XX OIL PALM International Conference

THE TRANSFORMATIVE POWER OF OIL PALM

Agroecological management of oil palm and impacts on soil health variables and crop nutrition

J-P. Caliman

SMART Research Institute (Pt SMART)

sinarmas agribusiness and food

Contribution:

SMART Research Institute:

Suhardi, Hasbullah, D. Purnomo, A. A. K. Aryawan, M. P. D. Cahyani, R. S. Tarigan, S. Listyaningsih, J. P. Dewi, D. Sentosa, B. Septiwibowo, B. Hadiwijaya, E. N. Azmi

University of Cambridge, University of Nottingham :

E. C. Turner, M. D. Pashkevich, S.H. Luke, K. M. Nicholass

Agro-Ecosystems
Biomass recycling
Ecology
Soil Degradation
Plant Drought Tolerance
Ecosystem Services
Plant Disease Resistance
Interactions
Adaptation
Agroecology
Living Organisms
Agriculture
Biodiversity
Soil Nutrients
Intercropping
Green House Gases
Wastes Recycling
Cover Crop
Climate Change
Soil Health
Soil Organic Matter
Best Practices
Integrated Pest Management

Agroecology:

FAO, OECD: Holistic and integrated approach, applying the concepts and principles of ecology to agriculture

Application of ecological concepts and principles to the design and management of sustainable agroecosystems
Gliessman (1998)

Optimize the relation between plants, animals, environment, humans
Dalgaards et al. (2002)

Integrative study of the ecology of the entire food system
Francis, et al. (2003)

Agroecology:

FAO, OECD: Holistic and integrated approach, applying the concepts and principles of ecology to agriculture

Not specifically associated to a particular farming system

Intensive agriculture
Extensive agriculture
Conservation agriculture
Regenerative agriculture
Organic agriculture
Biodynamic agriculture
…

Uses different sciences

Soil properties
Plant – insect interactions
Social sciences
Climate

Farmers survey (France): 75 % farmers involved in agro-ecology

TNC 19/09/2022

50 % of cereals French farmers are involved in agro-ecological practices © Pixabay

Practice	
Biomass recycling to soils	70 %
Soil covers	87 %
Leguminous crops	64 %
Plant resistant to diseases	88 %
Mechanical weeding	40 %
Solutions for N-fertiliser reduction	22 %
Biostimulants	43 %
Digitalization and Precision Agro to reduce inputs	69 %
Precision Agriculture equipment	64 %
…	

Objectives: reach environmental and financial sustainability
(60 % of farmers)

Challenges:
- **Technical (60 % of farmers)**
- **Financial (53 % of farmers)**

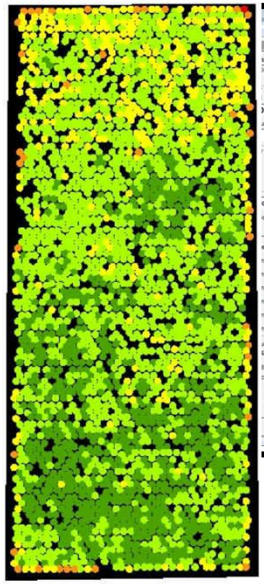
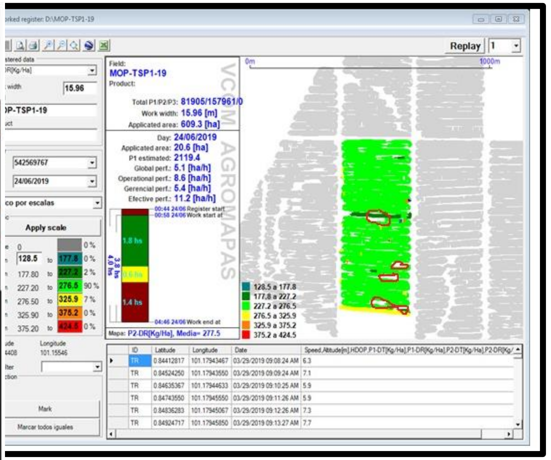
Agroecology Implementation in Oil Palm Cultivation






Practice
Integrated pest management
Barn owls, beneficial plants, pheromones, virus, …
Leguminous crops covers
Plant resistant to diseases
Selective weeding
Solutions for N-fertiliser reduction
Microbes (metarhyzium, mycorrhiza, bacteria, fungi, …)
Biostimulants
Digitalization and Precision Agro to reduce inputs
Precision Agriculture equipment
…

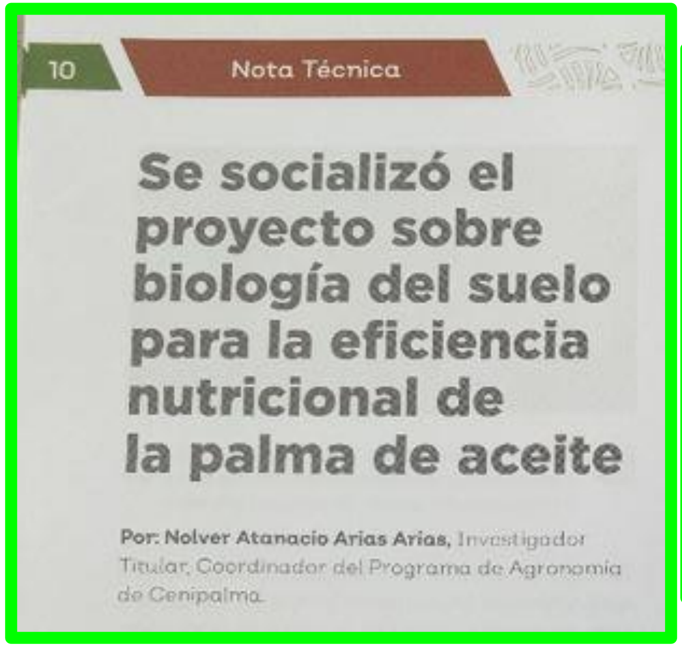
<u>Similar objectives and challenges</u>

Agroecology Implementation in Oil Palm Cultivation in Colombia

Practice
Integrated pest management
Barn owls, beneficial plants, pheromones, virus, …
Leguminous crops covers
Plant resistant to diseases
Selective weeding
Solutions for N-fertiliser reduction
Microbes (metharyzium, mycorrhiza, bacteria, fungi, …)
Biostimulants
Digitalization and Precision Agro to reduce inputs
Precision Agriculture equipment
…

Cenipalma special project on soil microba


10 Nota Técnica

Se socializó el proyecto sobre biología del suelo para la eficiencia nutricional de la palma de aceite

Por: Nolver Atanacio Arias Arias, Investigador Titular, Coordinador del Programa de Agronomía de Cenipalma

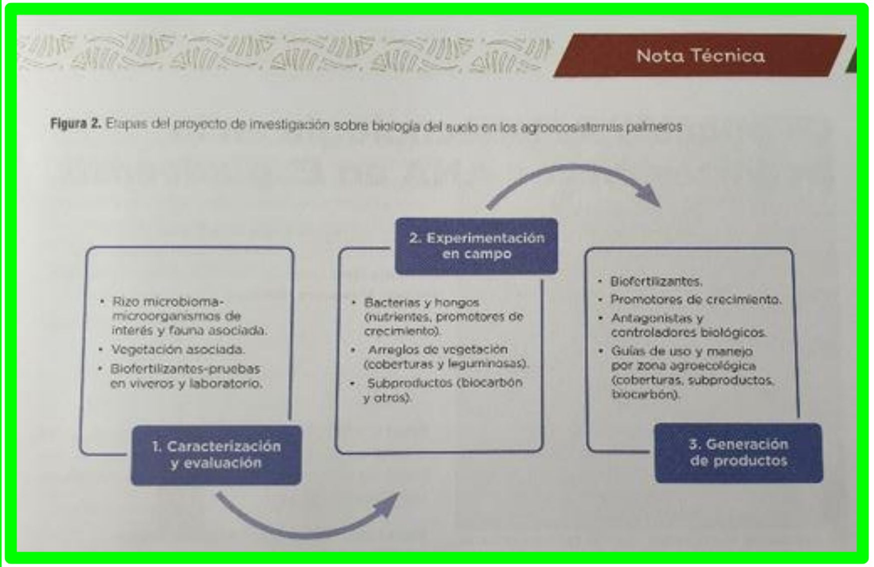


Figura 2. Etapas del proyecto de investigación sobre biología del suelo en los agroecosistemas palmeros

Soil is alive: decomposition of organic matter (nutrient, water, structure, …)

1 g soil = 600 000 000 bacteria
1 ha = 15 t bacteria (# 15 cows) !

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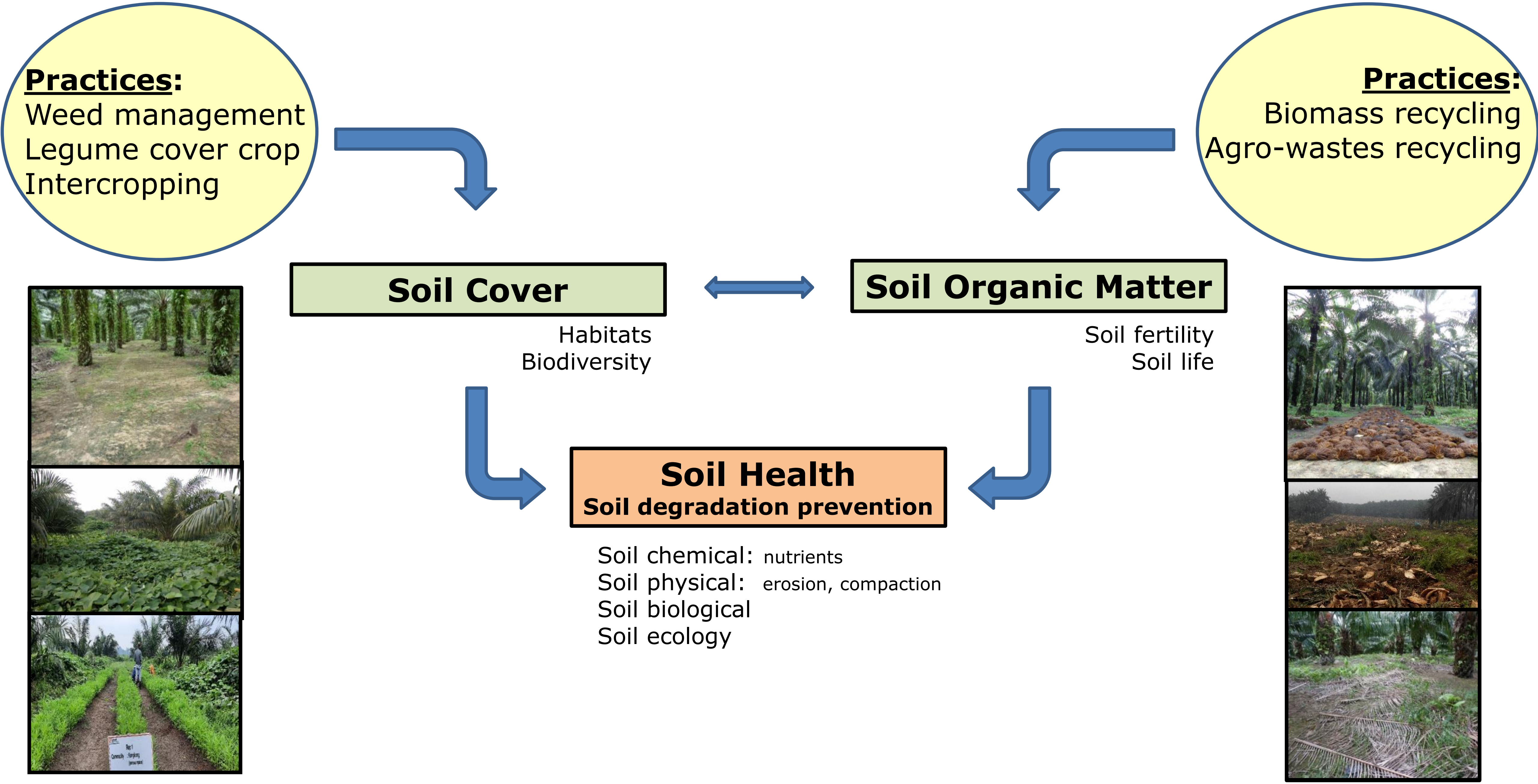
Agroecology Practices for Soil Health in Oil Palm



Soil Cover: weed management

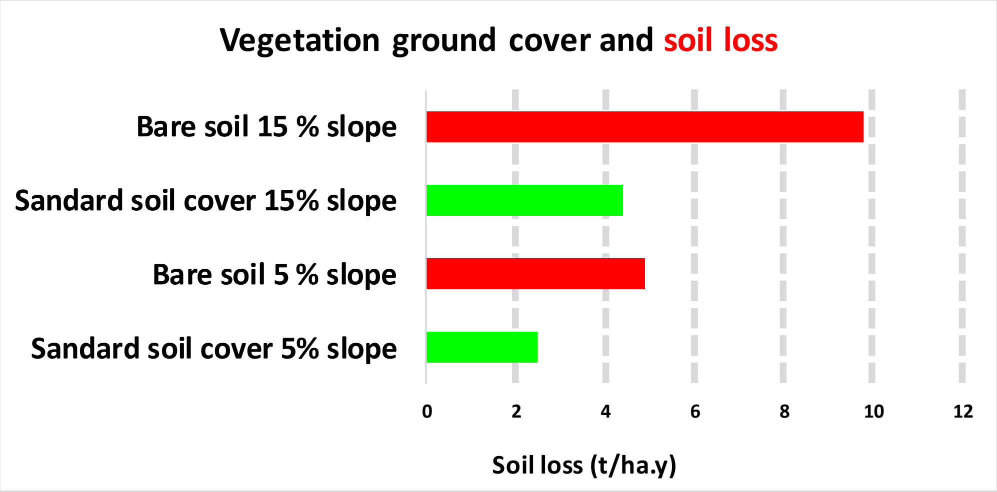
"Golf course" type

Selective weed control
(space, time, species, a.i., rate)

Bare soil
(high herbicides consumption)

Soil Cover: weed management; impact on soil physic (erosion)

Selective weed control
(space, time, species, a.i., rate)



Bare soil

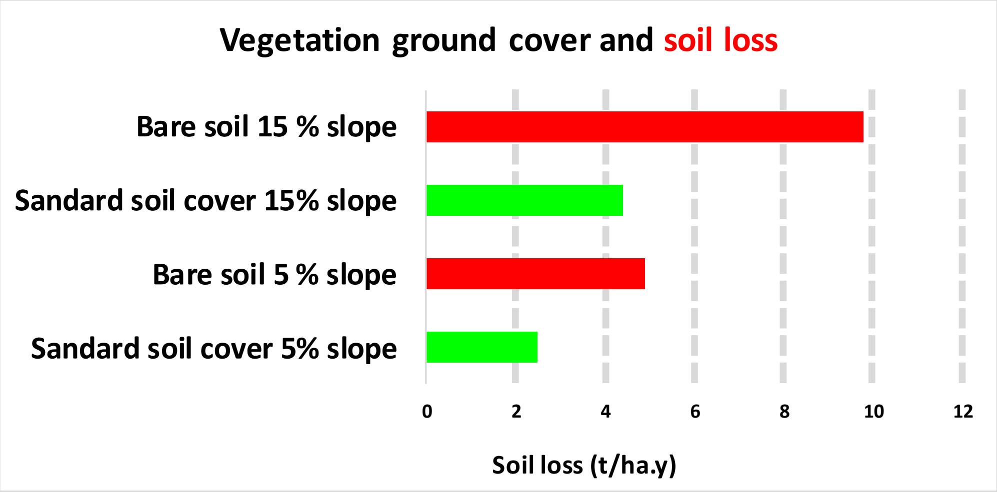
Soil needs long time to be produced: 1 mm needs 20 to 200 years

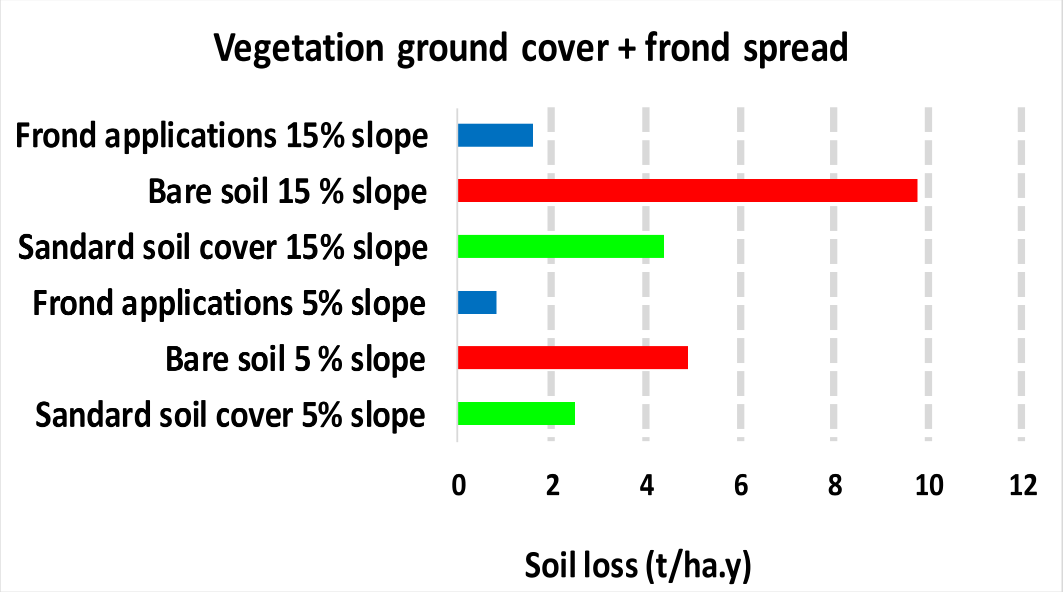
Soil Cover: weed + biomass management; impact on soil physic (erosion)

Selective weed control
(space, time, species, a.i., rate)

Bare soil

Fronds spread





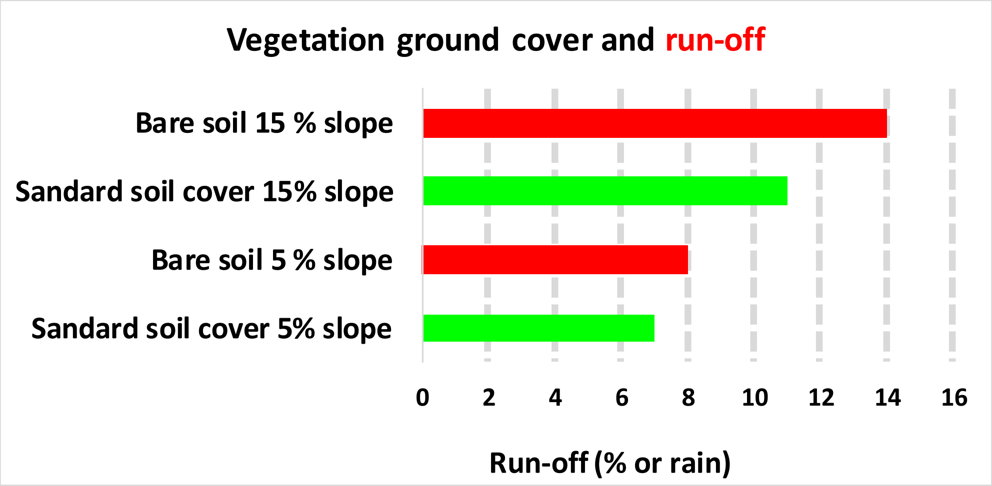
Soil needs long time to be produced: 1 mm needs 20 to 200 years

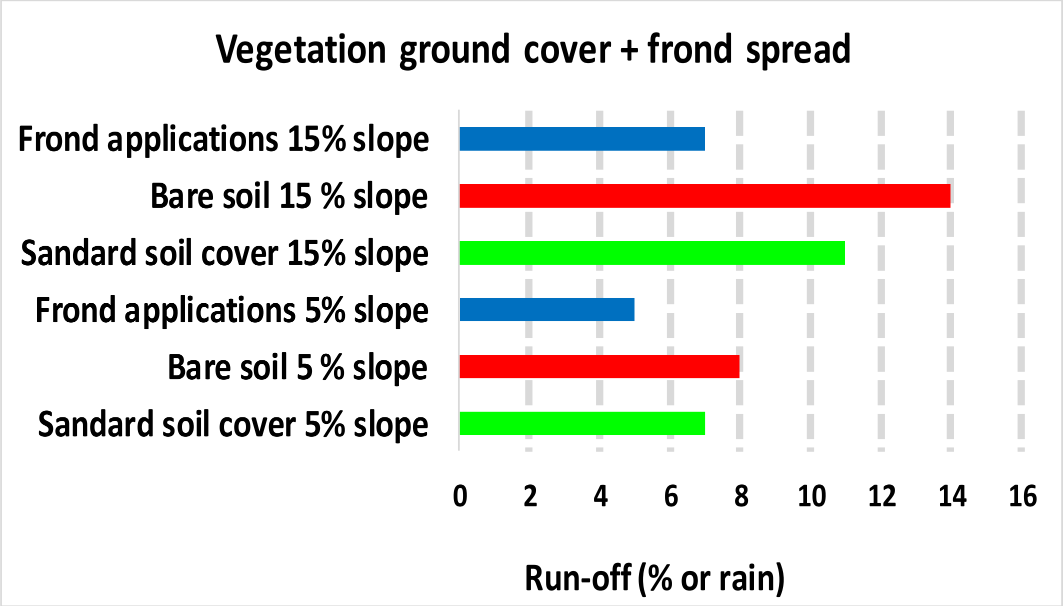
Soil Cover: weed + biomass management; impact on soil physic (run off)

Selective weed control
(space, time, species, a.i., rate)

Bare soil

Fronds spread





Run off increases water deficit

Soil Cover: weed + biomass management; impact on palm yield

Selective weed control
(space, time, species, a.i., rate)

Bare soil

		Standard ground vegetation cover (kg/palm.y)	Bare soil (kg/palm.y)	Bare/Standard
Indonesia	2015-2019	146.8	160.3	+ 9 %
Cote d'Ivoire	1969 (4 to 8 years old)	192.6	266.5	+38 %

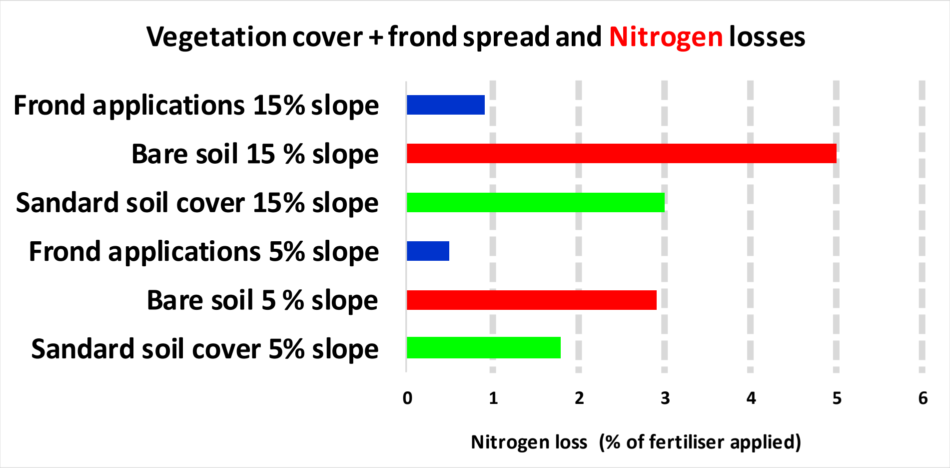
Soil vegetation cover increases water competition during drought (El Nino year: +25 %)

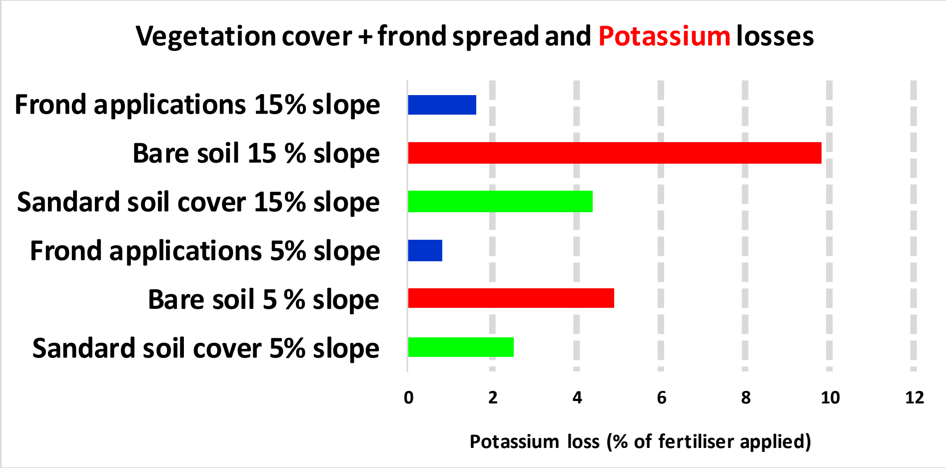
Soil Cover: weed + biomass management; impact on soil nutrients (losses)

Selective weed control
(space, time, species, a.i., rate)

Bare soil

Fronds spread





Soil cover and/or frond spreading reduces nutrients losses

Soil Cover: weed + biomass management; impact on soil nutrients (losses)

Selective weed control
(space, time, species, a.i., rate)

Bare soil

Fronds spread

Nutrients losses through run-off (% of input)

Weeds management	Nitrogen	Phosphorus	Potassium
Standard vegetation soil cover	1.1 %	1.4 %	0.6 %
Bare soil	2.5 %	2.7 %	0.8 %
Fronds spread (including harvesting paths)	0.6 %	0.4 %	0.4 %

Slope: 5 %

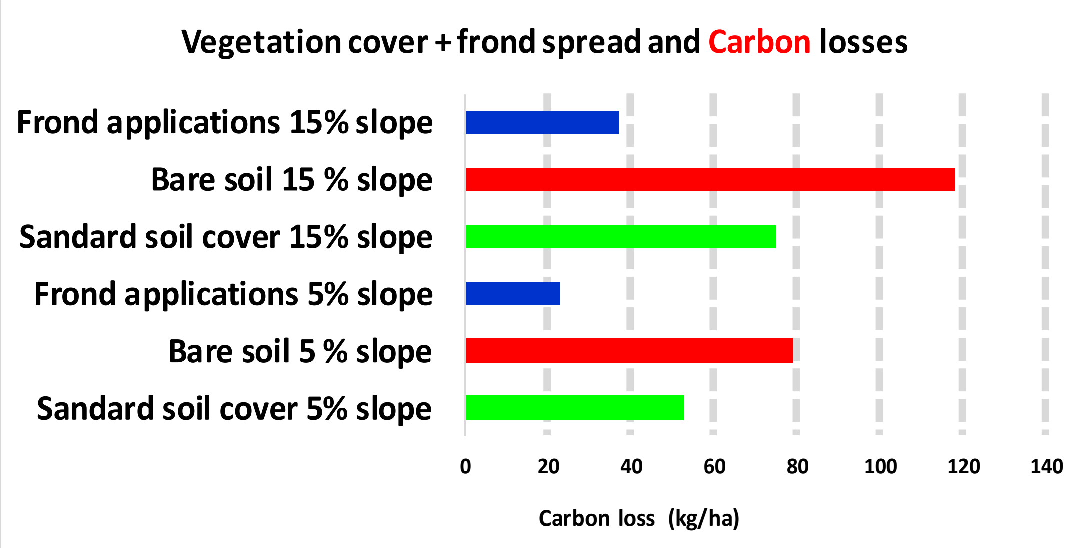
Soil cover and/or frond spreading reduces nutrients losses

Soil Cover: weed + biomass management; impact on Carbon loss

Selective weed control
(space, time, species, a.i., rate)

Bare soil

Fronds spread

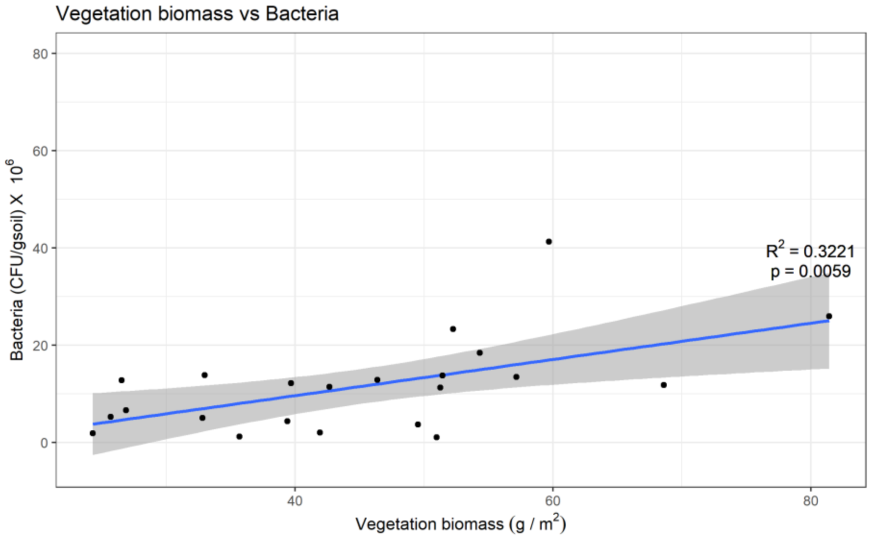


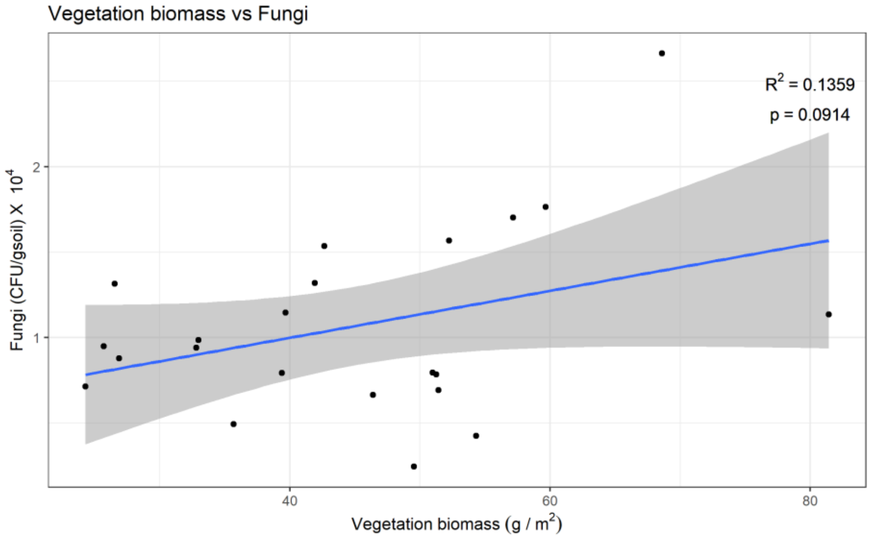
Soil cover and/or frond spreading reduces carbon losses through erosion and run-off

Soil Cover: weed management; impact on soil biology

Selective weed control
(space, time, species, a.i., rate)

Bare soil



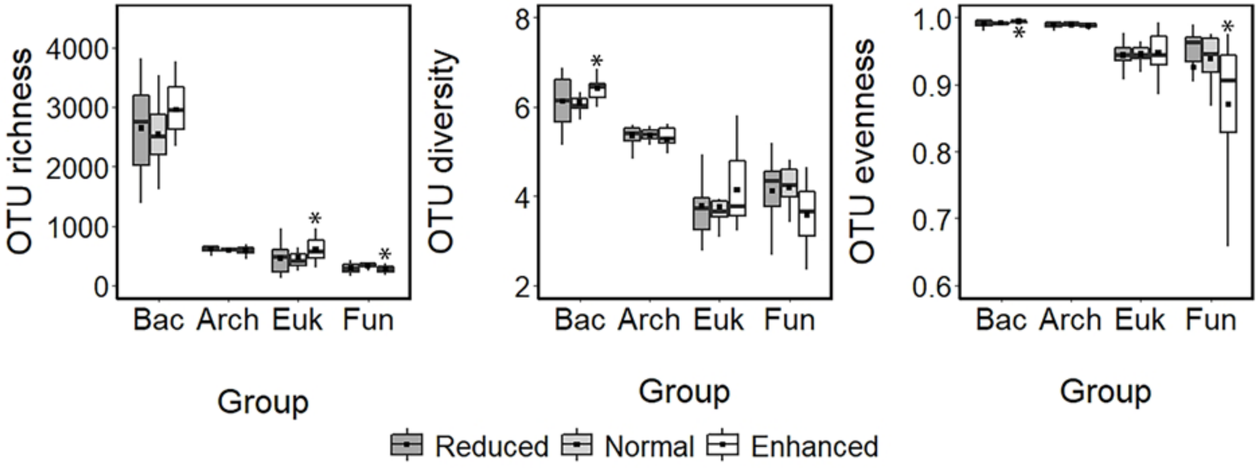


Vegetation cover enhances soil biological life: bacteria and fungi number increase

Soil Cover: weed management; impact on soil biology

Selective weed control
(space, time, species, a.i., rate)

Bare soil



<u>BEFTA</u>

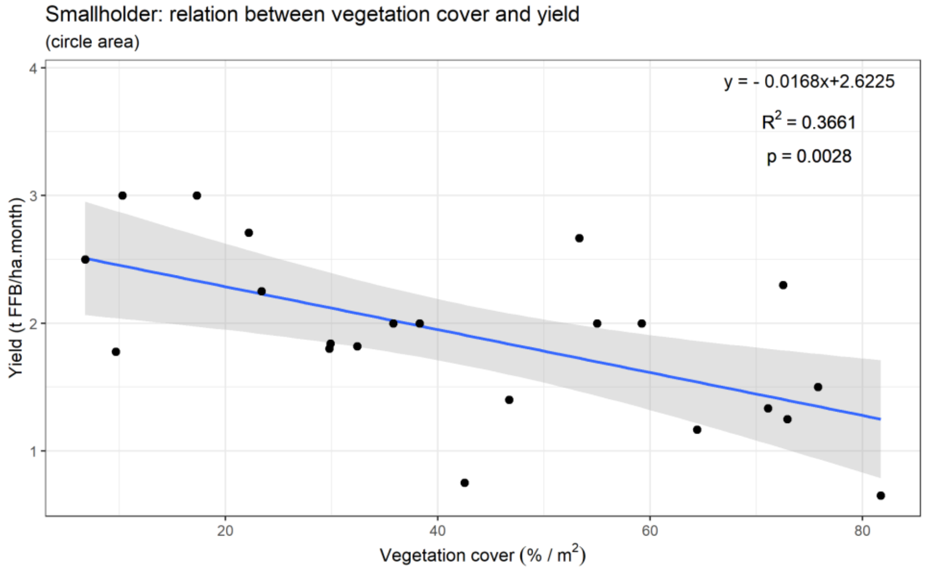
Operational Taxonomic Units (OTU)
. Richness
. Shannon’s diversity
. Simpson's evenness

Soil vegetation cover affect some aspects of the richness & diversity of soil microbial communities, and composition of all groups (metagenomic approach)

Soil Cover: weed management; impact on palm yield

Selective weed control
(space, time, species, a.i., rate)

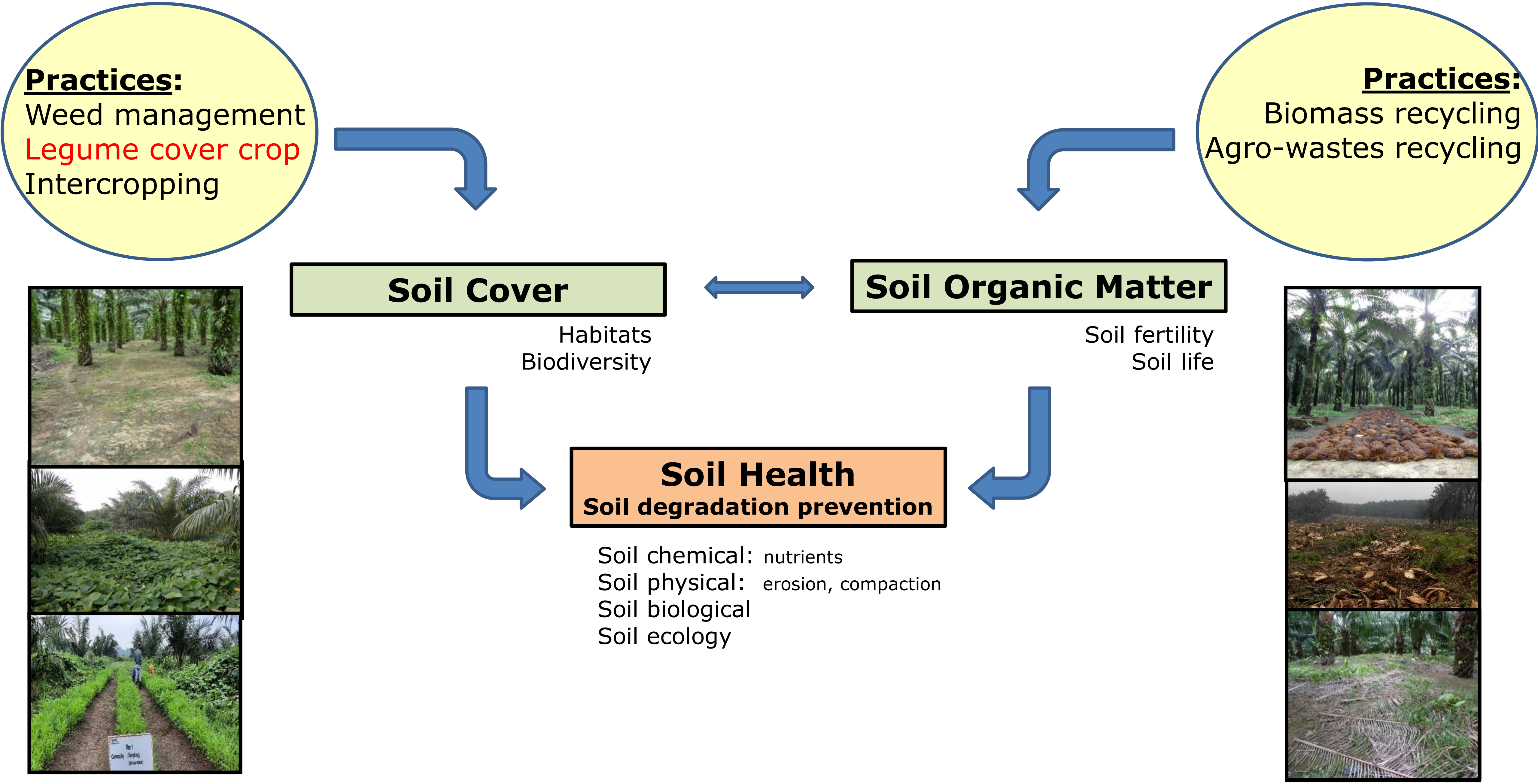
Bare soil



In smallholder plantations, un-managed ground vegetation covers might impact impacts harvested crop:

10 % soil cover in circle = - 5% yield

Agroecology Practices for Soil Health in Oil Palm



Soil Cover: Legume cover crop; impact on land biological characteristics



<u>Legume cover crop</u>: ecosystem services provided to oil palm cultivation

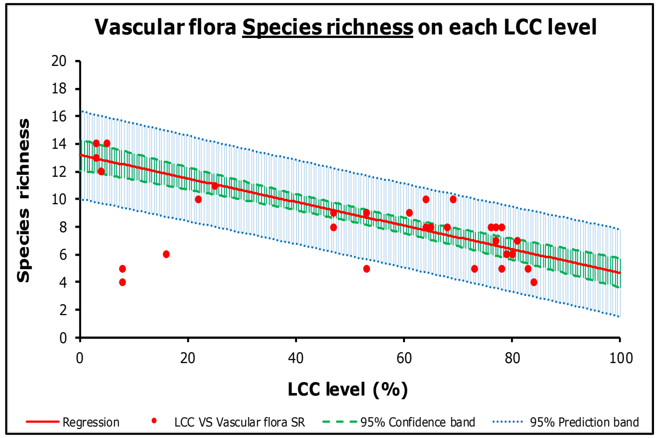
- **Soil physical protection**
- **Biological nitrogen fixation** (230 kg N/ha over 2 years)
- **Impact on land biological characteristics?**

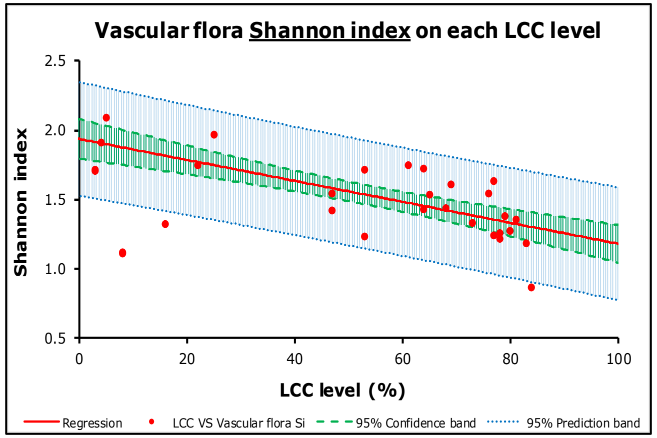
Soil Cover: Legume cover crop; impact on land biological characteristics

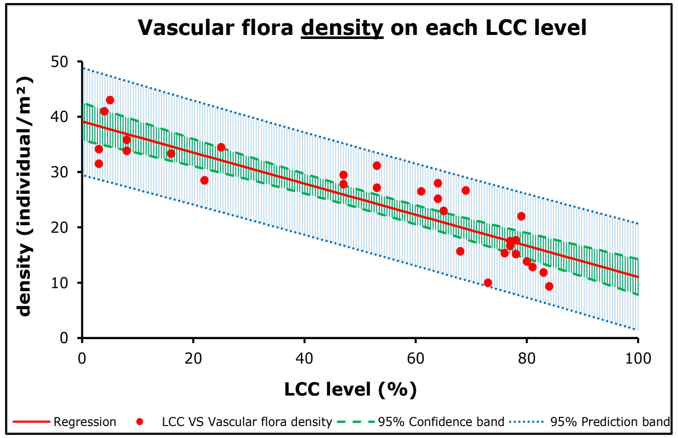
Study of mixed (LCC – weeds vegetation soil cover)

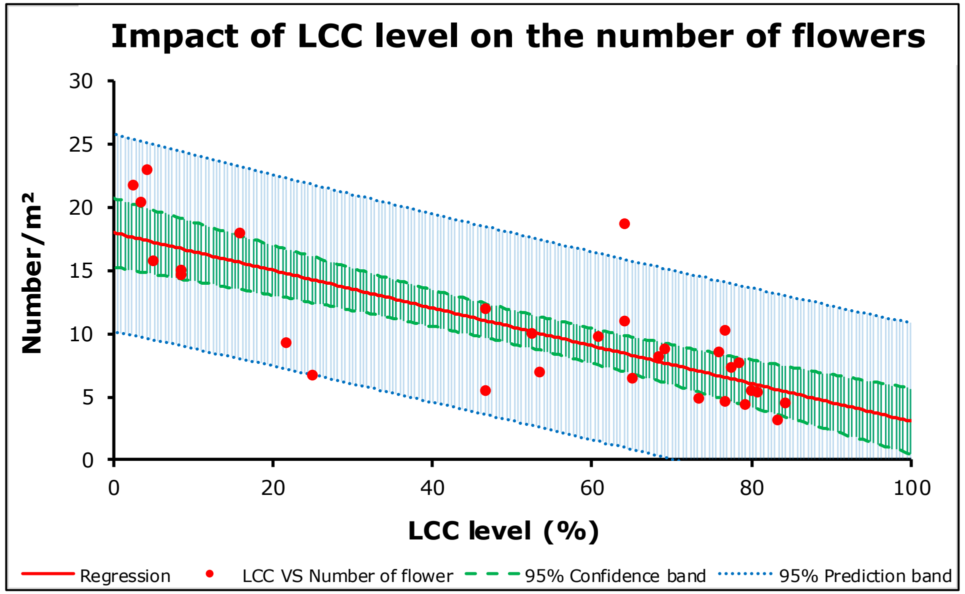
Soil Cover: Legume cover crop; impact on land biological characteristics

Study of mixed (LCC – weeds vegetation soil cover)





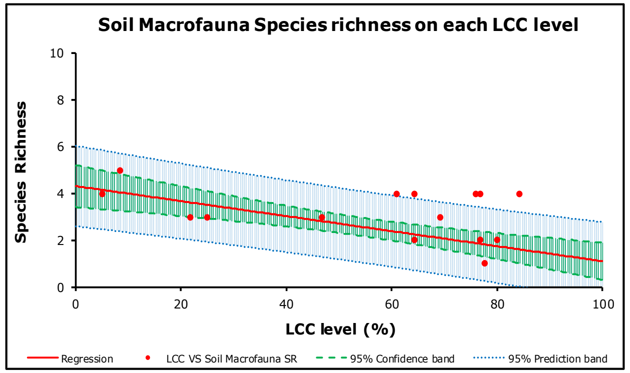


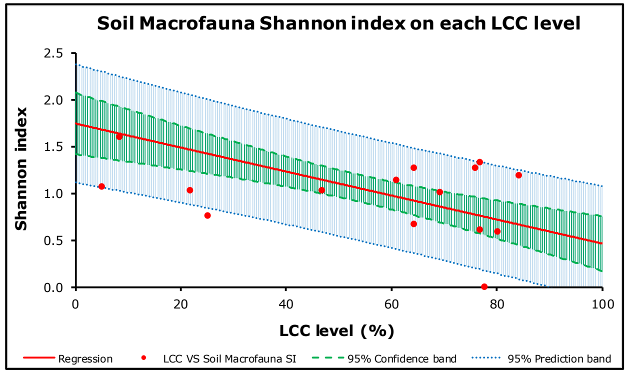


Mixed cover crop results in a higher number of flowers

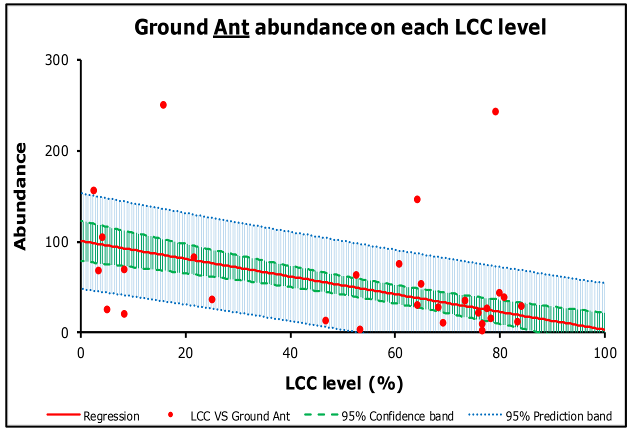
Soil Cover: Legume cover crop; impact on land biological characteristics

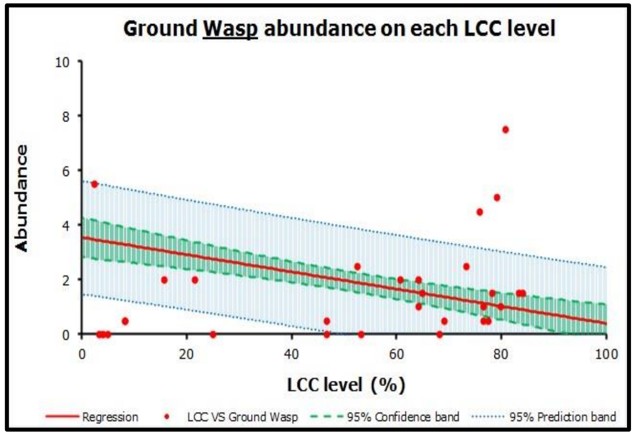
Study of mixed (LCC – weeds vegetation soil cover)

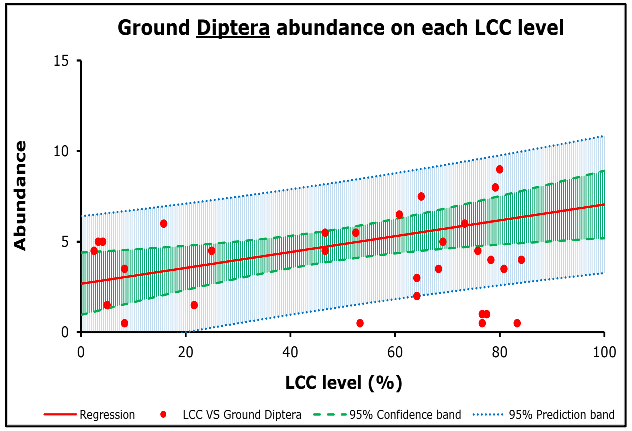


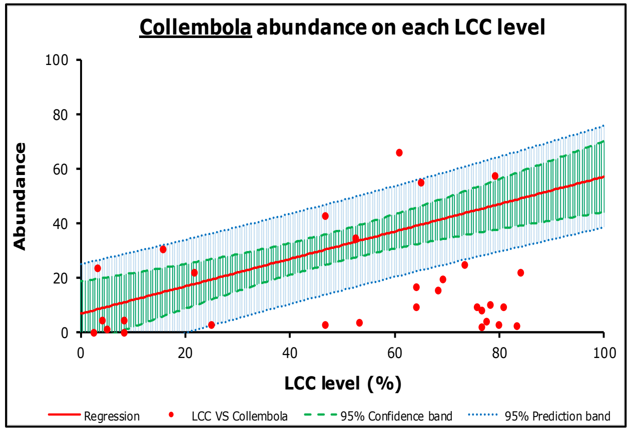


Mixed cover crop differently affects the richness and abundance of biological diversity at the soil level



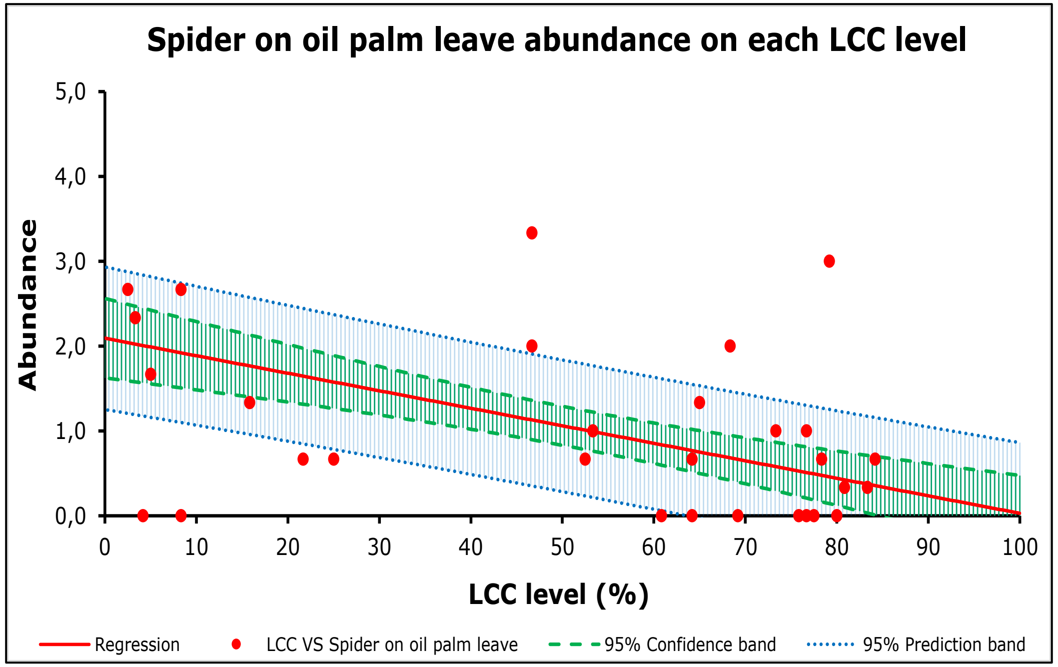


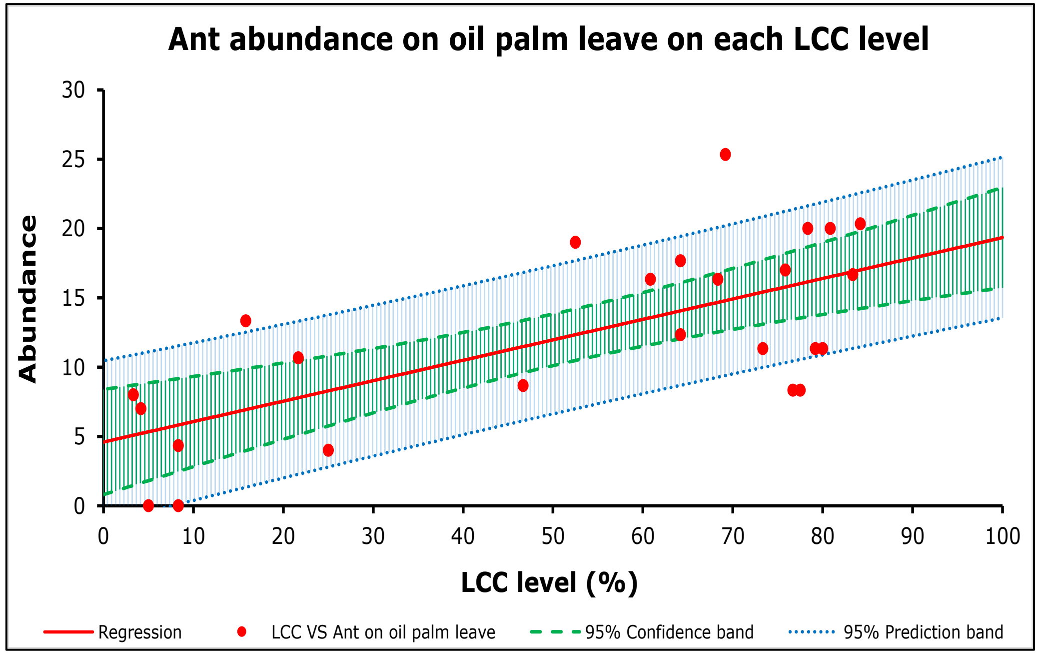




Soil Cover: Legume cover crop; impact on land biological characteristics

Study of mixed (LCC – weeds vegetation soil cover)





Mixed cover crop differently affects the abundance of biological diversity at the palm level

Soil Cover: Legume cover crop; impact on land biological characteristics

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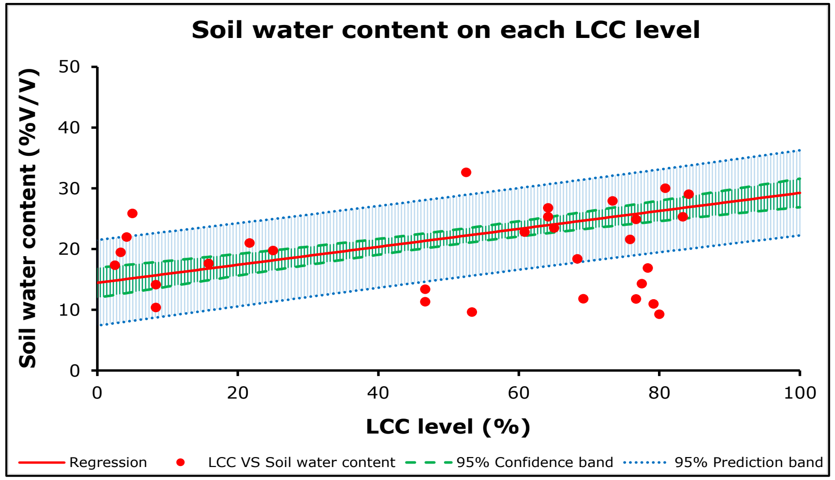
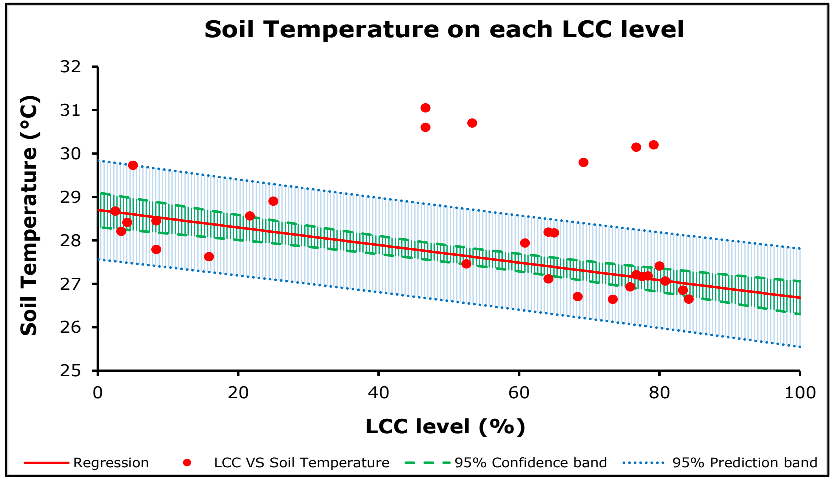
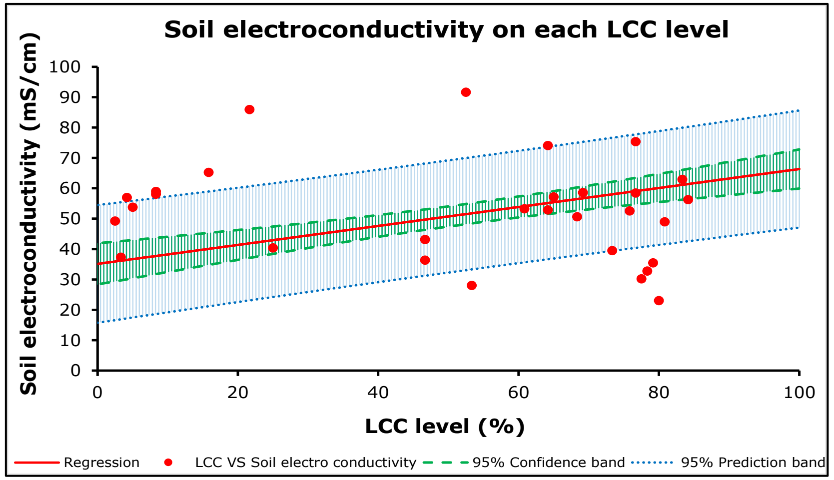
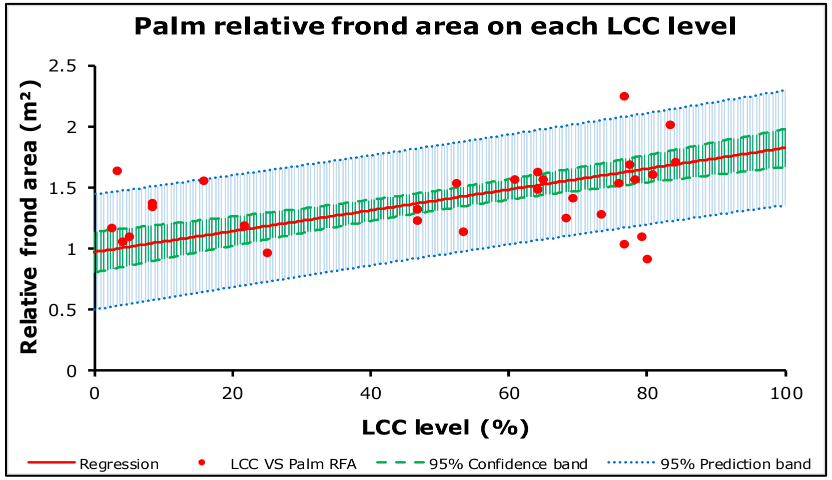








Mixed cover crop differently affects the characteristics of soil parameters

Mixed cover crop has relatively low impact on palm growth

Agroecology Practices for Soil Health in Oil Palm

Practices:
Weed management
Legume cover crop
Intercropping

Practices:
Biomass recycling
Agro-wastes recycling

Soil Cover

Habitats
Biodiversity

Soil Organic Matter

Soil fertility
Soil life

Soil Health
Soil degradation prevention

Soil chemical: nutrients
Soil physical: erosion, compaction
Soil biological
Soil ecology

Soil Organic Matter: Biomass management

Oil palm cultivation produces high amount of biomass

	Biomass (dry) (t/ha)	Carbon (t /ha)	N (kg/ha)	P_2O_5 (kg/ha)	K_2O (kg/ha)
Annual recycling					
Fronds	9 *(5-13)*	5	95	8	135
EFB	2.4 *(2.0-2.7)*	1.2	41	12	110
Replanting recycling					
Stem	61 *(46-82)*	30	281	31	775
Fronds	18 *(10-27)*	9	200	16	270
Roots	13 *(8-20)*	6	281	18	310

Soil Organic Matter: Biomass management; trunks at replanting

Trunk biomass
as <u>organic matter for field recycling</u>:

- **High nutrient value**
- **High carbon for biological activity**
- **High ecological impact**
- **High carbon emission**

Challenge to quantify these values

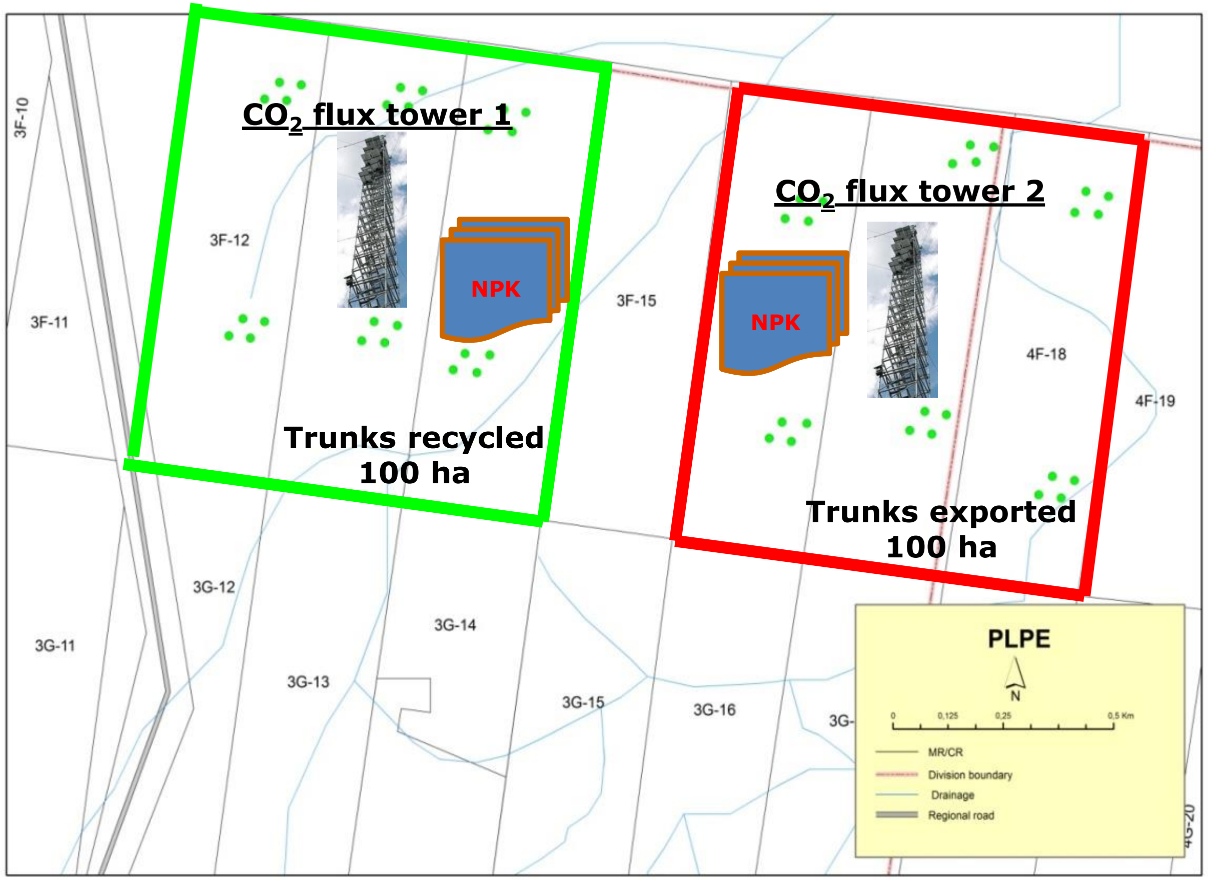
Trunk biomass
as <u>renewable energy</u>:

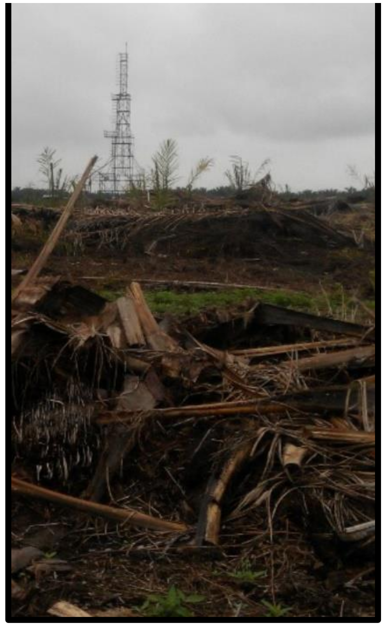
- **High monetary value,**
- **High demand**
- **Low carbon emission**

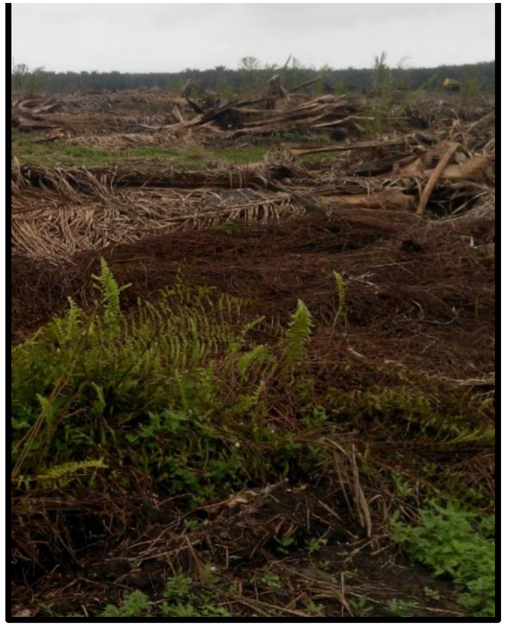
Soil Organic Matter: Biomass management; trunks at replanting

Study: impact of trunks export/recycling at replanting on palms performance and agroecosystem

- **Trunk export/recycling** (Q4-2016)
- **CO_2 fluxes & micro meteo**
- **Soil characteristics**
- **NPK nutrient response**
- **Palms performance**
- **Ecological characteristics**







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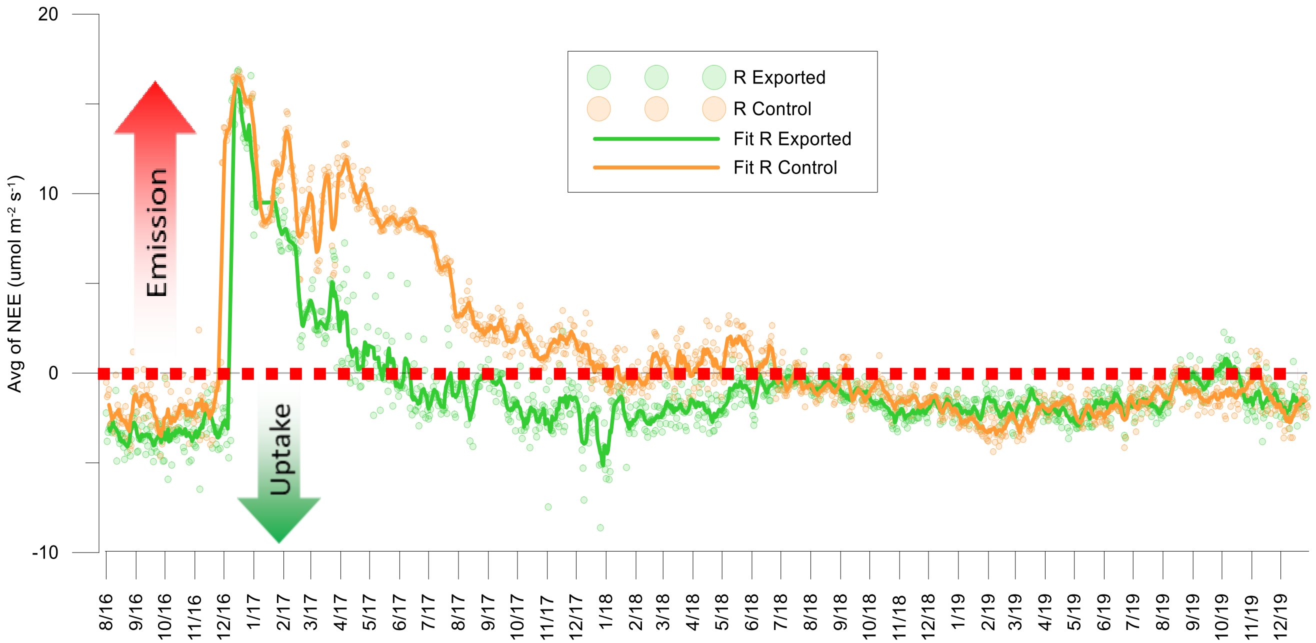

Trunk biomass export/recycling:

- **CO_2 emission 7 months/19 months**
- **CO_2 balance: 94 % lower**
  ie. > 6 % fixed in soil **(6-7 t C/ha)**

Soil Organic Matter: Biomass management; trunks at replanting

Study: impact of trunks export/recycling at replanting on palms performance and agroecosystem

- **Trunk export/recycling (Q4-2016)**
- CO2 fluxes & micro meteo
- Soil characteristics
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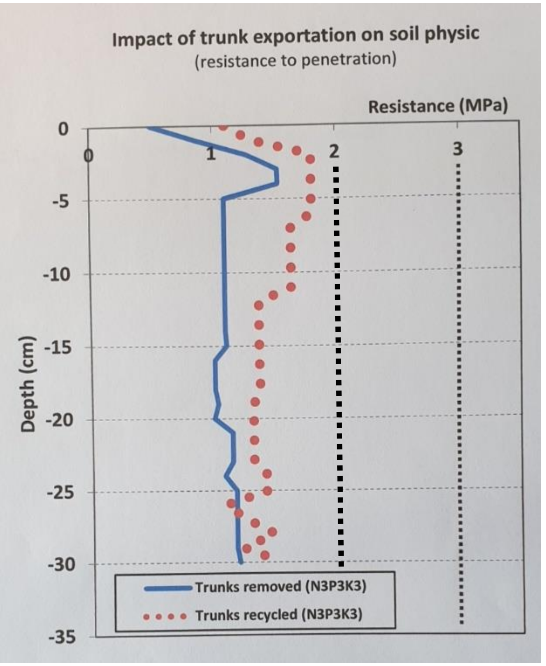
- Ecological characteristics

		recycled	export
C_{Org}	%	3.10	3.05
C/N		31	23
CEC	Me/100 g	9.0	7.5
B-sat	%	21	14
K_{exch}	Me/100 g	0.38	0.21
K_{tot}	ppm	112	84

Soil resistance



Trunk biomass export/recycling:

- **Soil chemistry affected**
- **Soil physic affected**

Soil Organic Matter: Biomass management; trunks at replanting

Study: impact of trunks export/recycling at replanting on palms performance and agroecosystem

- **Trunk export/recycling** (Q4-2016)
- CO2 fluxes & micro meteo
- Soil characteristics
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- Ecological characteristics

Leaf analysis

		recycled	export
Leaf nutrient – F3 (12 months)			
Nitrogen	%	2.94	2.83
Phosphorus	%	0.193	0.187
Potassium	%	1.33	1.19

Trunk biomass export/recycling:

- **Leaf analysis:**
  - N: - 4 %
  - P: - 3 %
  - K: - 11 %

Fertiliser rate increased by 20% not enough to compensate

Soil Organic Matter: Biomass management; trunks at replanting

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- CO2 fluxes & micro meteo
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FFB yield

		recycled	export
Bunch weight			
year 1 (30-41 mths)	t/ha	19.7	12.6
year 2 (30-41 mths)	t/ha	20.6	15.1
year 2 (30-41 mths)	t/ha	24.0	21.6

Trunk biomass export/recycling:

- **Yield affected by 23 %**

(36 %, 27 %, 10 % in year 1, 2 & 3)

Soil Organic Matter: Biomass management; trunks at replanting

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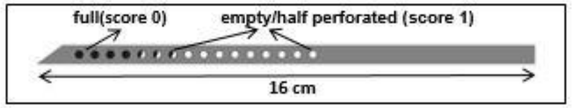
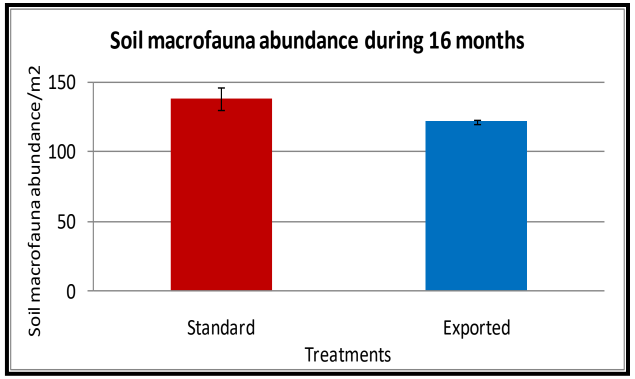
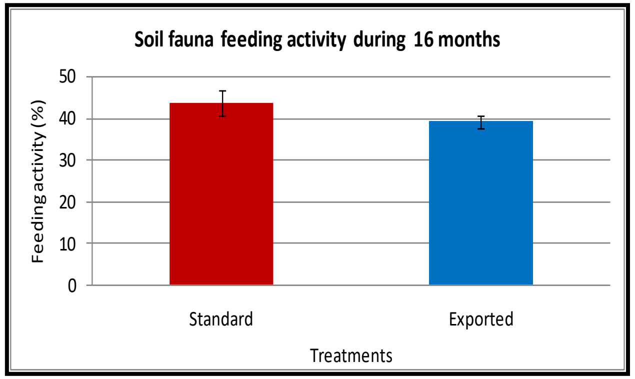
- Palms performance
- **Ecological characteristics**

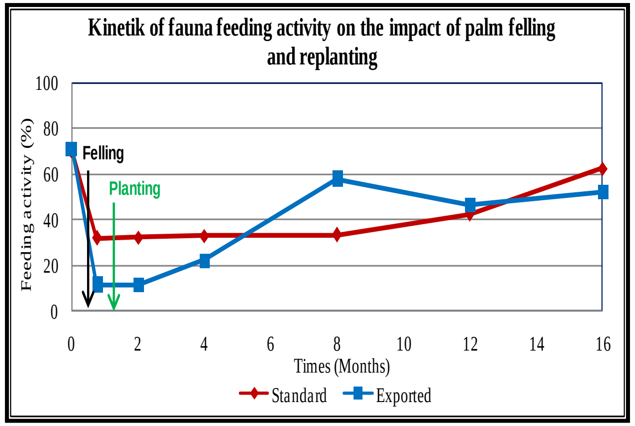


Trunk biomass export/recycling:

- **Macro and micro-organisms activities affected**







Agroecology Practices for Soil Health in Oil Palm

Practices:
Weed management
Legume cover crop
Intercropping

Practices:
Biomass recycling
Agro-wastes recycling

Soil Cover ⟷ **Soil Organic Matter**

Habitats
Biodiversity

Soil fertility
Soil life

Soil Health
Soil degradation prevention

Soil chemical: nutrients
Soil physical: erosion, compaction
Soil biological
Soil ecology

Importance of agroecological approach for N-fertiliser management

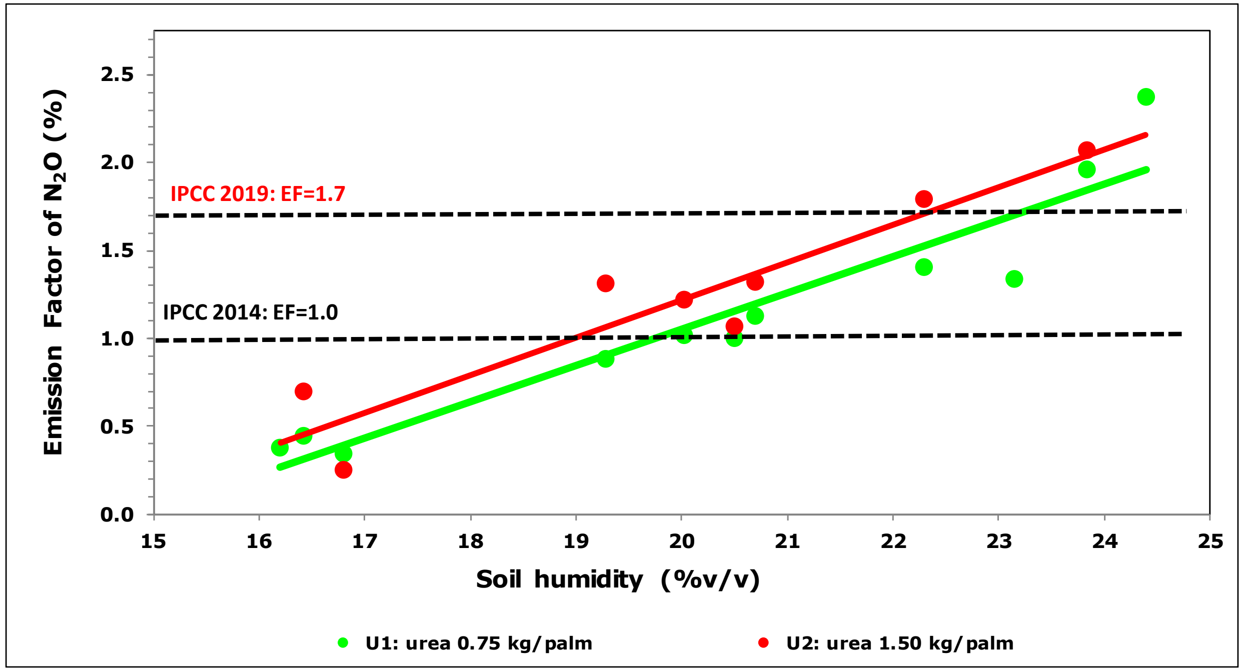
Importance of N-fertiliser

- For oil palm performance
- Contribution to production cost
- Environmental risk: GHG, air & water pollution

Drivers of nitrogen losses

- Soil physical, chemical, biological characteristics
  (texture, pore size spectrum, clay type, N content, soil organic matter, …)
  (soil moisture and temperature)
  (soil microorganisms, enzymatic activity, …)
- Rainfall factors (amount, frequency, intensity)
- Climatic parameters (temperature, wind, …)
- N-fertiliser type, form, rate, application quality, …
- Palm age

N_2O emissions



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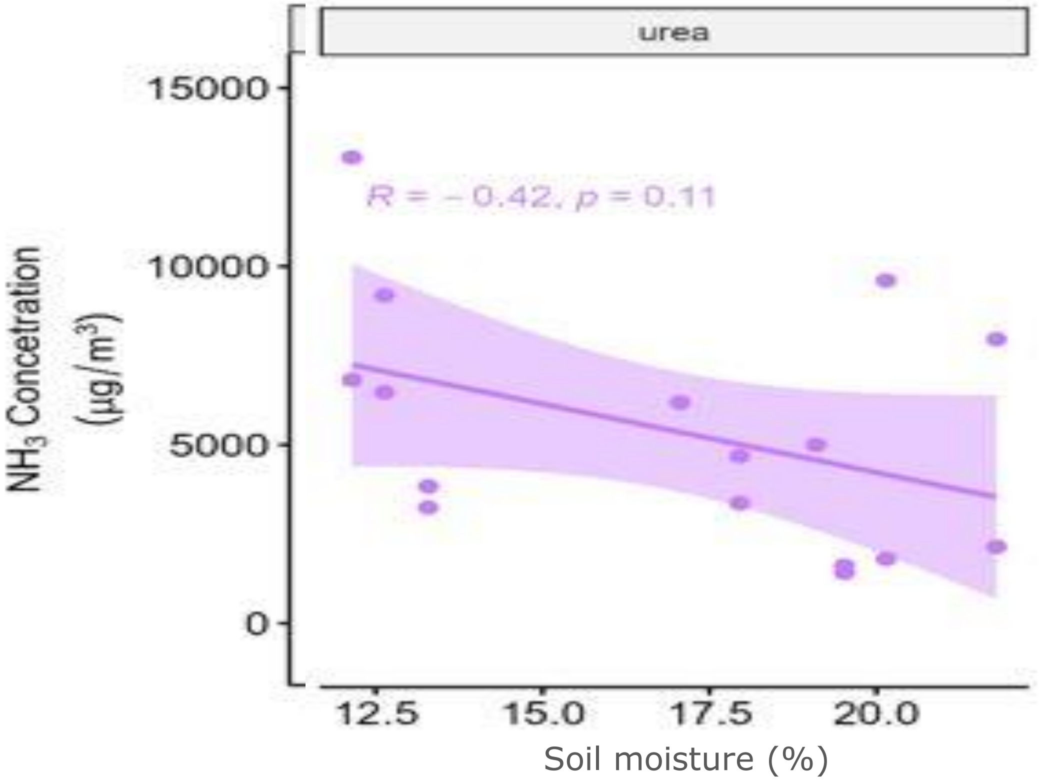
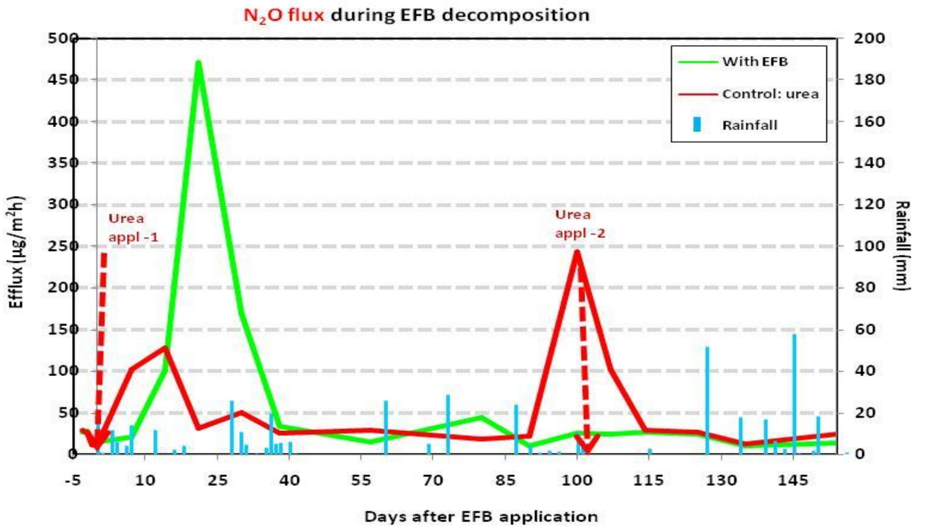
NH_3 volatilization



EFB applications has a much better N_2O emission factor compared to mineral urea fertiliser

EFB impact on soil CO_2 and N_2O emissions



	N-applied	$N\text{-}N_2O$ Emissions	
	(g/m²)	(g/m².y)	E.F. % of N applied
N-Urea	9.4	0.302	1.20
N-EFB (*)	20.0	0.265	0.34

Note: base line N_2O emissions = 0.00053 g/m² (ave. 3 days)

(*): applied for 2 years

Comments and Conclusions:

- **Agroecology approach is implemented by a growing number of farmers**
- **Agroecology is not restricted to soil and nutrition; it applies to other disciplines (control of pests, diseases, weeds, …), and supported by breeding, new technology, …**
- **While there are sets of practices available, it often still remains to quantify impacts, to evaluate the benefit for farmers**
- **Many ecological variables and subsequent agronomical impact have to be deciphered. Therefore Science must take the lead to quantify, develop and disseminate practices with Extension Services**

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International Conference

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POWER OF OIL PALM

Thanks