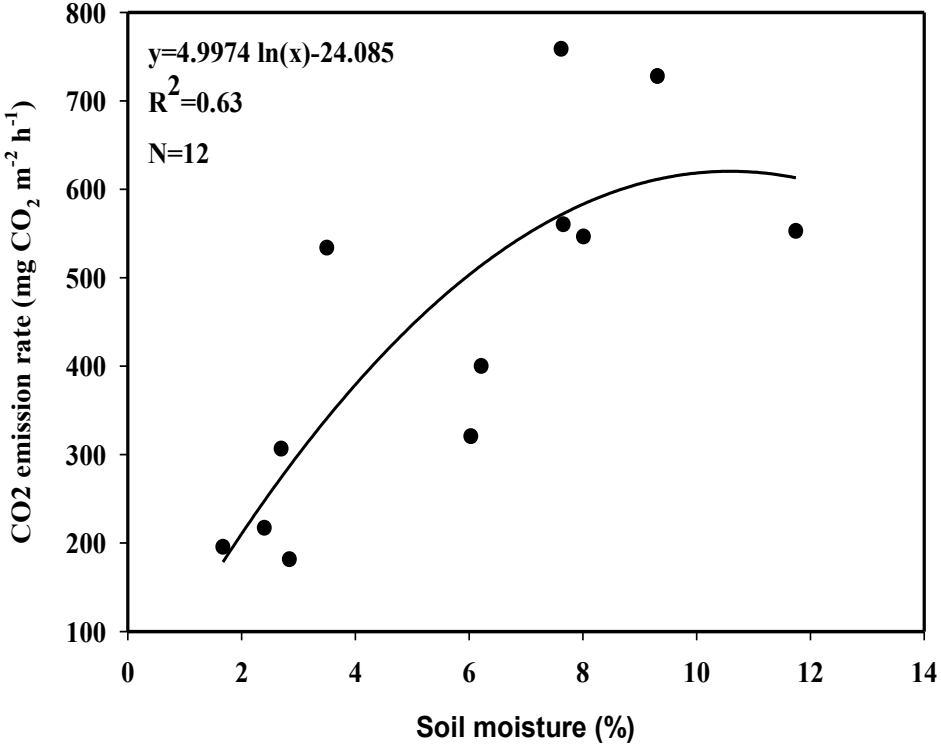
21

6. Rainfall, Soil moisture and Soil temperature

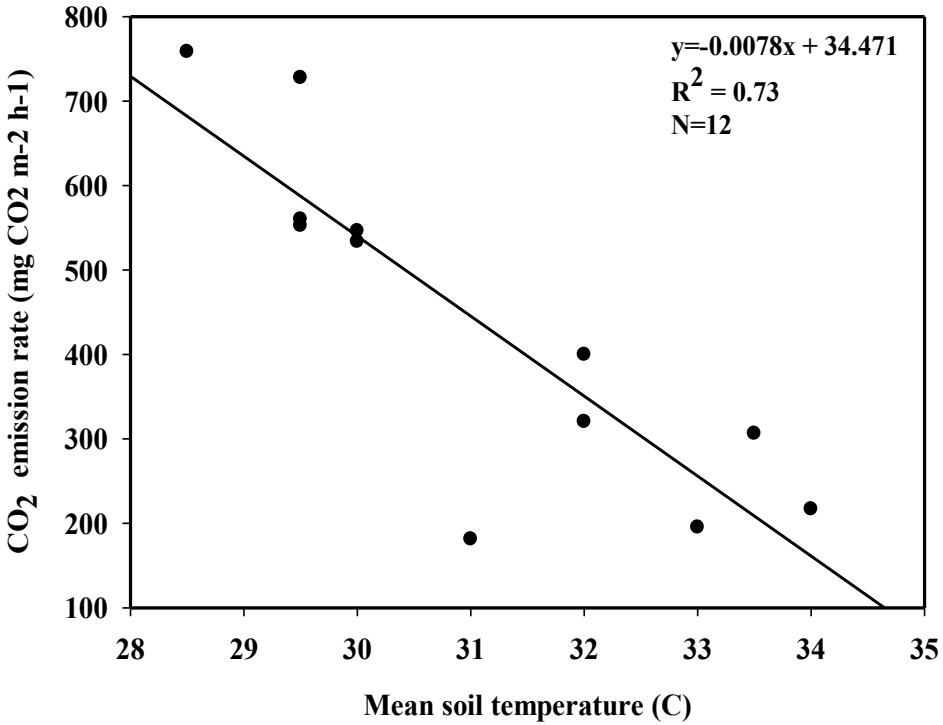


Monthly rainfall, average soil moisture and soil temperature at study site from July 2009 to June 2010.

7. Relationship between CO_2 emission and environmental factors



(a)



(b)

Relationship (a) between CO_2 emission from soil and soil moisture and (b) between CO_2 emission from soil and mean soil temperature

8. Carbon sequestration

Treatments	Carbon sequestration (tons C ha^{-1})		
	Plant organic carbon	Soil organic carbon	total
• non-vetiver grass	-	36.3	**36.3**
• Sri Lanka ecotype	10.9	67.9	78.8
• Surat Thani ecotype	**20.4**	**96.8**	**117.2**
• Prachuab Khiri Khan ecotype	13.9	81.3	95.2
• Roi Et ecotype	19.4	71.2	90.6

* Average organic carbon from vetiver grass 4 ecotypes and soil organic carbon at 24 months after planting

Conclusion

- Carbon can be more sequestered in vetiver grass cultivation areas than non-vetiver grass cultivation area. In this study, Surat Thani ecotype shows the highest trend of carbon sequestration.

- The CO_2 emission rate, the highest CO2 emission rate was observed in rainy season and the lowest CO2 emission rate was observed in the dry season.

- the obtained data can be transferred to soil and water conservation program and used to improve soil quality

Development Activities

Campaign on crop residues management by incorporate into soil for carbon sequestration

Implementation on trees plantation

Acknowledgement

- Land Development Department (LDD) , Thailand
- Office of the Royal Development Projects Board, Thailand

THANK YOU FOR YOUR ATTENTION