Aggregate Stability and Soil Carbon Storage as Affected by Different Land Use Practices

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Kyung-Hwa Han, Sang-Geun Ha, Byoung-Choon Jang

National Academy of Agricultural Science, RDA, Korea

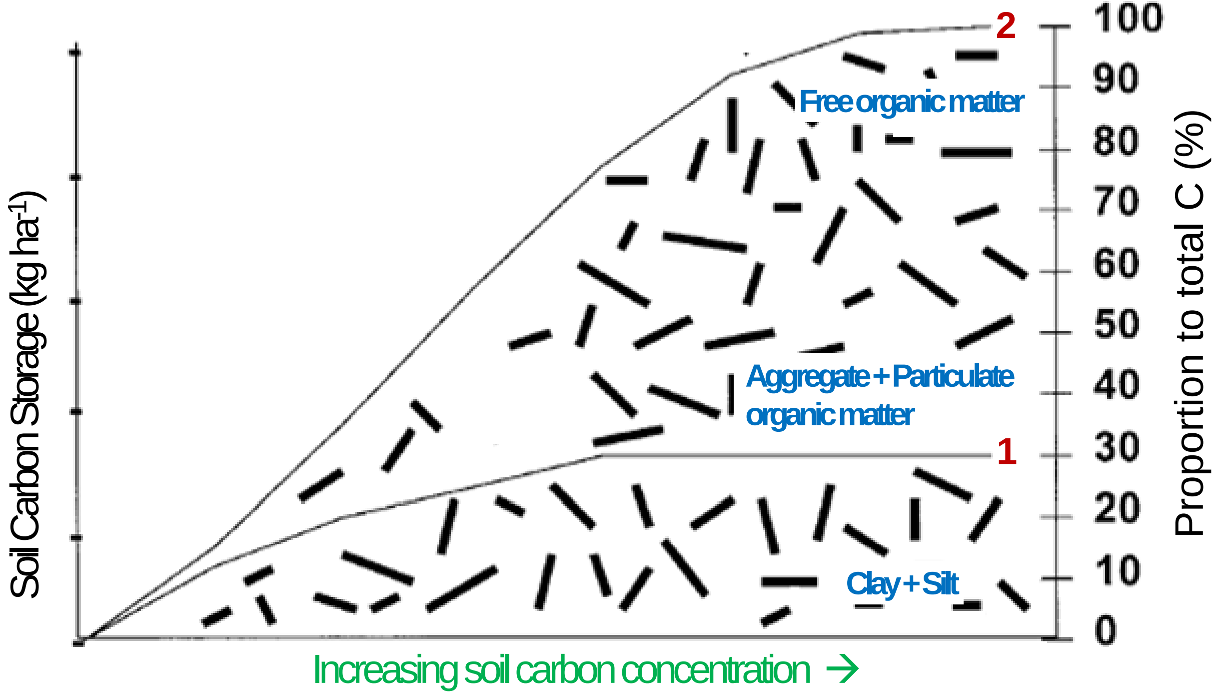
Contents

- Introduction
- Aggregate stability and soil carbon storage as affected by different
  - Land use types
    [forest, pasture, upland, paddy rice]
  - Fertilization types in upland cultivation
  - Fertilization types in paddy rice cultivation
- Conclusions

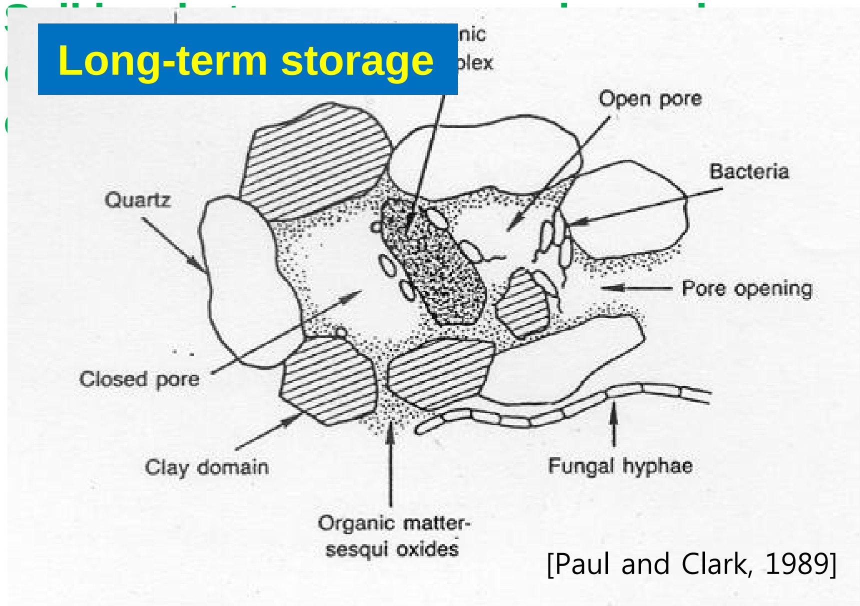
Carbon storage capacity of soils, *under a climate and a water regime*

1. Fixed capacity is related to clay + silt content.
2. Variable capacity is related to aggregate stability and C inputs,

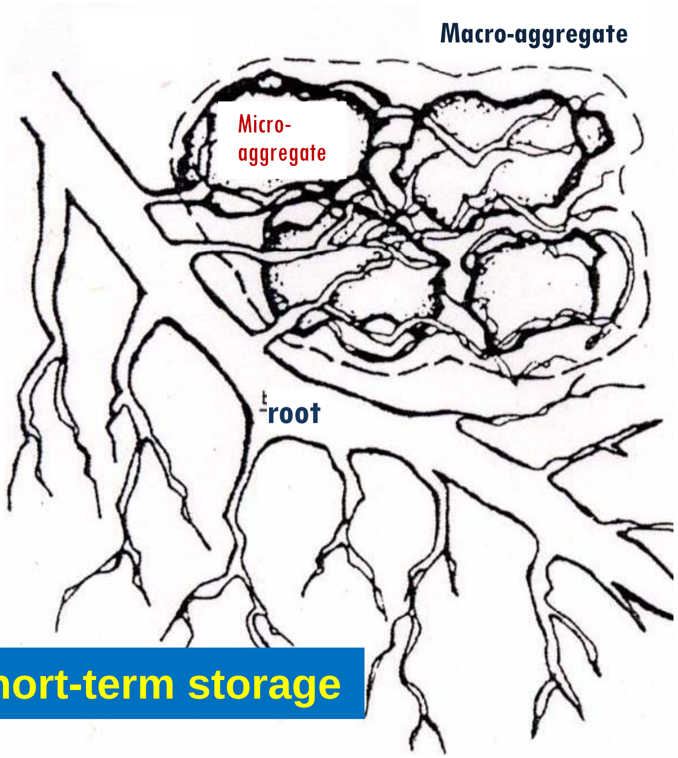
depending on vegetations and management practices



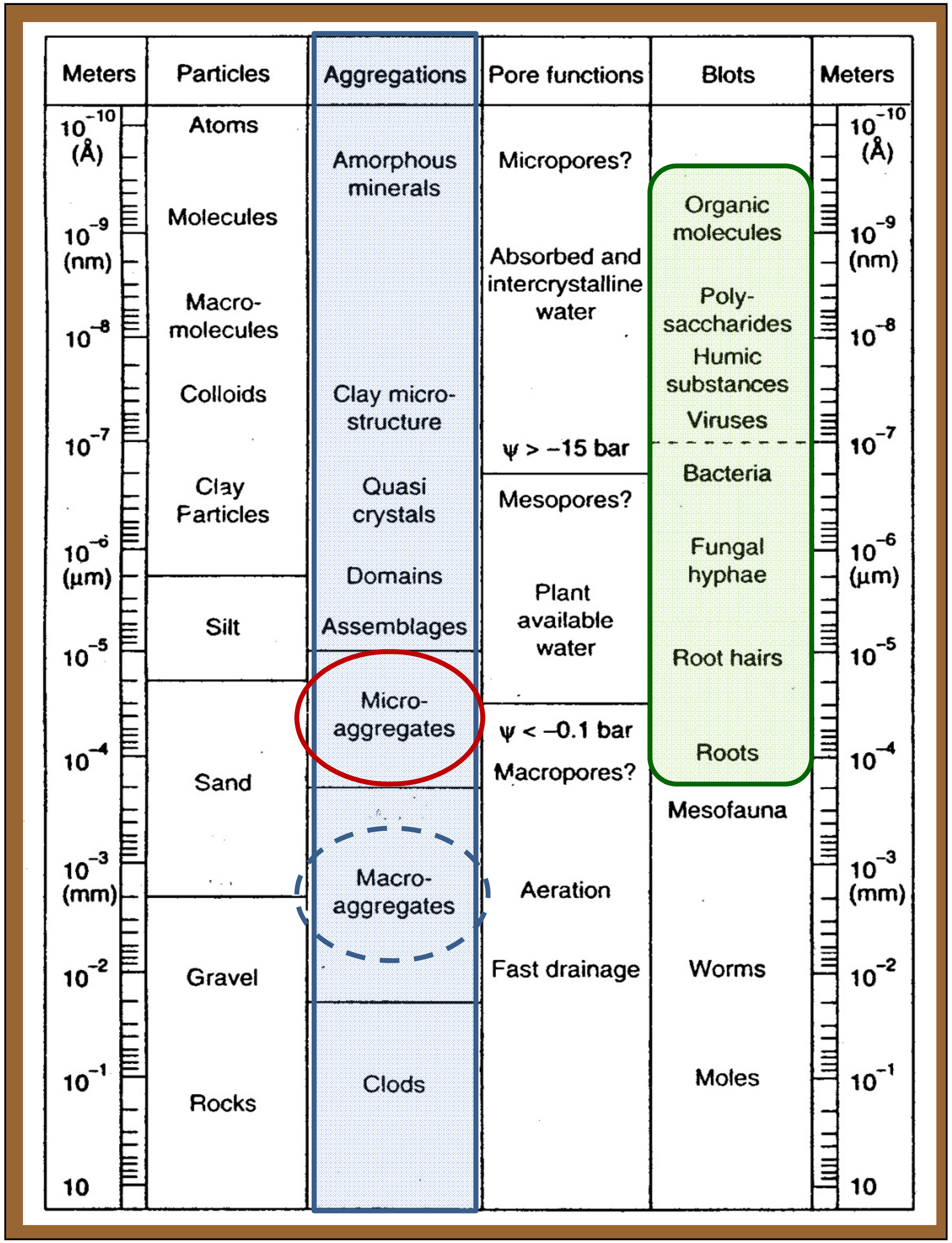
Long-term storage



[Paul and Clark, 1989]



Short-term storage



[Oades, 1984]

How to measure aggregate stability of soils ?

*Applying **external force** for breaking aggregate*

➔ *quantifying remained aggregates or dispersed particles*

1. Water stable aggregates content from **wet-sieving method**

Bulk soils or aggregates →

Yoder's method

→

2-4 mm

1-2 mm

0.5-1 mm

0.25-0.5 mm

→ Calculation after primary particles correction

2. Dispersibility test from measuring dispersed particles after **shaking**

Bulk soils or aggregates → Middleton method (turning-over shaking for 20 times) or end-over-end shaking →

➔ an indirect and discrete method for estimating aggregation

- Water stability test of aggregate is an indirect and discrete method for estimating aggregation, but it could give us a simple and fast answer for understanding the management effect on aggregation and carbon storage.
- In this study, therefore, we conducted to grasp the influences of land use types and management practices on the aggregate stability and soil carbon storage in Korea, belonging to temperate region and monsoon Asia.

Aggregate stability and soil carbon storage as affected by different

1. Land use types

   [forest, pasture, upland, paddy rice]

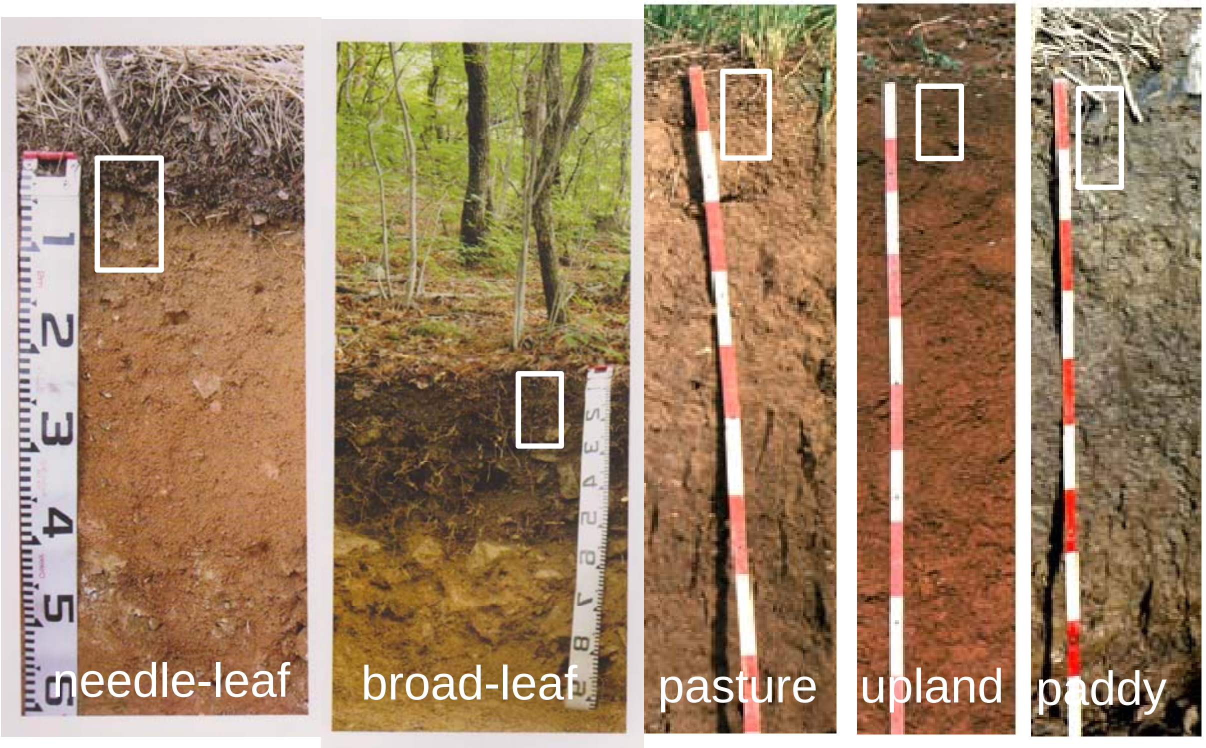
2. Fertilization types in upland cultivation

3. Fertilization types in paddy rice cultivation

Site descriptions and sampling method

- 7 sites with different elevations
- 5 land use types
  forest [needle-leaf, broad-leaf], pasture,
  annual upland crops, paddy rice
- Soil sampling : 0-15cm depth using cores (ϕ5cmx$h$15cm)
- Plant residue sampling : litters on soil surface

	Average g C kg soil
Elevation 0-200m	13
Elevation 200-400m	13
Elevation 400-600m	17
Elevation 600-800m	32



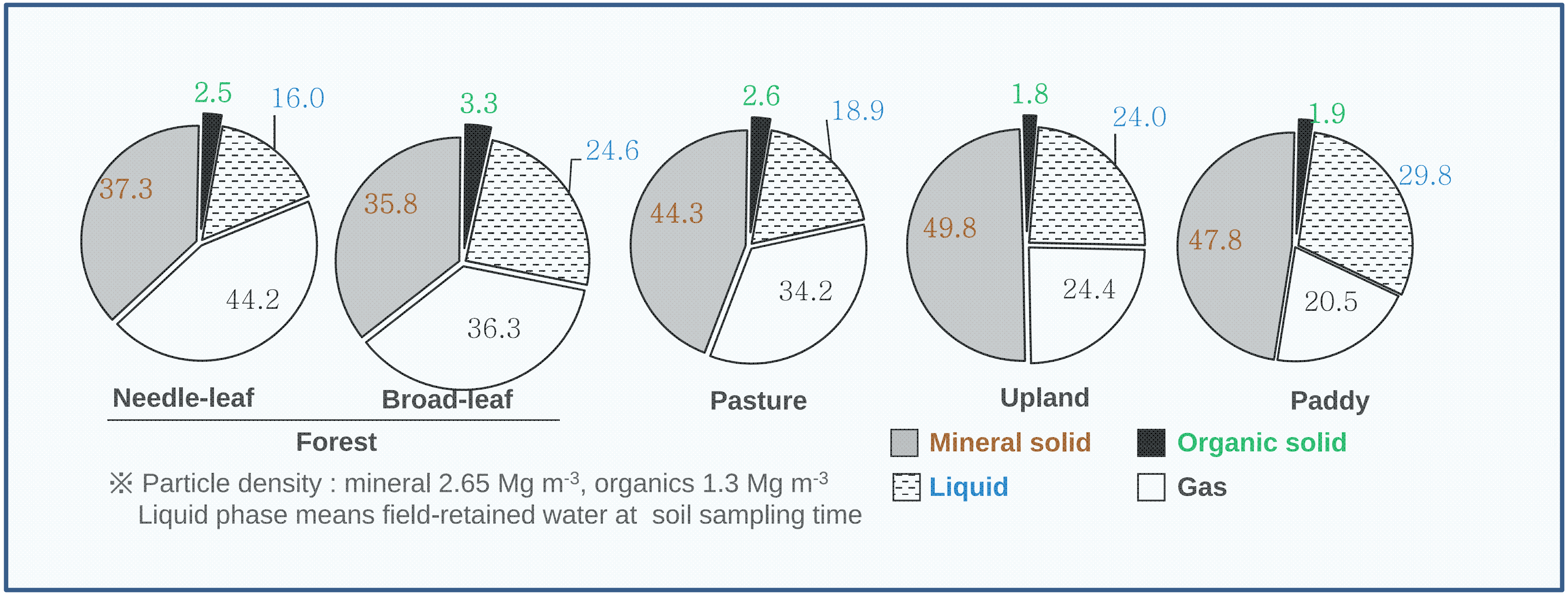
Soil organic carbon and water stable aggregates

Land use types	SOC* (g C kg^{-1})	Light fraction※ in SOC		Plant residue C/N	WSA>0.25 mm (g $100g^{-1}$)
		content (g C kg^{-1})	C/N		
FN	20	5.6	24	43	54.1
FB	27	5.4	20	27	56.8
Pasture	16	1.9	16	21	48.5
Upland	10	0.9	16	NA§	35.8
Paddy	11	0.8	18	NA	45.8

*Soil organic carbon; §Not analyzed ; FN: needle-leaf forest; FB: broad-leaf forest; WSA: water stable aggregate

※ isolated from soils by flotation on dense liquid (Gregorich and Ellert, 1993)

Soil 3-phase 4-component



- Organic solid shares in soil volume : FB>Pasture>FN>paddy>upland
(cf. weight basis : FB>FN>Pasture>paddy>upland, *same to SOC content***)**

- Bulk density : FN 1.05, FB 1.04, Pasture 1.24, Upland 1.37, Paddy 1.32 Mg m^{-3}

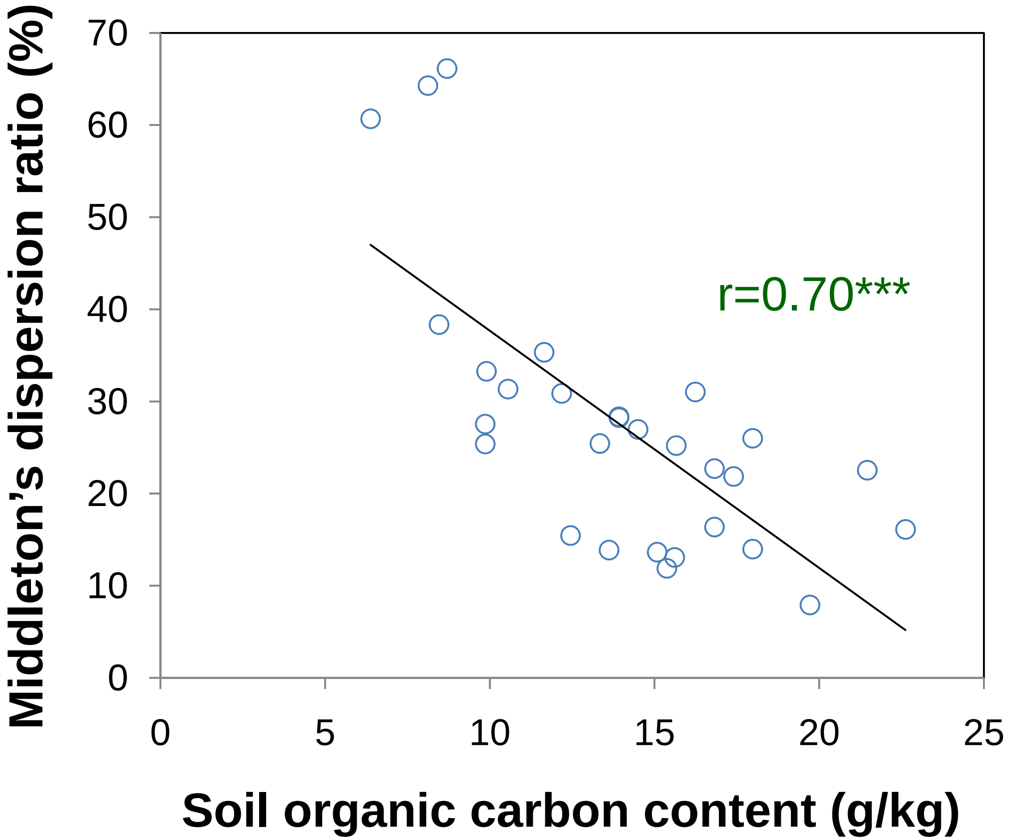
Correlation between soil organic carbon and structure factors.

Land use types	Bulk density (Mg m^{-3})	Mineral Solid (%, v/v)	Pore (%, v/v)		Particle size distribution (g 100g^{-1})			WSA >0.25mm (g 100g^{-1})
	Correlation coefficient§ with soil organic carbon (r, N=21)							
			Liquid	Gas	Sand	Silt	Clay	
FN	-0.76	-0.83	+0.69	-0.17	-0.67	+0.60	+0.61	+0.72
FB	-0.92	-0.96	+0.66	+0.12	-0.92	+0.90	+0.51	+0.91
Pasture	*-0.37*	-0.61	+0.87	-0.69	-0.54	+0.63	+0.48	+0.80
Upland	*-0.10*	*-0.33*	*+0.11*	*+0.19*	*-0.36*	*+0.31*	+0.45	+0.63
Paddy	*-0.25*	*-0.32*	*+0.38*	*-0.27*	-0.76	+0.82	+0.52	*+0.12*

§0.55>r>0.43 : * *P<0.05;, r>0.55 :* ** *P<0.001*; FN: needle-leaf forest; FB: broad-leaf forest

- **WSA>0.25mm content is difficult to explain the storage levels of organic carbon in paddy soils.**
  ➔ We need other indicator of aggregate stability and carbon storage for paddy soils.
  ➔ Dispersibility test has been reported as one of water stability tests

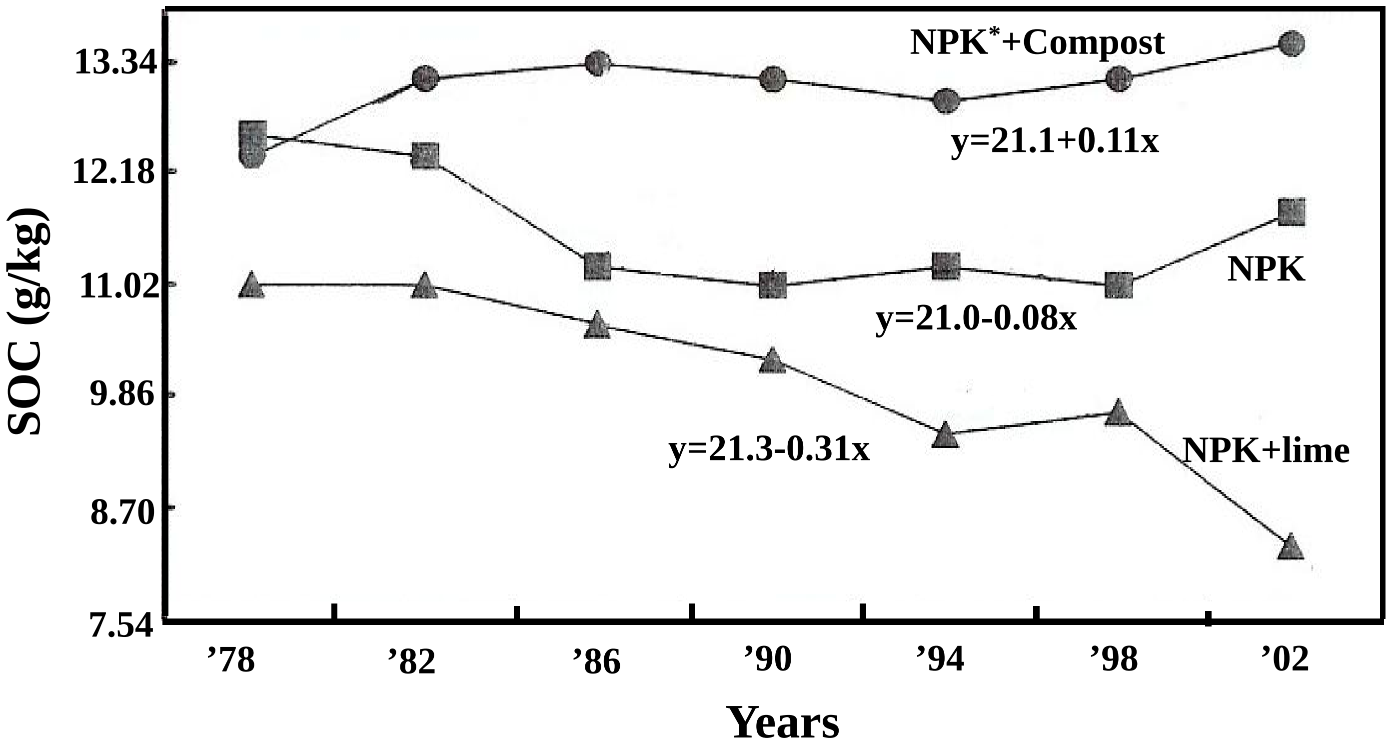
Correlation between soil organic carbon and dispersibility test in paddy soils.



※ Middleton's dispersion ratio indicates [(%silt+%clay) after dispersion of soil in water]/ [(%silt+%clay) in soil] x 100. Data adopted from Han (2009).

2. Aggregate stability and soil carbon storage as affected by different fertilization types under upland cultivation

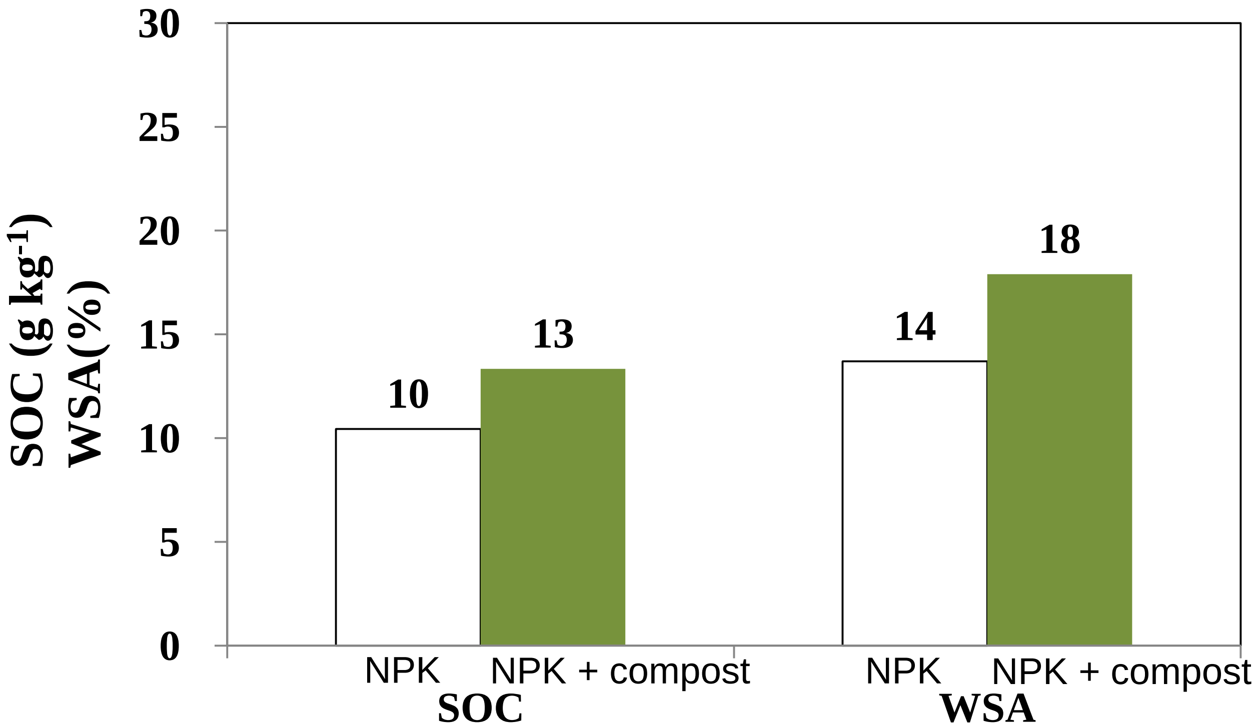
Soil organic carbon in long-term fertilization field



※Field plots at GyeongBuk Agricultural Research & Extension Services. **Soybean-barley cropping system**: SOC: soil organic carbon; *NPK: chemical fertilizer; compost application rate 10 MT/ha; Lime 1.5Mg/ha; **Silt loam**.

Data adopted from NIAST (2004)

Soil organic carbon and aggregate stability as affected by fertilization

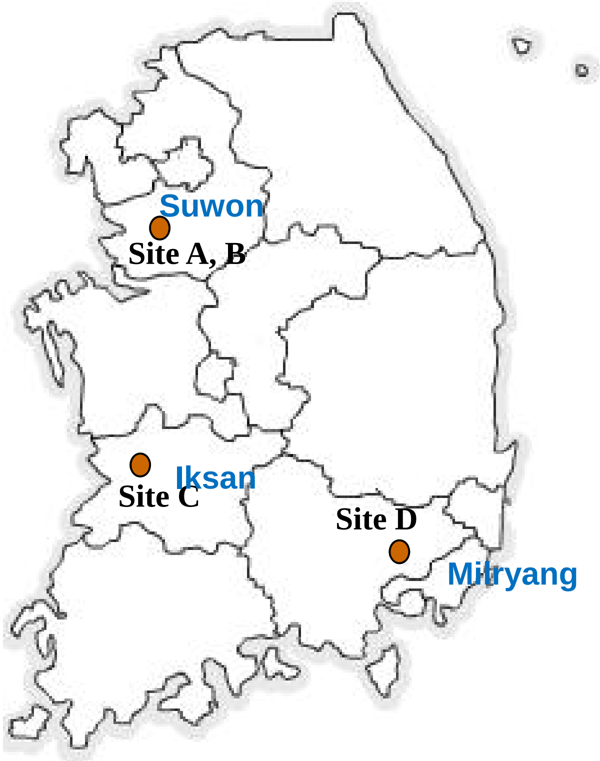


※Field plots at GyeongBuk Agricultural Research & Extension Services. **Soybean-barley cropping system**: SOC: soil organic carbon; *NPK: chemical fertilizer; compost application rate 10 MT/ha; **Silt loam**; WSA: water stable aggregate >0.25mm Investigated in 2003.

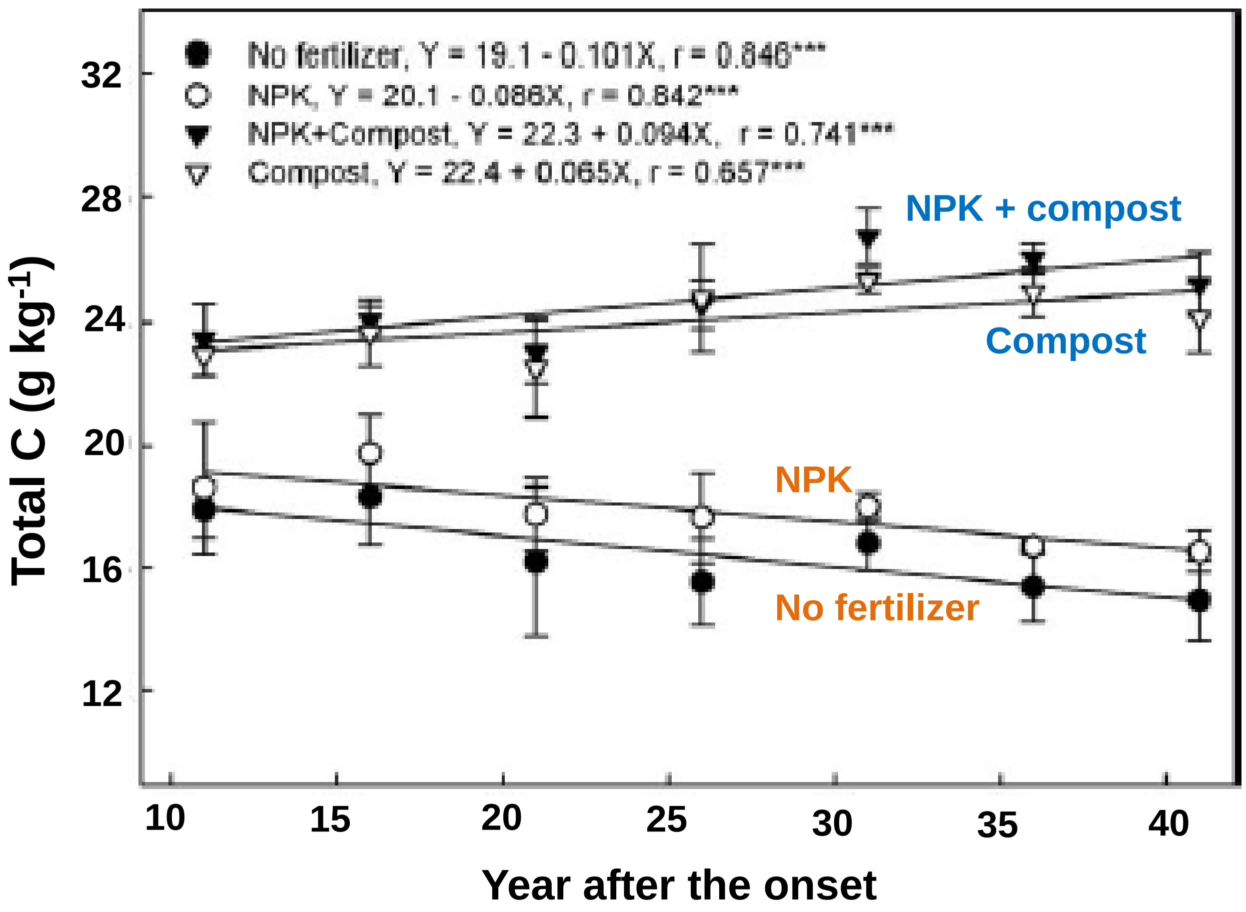
Site descriptions and treatments

Site		Treatments
A[a]	T0	NPK (standard chemical fertilization)
	T1	NPK+Rice straw compost (15MT/ha)
B[b]	T0	Conventional cultivation
	T1	Green manure (hairy vetch)
C[b]	T0	NPK (standard chemical fertilization)
	T1	Fresh straw (5MT/ha)
	T2	Rice straw compost (10MT/ha)
D[b]	T0	No fertilization
	T1	Rice straw compost (10MT/ha)
	T2	NPK (standard chemical fertilization)
	T3	NPK + Rice straw compost (10MT/ha)

[a]National Academy of Agricultural Science Experimental Field
[b]National Institute of Crop Science Experimental Field



Soil carbon change in long-term fertilization field (Site D)



※ Data adopted from Lee et al. (2009)

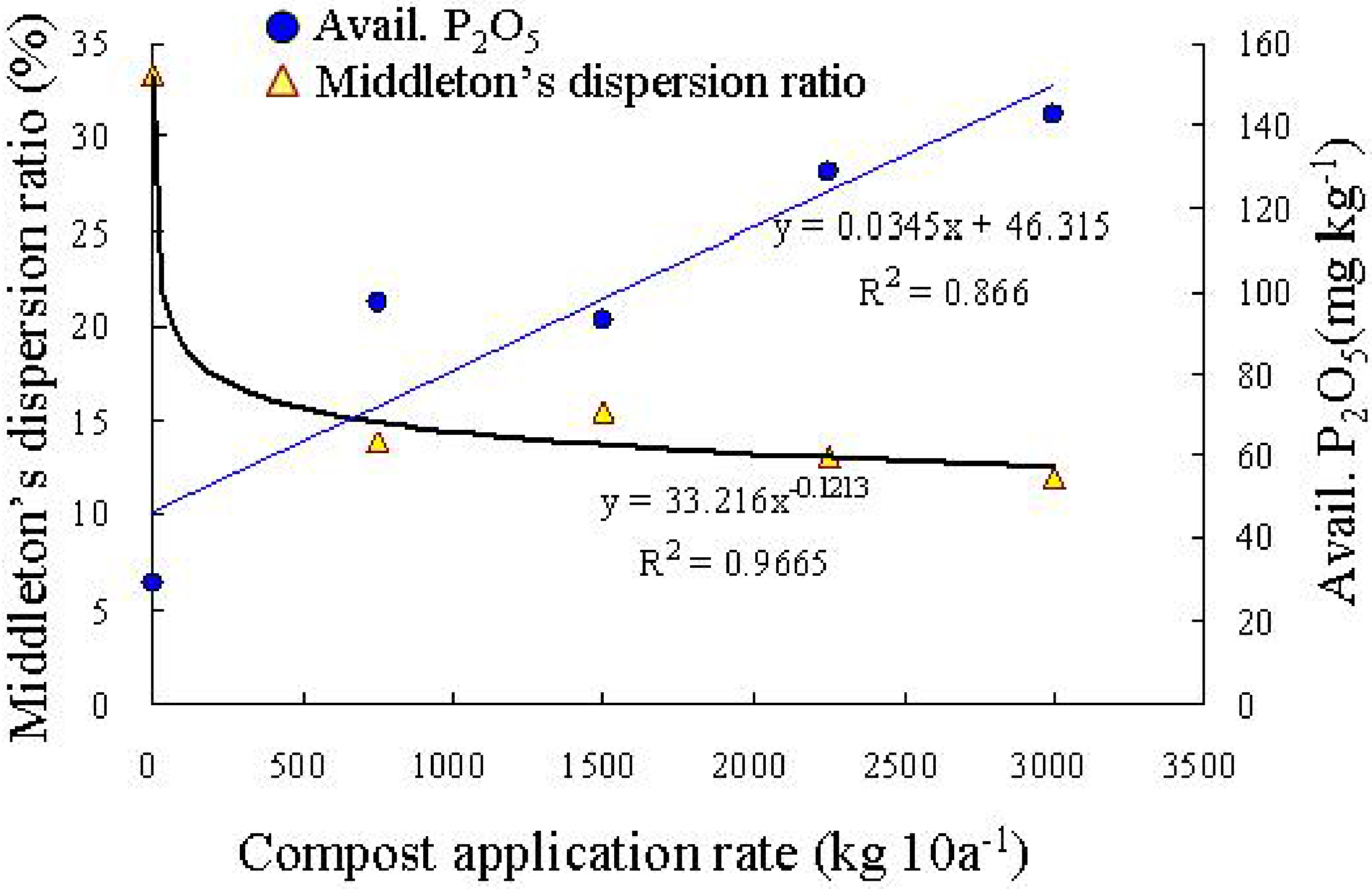
Soil organic carbon and physical properties

Site		SOC[*] g C kg^{-1}	DR[§]	BD[a] Mg m^{-3}	Vs[b] %	Vw[c] %	Va[d] %	TPS[e] %	MP[f] %	AP[g] cm sec^{-1}	Yamanaka hardness mm
A	T0	10	25.4	1.47	55.6	40.0	4.4	44.4	2.7	0.08	13.4
	T1	15	13.6	1.12	42.2	46.1	11.6	57.8	12.0	0.23	12.4
B	T0	18	14.0	1.13	42.8	39.6	17.6	57.2	22.2	0.70	14.8
	T1	20	7.9	1.12	42.4	43.1	14.5	57.6	30.5	0.75	13.8
C	T0	8	38	1.22	46.0	43.1	10.9	54.0	10.4	0.23	16.0
	T1	11	31	1.21	45.8	45.2	9.0	54.2	12.9	0.34	16.0
	T2	12	35	1.04	39.3	39.5	21.3	60.7	16.9	0.42	15.4
D	T0	16	31.0	1.32	49.8	30.2	20.0	50.2	18.0	0.45	22.6
	T1	21	22.5	1.14	43.0	41.9	15.1	57.0	17.1	0.65	16.8
	T2	17	16.4	1.28	48.3	39.3	12.4	51.7	10.0	0.58	17.0
	T3	23	16.1	1.01	38.0	31.4	30.5	62.0	22.3	0.95	16.6

[*]Soil organic carbon; [§]Middleton's dispersion ratio indicates [(%silt+%clay) after dispersion of soil in water]/[(%silt+%clay) in soil] x 100. ; [a]Bulk density; [b]Volume ratio of solid phase; [c]Volume ratio of liquid phase; [d]Volume ratio of gas phase; [e]Total pore space; [f]Macroporosity; [g]Air permeability.

Data adopted from Kim et al. (2004), Han (2009) and NIAST (2004)

Compost effect on aggregate stability and available phosphate content (Site A)



※ Middleton's dispersion ratio indicates [(%silt+%clay) after dispersion of soil in water]/ [(%silt+%clay) in soil] x 100.
Data adopted from Han (2009).

Conclusions

- Soil organic carbon content largely depends on the amount of organic inputs according to vegetation types and organic amendments.
- Aggregate stability and soil organic carbon each other was correlated, provided the method of stability test was properly chosen considering the characteristics of aggregate formation-breakdown in different land use types, especially paddy field.
- It could be considered, therefore, that aggregate stability test with verified method is useful for assessing organic carbon and aggregation in soils.
- In addition, we concluded that land management practices giving higher organics, necessarily considering material balance in soils such as P, and lower disturbance to soil could result in higher macro-aggregation and carbon storage.

Thank you for your attention