EFFECTS OF VETIVER CULTIVATED AND INCORPORATED INTO PADDY FIELD ON SOIL QUALITY, RICE PRODUCTION AND METHANE EMISSION

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Outline

Introduction

Huay Sai Royal Development Study Center,
Phetchaburi Province, about 200 km south of Bangkok

His Majesty King Bhumibol suggested of the cultivation of vetiver since

(1) Vetiver can withstand drought and floods;

(2) It can grow in all types of soil and is highly tolerance to soil; and

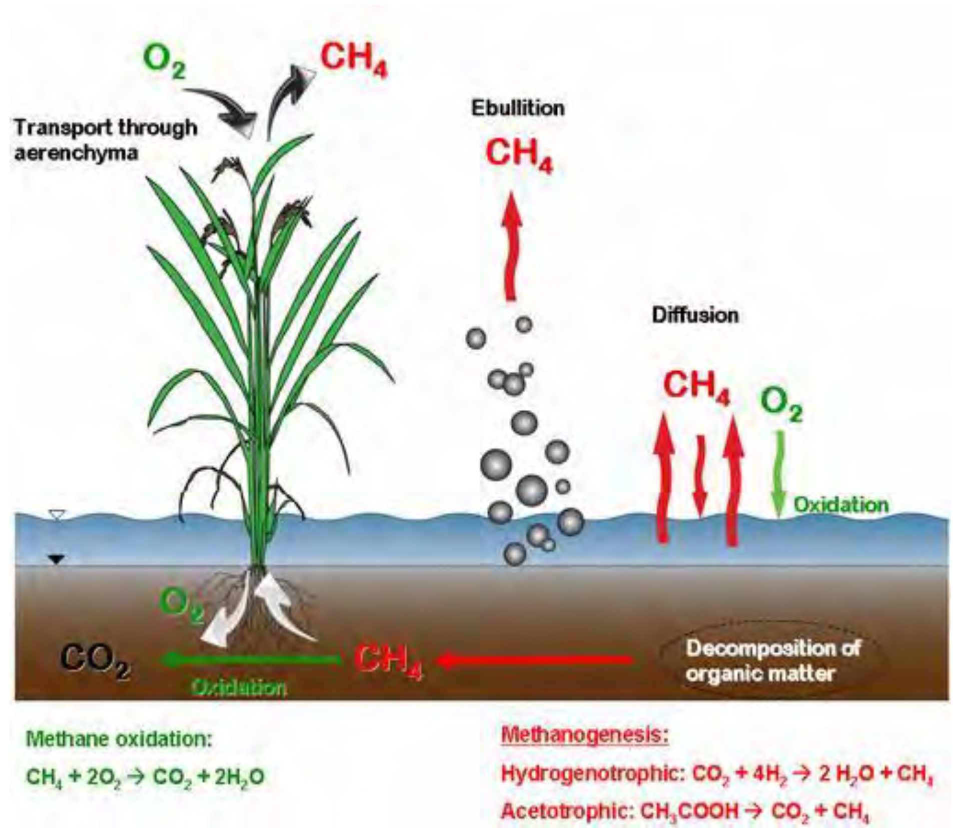
(3) It has strong fibrous root that penetrates and binds the soil to a depth of 3 meters and thus protects soil from being washed off.

Vetiveria zizanioides (L.) Nash.

"… the decomposition of fresh vetiver grass which was plowed 10 cm below the soil surface released N, P and K the rate of 4.3, 2.2 and 20.5 kg/ton
which was equivalent to 11 kg of triple superphosphate and 41 kg of KCl (Chairoj and Nagara, 1999).

Therefore, vetiver has potential to be cultivated and incorporated into the soil to improve soil quality…"

Meanwhile, flood rice fields are one of the major sources of the methane emission. The rate of emission depends on several factors included soil properties.



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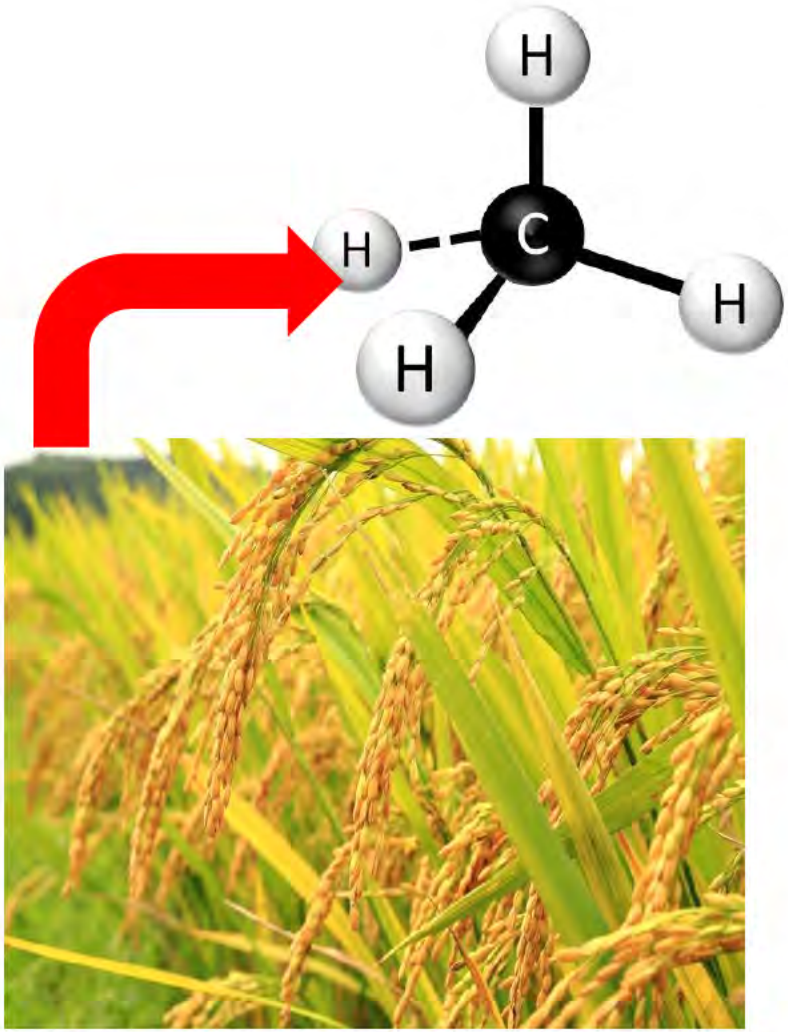
Objective



This study aimed to investigate the effects of the restoration of paddy field by vetiver cultivated, plowed under and incorporated into the soil on soil properties, rice yield and methane emission

Materials and Methods

Materials and Methods

-This study was conducted in farmer paddy field of 1,600 m^2, located nearby Huay Sai Royal Development Study Center.

- The soil fertility was low since it was coarse-textured sandy loam with hard pan in saline accumulated layer. Moreover, these soils are water saturated during the rainy season and are subject to temporary flood (flash flood).

- The annual mean precipitation in the area was 954.8 mm.

- The paddy field was separated into 2 plots of 800 m^2 each.
- During October 25, 2009 to March 8, 2011 (500 days), the soil in these 2 plots was treated differently.
  - One plot was utilized for rice production for 3 consecutive paddy - sunn hemp cropping sequences. Sunn hemp (*Crotalaria juncea* L.) was sown as green manure crop after rice harvesting and was plowed in when it was about 50 days-old. Sunn hemp was reported to be an excellent soil improving crop. It produced high OM and was able to fix N. The root system of sun hemp is characterized by long and strong taproot.
  - Simultaneously, the other plot had been withdrawn from rice production for vetiver (*Vetiveria zizanioides* (L.) Nash; ecotype Surat Thani) cultivation with 0.3 X 0.3 m inter-planted spacing. The planting started at the beginning of the rainy season (October 25, 2009). During 500 days of cultivation, no fertilizer and herbicide had been added. The shoot of vetiver was cut off at 120, 240 and 360 days after transplanting. On March 8, 2011 (500 days after transplanting), vetivers were plowed under and incorporated into the paddy soil. The shoot height of vetivers was ranging from 80 to 120 cm and root length from 40 to 50 cm which indicated their poor growth.

Field management of the study site during 2011

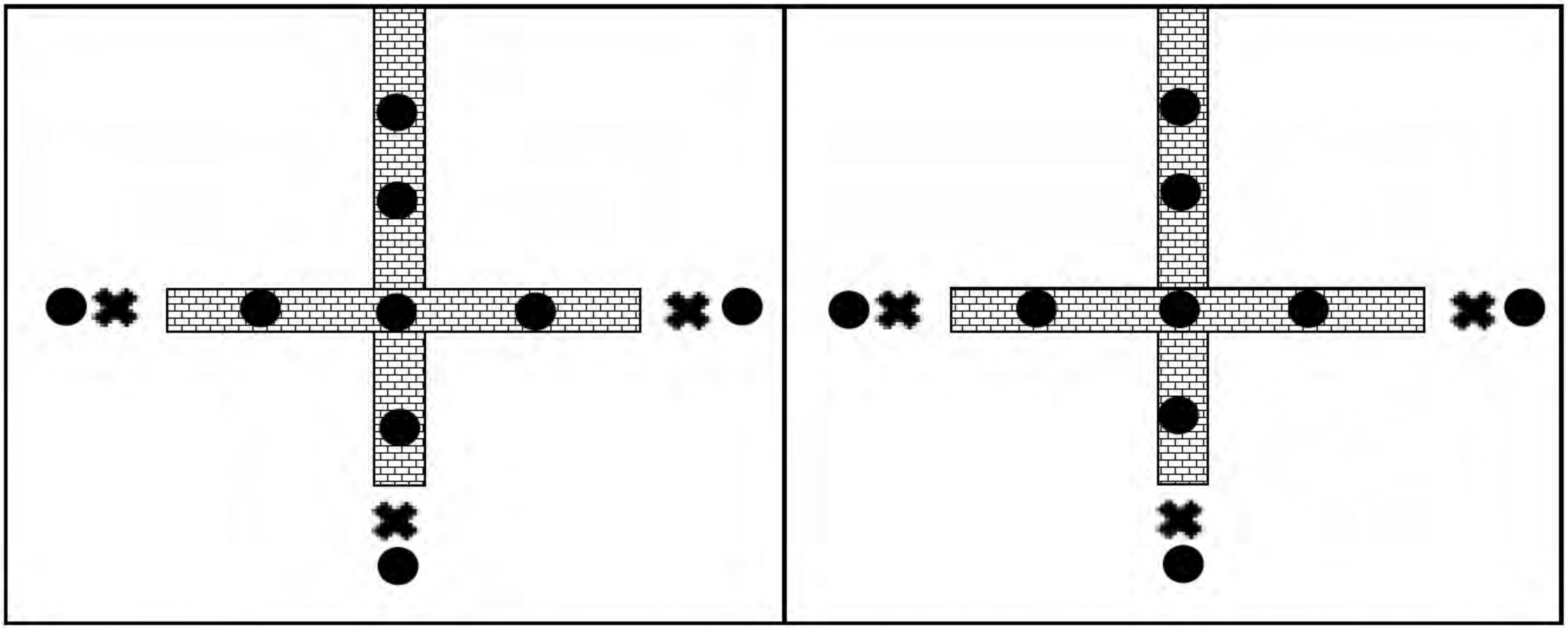
Activities	Date	Days after broadcasting
Incorporated of vetiver into soil	Mar 8	-115
Incorporated of sunn hemp into soil	Apr 3	-89
Plowing/ Tillage	Apr 3	-89
Puddle; mixing compost as basal fertilizer (1,875 kg/ha)	Jul 1	-1
Broadcasting (seeding rate 200 kg/ha)	Jul 2	0
Brief flooding and drainage; mixing liquid fertilizer (125 l/ha)	Jul 2-3	0 - 1
Continuous flooding at 5 cm depth	Jul 11- Oct 15	9 -105
Pre-harvest drainage	Oct 15	105
Harvest	Oct 29	119

Samplings and Analysis

Soil Samplings

Sampling stations

Vetiver plot 800 m² **Without vetiver plot 800 m²**



● 9 Soil sampling stations ✖ 3 Gas sampling stations

- Collected from 9 stations (3 times) i.e. before rice plant cultivation, rice boosting stage and rice harvesting

- Each station, surface soil samples (0-15 cm depth) were collected for further analysis according to Soil Survey Staff (1996)

- Measured soil pH, soil EC and redox potential (during 6 times of gas sampling)

Parameter	Method
1. Soil pH	pH meter
2. Conductivity	Conductivity Meter
3. Redox Potential: Eh	Oxidation Reduction Potential Meter
4. Soil Texture	Hydrometer Method
5. Organic Matter	Walkley and Black Method
6. Total Nitrogen	Kjeldahl Method
7. Available Phosphorus	Bray II Determine by Spectrophotometer
8. Exchangeable Potassium	Ammonium Acetate Extraction Determine by AAS

Rice Plant Samplings

- Collected from 5 times during different growth stages i.e. seedling, tillering, booting, milk grain and harvesting using quadrat technique

-Sampling for stem height and harvested to estimate root length and biomass

-In harvesting stage, recorded for harvesting index and rice yield

Gas Sampling and Analysis

Crop details and gas sampling dates

Growth stage of rice	Days after broadcasting	Growth period	Days after broadcasting	Gas sampling date
1. Germination	0-3	Jul 2 - 5	1	3 Jul
2. Seedling	3-29	Jul 5 - 31	16	18 Jul
3. Tillering	29-58	Jul 31 - Aug 29	34	5 Aug
4. Booting	63-83	Sep 3 - 23	67	7 Sep
5. Milk grain	89-100	Sep 29 -Oct 10	94	4 Oct
6. Harvesting	109-119	Oct 19 - 29	117	27 Oct

Gas Sampling and Analysis

Acrylic chamber was equipped with an electric fan for circulation, a thermometer and a sampling hole covered with a rubber septum.

acrylic base

Acrylic chamber of 30 x 30 x 40 cm

A thermometer and a sampling hole covered with a rubber septum.

Gas Sampling and Analysis

Inserted acrylic base into the soil about 5 cm deep in advance.

During sampling, placed chamber over base. Water seal in a channel was used to surround the chamber in order to make the system airtight.

Gas samples were collected at 0, 15 and 30 min accumulative time.

Five ml of gas was withdrawn first by a syringe, then it was injected into the evacuated tube.

The air temp. and soil temp. were measured.

All measurements were conducted in the morning 9.00-12.00 hrs.


5
10
15
20
ml
NIPRO


25
SINGLE USE ONLY
NIPRO

Gas Chromatography, Flame Ionization Detector (GC/FID)

The methane flux was calculated using the following equation

$$F = \frac{BV_{std} \times dC \times MW \times 10^3 \times 60}{10^6 \times 22{,}400 \times A \times dt} \quad mg/m^2/hr$$

→ Equation 1

$$BV_{std} = \frac{BV \times B.P. \times 273}{(273+T) \times 760}$$

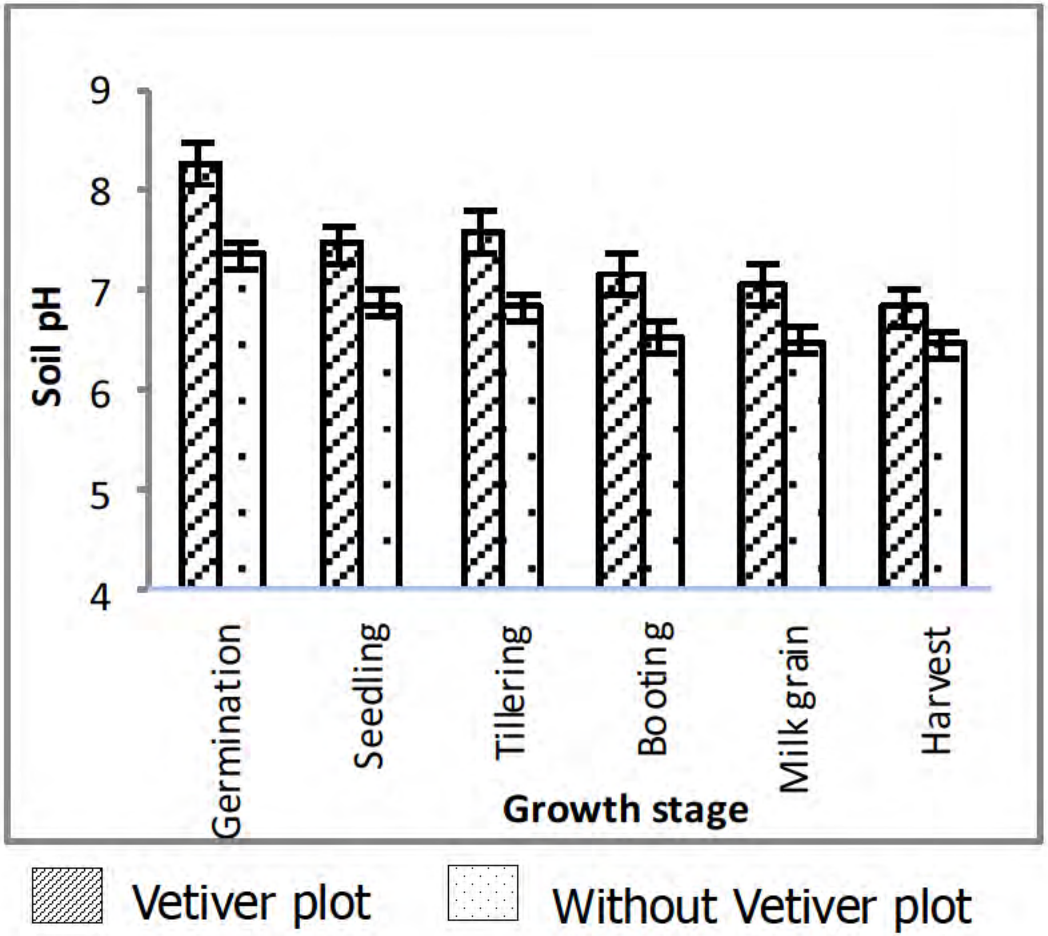
→ Equation 2

F = methane flux ($mg/m^2/h$)
BV = volume of the chamber (cm3)
B.P. = barometric pressure (mmHg)
MW = molecular weight of methane gas (16)
T = temperature (°C)
A = bottom area of the chamber (m2)
dC = the change in the methane concentration in the chamber during the period Δ t (min)
dt = time (min)

Results and Dicussion

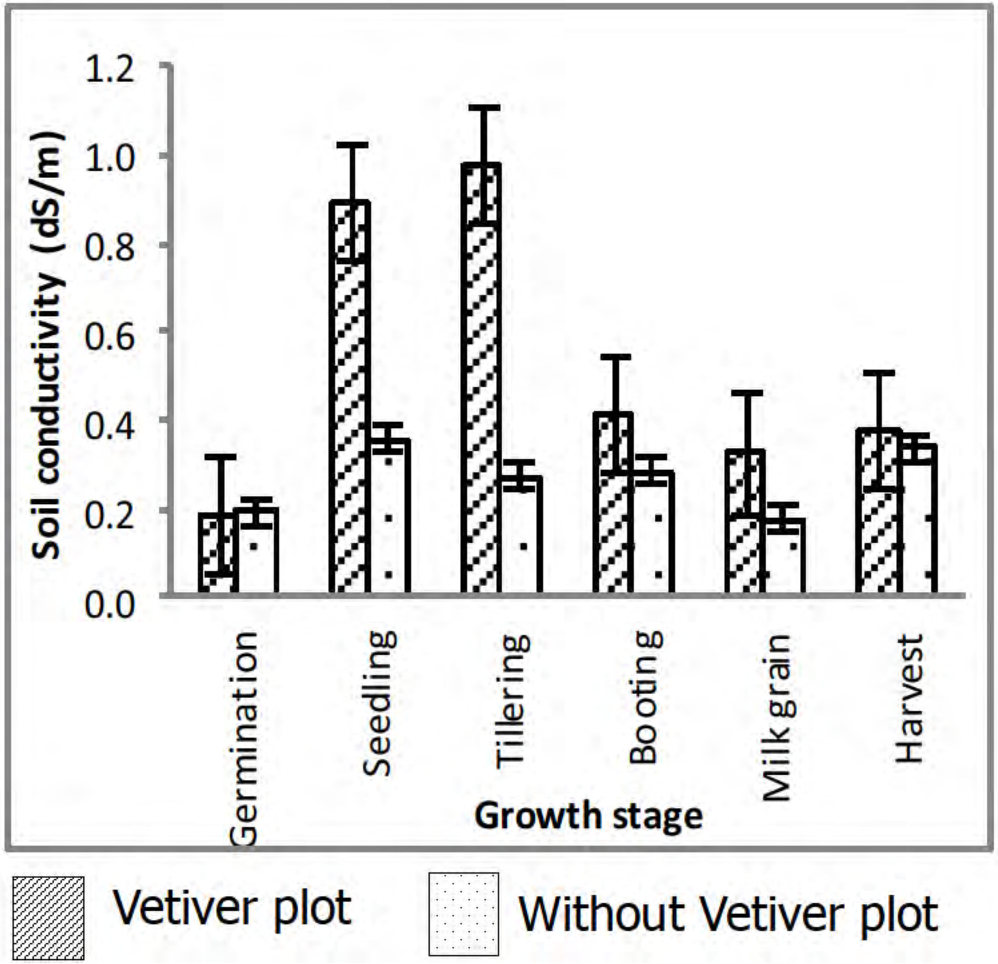
Soil Physical and Chemical Properties

pH



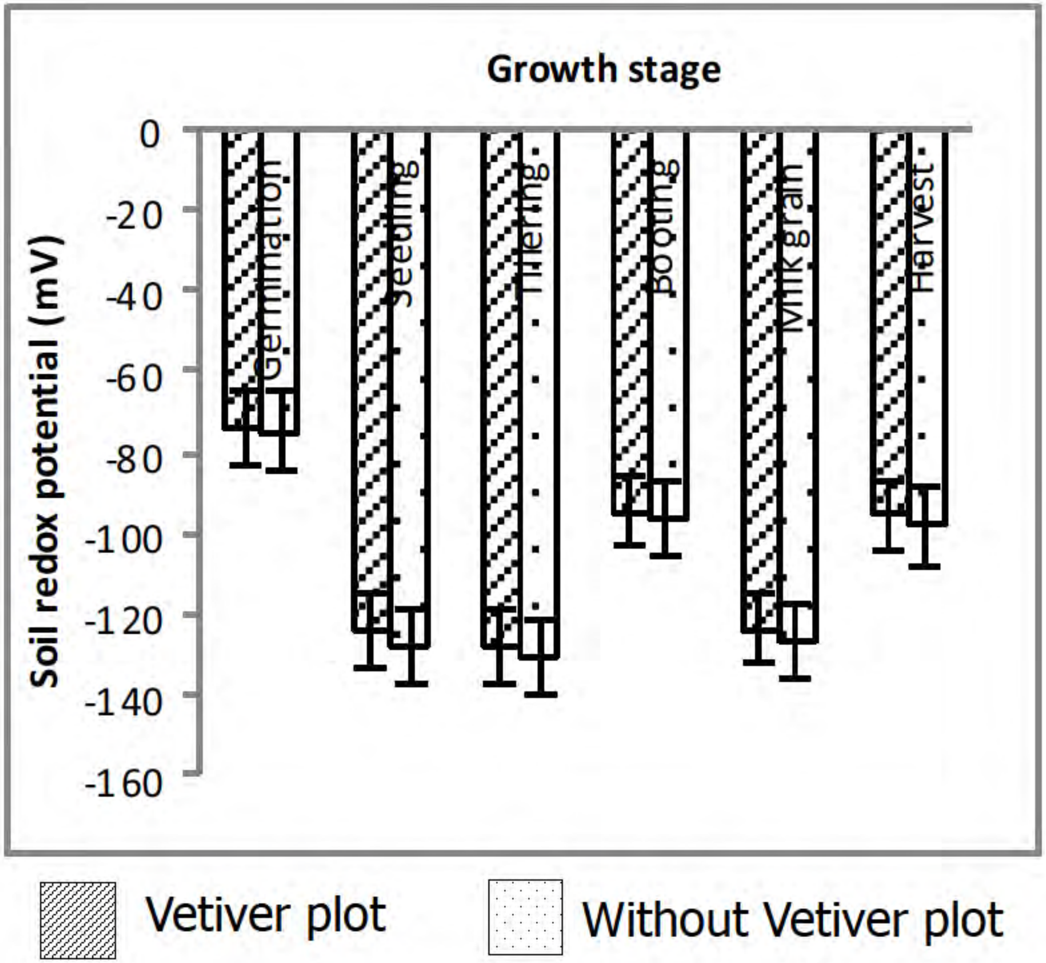
- The lower pH in without vetiver plot may be due to earlier practices of application of compost and bio-fertilizer during 3 consecutive crops of rice cultivation prior to this study. Whereas, in vetiver plot, zero input of compost and chemical fertilizer for 500 days may restore the pH to the natural level.
- The soil pH in both plots were gradually decreased to nearly neutral during harvesting period.

EC



The EC values of soil samples ranging from 0.2 to 1 dS/m indicated that the soils were non saline, thus, they had no detrimental salinity effects for plants.

Eh



-The soil Eh in both plots in all rice growth stages were gradually decreased (except for during harvesting stage which flooded water had been drained for 2 weeks before harvest; and rice booting stage).

-This trend was the result of oxygen diffusion is 10,000 times slower in water than in air. Thus, a lower redox potential was formed.

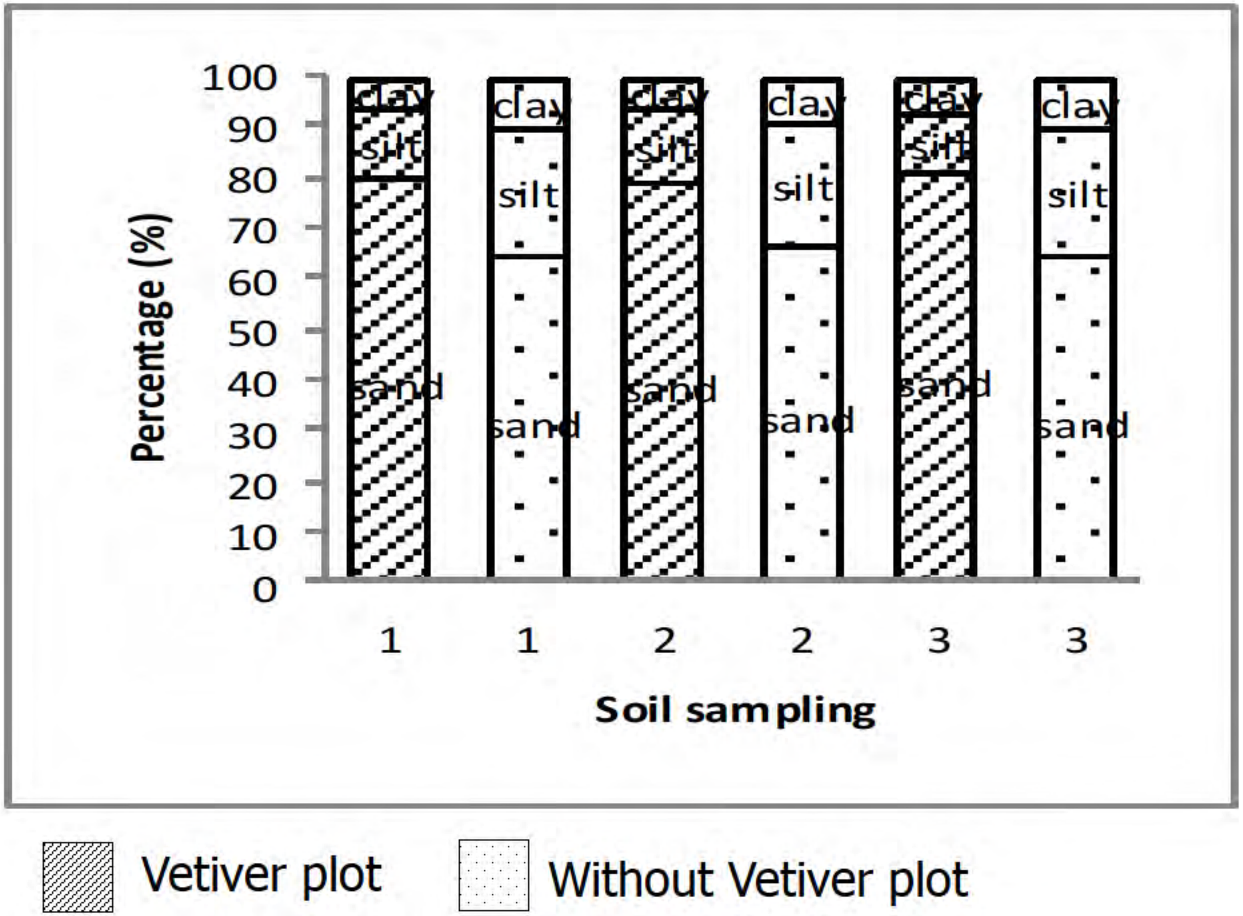
The soil Eh in vetiver plot was slightly higher than without vetiver plot in all rice growth stages. This may be the results of

(1) higher percentage of sand particles in vetiver plot; and

(2) the cultivation of vetiver which had deeper and numerous fibrous root system in comparison to sunn hemp in the plot without vetiver.

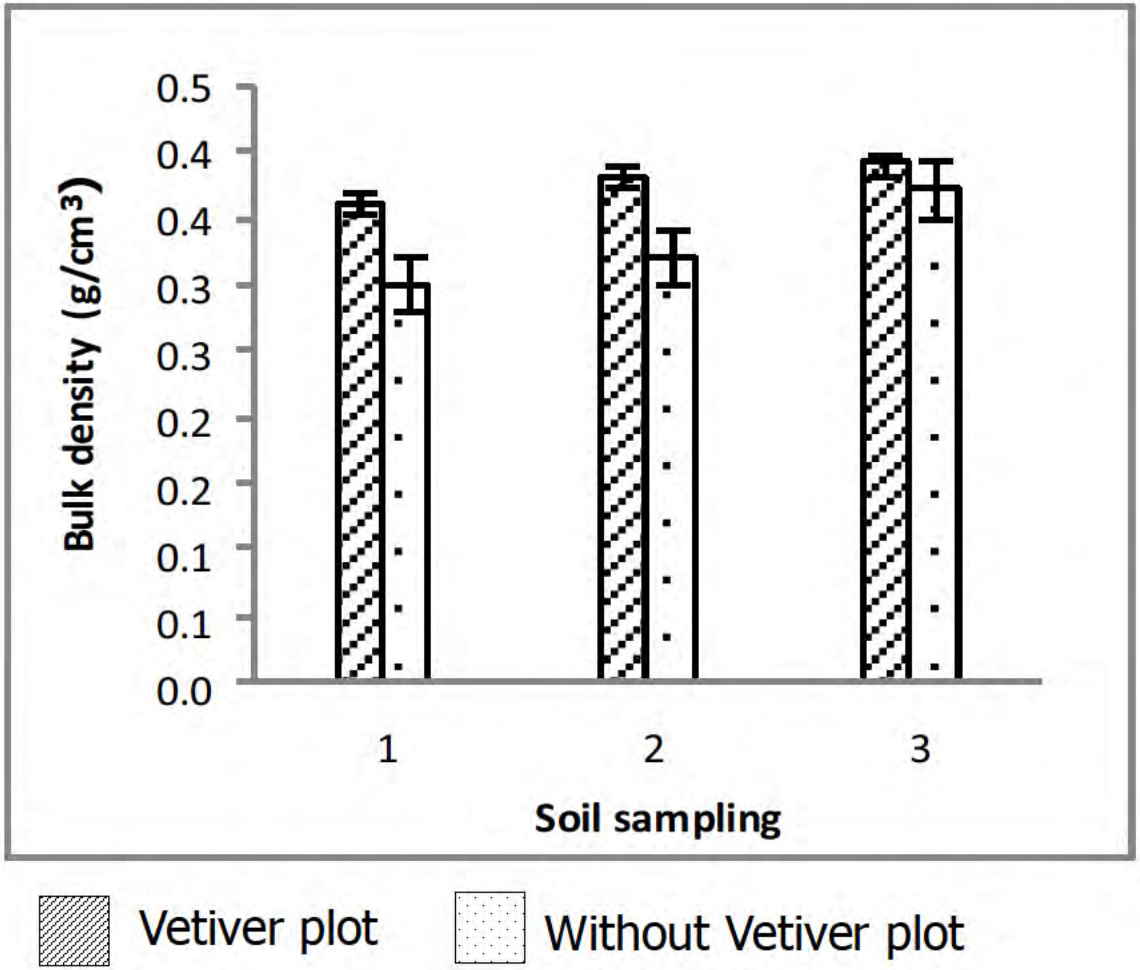
The vetiver root may penetrate deep into the soil and bind particles into aggregates. Thereby the aggregates and pore of soil in vetiver plot may improve the movement of air. As a result, more O_2 could diffuse into the soil.

Texture



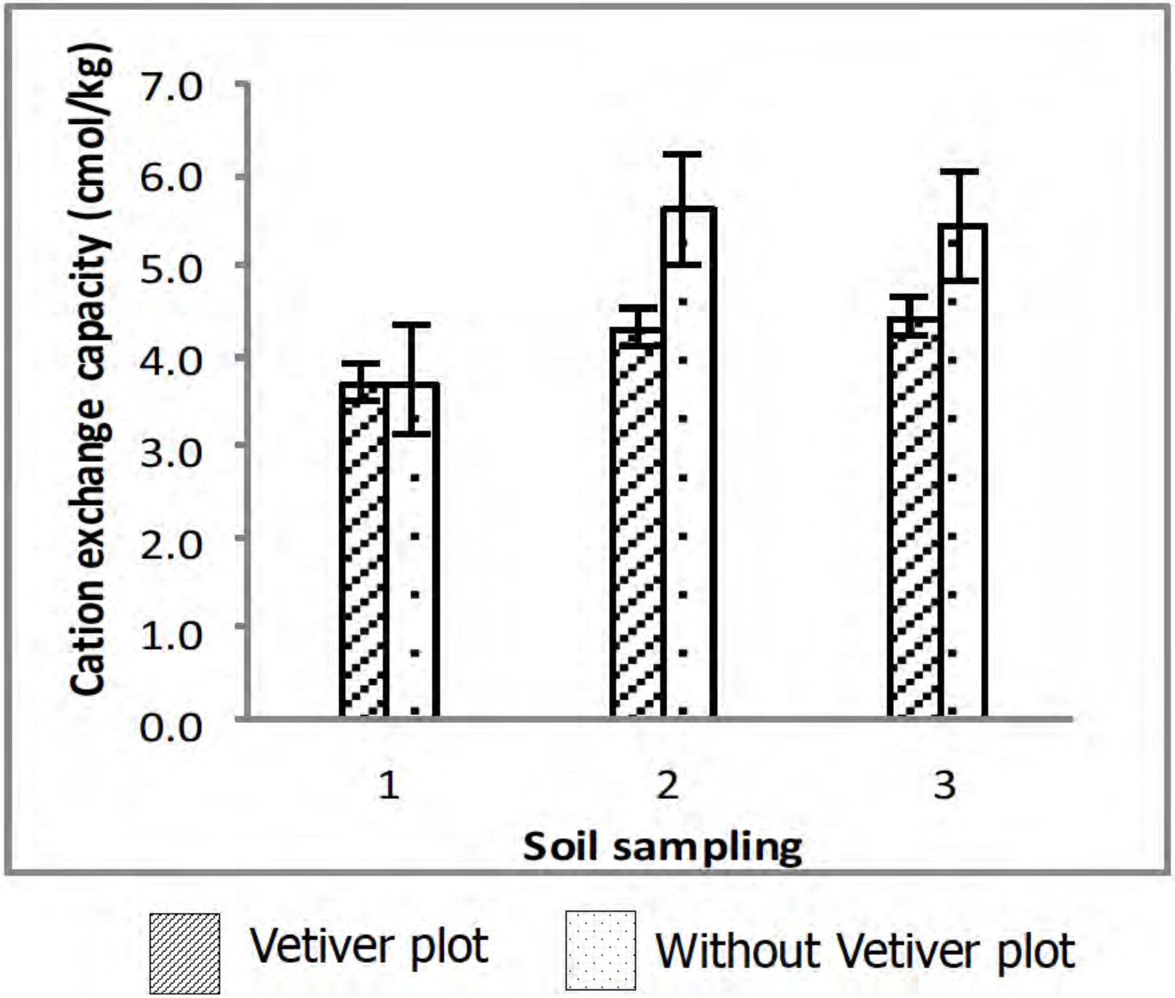
Soil in vetiver plot was loamy sand with 79-81% sand and 6-7% clay whereas soil in without vetiver plot was sandy loam with 65-67% sand and 9-10% clay.

Bulk density



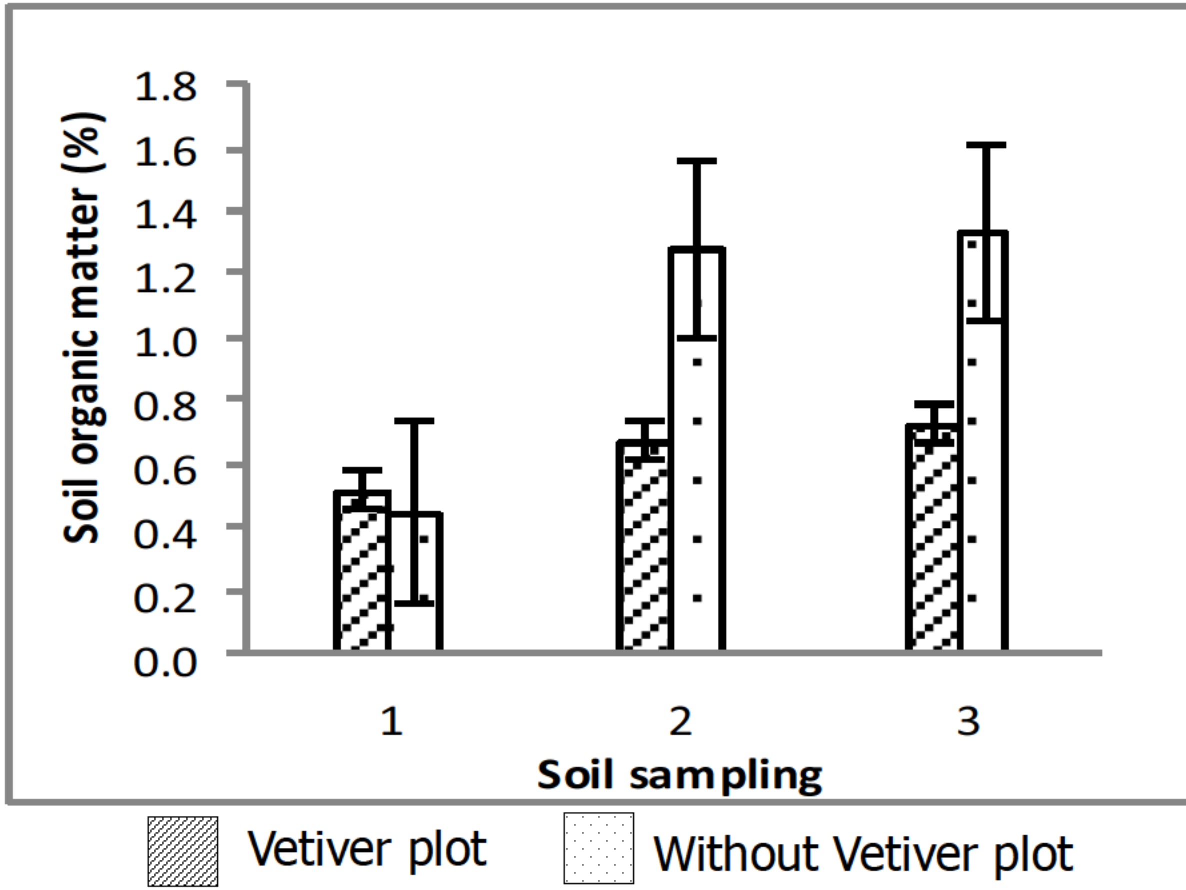
- In the beginning of the study, soil in vetiver plot had higher bulk density than without vetiver plot (1.3 and 1.2 g/cm^3, respectively). This may be due to coarser soil texture and lower OM in vetiver plot.
- Generally, sandy soils have relatively high bulk density since total pore space in sand is less than that of silt or clay soils. In addition, soil contains higher organic matter have lower bulk density.

CEC



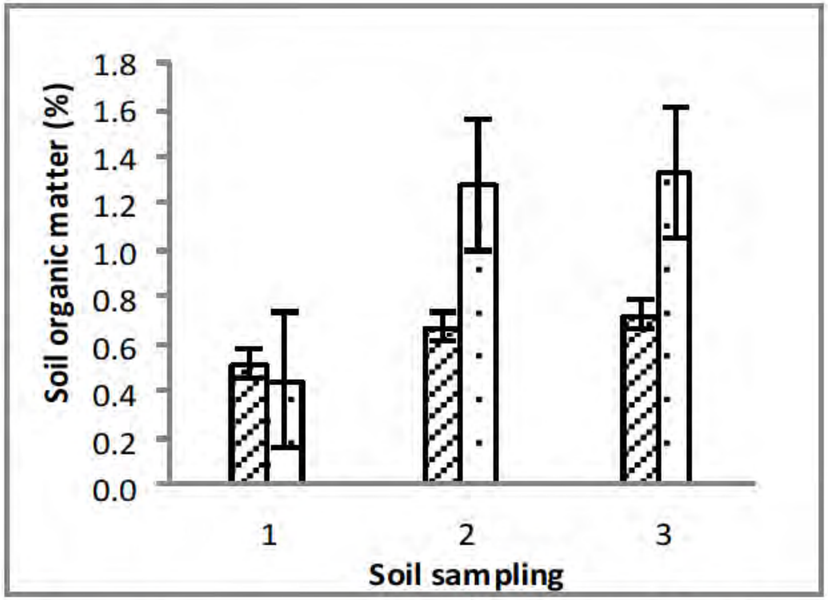
Cation exchange capacity (cmol/kg)
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
1
2
3
Soil sampling
Vetiver plot
Without Vetiver plot

Organic Matter

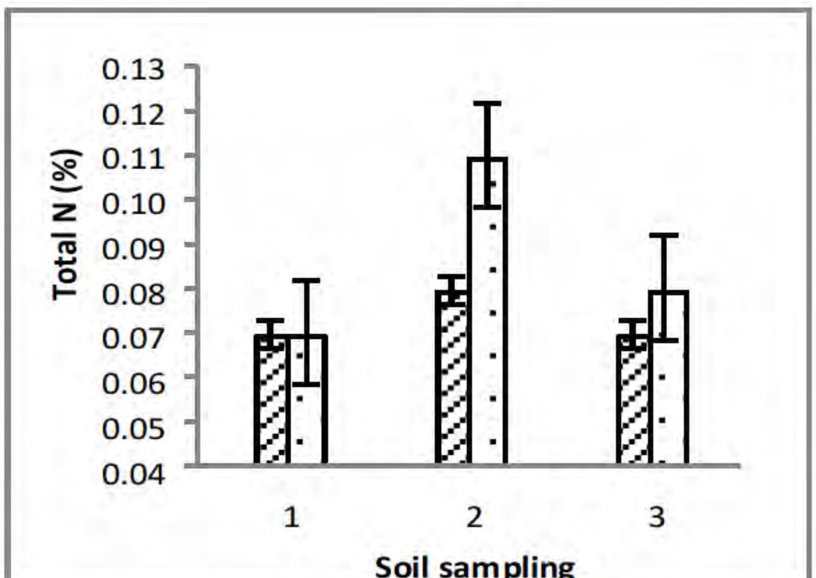


- In the beginning of the study, OM in vetiver plot was higher than without vetiver plot. This may be due to the different between the duration of plowing and incorporation of vetiver and sunn hemp into soil, i.e. vetiver and sun hemp were incorporated into soil 45- and 15-days before 1st soil sampling, respectively. Thus some part of vetiver could be decomposed.
- But for the 2nd and 3rd soil samplings,OM showed the opposite trend, i.e. it was higher in without vetiver plot. Similar trends were found in total N and available P.

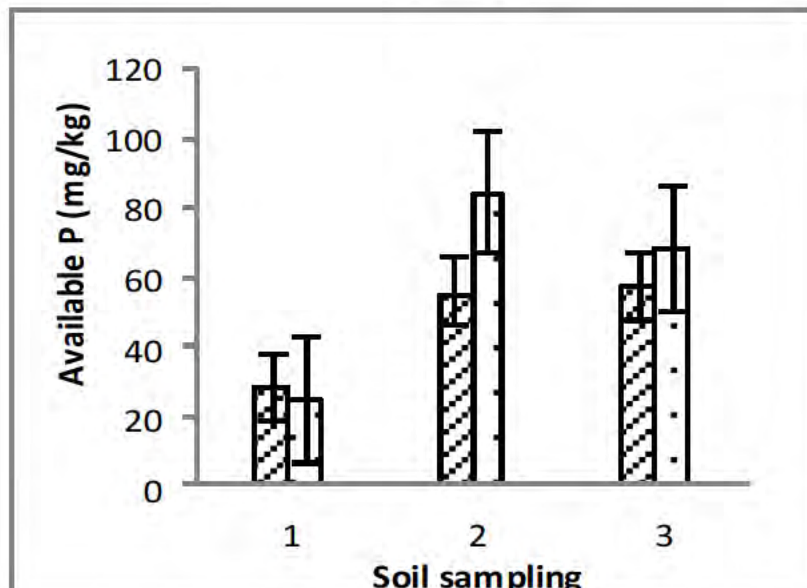
Organic Matter



Total nitrogen



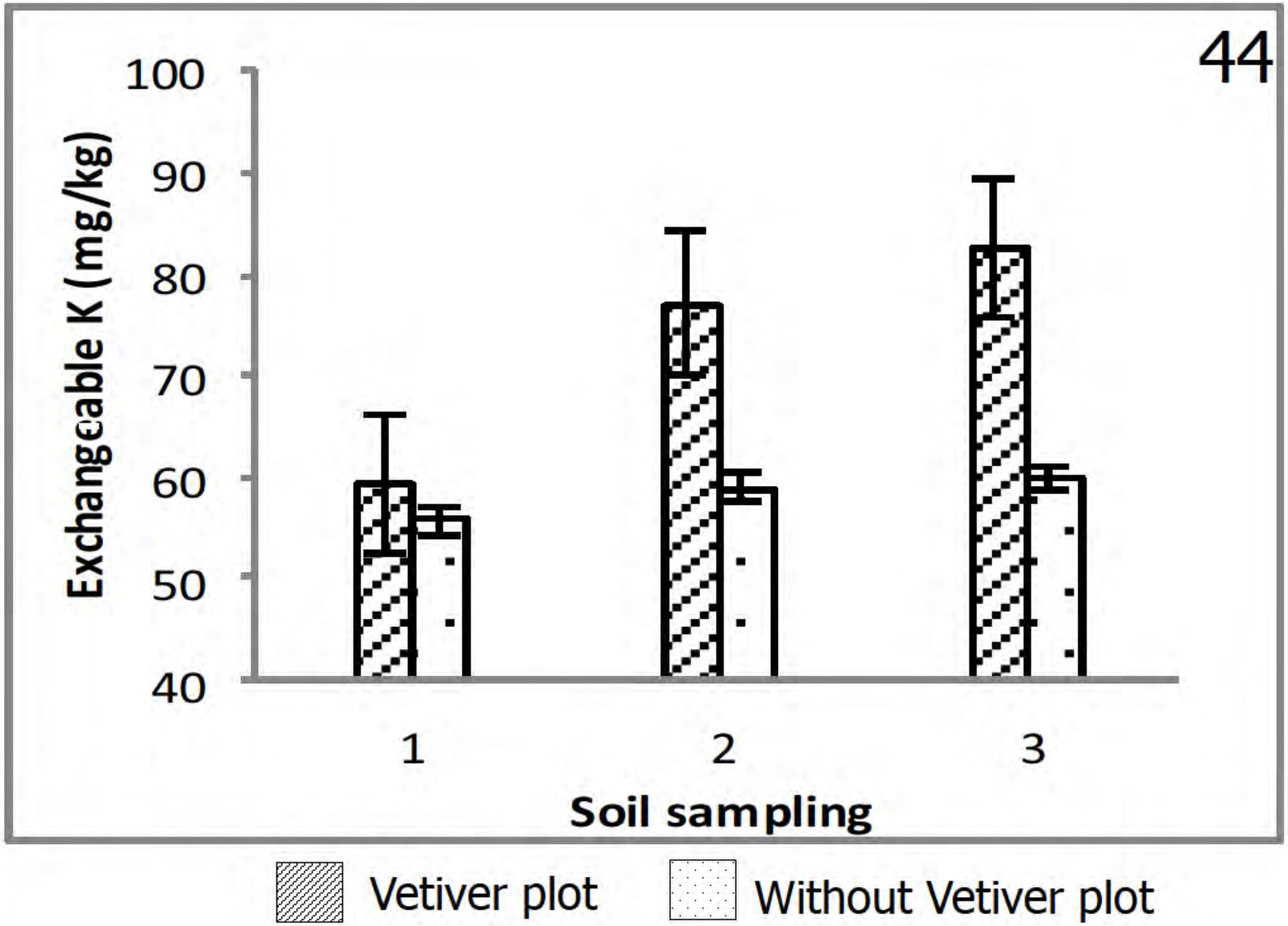
Available phosphorus



0.00

Vetiver plot   Without Vetiver plot

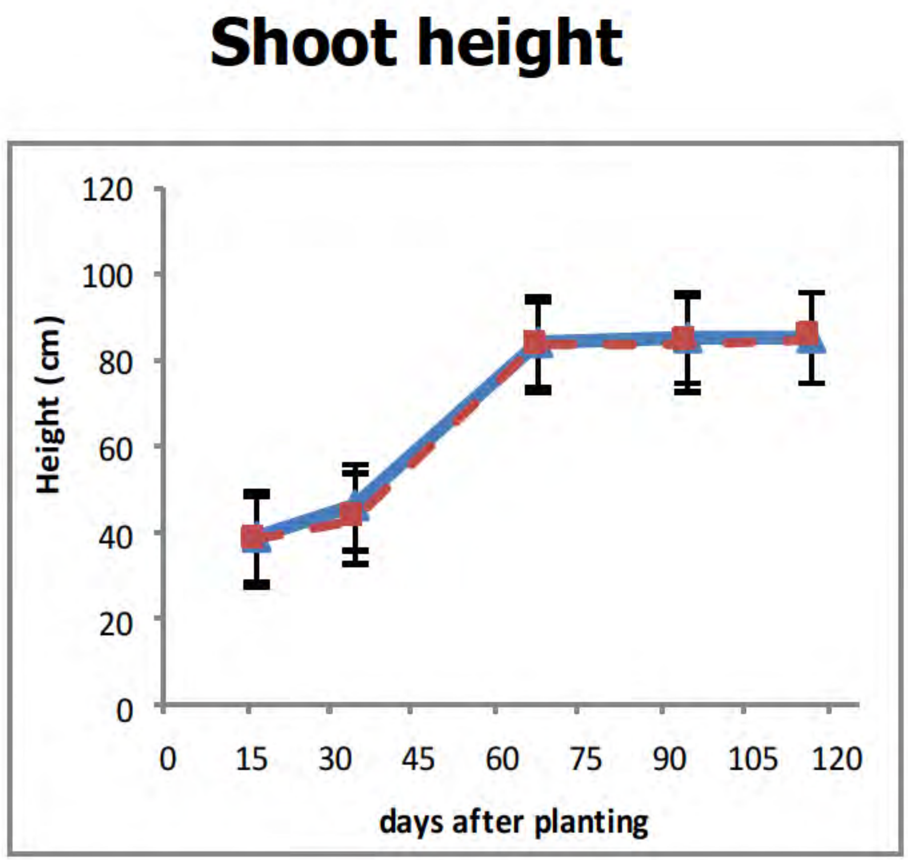
Exchangeable potassium

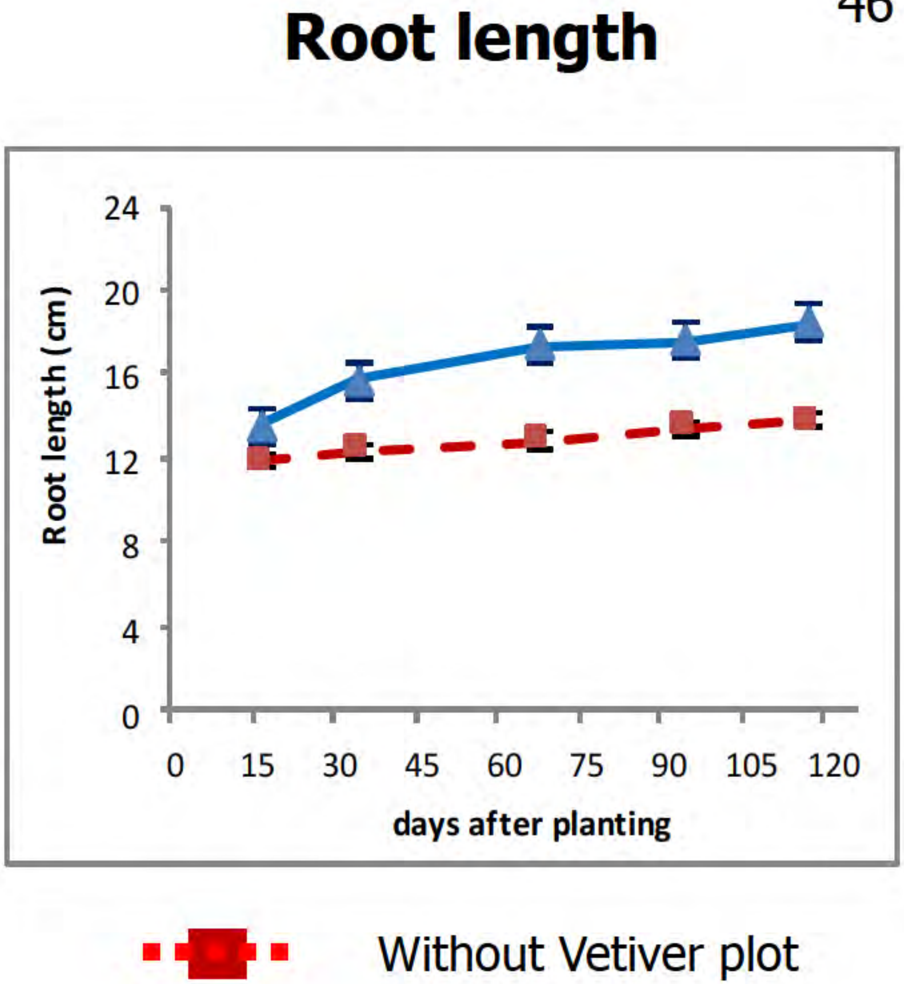


- Exchangeable K in vetiver plot was higher than without vetiver plot in all sampling times. This may be due to higher K constituent in vetiver than sunn hemp (15.46 and 2.40 % dry weight, respectively).

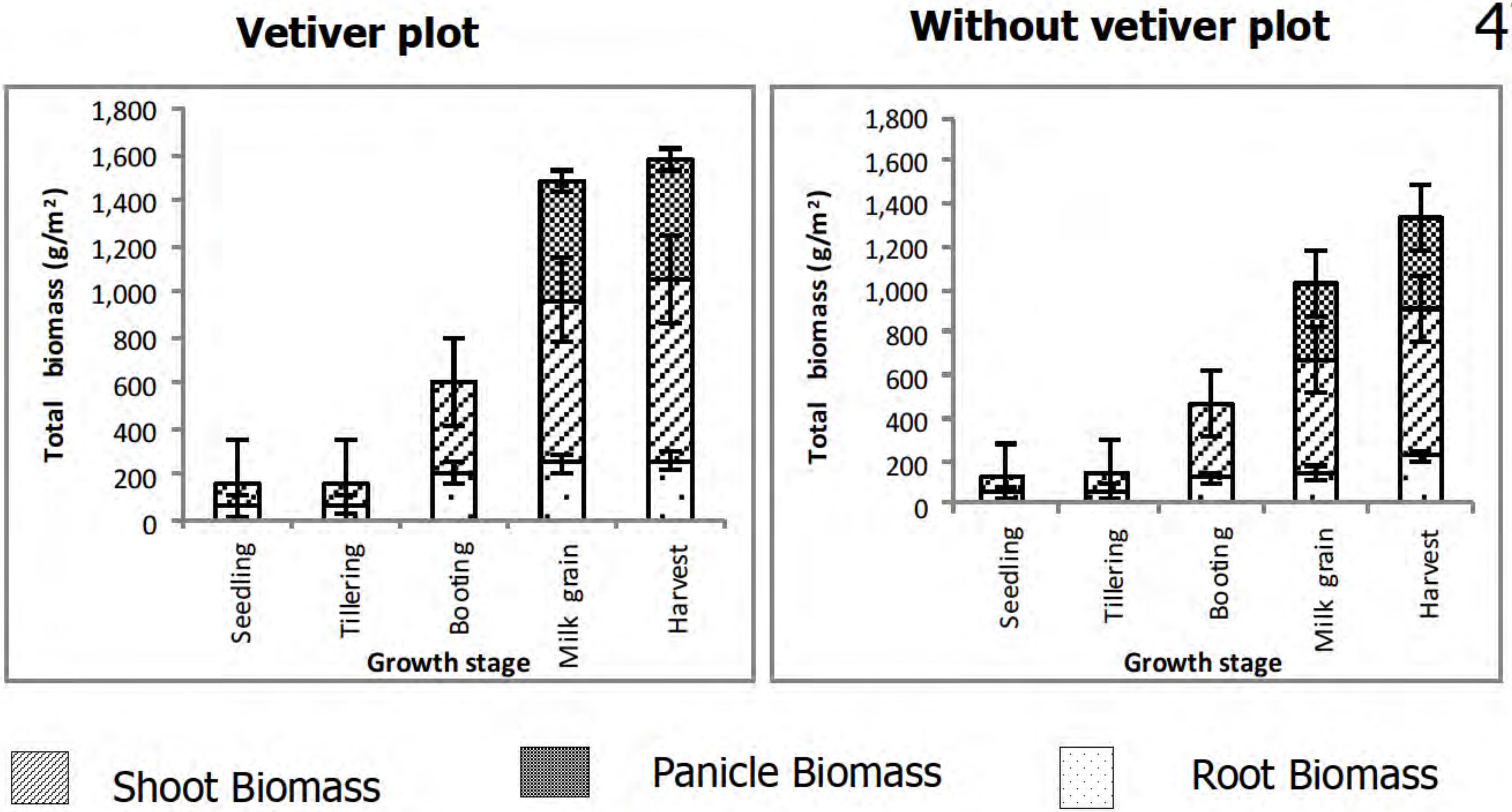
- As a result, higher K could be released when vetiver was decomposed.

Growth of Rice Plant





Shoot height and root length of rice plants in vetiver plot were higher than without vetiver plot in all growth stages.



The biomass of rice plants in vetiver plot were higher than without vetiver plot in all growth stages.

Average rice grain yield and harvesting index

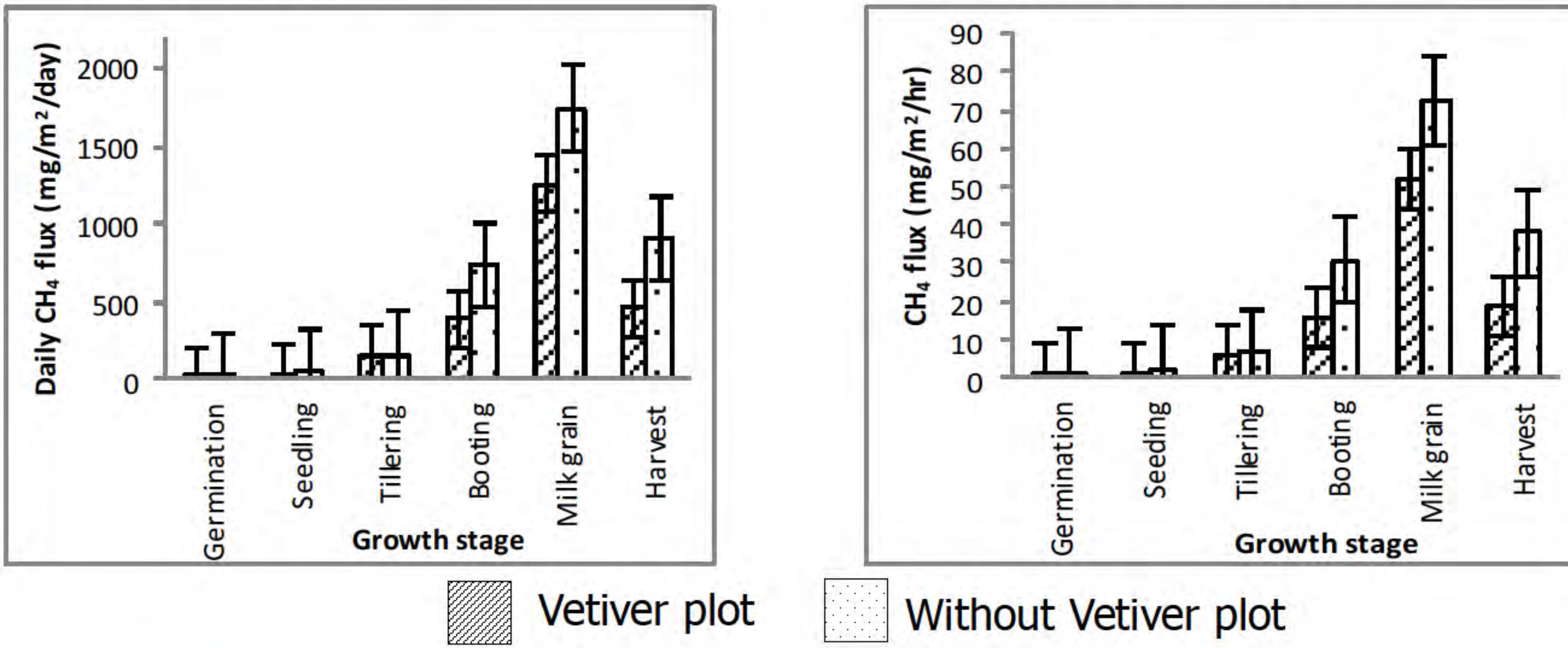
Average rice grain yield and harvesting index

Parameters	Vetiver plot	Without vetiver plot
No. of panicle per area (m^2)	211$\pm$ 18	197 $\pm$ 18.4
No. of grains per panicle	57.7 $\pm$ 6.7	44.0 $\pm$ 5.2
Percent of good quality grains	72.5 $\pm$ 3.5	65.5 $\pm$ 2.2
1,000 grain weight (g)	23.7 $\pm$ 1.0	22.6 $\pm$ 1.3
Grain yield (kg/ha)	2631 $\pm$ 41	2344 $\pm$ 40

In harvesting stage grain yield and all havesting index in vetiver plot was higher than without vetiver plot. .

Methane Fluxes

Hourly methane fluxes / Daily methane fluxes



-Methane fluxes gradually increased from germination stage and reached a maximum in milk grain stage. Fluxes then declined in harvesting stage.

- Methane fluxes in vetiver plot were lower than without vetiver plot in all rice growth stages.
- This may be the result of soil improvement by vetiver which contributed to better diffusion of O_2 deep into the soil. Since methane can be produced by methanogens in anaerobic environment, thus the production of methane declined.

-The highest methane flux in milk grain stage was 1,250 mg/m^2/day in vetiver plot and 1,740 mg/m^2/day in without vetiver plot.

-The average methane fluxes in both plots during the entire growth period were 379 mg/m^2 in vetiver plot and and 607 mg/m^2 in without vetiver plot.

- The methane fluxes were lower than other studies which may due soil properties which was coarsed texture and contained low OM.

Conclusion

Restoration of deteriorated paddy field

Higher soil exchangeable K and soil redox potential

Improve rice production, harvesting index and carbon accumulation in rice plant

Mitigate methane emission during rice plant cultivation

Acknowledgement

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Thank you

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