Correlation between Vetiver root biomass with soil organic carbon and CO_2 emission in agricultural areas of the southern part of Thailand

Kamalapa Wattanaprapat, Khamchai Kanjanathanaset, Isariya Meesing and Pornpat Nopmalai

Research and Development of Land Management Division
Land Development Department,
Ministry of Agriculture and Cooperatives, Thailand

Introduction

- Soil carbon sequestration and storage by plant is an important process
- Plant photosynthesis is an important to store carbon into the soil
- Vetiver grass has the high amount of biomass

Special characteristic

- high biomass, long massive roots
- sequestering carbon into the soil
- LDD has promoted farmers to use Vetiver for soil and water conservation,
- Vetiver applcation is both in agricultural and non-agricultural areas

Objectives

- to emphasize comparison of root growth and biomass of 6 ecotypes of vetiver grass,
- to observe changes in soil organic carbon and CO_2 emissions from the soil surface,
- to estimate the correlation between such factors to study changes of soil carbon stock.

Study site

Study site:

Surat Thani Land Development Station,
Surat Thani province

UTM 47P 563906E / 1012220N

Study site

Soil profile
Phatthalung soil series

Soil texture: loamy to clay loam,
Slope: 0-2% with deep profile,
Drainage: moderately low to low,
Infiltration: low and water runoff,
Soil fertility: low
(Soil survey staff, 2006)

Material and methods

The experimental design was randomized complete block design (RCBD): 7 treatments, 3 replications. The treatments are as follow:

Treatment 1: non-vetiver grass (control)

Treatment 2: Sri Lanka
Treatment 3: Surat Thani
Treatment 4: Songkla 3
Treatment 5 - Prarat Chatarn

} *C. zizanioides*

Treatment 6 - Prachuab Khirikhan
Treatment 7 - Roi Et

} *C. nemoralis*

Vetiver ecotype

Sri Lanka

Surat Thani

Songkla 3

Prarat Chatarn

Prachuab Khirikhan

Roi Et

Vetiver grass plantation

Vetiver grass was planted with spacing 50x50 cm in plot size 4x6 m^2 without fertilizer application.

Vetiver grass plantation

Vetiver Leave were cut and mulched on soil surface at every 4 months for 5 times, and the first cutting was at 8 months of this experiment.

Data Collecting: soil sample

Soil samples were collected in each experimental plot at 3 soil depth: 0-15, 15-30 and 30-50 cm.

The soil samples were collected before experiment and every 4 months for 2 years, and

Determination of some physical and chemical of soil properties such as organic carbon content and soil bulk density.

Data Collecting: plant sample

Vetiver grass was sampled and collected as leaves and roots part in 1 clump in each plot.

Root length and biomass of root and leaves were measured and determined organic carbon content in laboratory.

Vetive sampling

Data Collecting: CO_2 sample

CO_2 sampling from the soil surface was measured by using portable CO_2 meter (model GM70) with a static closed chamber, and recorded once a month for 2 years of this experiment.

Organic carbon content

Organic carbon in root

$$C_{root\ vetiver} = OC \times Biomass$$

OC = organic carbon content (%)
Biomass = dry weight of root (t ha^{-1})

Organic carbon in soil

$$C_{0\text{-}15} = OC_{0\text{-}15} \times D_{0\text{-}15} \times V_{0\text{-}15}$$
$$C_{15\text{-}30} = OC_{15\text{-}30} \times D_{15\text{-}30} \times V_{15\text{-}30}$$
$$C_{30\text{-}50} = OC_{30\text{-}50} \times D_{30\text{-}50} \times V_{30\text{-}50}$$
$$C_{soil} = C_{0\text{-}15+} C_{15\text{-}30} + C_{30\text{-}50}$$

C_{soil} = soil carbon stock (kg C m^{-2})
OC = soil organic carbon (%)
D = soil bulk density (g cm^{-3})
V = soil volume/area (m^3)

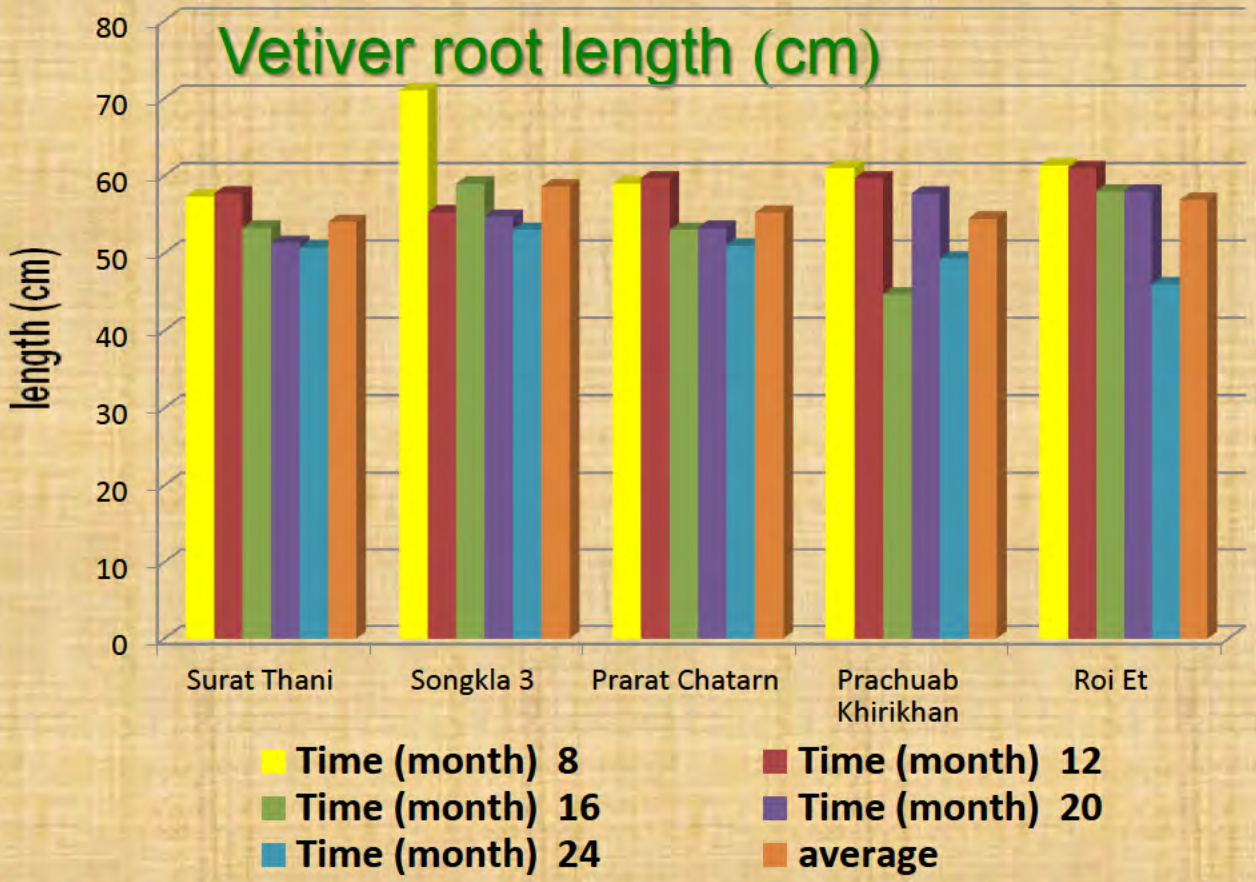
Results and discussion

Vetiver root length (cm)

Ecotype	Time (month)					average
	8	12	16	20	24	
Sri Lanka	70.3	54.3	48.3	52.7	48.3	54.78
Surat Thani	57.3	57.7	53.3	51.3	50.7	54.06
Songkla 3	71.0	55.3	59.0	54.7	53.0	58.60
Prarat Chatarn	59.0	59.7	53.0	53.3	51.0	55.20
Prachuap Khirikhan	61.0	59.7	44.7	57.7	49.3	54.48
Roi Et	61.3	61.0	58.0	58.0	46.0	56.86
F test	ns	ns	ns	ns	ns	-

ns - non significant

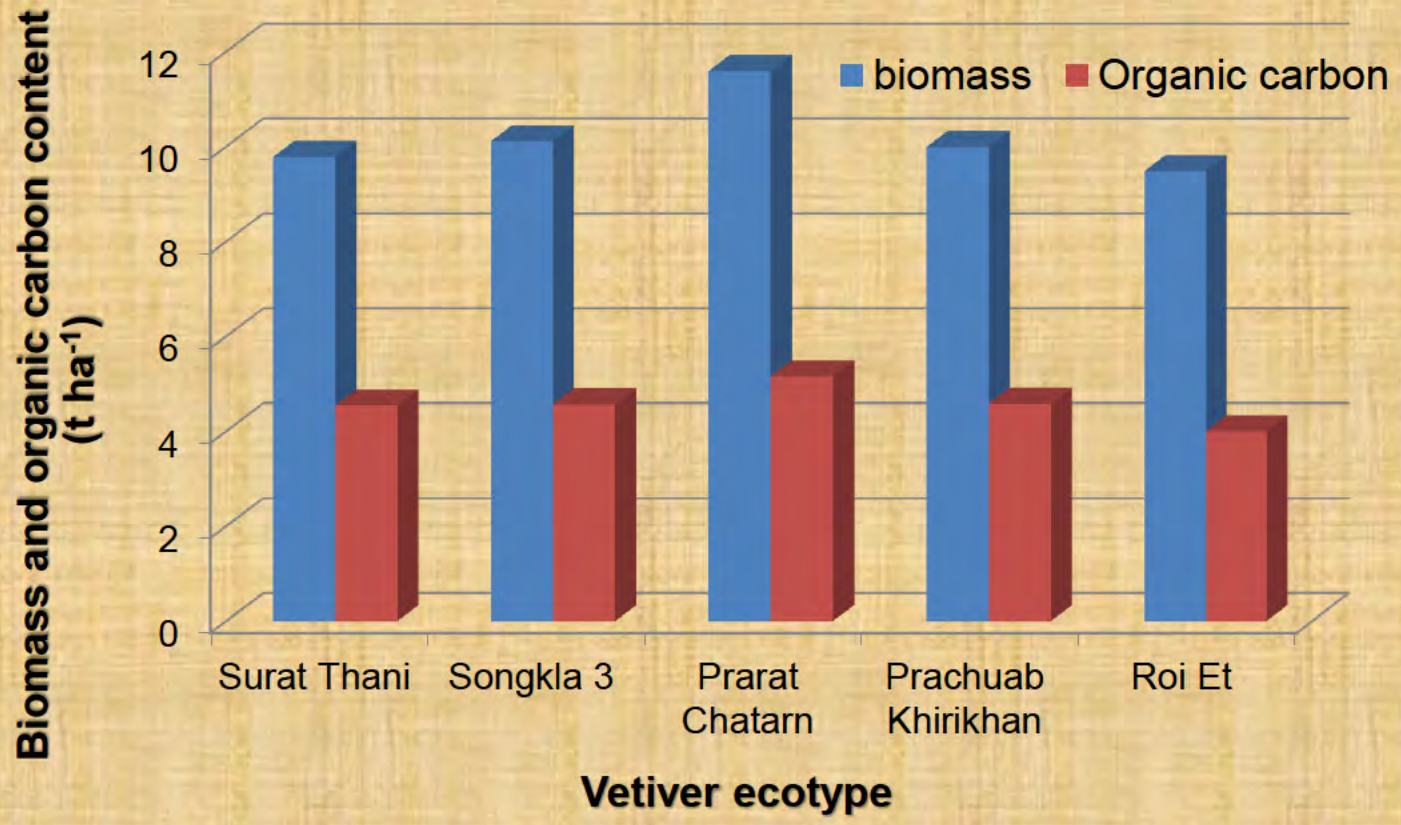
Results and discussion



- Vetiver root length of 6 ecotypes were not significantly different with average length 54.06-58.60 cm.
- Ecotype Songkla 3 had the highest root length 58.60 cm.

Results and discussion

Biomass and organic carbon content in vetiver roots (t ha^{-1})



Results and discussion

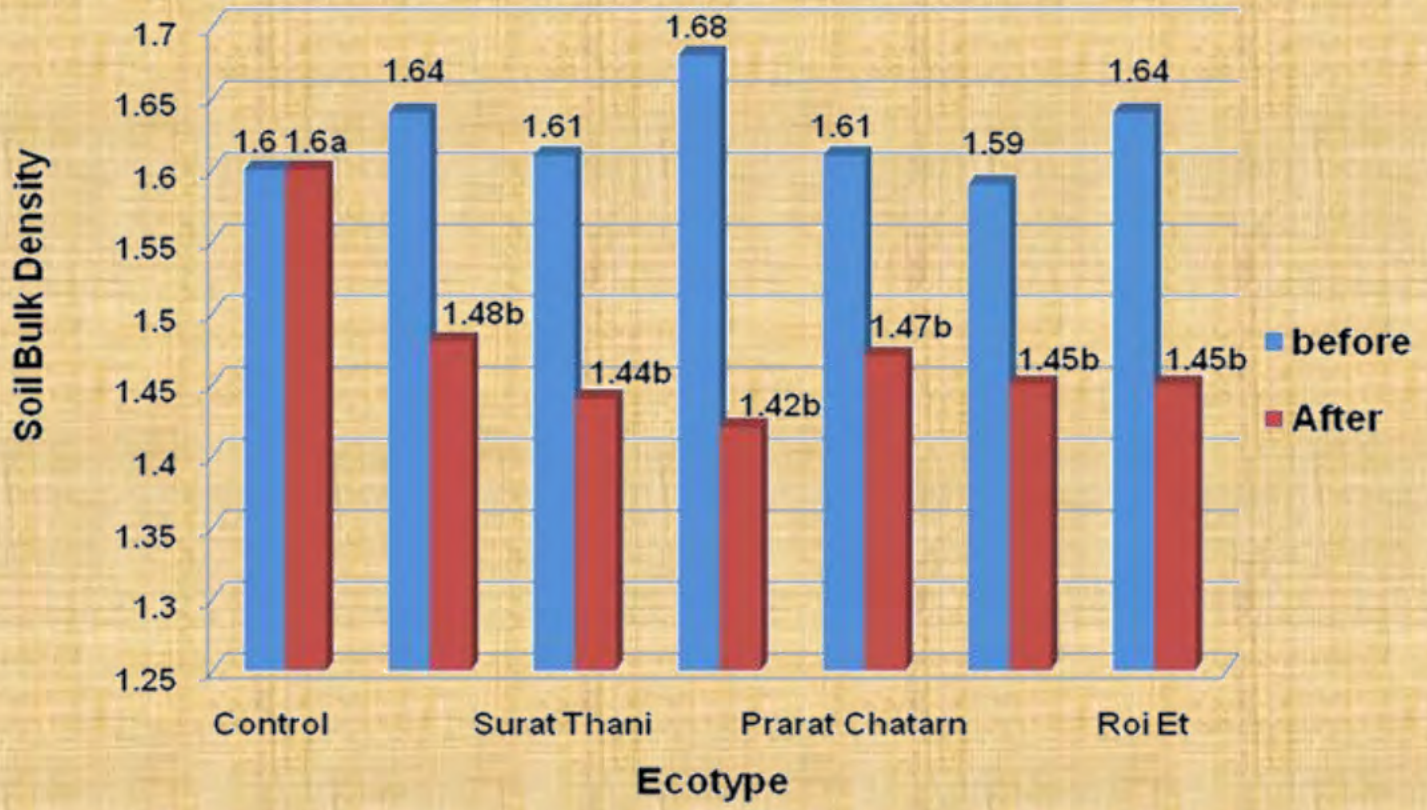
Soil bulk density (g cm^{-3})

Ecotype	Before experiment				After experiment			
	0-15 cm	15-30 cm	30-50 cm	average	0-15 cm	15-30 cm	30-50 cm	average
Control	1.60	1.64	1.65	1.63	1.60a	1.65a	1.60	1.62
Sri Lanka	1.64	1.59	1.69	1.64	1.48b	1.52b	1.51	1.50
Sura Thani	1.61	1.50	1.71	1.61	1.44b	1.44bc	1.66	1.51
Songkla 3	1.68	1.58	1.68	1.64	1.42b	1.48bc	1.61	1.50
Prarat Chatarn	1.61	1.59	1.67	1.62	1.47b	1.45bc	1.47	1.46
Prachuab Khirikhan	1.59	1.54	1.64	1.59	1.45b	1.39c	1.53	1.46
Roi Et	1.64	1.60	1.71	1.65	1.45b	1.52b	1.54	1.51
F-test	ns	ns	ns	-	*	**	ns	-

ns non significant * significant at $p < 0.05$ ** significant at $p < 0.01$

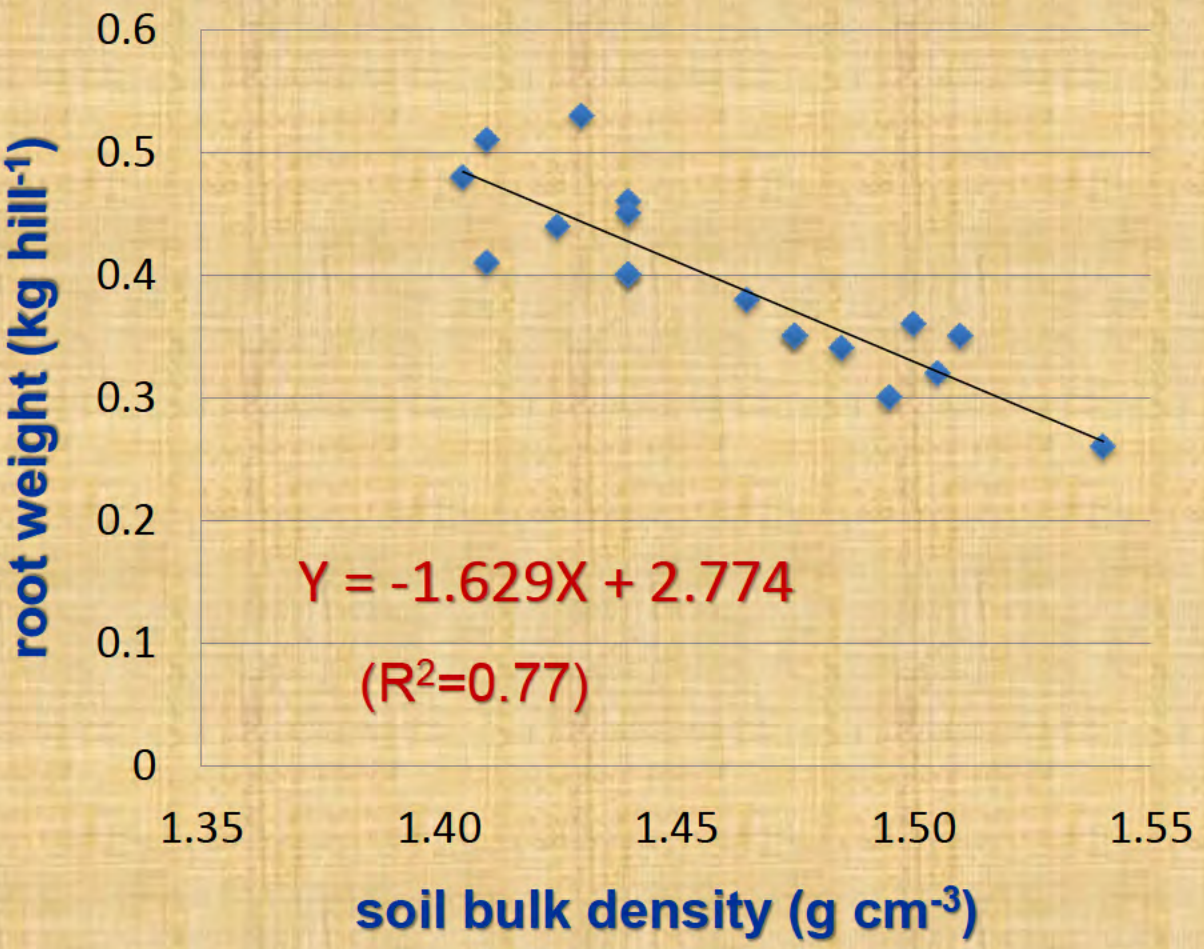
Results and discussion

Soil depth 0-15 cm



Soil bulk density (g cm^{-3}) in control plot and planting vetiver plot

Results and discussion



Correlation: soil bulk density and vetiver root biomass

Results and discussion

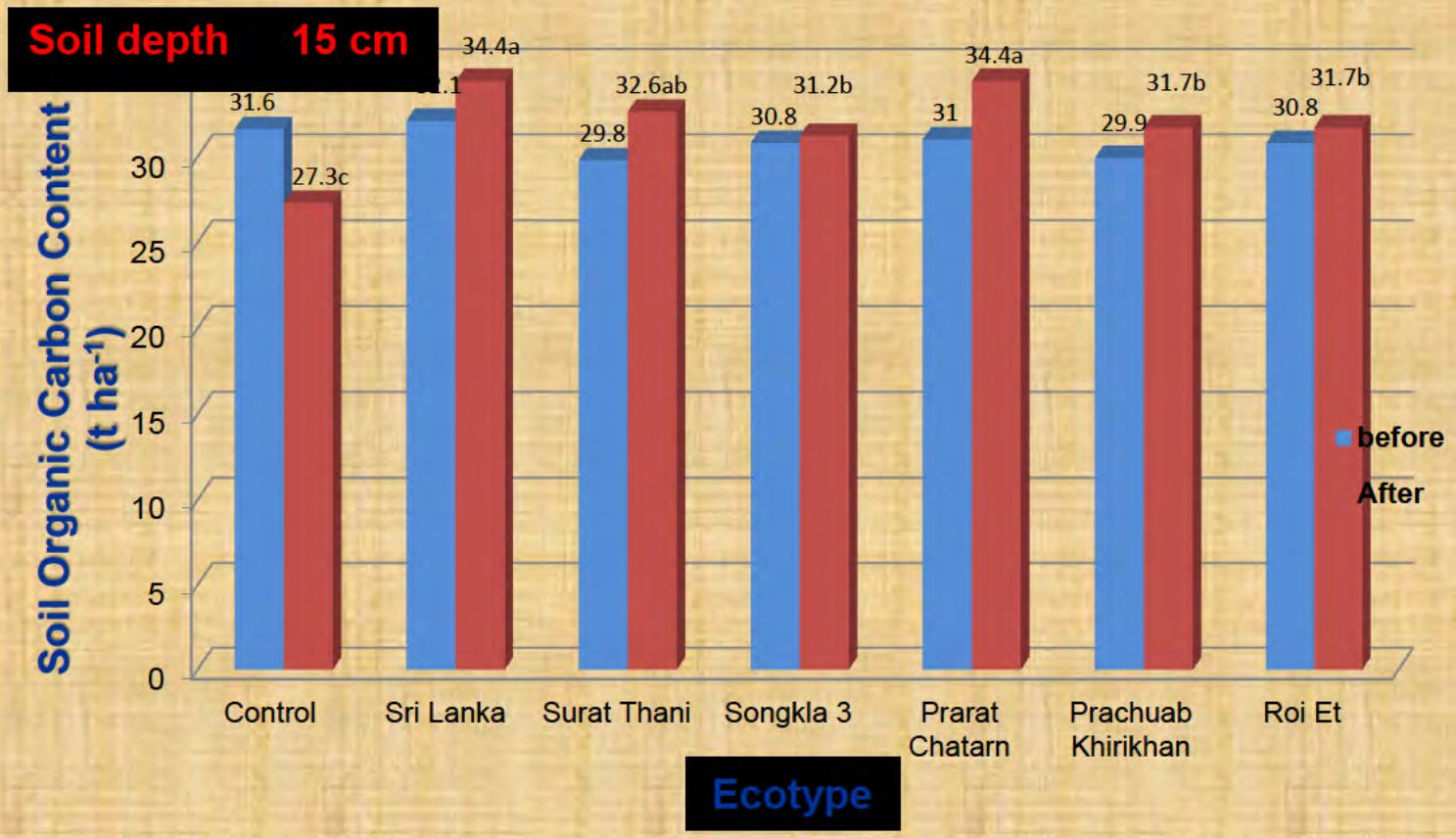
Soil organic carbon content (t ha^{-1})

Ecotypes	Before experiment			After experiment		
	0-15 cm	15-30 cm	30-50 cm	0-15 cm	15-30 cm	30-50 cm
Control	31,6	18.7	22.2	27.3c	18.8	26.8
Sri Lanka	32.1	19.1	22.8	34.4a	19.2	25.1
Surat Thani	29.8	18.1	22.3	32.6ab	20.0	28.8
Songkla 3	30.8	17.0	21.1	31.2b	20.2	26.8
Prara Chatarn	31.0	17.3	21.9	34.4a	20.3	25.4
Prachuab Khirikhan	29.9	17.5	21.6	31.7b	20.7	29.3
Roi Et	30.8	17.6	23.0	31.7b	21.0	28.3
F-test	ns	ns	ns	**	ns	ns

ns - non significant ** significant at $p < 0.01$

Results and discussion

Soil Organic Carbon Content (t ha^{-1}) at beginning and after experiment



Results and discussion

CO_2 emission

For estimation of carbon content from CO_2 emission from the soil surface above mentioned,

it was found that 4 ecotypes of *C. zizanioides* released carbon from soil surface 1.26-1.35 kg C m^{-2} y^{-1},

while 2 ecotypes of *C. nemoralis* released carbon in range of 1.19-1.24 kg C m^{-2} y^{-1}.

It showed that *C. zizanioides* released carbon higher than *C. nemoralis*

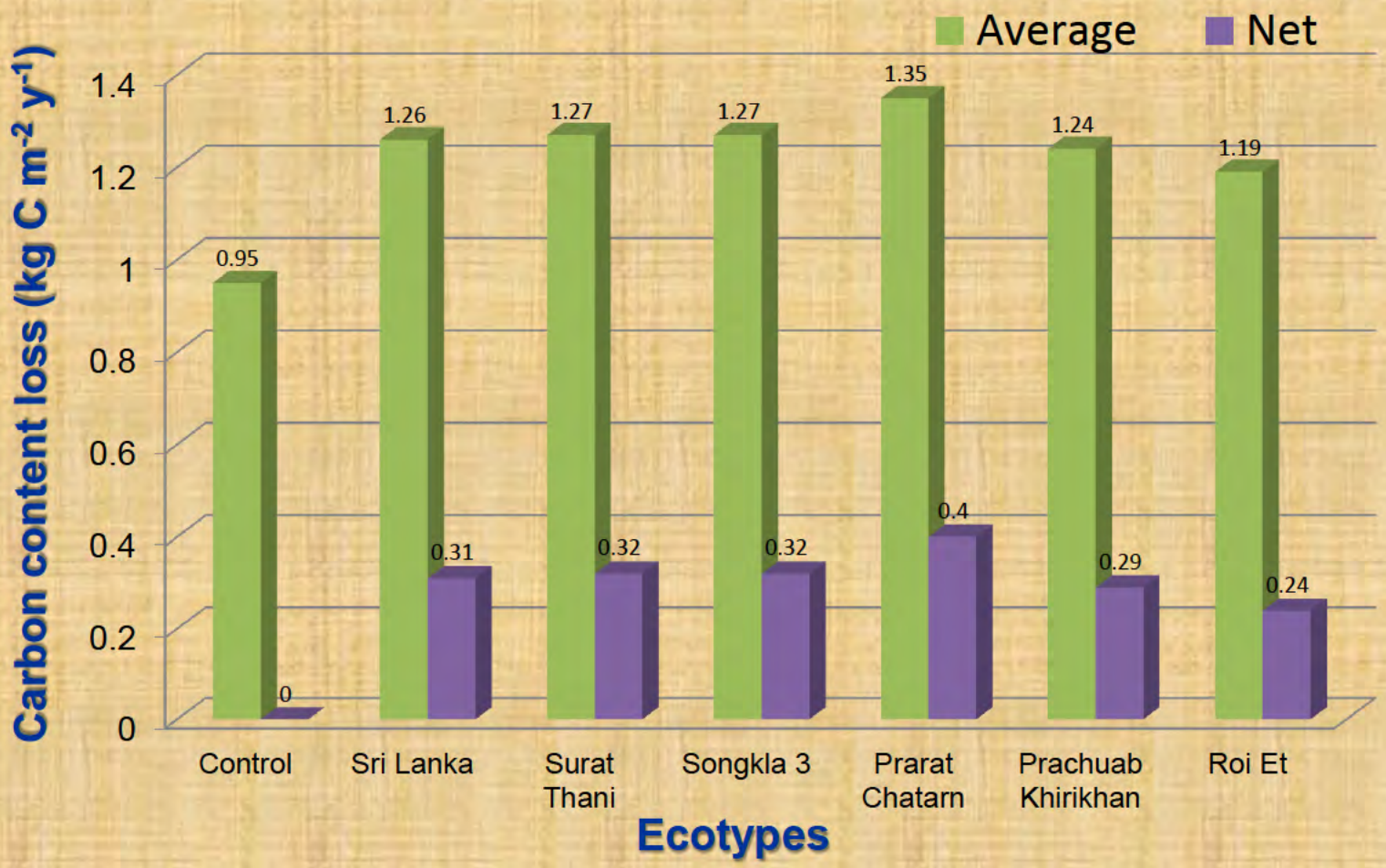
Results and discussion

CO_2 emission

Carbon content loss from the soil (kg C m^{-2} y^{-1})

Ecotypes	year 1	year 2	Average	Net loss
Control	1.00	0.90	0.95	0
Sri Lanka	1.30	1.22	1.26	0.31
Surat Thani	1.34	1.20	1.27	0.32
Songkla 3	1.36	1.18	1.27	0.32
Prarat Chatarn	1.43	1.27	1.35	0.40
Prachuab Khirikhan	1.30	1.17	1.24	0.29
Roi Et	1.22	1.16	1.19	0.24

Results and discussion



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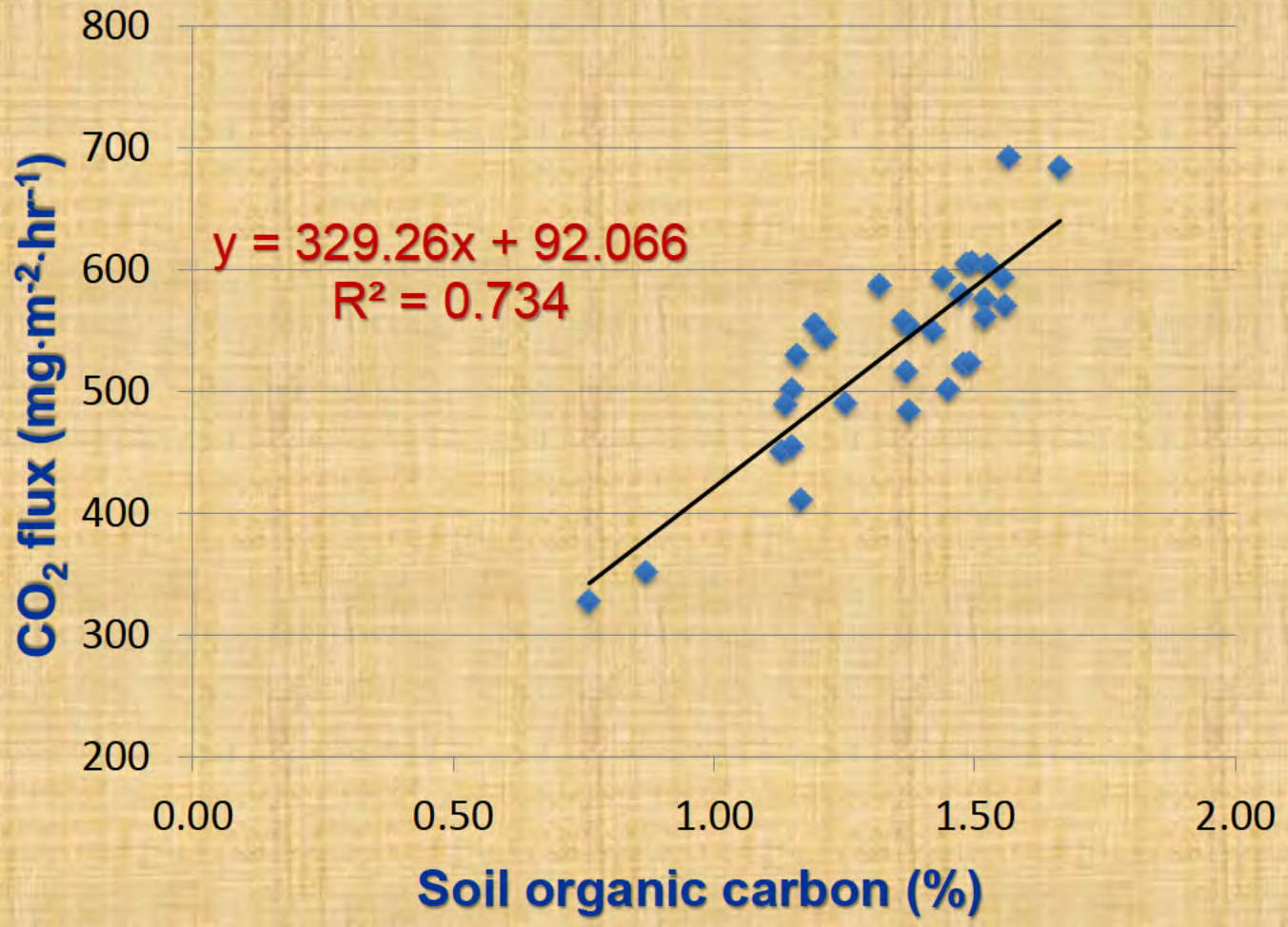
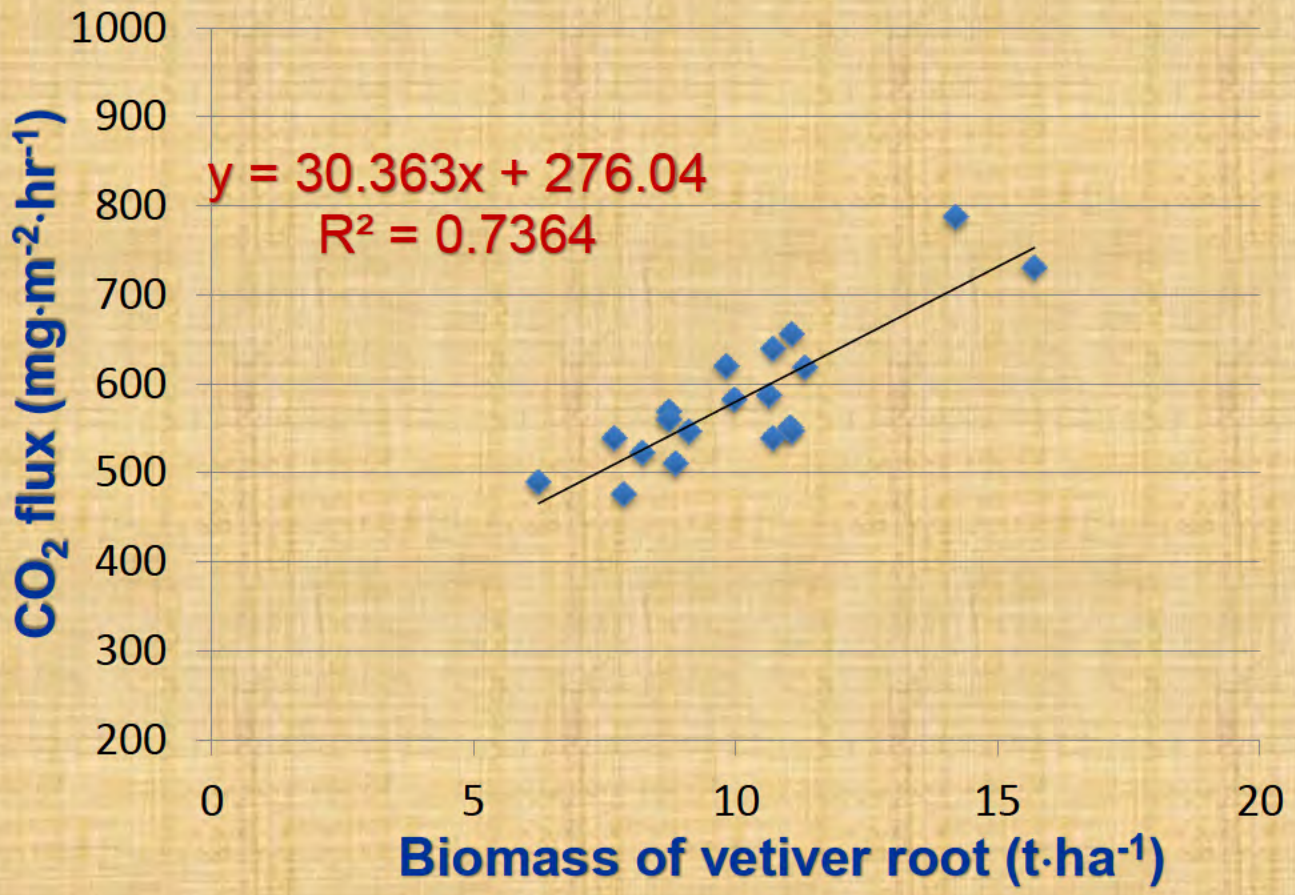


Correlation: soil organic carbon and CO_2 emission from soil surface

Results and discussion



Correlation: root biomass and CO_2 emission from soil surface for 2 years

Results and discussion

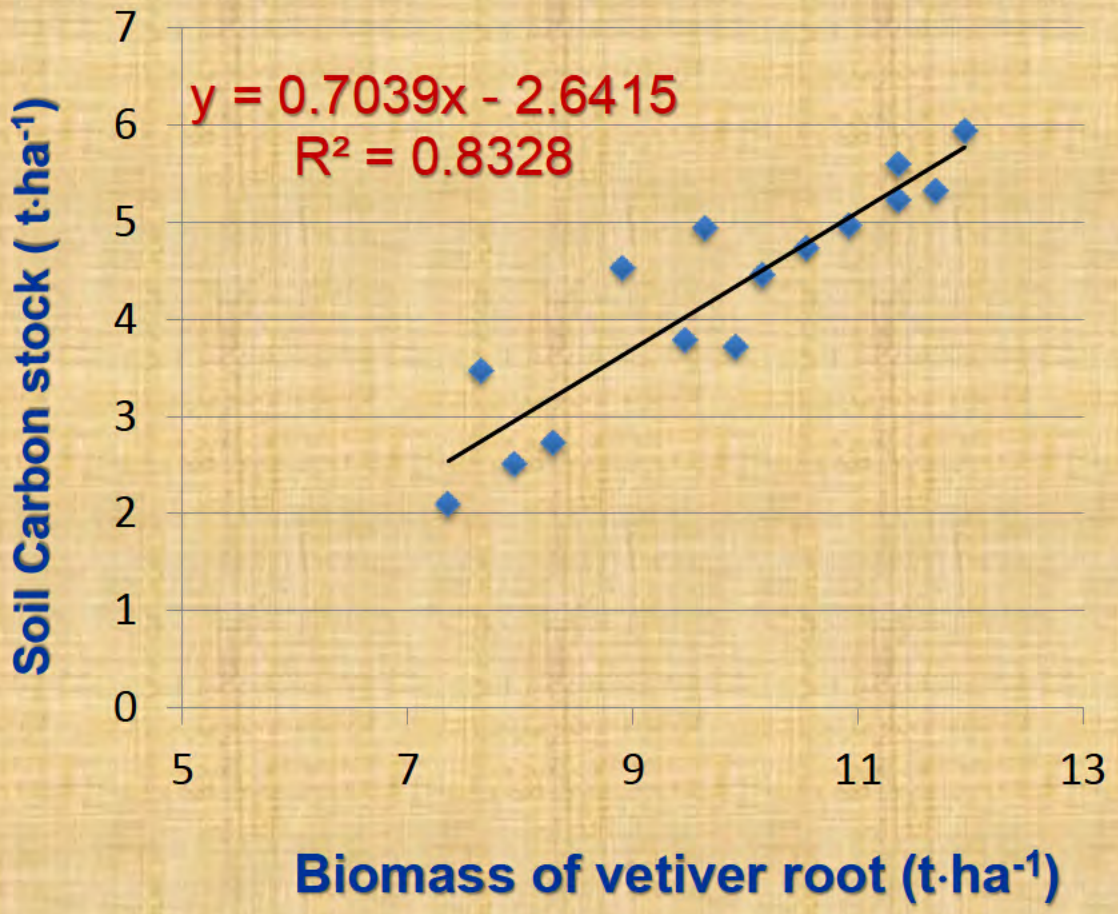
Soil Carbon Stock

Soil carbon stock at 0-30 cm soil depth before and after the experiment ($t \cdot ha^{-1}$)

Ecotypes	Before experiment	After experiment	Change in soi carbon
Control	50.31	46.13	-4.19
Sri Lanka	51.19	53.63	+2.44
Surat Thani	47.88	52.63	+4.75
Songkla 3	47.81	51.38	+3.56
Prarat Chatarn	48.31	54.69	+6.38
Prachuap Khirikhan	47.38	52.38	+5.00
Roi Et	48.38	52.69	+4.31

Remark: - means organic carbon lost from soil
+ means organic carbon storage into soil

Results and discussion



Correlation: root biomass and soil carbon stock

Conclusion

The root biomass changes followed a similar pattern to that of root length with no significant differences.

Soil bulk density is highly correlated with root biomass. This negative relationship is $Y = -1.629X + 2.774$ ($R^2 = 0.77$). Soil bulk density regulates root length and biomass.

The soil organic carbon content in the soil surface layer (0-15 cm) is higher than in the deeper layer. The correlation between soil organic carbon with CO_2 emissions is positive as $Y = 329.2X + 92.06$ ($R^2 = 0.734$).

Conclusion

This relationship shows that increasing amounts of soil organic carbon promotes CO_2 emission, the correlation between root biomass and CO_2 emission is $Y = 30.36 + 276.0$ ($R^2 = 0.736$).

The amount of soil carbon stock is lost in the control plot but increase in Vetiver plots. The high correlation between root biomass with carbon stock is positive as $Y = 0.703X + 2.641$ ($R^2 = 0.832$).

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