Soil Carbon Sequestration and Sustainable Development of Agricultural under Climate Change in Taiwan

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Taiwan's Participation

- **Taiwan Agricultural Research Institute (TARI)** is representative of Taiwan, R.O.C., to join the "*4‰ Initiative*" since November 14, 2016, and aims to achieve the goal of increasing 4‰ of SOC every year.

- Ministry of Foreign Affairs is representative of Taiwan to participate in the governance of the "4‰ Initiative association" in Nov. 17, 2016, at COP22 in Marrakech.

DECLARATION OF INTENTION OF SUPPORT FOR THE

4 PER 1000
SOILS FOR FOOD SECURITY AND CLIMATE


Annex 1: The Paris Declaration.

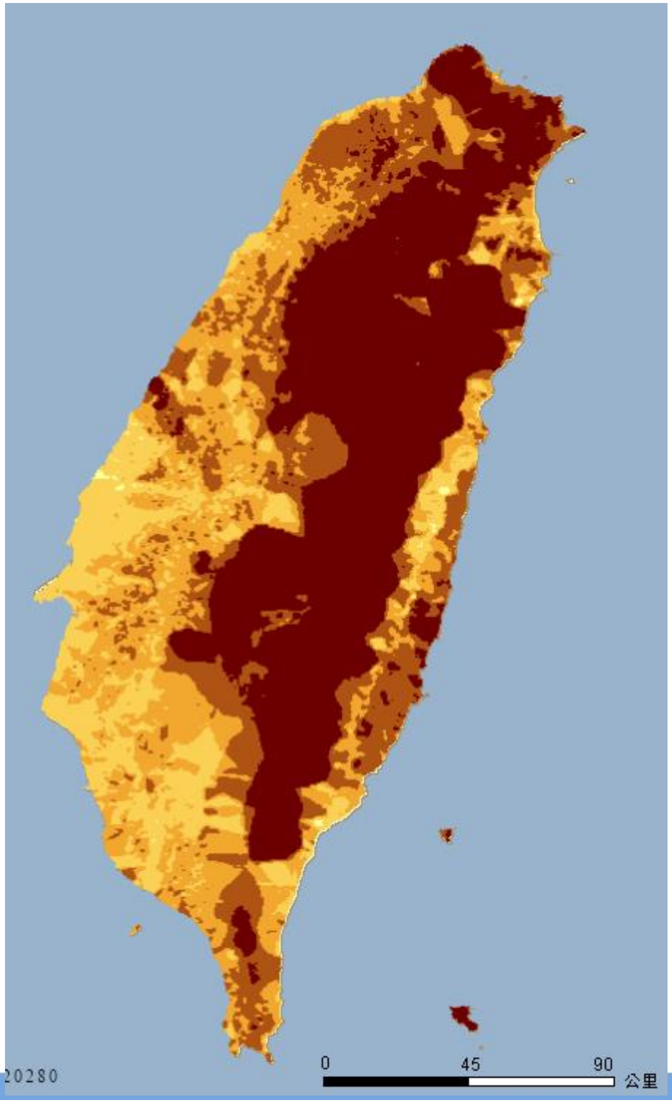
Date :
2016/11/14

Signature :

Practices and Action plan in Taiwan

4‰ Initiative - Objectives of four pillars -	**Taiwan** - Practices and Action plans -
Pillar 1. Assessing the carbon sequestration potential	**- Estimate Taiwan SOC and the carbon sequestration potential.**
Pillar 2. Designing carbon sequestration strategies and co-benefits	**- Assesse possible strategies for soil carbon sequestration and co-benefits under various cropping systems.**
Pillar 3. Identifying and creating policies for adoption of 4 per 1000 practices	**- Policies and financial support by government**
Pillar 4. MRV soil carbon sequestration	**Under study**

Taiwan SOC (Soil Organic Carbon)



Land	SOC (10^3 Mg)
Farmland	77,000[1]
Forest	160,000[2]
Total	237,000

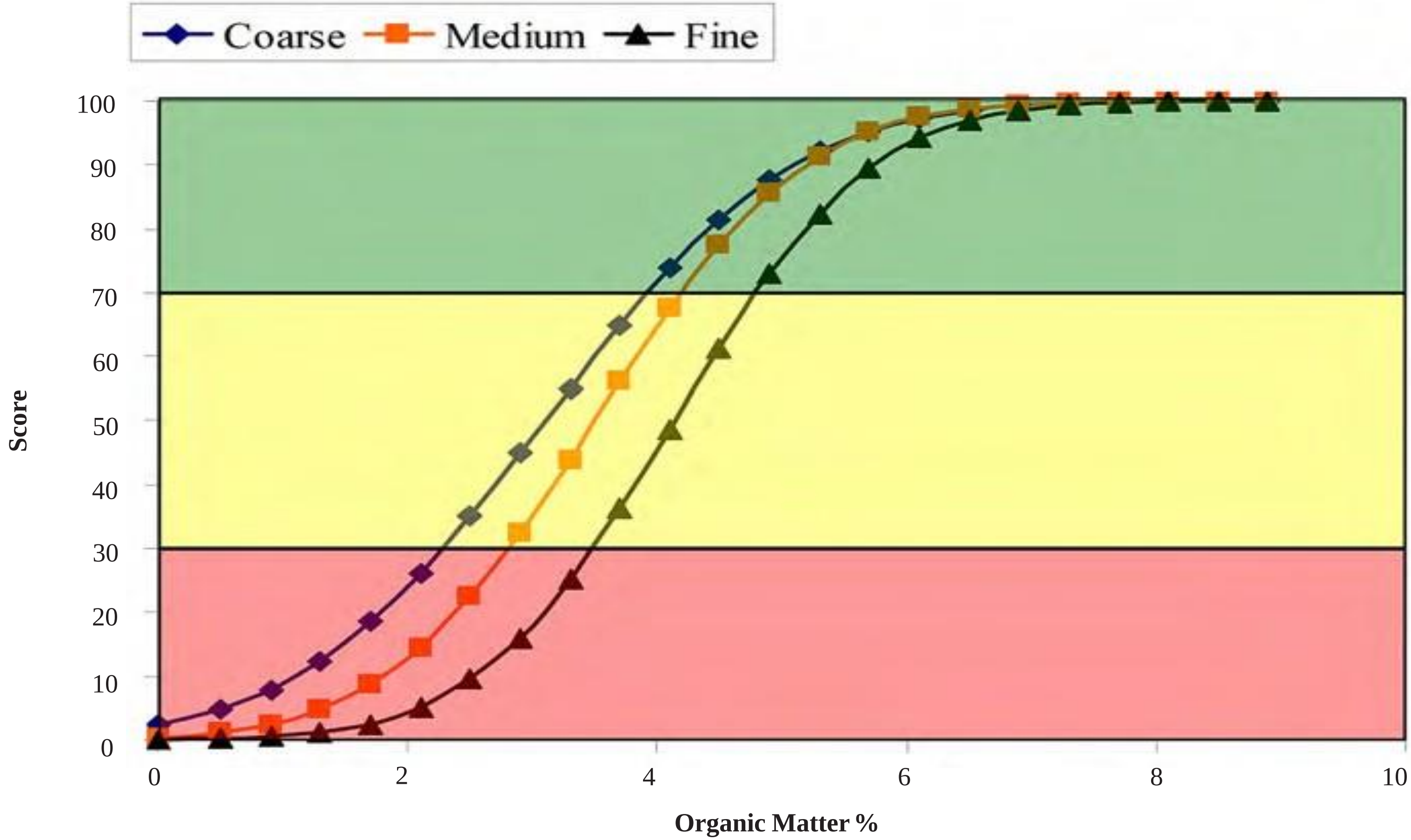
(0-100cm)

SOM(%)

- <1%
- 1-2%
- 2-3%
- 3-5%
- >5%

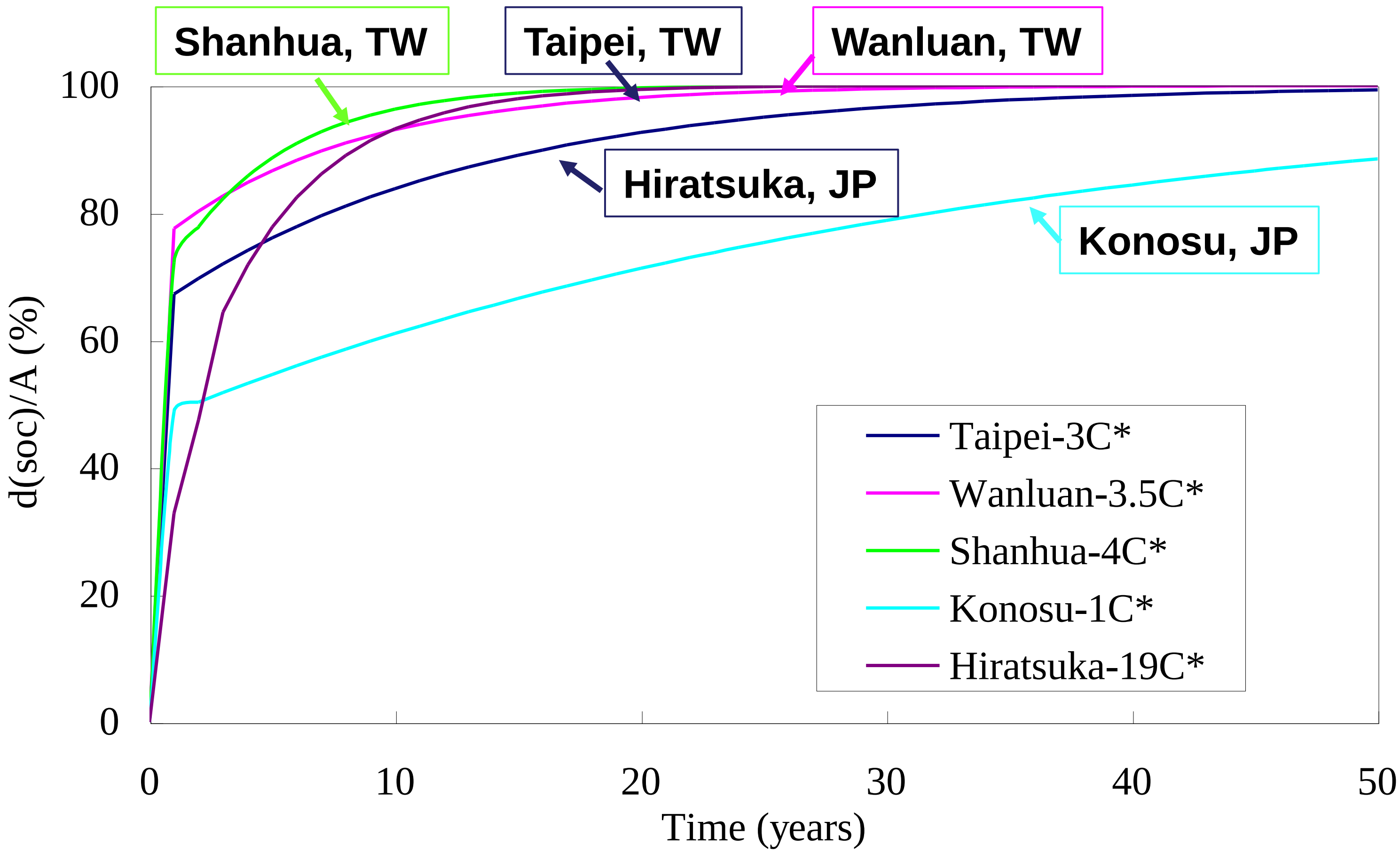
Source: 1:Jien, *et al.*, 2010
2:Tsai, *et al.*, 2010

Soil Organic Matter Scoring

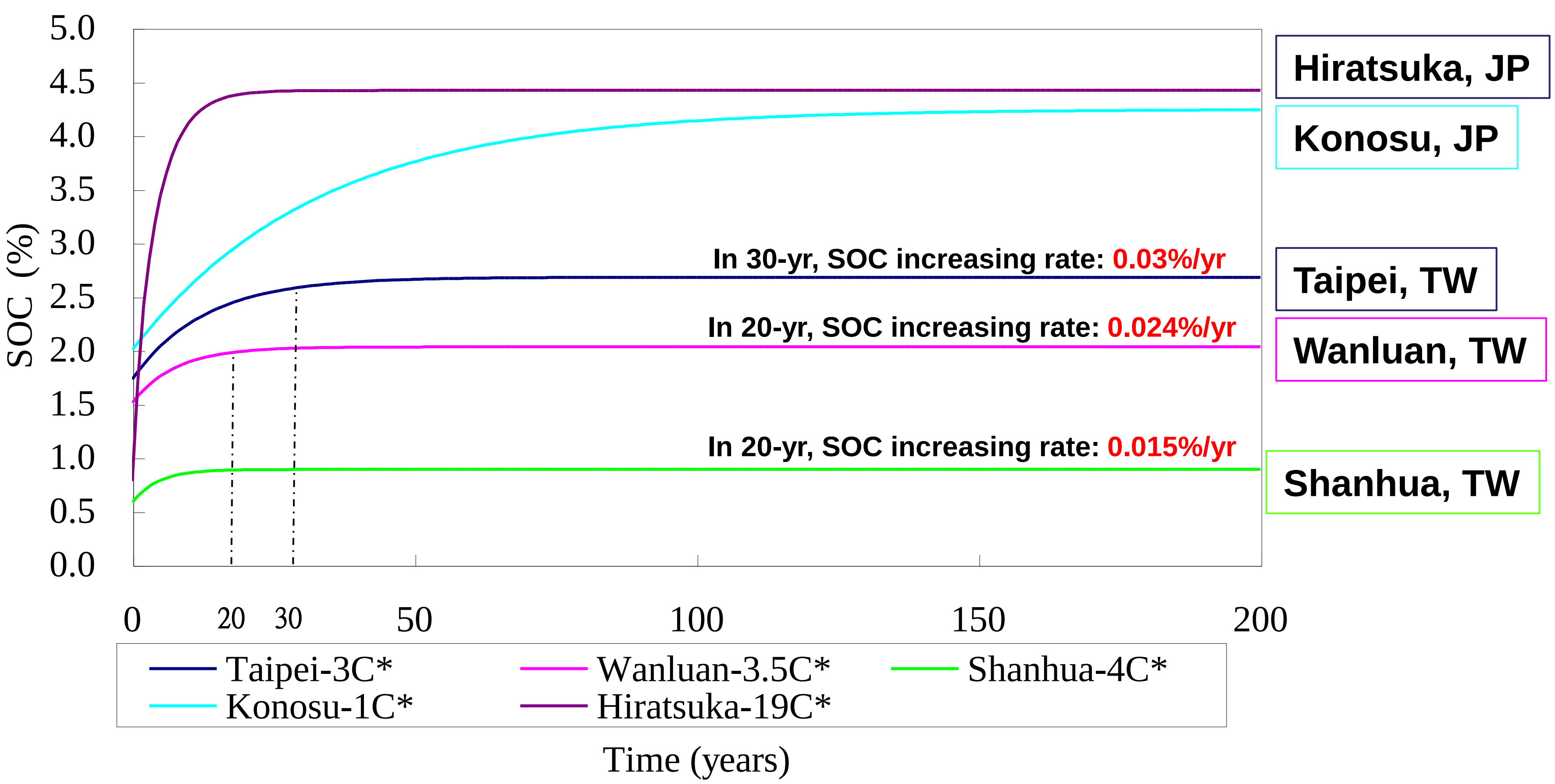


(Cornell Soil Health Assessment Training Manual, 2009)

SOC Decomposition on Study Sites in Taiwan(TW) and Japan(JP)

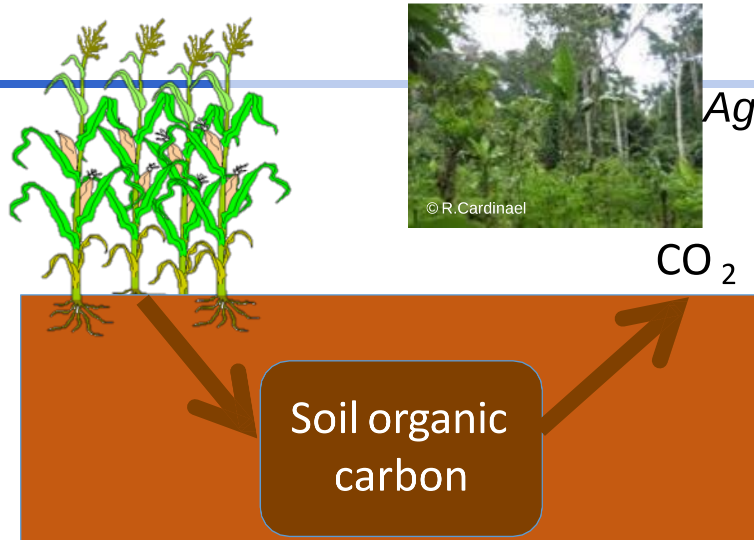


SOC Accumulations on Study Sites in Taiwan(TW) and Japan(JP)



Limits and feasability: practices

Integrated soil fertility management



Agroforestry

Conservation agriculture

Water management

Annual 4 per 1000 increase locally attainable
Great variability of C storage rates (climate, soil..)
Limits : biomass availability, nutrients, water, soil…

Cover crops

Organic fertilization

Rangeland management

1.Livestock Manure application in farmland

Manure

- In the past Manure is treated in three-stage process, and then discharge to the surface water.

Solid-liquid Separator

Liquid

>95% **Discharge to the surface water**

Challenges:
1. Costly
2. Difficult to meet the standards.
3. Loss of nutrient

Solid

<5% **Re-use in farmlands**

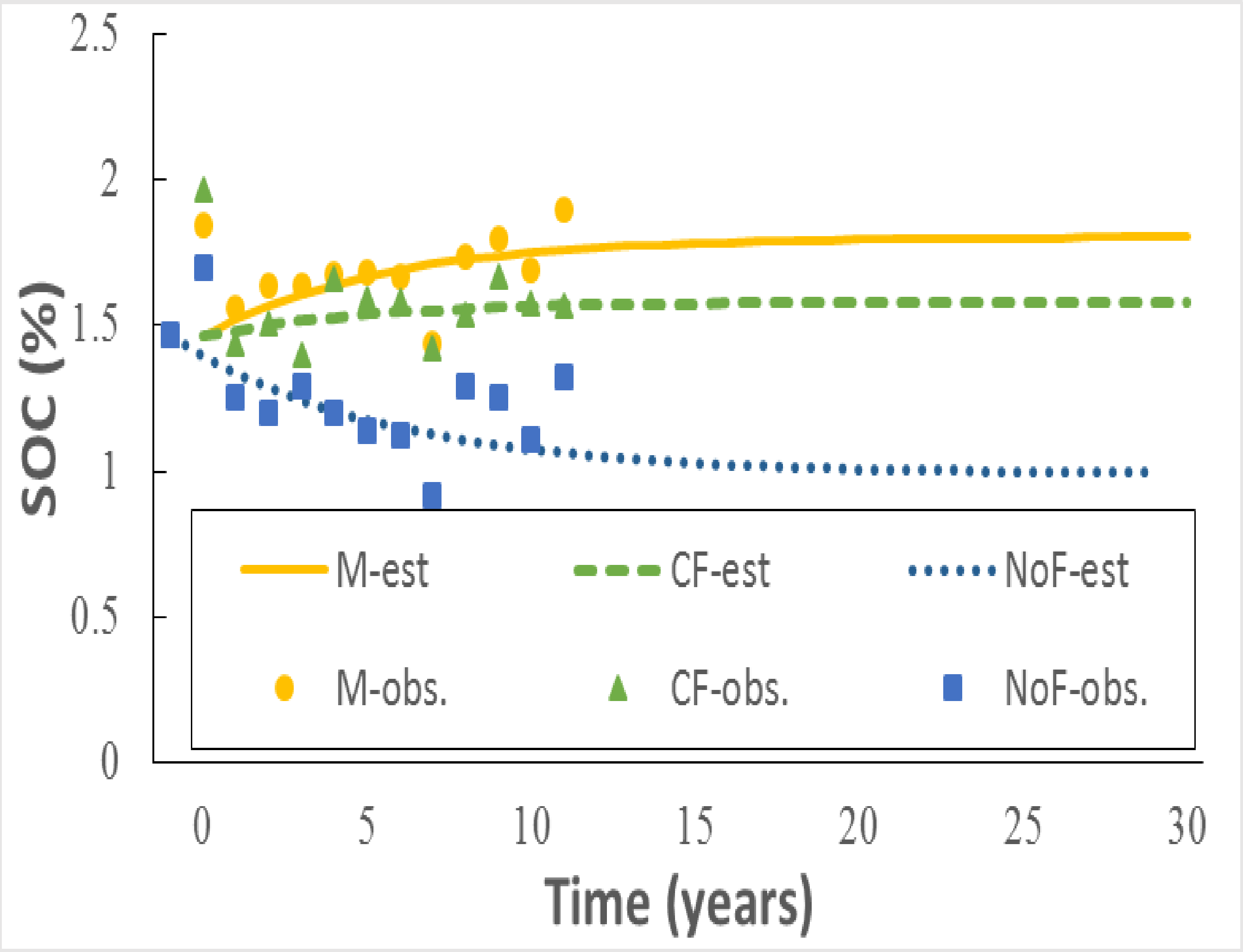
Anaerobic fermentation

- Now Manure can be reused in farmlands

Re-use in farmlands

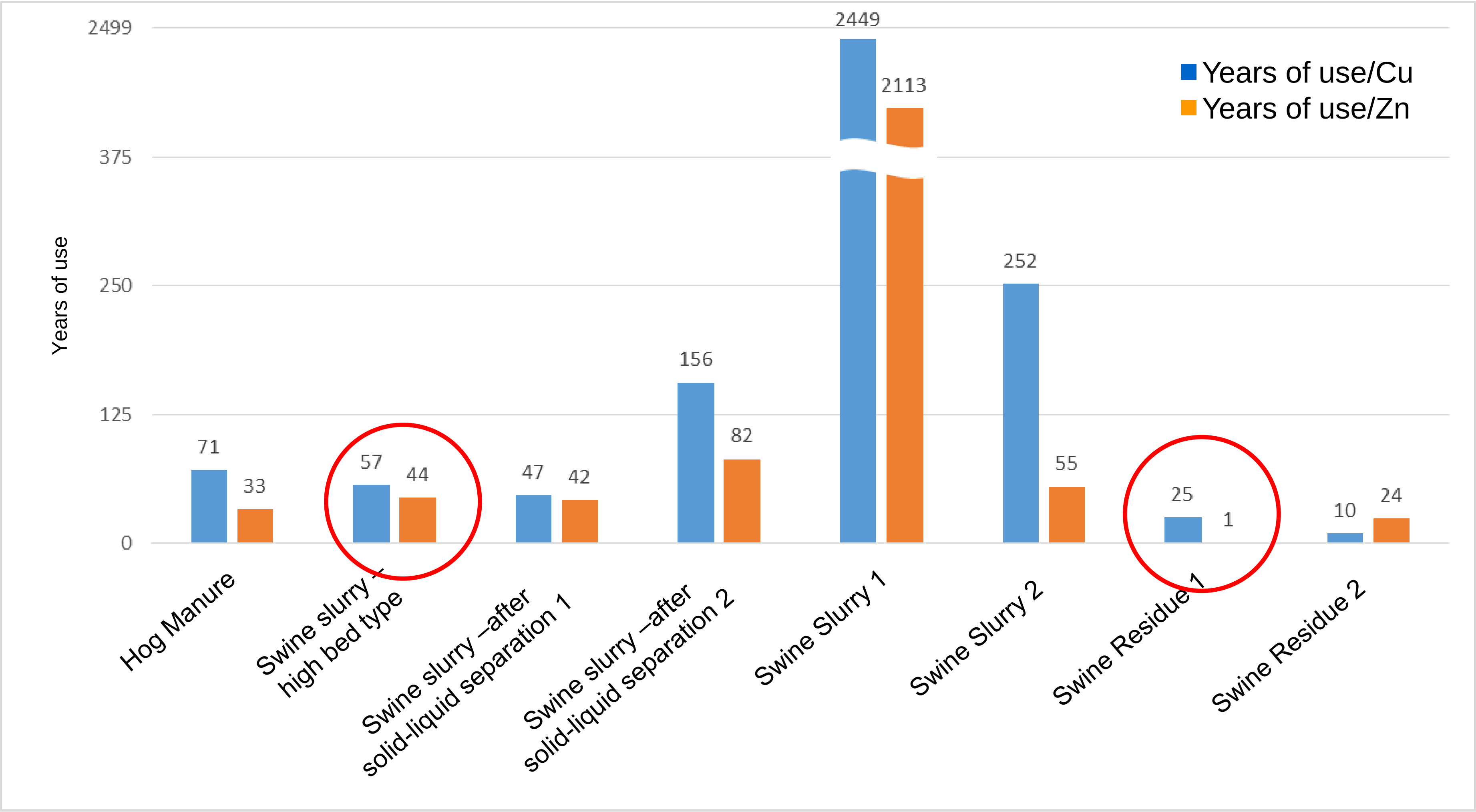
Circular agriculture

Swine Manure application in farmland



NoF: no fertilizer
CF: chemical fertilizer
M: swine manure
obs: observed data
est: estimated data by model

Duration of application to reach the environmental monitoring criteria for heavy metals accumulation in soil



2. Organic Farming: Challenges

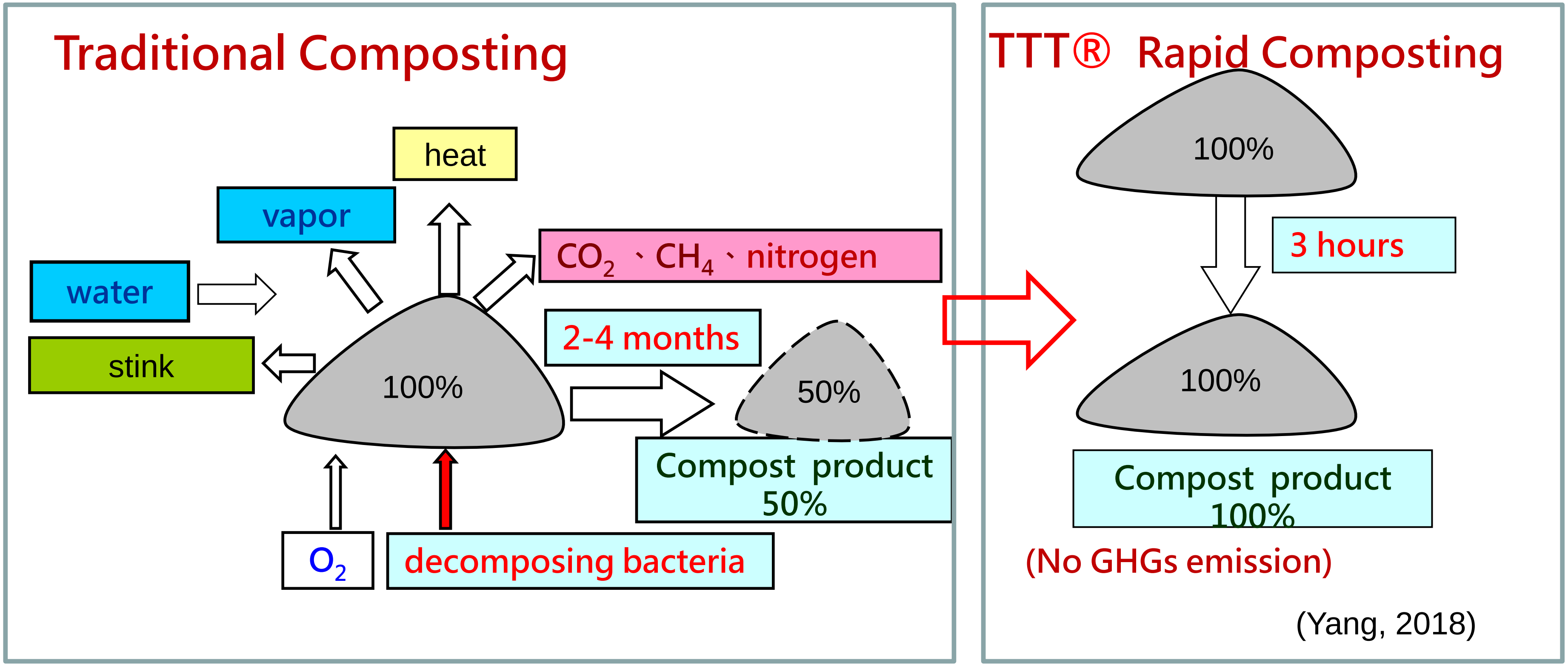
- Low profit during the transition period: -20~50%
- Certification: the standards are restricted on heavy metal contents and organic materials
- Polluted Circumstances: next to conventional farms and polluted by the residual pesticides.
- Pest and insect damage

https://encrypted-tbn1.gstatic.com/images?q=tbn:ANd9GcTFE1zicldXd6bmHDwoUCkrZVB5SkxD96L_B4OXc_O6kcDtgGl1fA

- Cost of certification: higher cost on production and extra cost on environmental monitoring (US$800~1000).

Technology for Rapid Composting

- Enhance the humification process
- Reduce the GHGs and odor emission and mass loss during composting



* > 10 milliom Mg organic waste produced per year need to be reused

3.Orchard Grass Cultivation: Opportunities

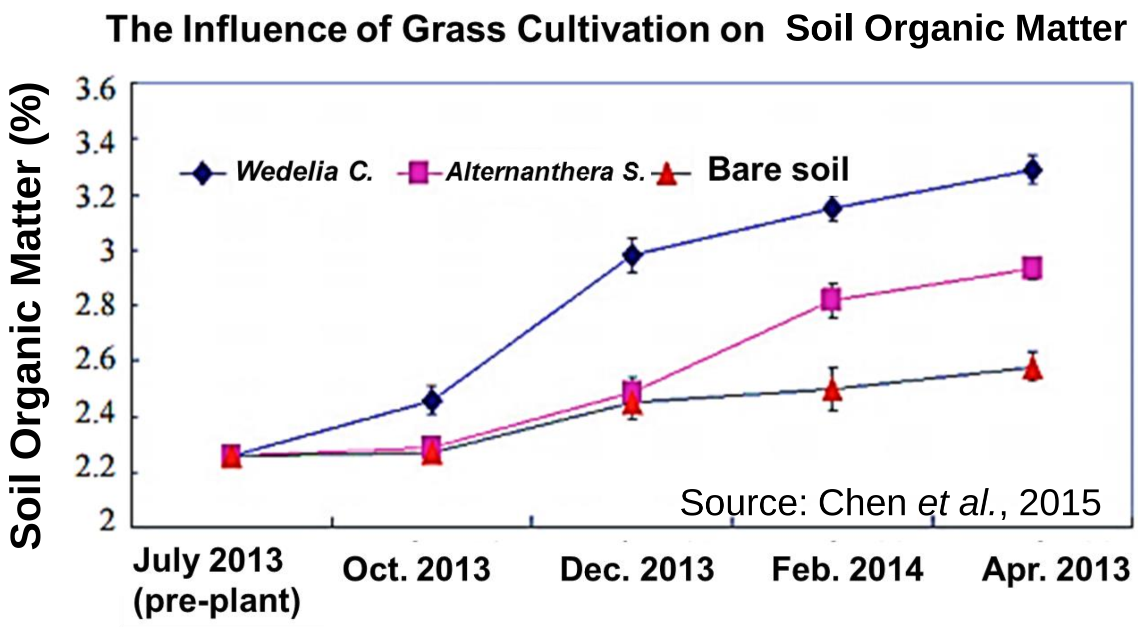
- Inhibit weed growth
- Control the damages of insect and pest
- Improve the soil and water conservation
  - preserve the soil nutrients and organic carbon content
  - Improve the physical and chemical properties of soil
  - Increase the soil drainage and porosity
- Environmental conservation
- Increase biodiversity

http://www.kskk.org.tw/satoyama/wp-content/uploads/2013/12/IMG_1908-350x233.jpg

http://www.nafertino.com.tw/sites/default/files/technology/12106818_1057789220944661_8568466494234955889_n.jpg

3.Orchard Grass Cultivation: case study

- Kaohsiung District ARES, wax apple orchards
- ***Wedelia chinensis*** *and* ***Alternanthera sessilis***



- Soil organic matter increase ~1% in 9 months.

4.Green manure crops cultivation

***Glycine max* (L.) Merr.**
(soybean)

***Sesbania roxburghii* Merr.**
(Taiwan Sesbania)

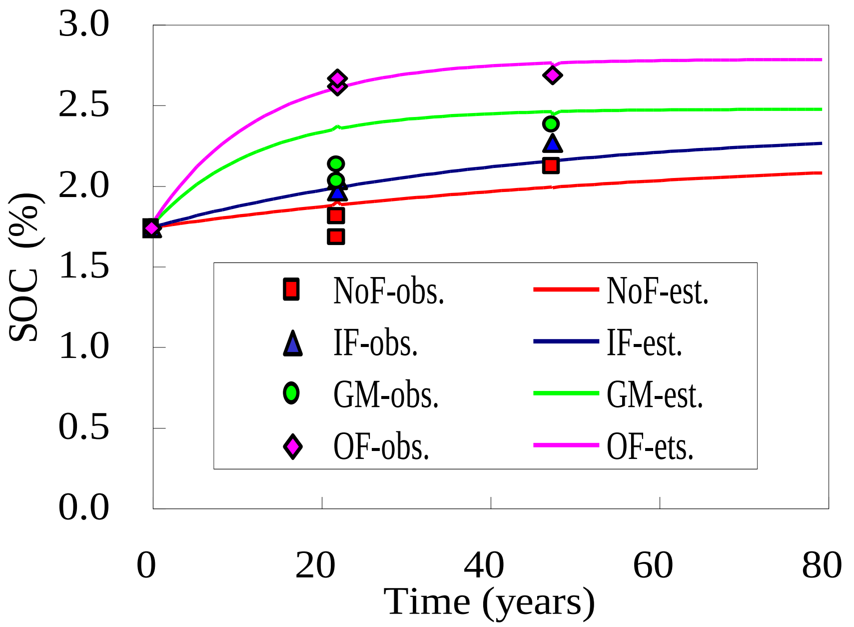
***Astragalus sinicus* L.**
(Chinese milk vetch)

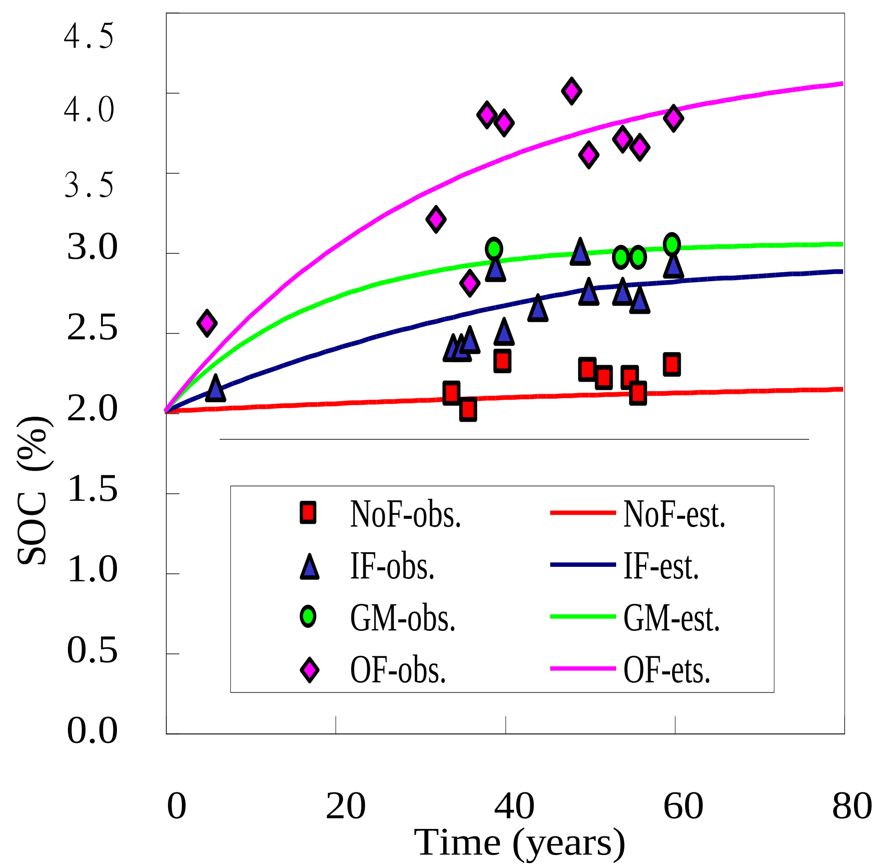
Cosmos bipinnatus
(cosmos)

***Brassica campestris* L.**
(Trunip Rape)

4.Green manure crops cultivation

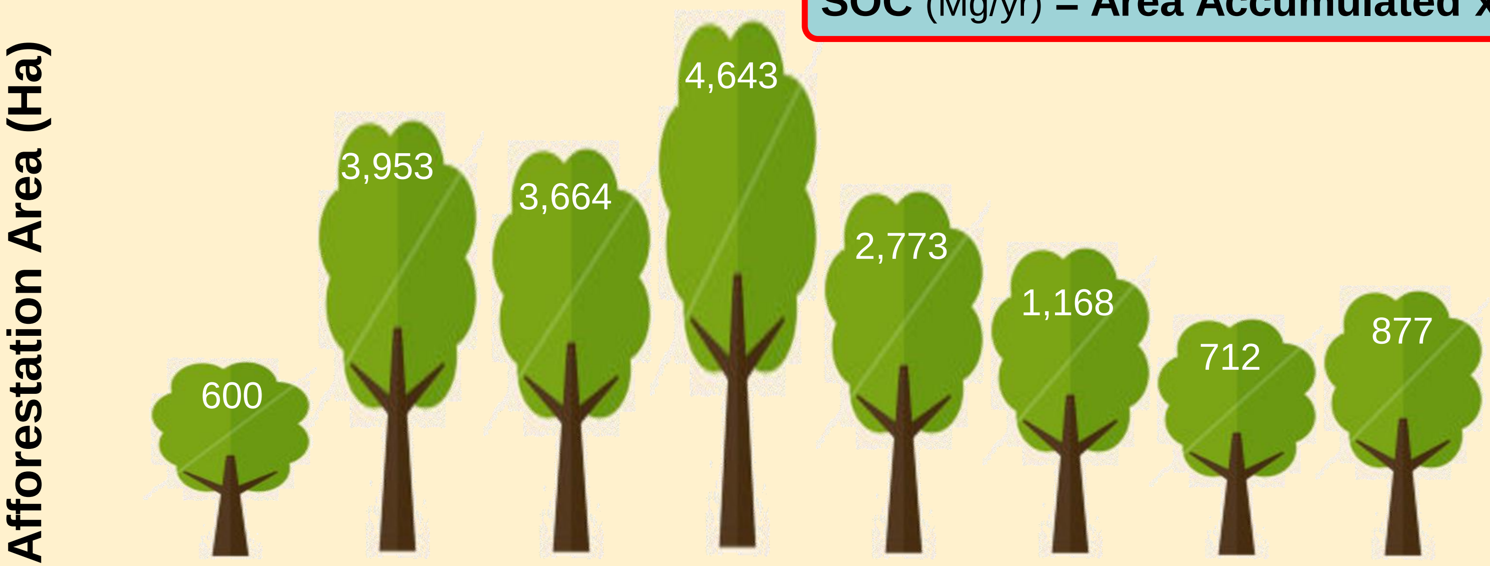
NoF: no fertilizer	**IF**: Inorganic fertilizer
GM: green manure	**OF**: organic fertilizer
obs: observed data	**est**: estimated data by model





5. Afforestation in plain areas

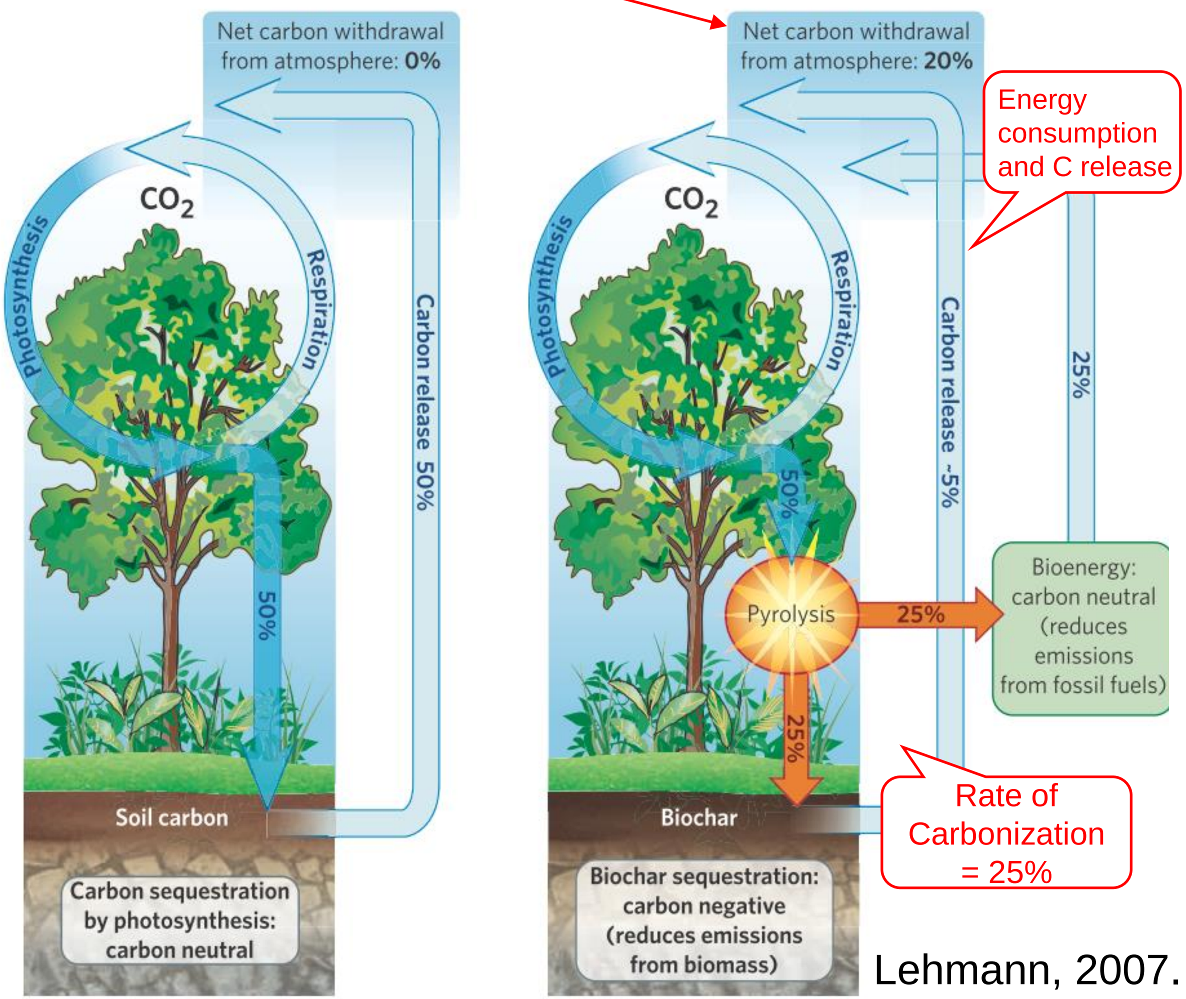
SOC (Mg/yr) **= Area Accumulated x 2000 x 0.02%**



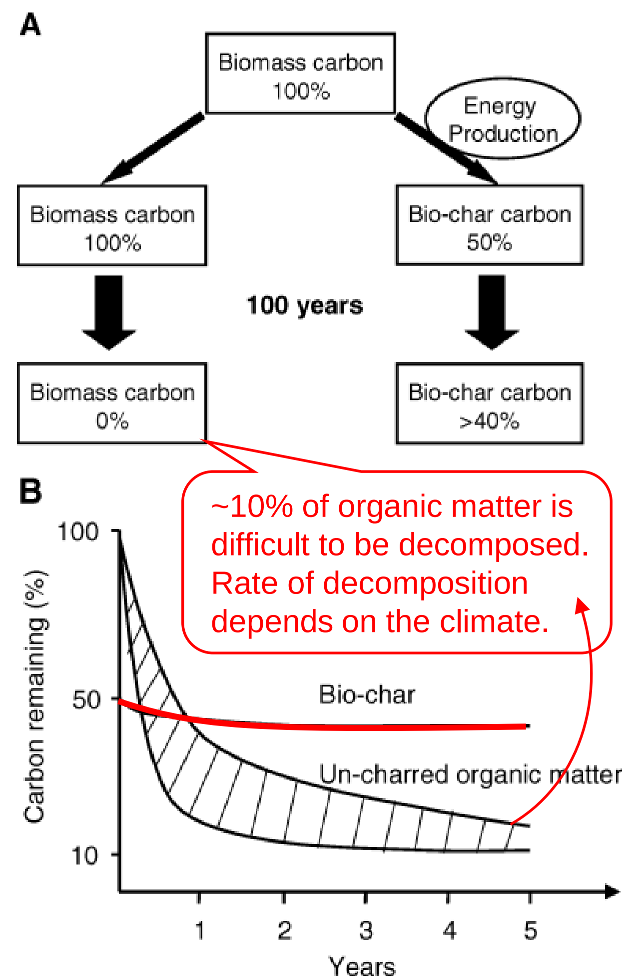
YEAR	2008	2009	2010	2011	2012	2013	2014	2015
Area Accumulated	609	4,562	8,226	12,869	15,642	46,810	17,522	18,399
SOC Mg/yr	**245**	**1,825**	**3,300**	**5,150**	**6,260**	**6,700**	**7,000**	**7,400**

6.Carbon Sequestration of Biochar and the Carbon Cycle in the Nature

When C turned to be biochar, the rate of C release is slower
➔ **Carbon Sequestration**

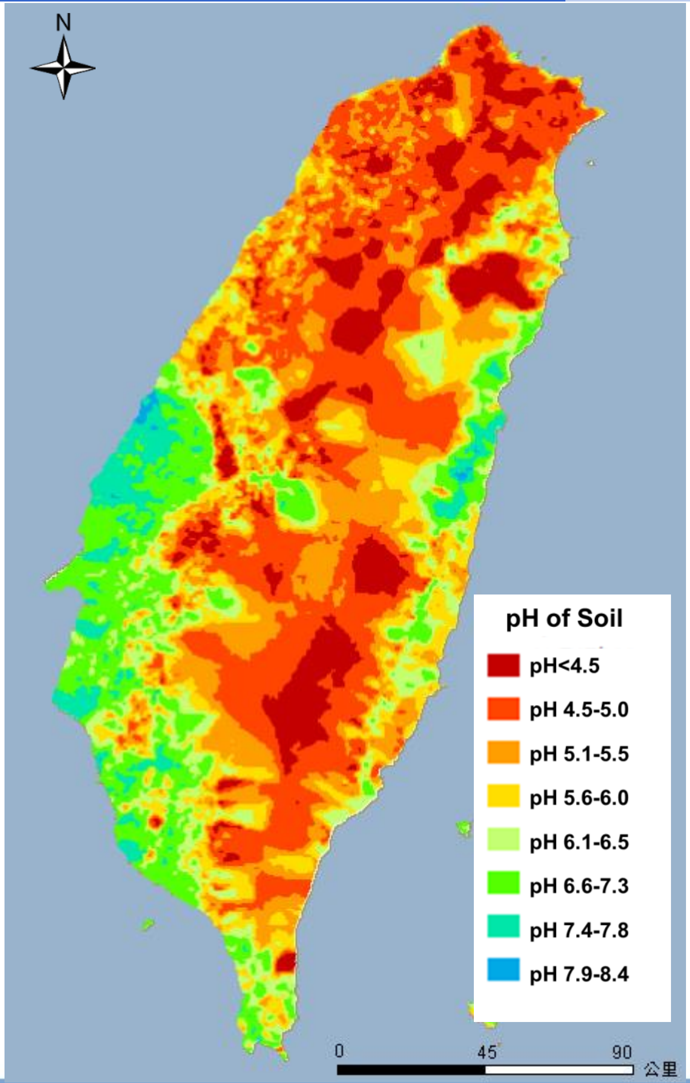


Lehmann, 2007.



Lehmann et al., 2006.

Assessment of carbon sequestration by applying Biochar



- **Most of Biochar is highly alkaline**
-
- **Strong acid soil** (pH<5.5)**: ~ 300,000 ha**
  (Tan et al., 2005)
- **2% biochar application :**
  It tends to be beneficial on production by applying 2 % biochar on acid soils.

  30% of applied biochar will be decomposed after 100 years.
- **Potential C sequestration on top soil: ~3.9 million tons**
  ➔ about 14.3 million tons of CO_2 equivalent.

Taiwan's potential SOC sequestration in farmland

Practices		Increasing SOC in 25-yr (%)	Area(10^3 ha)	SOC (10^3 Mg)
Manure Reuse	Swine	0.2	120	480
	Poultry	0.4	100	800
	Cattle	0.2	15	160
Green Manure		0.1	400	800
Organic Farming		0.4	40	320
Biochar		0.7	300	3,900
Orchard Grass Cultivation		0.5	180	1,800
Afforestation in plain areas		0.4	18	144

Total = 336 x 10^3 Mg/yr

4.4 ‰ of Agro-SOC
1.4 ‰ of (Agro+Forest)-SOC

Current practices in farmland

Practices		Increasing SOC (%/yr)	Area(10^3 ha)	SOC (10^3 Mg)
Manure Reuse	Swine	0.008	1	0.16
	Poultry	0.016	100	32
	Cattle	0.008	1	0.16
Green Manure		0.004	200	16
Organic Farming		0.016	10	3.2
Biochar		0.028	0.5	0.28
Orchard Grass Cultivation		0.02	10	4
Afforestation in plain areas		0.0175	18	6.3

Total = 62x 10^3Mg/yr

0.8 ‰ of Agro-SOC
0.3 ‰ of (Agro+Forest)-SOC

Policies and financial supports from governments

- Promote and financial support for manure application in farmland **($3 million USD)**
- Subsidize the organic fertilizer for organic farming **($1,000 USD/ha)**
- Provide the seeds with subsidy to cultivate green manure **($500 USD/ha)**
- Promote the grass cultivation on orchard
- Financial support for the research on biochar applications in farmland **($2 million USD)**

Action plans in the future

- Reduce the content of Cu and Zn of feeding to reduce their accumulation in soil for the reuse of livestock.
- Estimate precisely the rate of soil carbon sequestration of various strategies by long-term experiments.
- Establish the feedstock collection system and quality classification of biochar, and manage the biochar applications.
- Develop the methods of monitoring, reporting and verification (MRV) of national SOC sequestration.
- Promote the new technology and strategies for SOC sequestration.

THERE IS A LONG WAY TO GO !

THANK YOU FOR YOUR ATTENTIONS

https://www.youtube.com/watch?v=AY9YVwJZDvw