Study on Carbon Storage and Carbon Balance in Vetiver Grass Cultivation Areas in Northern Thailand

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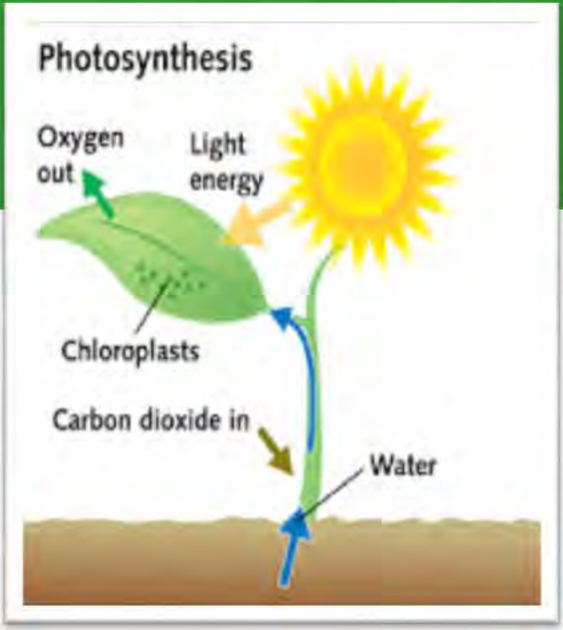
Presentation Outline

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

❖Introduction



- Soil carbon derived from photosynthesis process converting CO_2 gas in the atmosphere to organic carbon in plant biomass.
- Decomposed dead plant by soil microorganism will be transformed to organic carbon into the soil.

  - Vetiver grass has a long fibrous system and always germinates new tillers, resulting to produce a high amount of biomass. Therefore, it is capable to accumulate the greater amount of carbon into the soil (Limtong, 2008a)

❖ Objectives

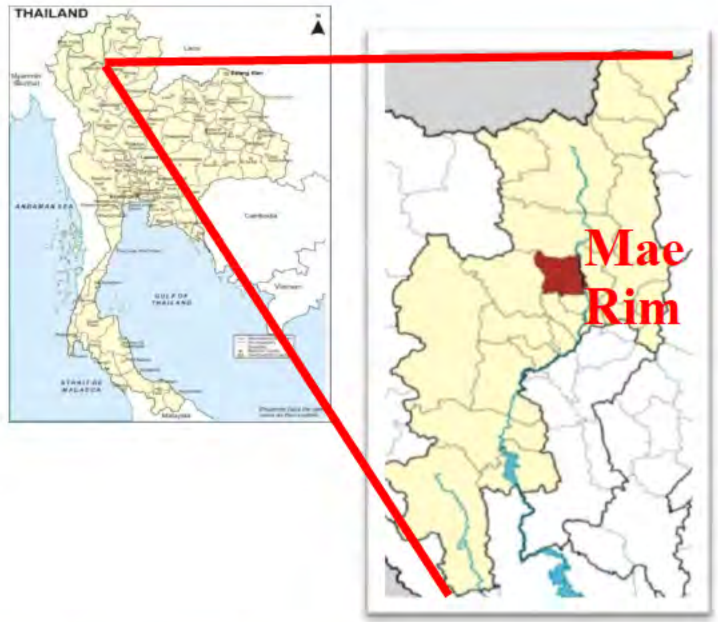
1. To determine biomass of some ecotypes of vetiver grass and carbon storage
2. To determine carbon emission from soil and carbon balance in non- vetiver grass and vetiver grass cultivation areas

Materials and Methods

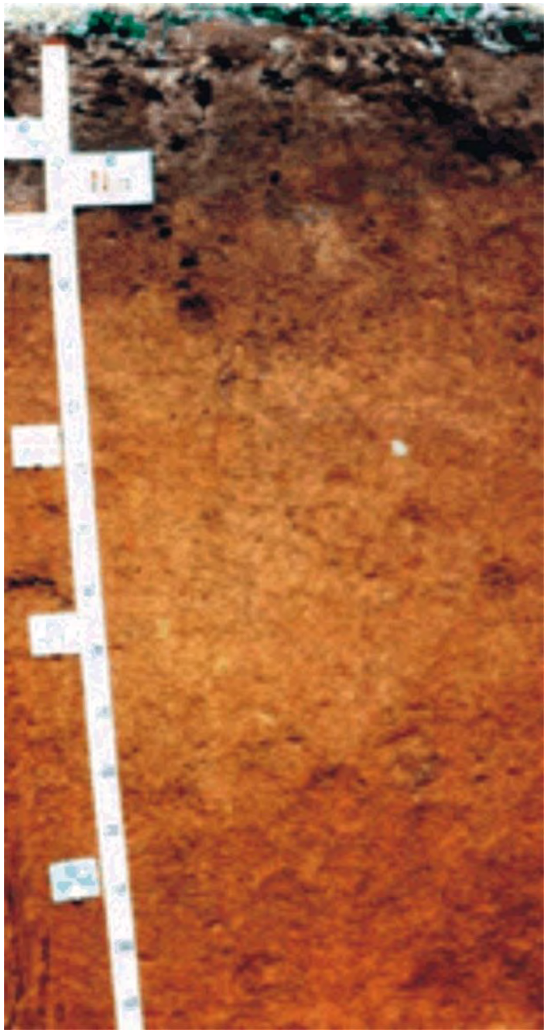
1. Description of Experiment Site

Chiang Mai Land Development Station, Marim District,Chiang Mai Province, Northern Thailand

- "Rose of the North" is a cultural and natural wonderland with ethnic diversity, a multitude of attractions and welcoming hospitality
- Largest city in Northern Thailand ,700 km north of Bangkok, Elevation 310 m, area 40.2 sq. km.
- Climate; high temp. 32.2 °C, low temp. 20.8 °C, minus temp. at high mount , rainfall 1,130.6 mm



❖ Soil characteristic



- Nong Mot soil
- Soil was classified as fine, kaolinitic, isohyperthermic Typic Kandiustults (Soil Survey Staff, 2006)
- loamy or loamy clay soil texture
- dark brown to very dark gray brown
- pH 5.0-6.0

Experiment design

Randomized Complete Block Design (**RCBD**)
7 treatments , 3 replications

- non - vetiver grass planting (control)
- 6 ecotypes of two vetiver species;

  Chrysopogon zizanioides 4 ecotypes;

  Sri Lanka, Surat Thani, Mae Har , Prarat Chatarn

  Chrysopogon nemoralis 2 ecotypes;

  Prachuab Khirikhan, Roi Et.


control


Sri Lanka


Surat Thani


Prachuab Khirikhan


Roi Et


Mae Har


Prarat Chatarn

Step to study

- Preparation of the experimental plots & young vetiver plants
- vetiver grasses were planted on June 2008- July 2010 for 2 years
- Plot size 4x6 m with planting spacing 50x50 cm
- Leaves were cut and mulched in each plot 5 times, when 8, 12, 16, 20 and 24 months after planting

❖Vetiver Grass Sampling and Analysis

- The above & belowground biomass (leaves & roots) were collected &determined organic carbon , total nitrogen , phosphorus , potassium

❖ leaves & roots were determined total biomass

Weighting of leaves & roots

Soil sampling & analysis

- Sampling of disturbed soil 3 level;0-15, 15-30, 30-50 cm depth to determine soil pH, soil organic carbon, available phosphorus & exchangeable potassium

- Sampling of undisturbed soil 3 level; 0-15, 15-30, 30-50 cm depth by core method to determine soil bulk density and soil moisture

Gas Sampling

- Setting up a static closed chamber in all plots
- PVC chamber with cover has an inner diameter 20 cm & height 25 cm. Its base was installed, inserted into the soil
- Measuring CO_2 from soil surface every month by using a Hand-Held CO_2 Meter (model GM70)
- Temperature in chamber , soil, air around chamber were also measured by a thermometer
- Soil samples were collected to determine soil moisture

Calculation of Carbon Content in Vetiver Grass and Soil

Vetiver grass

$$C_{vetiver} = C_{leaf} + C_{root}$$

$$C_{leaf} = \%\ OC_{leaf} \times M_{leaf}$$

$$C_{root} = \%\ OC_{root} \times M_{root}$$

$C_{vetiver}$ = total carbon content (t ha^{-1})

C_{leaf} , C_{root} = total carbon content in leaf and root (t ha^{-1})

% OC_{leaf}, % OC_{root} = percentage of organic carbon in leaf and root (%)

M_{leaf}, M_{root} = biomass of leaf and root (t ha^{-1})

Soil sample

$$C_{soil} = C_{0\text{-}15} + C_{15\text{-}30} + C_{30\text{-}50}$$

$$C_{0\text{-}15} = \%\,OC_{0\text{-}15} \times D_{0\text{-}15} \times V_{0\text{-}15}$$

$$C_{15\text{-}30} = \%\,OC_{15\text{-}30} \times D_{15\text{-}30} \times V_{15\text{-}30}$$

$$C_{30\text{-}50} = \%\,OC_{30\text{-}50} \times D_{30\text{-}50} \times V_{30\text{-}50}$$

C_{soil} = soil carbon stock of 3 soil layers 0-15, 15-30,30-50 cm (t ha^{-1})

$C_{0\text{-}15}$, $C_{15\text{-}30}$, $C_{30\text{-}50}$ = soil carbon content in 0-15, 15-30, 30-50 cm (t ha^{-1})

% $OC_{0\text{-}15}$, % $OC_{15\text{-}30}$, % $OC_{30\text{-}50}$ = percentage of organic carbon in 0-15, 15-30, 30-50 cm (%)

$D_{0\text{-}15}$, $D_{15\text{-}30}$, $D_{30\text{-}50}$ = soil bulk density in 0-15, 15-30, 30-50 cm (g cm^{-3})

$V_{0\text{-}15}$, $V_{15\text{-}30}$, $V_{30\text{-}50}$ = soil volume of each layers (m^3 m^{-2}).

CO_2 Emission Rate (F) **Calculation** (Hutchinson and Mosier,1981)

$$Ci = \frac{qiMP}{RT}$$

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

qi = volume / volume concentration ($m^3\ m^{-3}$)

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

P = atmospheric pressure (1 atm)

R = gas constant ($8.2058 \times 10^{-5}\ m^3.atmK^{-1}\ mol^{-1}$)

T = average temperature inside the chamber (K).

$$F = \frac{V}{A} \frac{\triangle Ci}{\triangle t}$$

F = emission rate ($mg\ CO_2\ m^{-2}\ h^{-1}$)

V = volume of chamber (m^3)

A = surface area of the chamber (m^2)

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

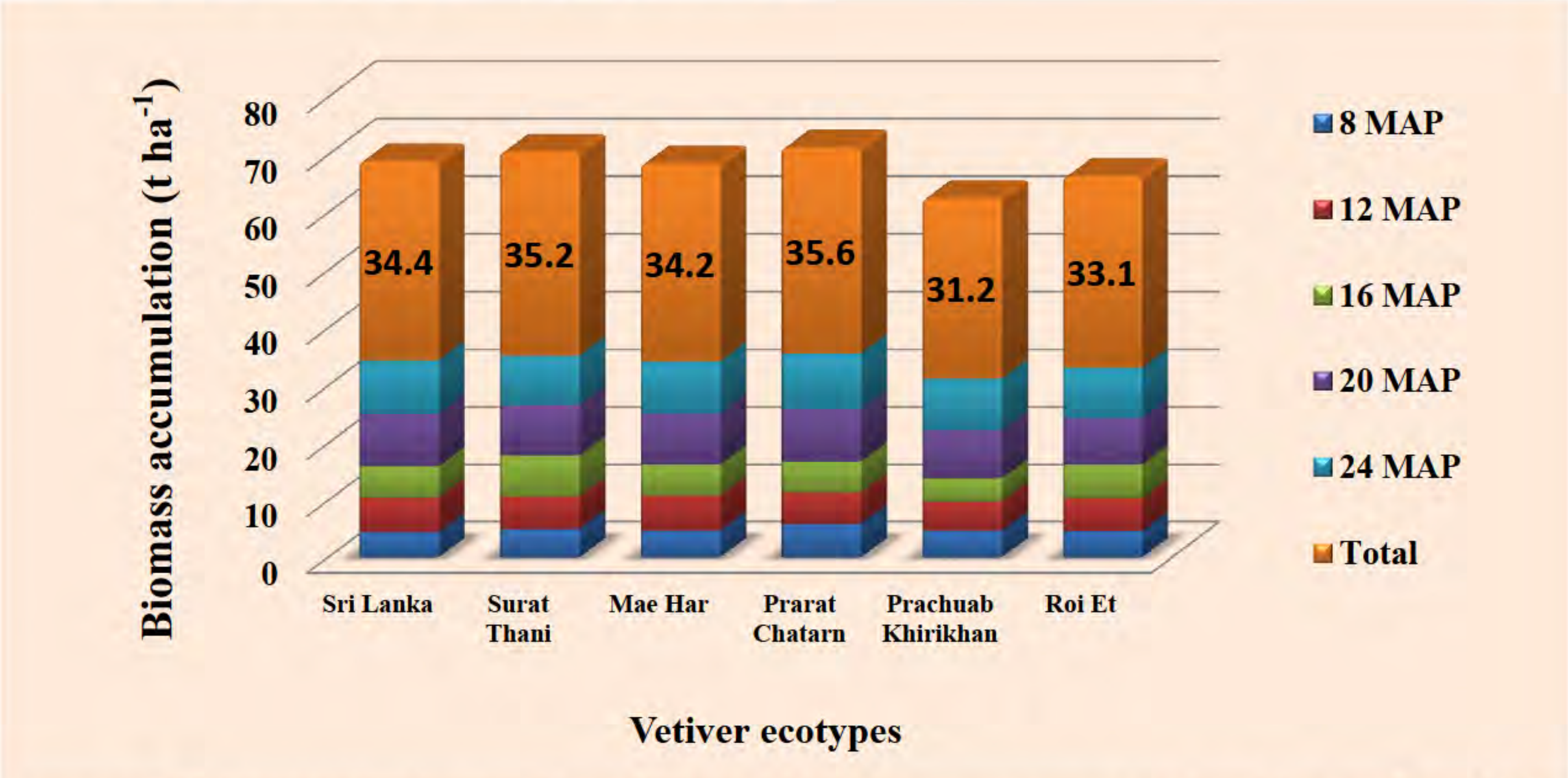
❖Results & Discussion

1. Initial soil physical and chemical properties

Soil depth (cm)	Bulk density ($g\ cm^{-3}$)	pH	OM (%)	P ($mg\ kg^{-1}$)	K ($mg\ kg^{-1}$)
0-15	1.56	4.7	1.12	5	36
15-30	1.43	5.3	0.90	2	29
30-50	1.64	5.2	1.14	1	34

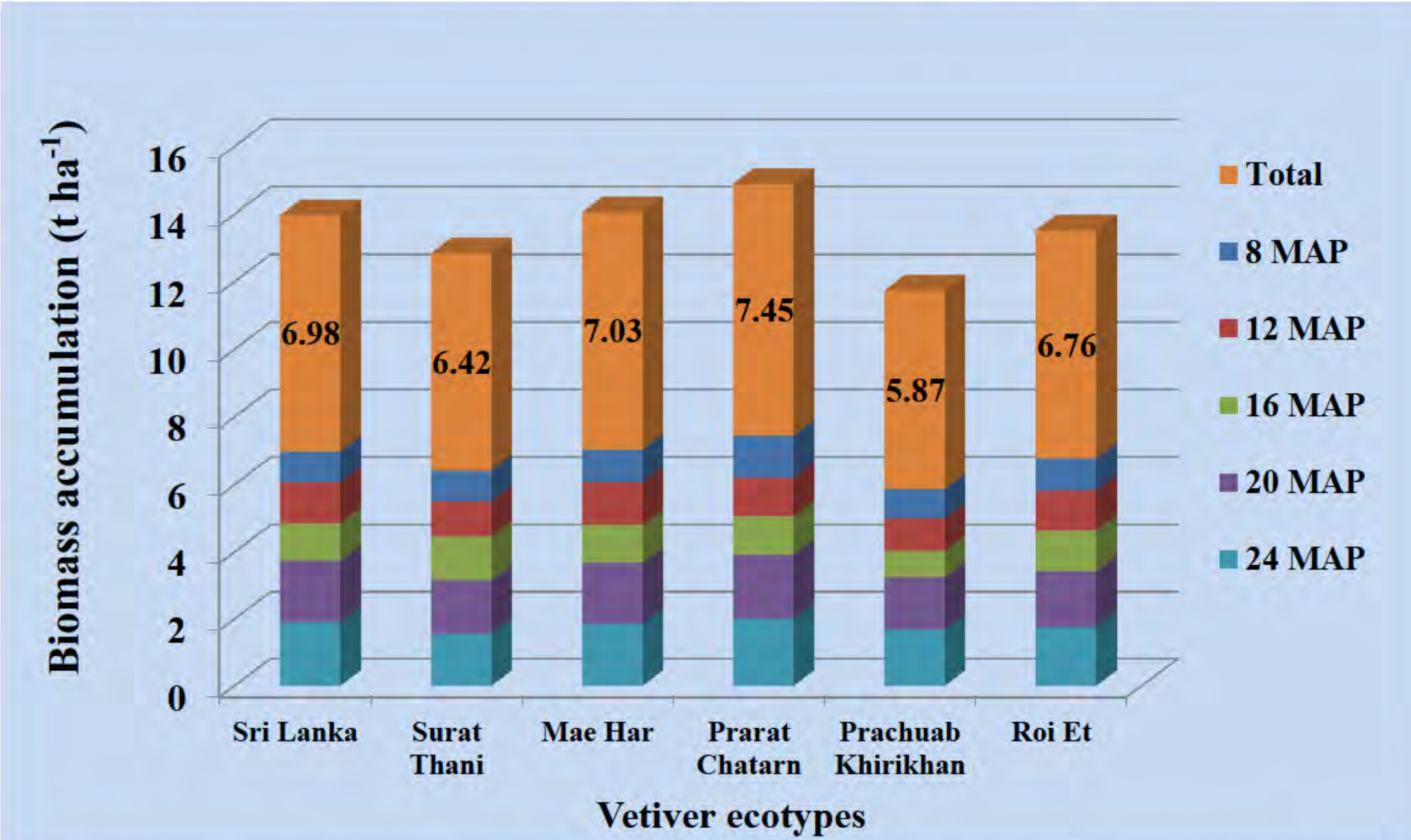
- Soil BD was 1.43 - 1.64 g cm^{-3}. Soil pH was strongly to very strongly acid. Soil OM was moderately low to low . P was low to very low. K was low to very low.
- Soil fertility was estimated as low to moderate level.

2. Biomass accumulation ($t\ ha^{-1}$) of vetiver grass at 8,12,16,20 and 24 months after planting (MAP)



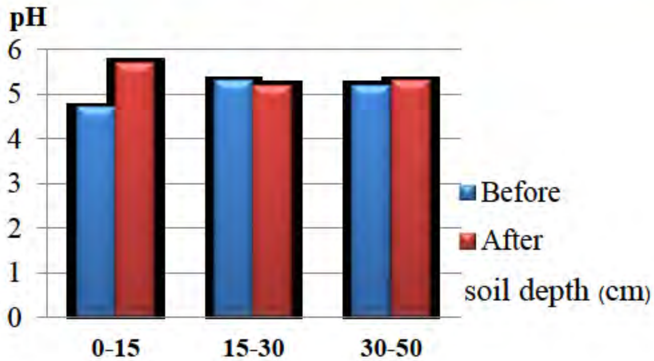
- Amount of biomass accumulated in 6 ecotypes were not significantly different
- Prarat Chatarn had the highest biomass (35.6 $t\ ha^{-1}$)
- Biomass of *C. zizanioides* was higher than *C. nemoralis, since C. zizanioides* had the growth and roots system better than *C. nemoralis*.

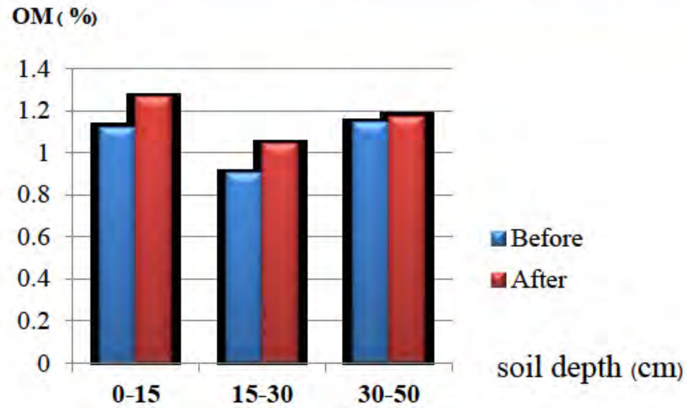
3 Total organic carbon content (t ha^{-1}) in vetiver grass (leaves & roots) at 8,12,16, 20,24 months after planting (MAP)

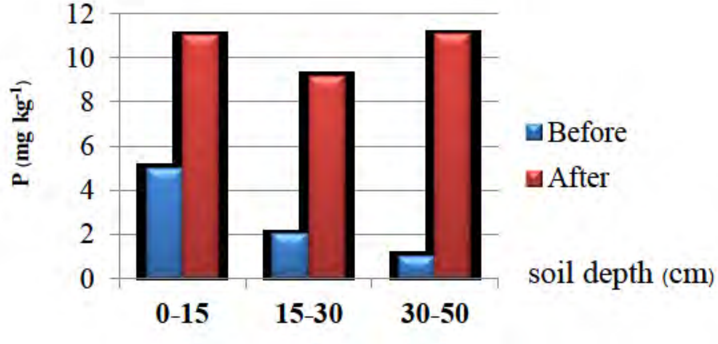


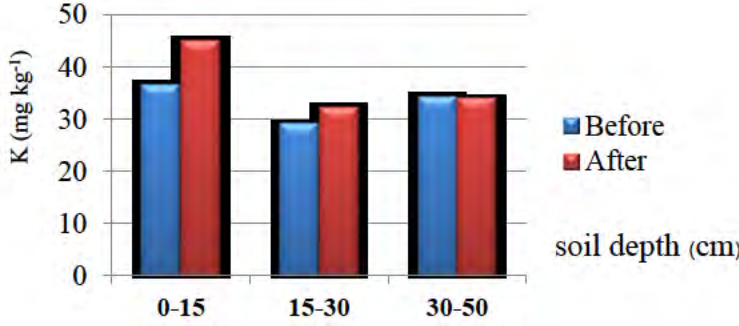
- Amount of TOC accumulated in 6 ecotypes were not significantly different
- Prarat Chatarn had the highest TOC (7.45 t ha^{-1})
- TOC of *C. zizanioides* was higher than *C. nemoralis*.

4 Soil chemical properties at before & after planting vetiver grass





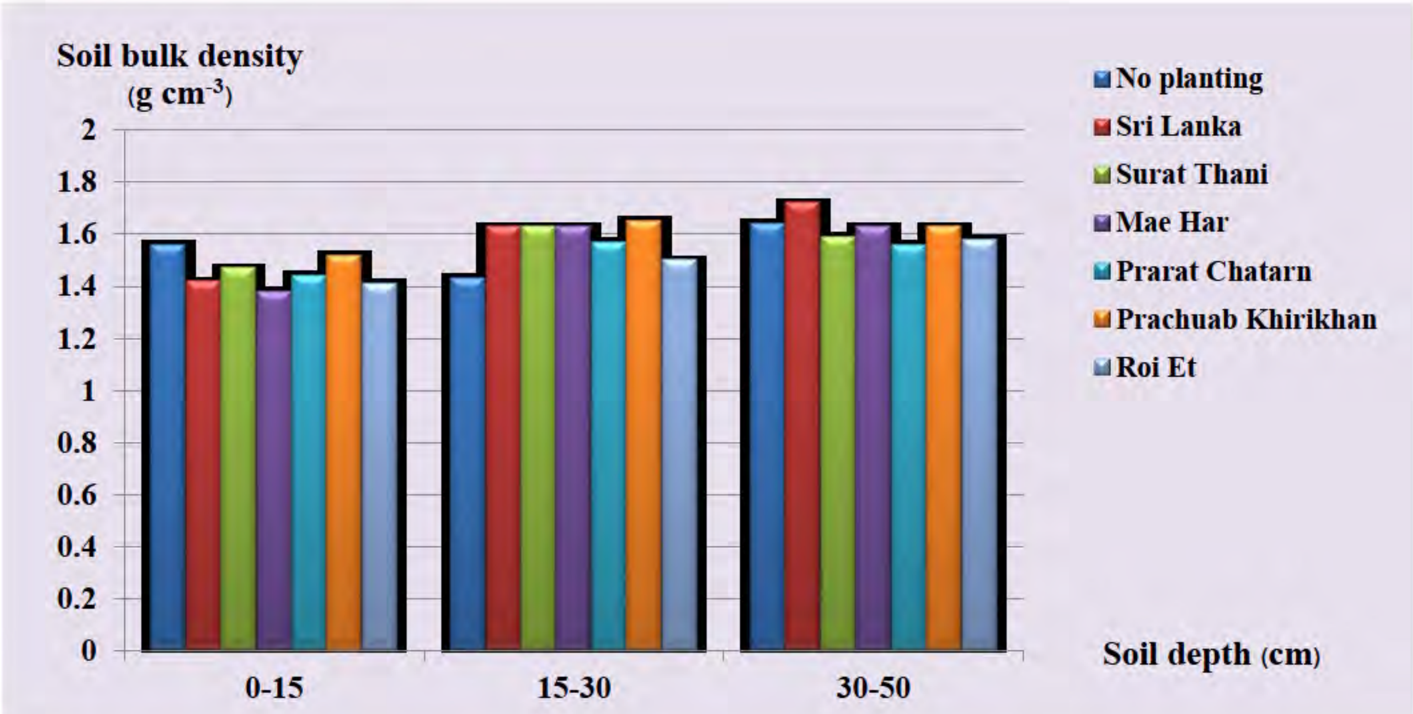




-At the end of experiment (2 years), amount of OM, P, K and pH at 0-50 cm depth, were increased different from the beginning of experiment

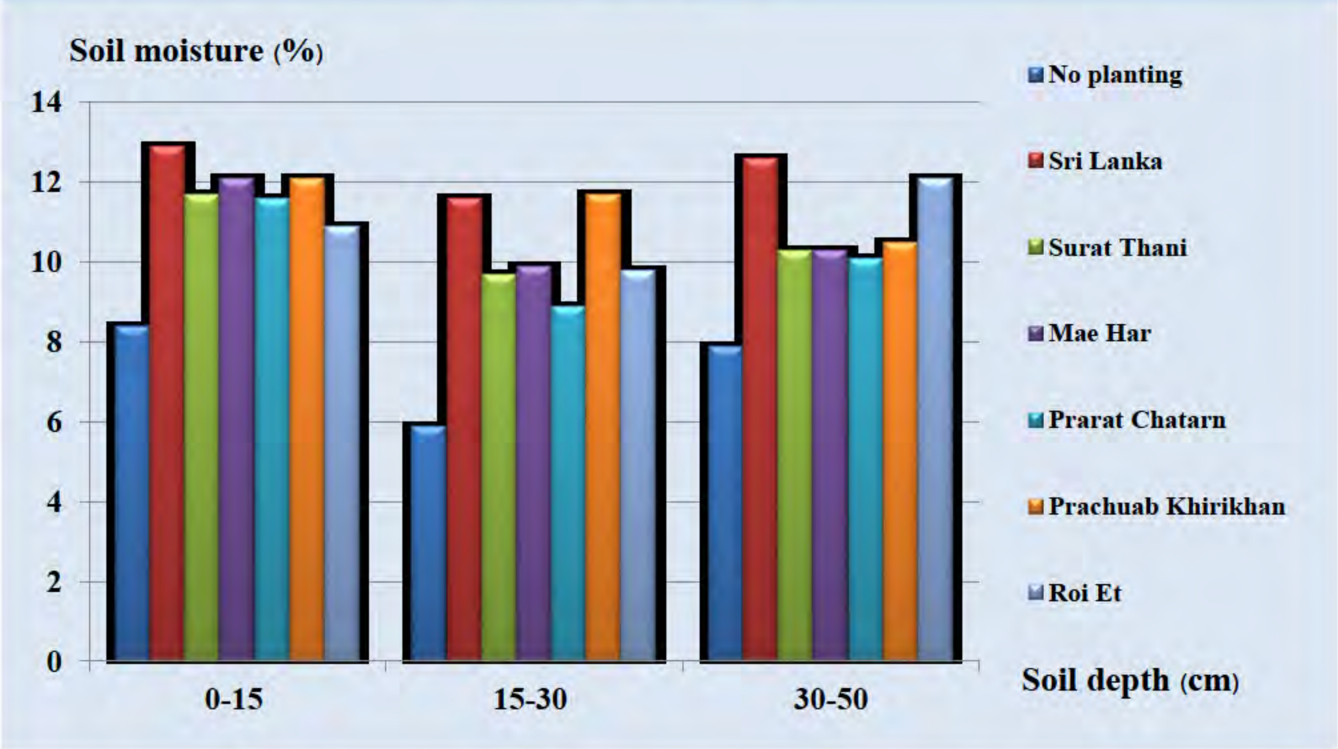
-Increasing in soil OM and nutrients are derived from decomposing of leaves mulching and mature roots at belowground. (Limtong, 2008b; Sriyaem &Thepsupornkul,2008)

5. Soil bulk density (g cm^{-3}) under vetiver grass plot and no vetiver planting



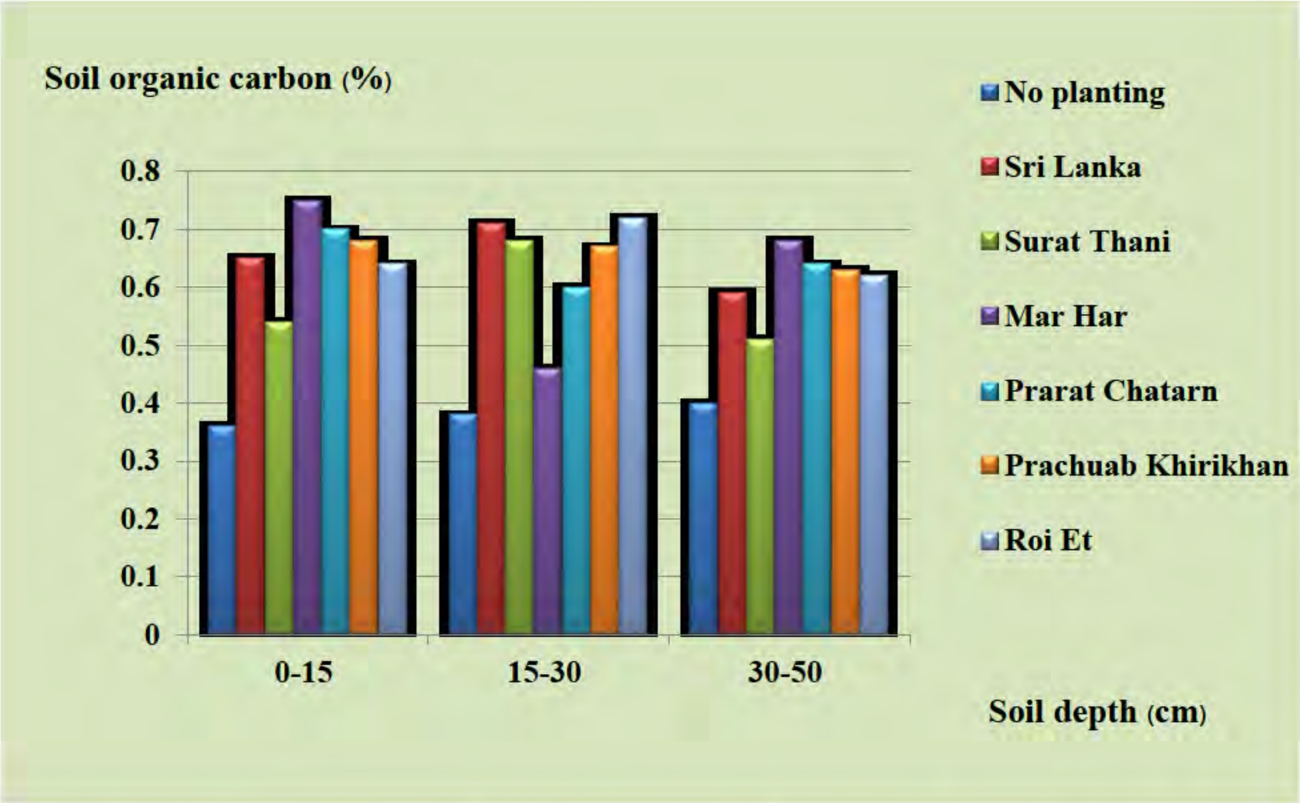
- 2 years vetiver grass planting, bulk density was decreased as compared to the control.
- Since vetiver roots help increase distribution of soil porosity and soil space volume, eventually resulting in decreasing in bulk density (Wattanaprapat et.al.,2014)
- Soil porosity in the soil with cover crop had greater than the soil without cover crop (Puangwarin & Sukviboon,1994)

6. Soil moisture (%) in no vetiver planting and vetiver grass cultivation plot at various soil depth



- At the end of experiment, soil moisture content(SMC) in the control was 7.4 %. While SMC under the vetiver grass planting was increased 10.2 - 12.3 %
- Root system acts as absorbing and storing water in the soil
- Mulching of cut leaves maintained soil moisture higher than the control, protected the sunshine ,reduced soil temperature & water evaporation from soil surface (Kittiyarak et al.,1997; Chomchalow, 2009).

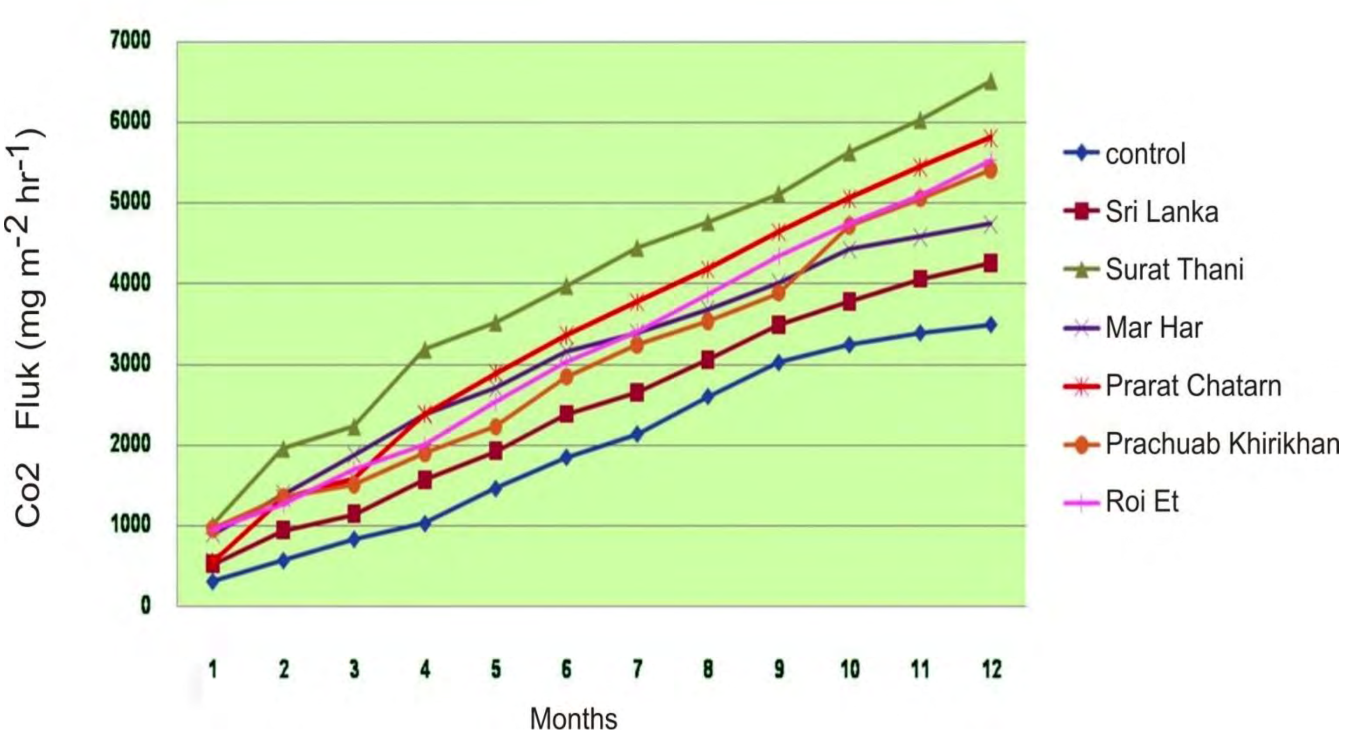
7. Soil organic carbon content (%) at various soil depth



- Amount of SOC in vetiver grass plot and control were obviously different
- Vetiver grass plot had SOC content greater than the control

-Non-vetiver cultivation plot had the lowest OC content 0.19 %. (Hannamthieng,2010)

8. CO_2 emission rate (mg C $m^{-2}h^{-1}$) from soil surface



- Planting vetiver grass increased CO_2 emission comparing to the control
- Surat Thani produced the highest amount of CO_2 accumulation 6,518 mg C $m^{-2}h^{-1}$
- Non-vetiver grass plot produced the lowest CO_2 accumulation 3,496 mg C $m^{-2}h^{-1}$

9. Soil carbon balance (kg C $m^{-2}y^{-1}$) in non-vetiver grass and vetiver grass cultivation areas

$$C_{balance} = (C_{soil} + C_{root} + C_{leaf(1)}) - (C_{leaf(2)} + C_{released\ soil})$$

$C_{balance}$ = soil carbon balance in each ecotype

C_{soil} = carbon content in soil

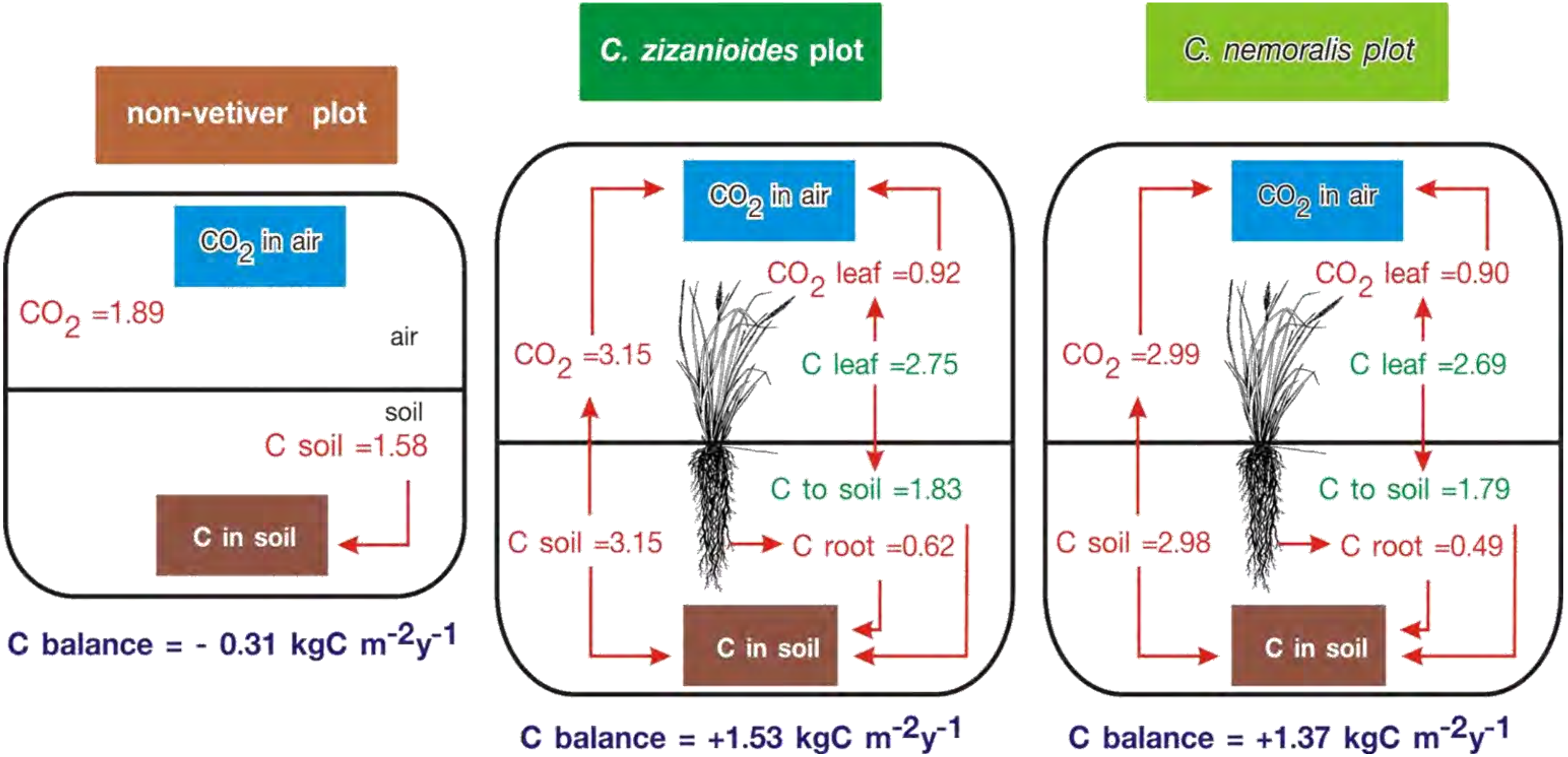
C_{root} = carbon content in root

$C_{leaf(1)}$ = carbon content of leaf accumulated in soil

$C_{leaf(2)}$ = carbon content of leaf released as CO_2

$C_{released\ soil}$ = carbon content in soil released as CO_2

9. Soil carbon balance (kg C $m^{-2}y^{-1}$) in non-vetiver grass and vetiver grass cultivation areas (continued)



- Non-vetiver grass cultivation system caused soil carbon loss 0.31 kgC $m^{-2}y^{-1}$.
- Vetiver grass cultivation areas increased soil carbon storage 1.37- 1.53 kgC $m^{-2}y^{-1}$.
- *C.zizanioides* cultivation areas raised carbon storage higher than *C.nemoralis.*

Conclusion

- Vetiver grass cultivation areas with mulching of cut leaves comparing to non- vetiver grass cultivation areas increased soil carbon storage and CO_2 emission from soil surface.
- Vetiver grass cultivation increased soil carbon storage.
- Non- vetiver grass cultivation areas resulted in loss of soil carbon storage.

- The agricultural cropping system with vetiver grass cultivation helps to increase soil carbon storage and improve soil chemical and physical properties.
- Uses of vetiver grass is a simple and cheap technology. Farmers can practice by themselves easily. Therefore, it is a sufficient and sustainable farming for development of the communities and nationwide.

Thank you for the attention