Chronological Changes of Soil Carbon Stock in Korea

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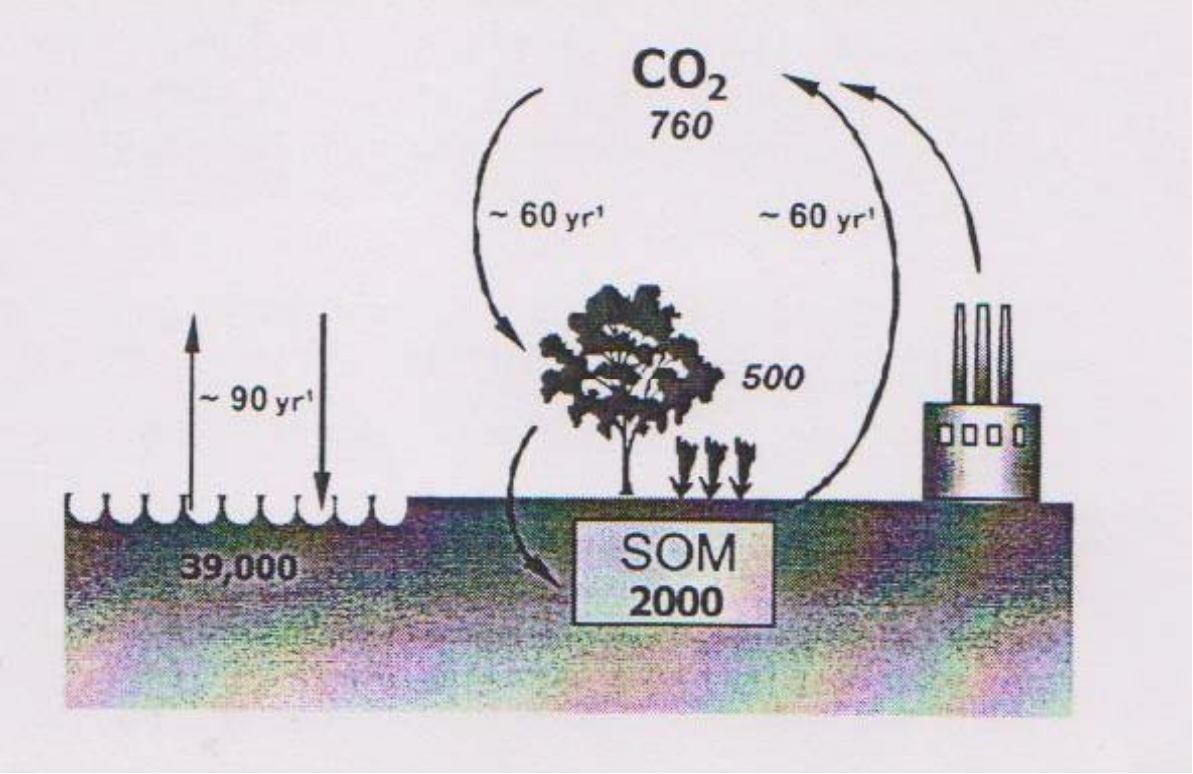
1. Introduction

Soil Organic Carbon (SOC)

- Soil organic carbon (SOC) is composed of a plant debris and decomposition intermediates and microorganism.

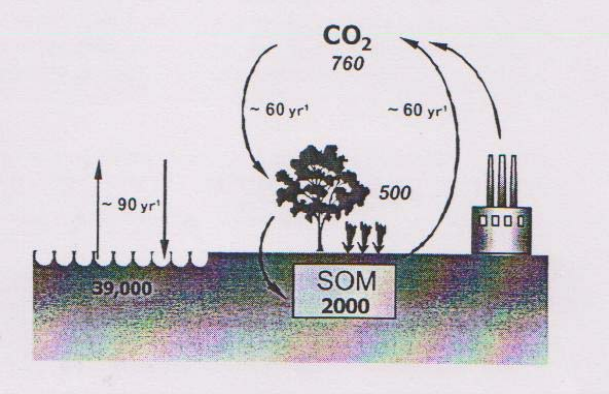
- The C occurs in four pools:
  - Atmosphere, Terrestrial biota, Soil, and Ocean.
    - 760 Pg C in atmosphere,
    - about 500 Pg C in terrestrial biota,
    - about 1,500 to 2,000 Pg C in soil,
    - 39,000 Pg C in the oceans.

Carbon Cycle among Pools



- The amount in soils is at least 2 times that in the atmosphere.

Carbon Cycle among Pools



- Climate change occurs by CO_2 increase of atmosphere.
- If CO_2 of ocean is equilibrated with atmosphere, To mitigate CO_2 increase of atmosphere, we must
  - ✓ **reduce** CO_2 from fuel or
  - ✓ **increase** C sequestration of soils.

- Can the soils accumulate more carbon?
- If yes, how much C can be sequestered in soil? To know C sequestration of soil, we must know
  - ✓ **SOC stock** and
  - ✓ **C** sequestration **potential**.

C Sequestration Potential of Soil

- C sequestration potential is different from
  - soil site characteristics
    - altitude and vegetation
  - management practices
    - Paddy soil, upland soil
  - soil properties
    - parent material and soil texture, etc

- Monitoring SOC of the soils is prerequisite.

Database of C Stock in Korea

- Korea has established fertilizer recommending system since 1980.
  - SOC is an indicator for recommending N fertilizer.
  - The C of the soils is determined by total organic C.
- Korea has performed projects on soil testing.
  - More than 150 county laboratories have taken part in.
  - The 5 projects
    - 1980~1989: Ten years project on integrated soil improvement for paddy soils
    - 1995~1999: Five years project on integrated soil improvement for upland soils
    - 2000~2004: Soil testing on the fields of cultivating strategic crop
    - 2005~2008: Soil testing on the fields for major crop
    - 2009~ : Soil testing for farm land
- The data of soil testing has been input in agricultural soil information system
  - It can be input multiplicate to recommend fertilizers for several crops.

Objects

- Introduce SOC Stock in Korea
  - Chronological changes of SOC at different
    - Crops
    - Management practices
    - Soil properties
  - Find major indicators for C stock
    - Relationship between SOC changes and soil factors
- Establish the possible C sequestration
  - By comparing SOC stock and C sequestration potential
    - C sequestration potential according to soil properties
  - By adapting the management practices on C sequestration

2. Chronological changes of SOC in Korea

Chronological changes of SOC

Table 1. Chronological changes for Korean arable soils

Soils	Project period	Sample sites (Number)	SOC (g C kg^{-1})	
			Mean	Standard deviation
Paddy soils	1980~1988	616,687	13.2	5.2
	2000~2004	393,292	13.5	8.0
	2005~2008	493,927	13.6	8.5
	2009	348,950	13.3	5.5
Upland soils	1995~1999	890,588	14.0	9.1
	2000~2004	136,786	16.9	13.3
	2005~2008	399,004	16.5	14.4
	2009	240,393	15.8	12.3

What is the driving force for SOC change?

Chronological changes in paddy rice

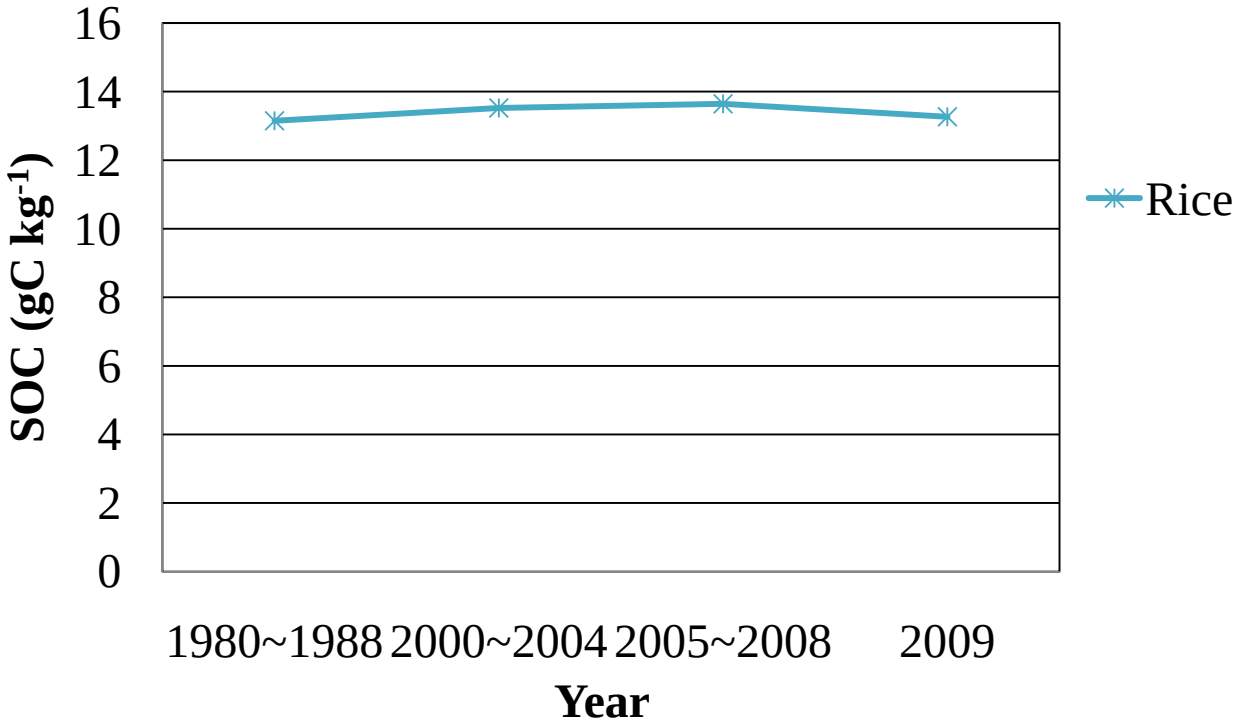
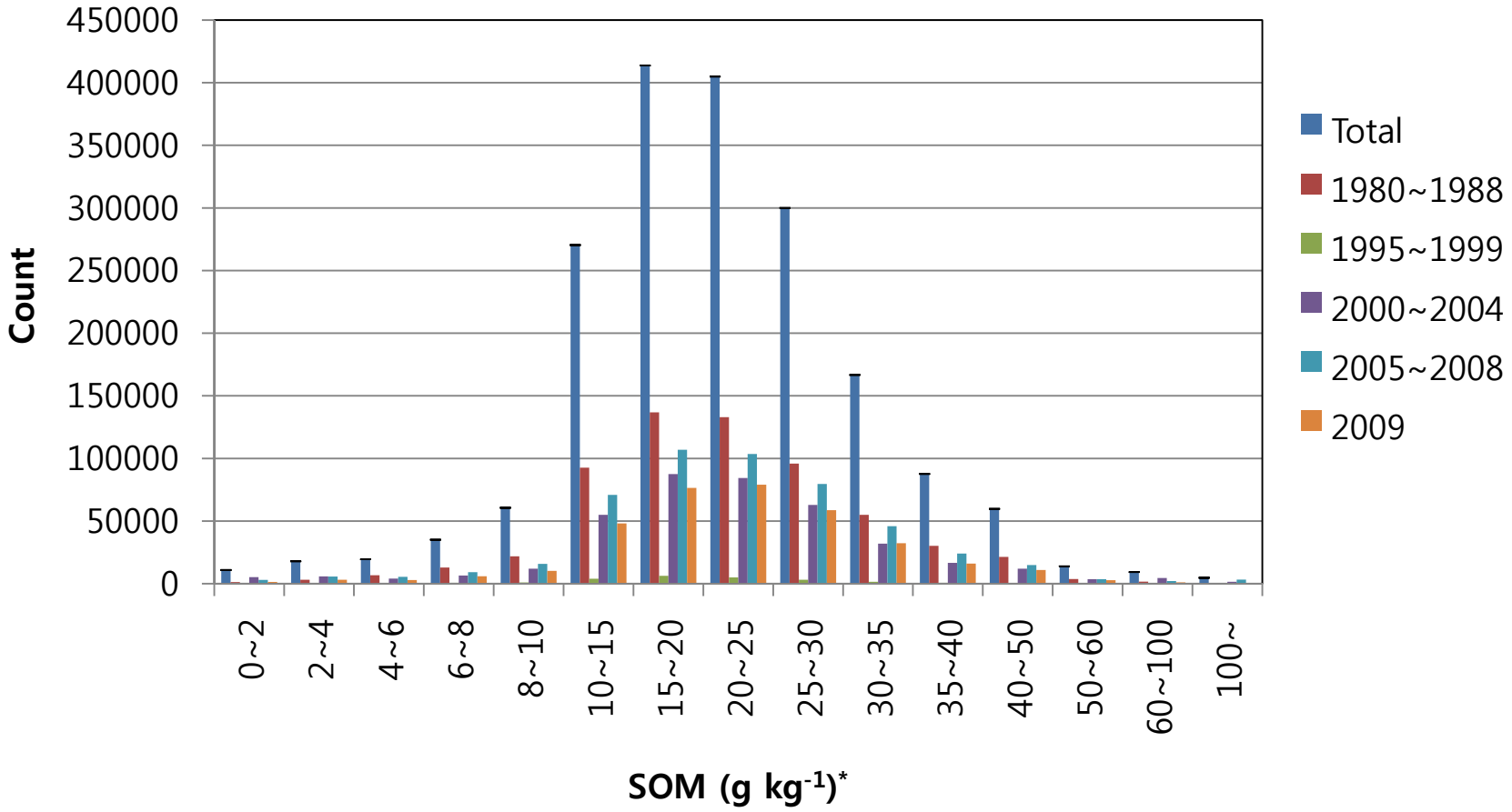


Fig. 1. Chronological changes of SOC of paddy rice.

Distribution of SOC in paddy soils



* SOM = 1.724*SOC

Chronological changes in upland crops

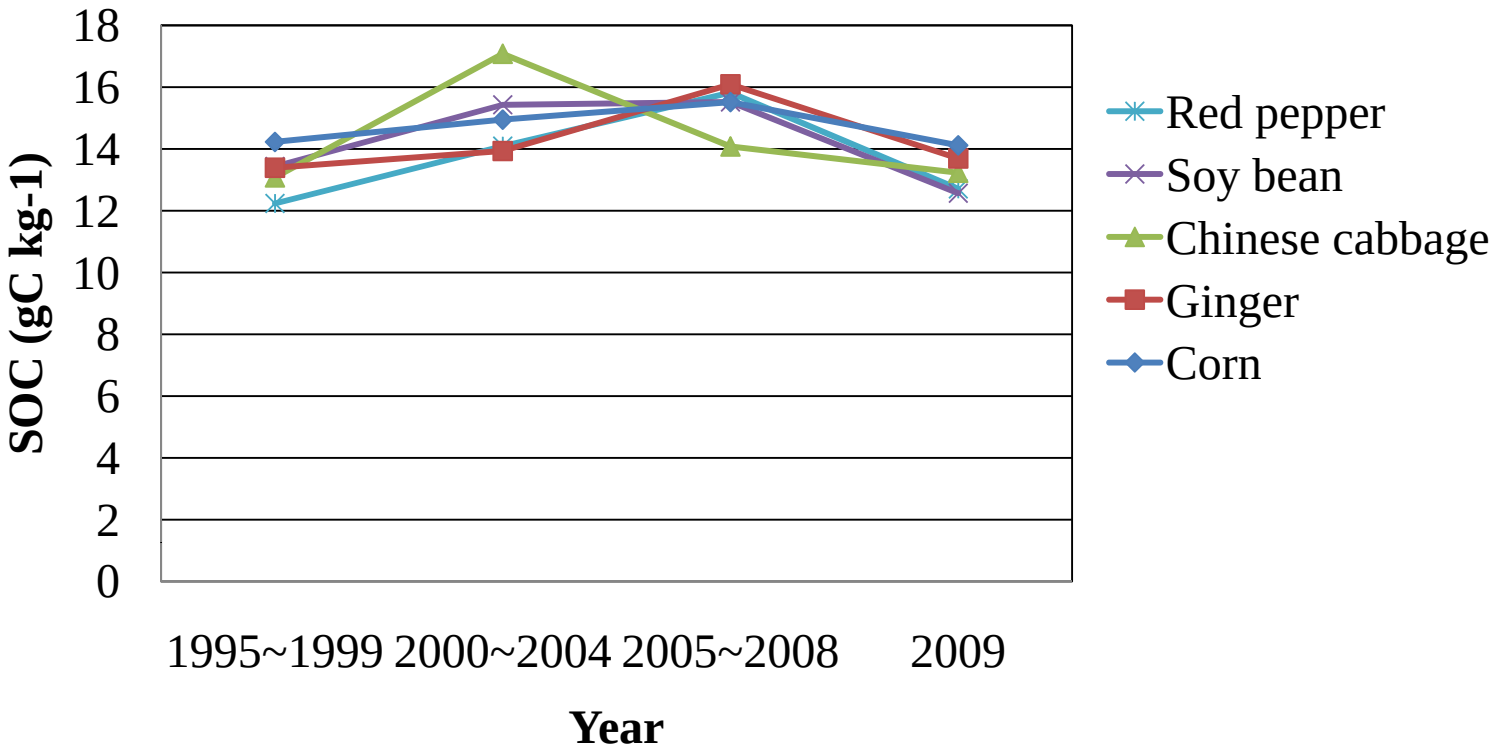
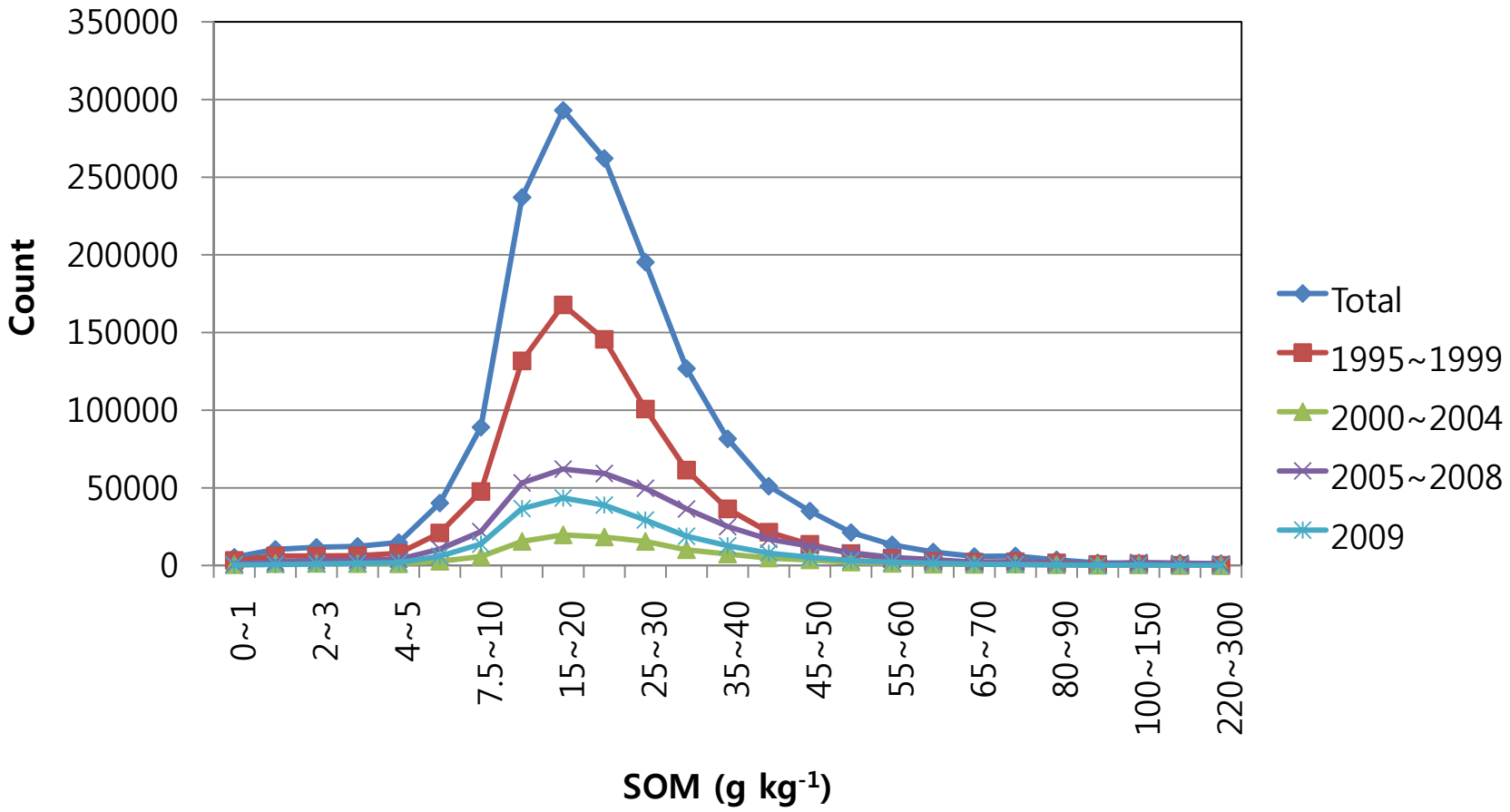


Fig. 2. Chronological changes of SOC of upland soils cropping major crops.

Distribution of SOC in upland soils



Could SOC be changed by management practices?

✓ Chronological changes of SOC

- Sustained constant level in paddy soils: **13** g C kg^{-1}
- Changed by year or by different crops: **14~17** g C kg^{-1}

⇒ **SOC was changed by land use**

✓ SOC of upland soils

- All arable upland soils in the later 1990s: **14.0** g C kg^{-1}
- Beneficial crops in the 2000s: **15.8~16.9** g C kg^{-1}

⇒ **SOC was changed by applying compost**

∴ **Management practices are the driving force for SOC change**

3. The Effects of Soil Properties on SOC Stock

Is SOC of paddy soils related to soil properties?

The effect of topography in paddy soils

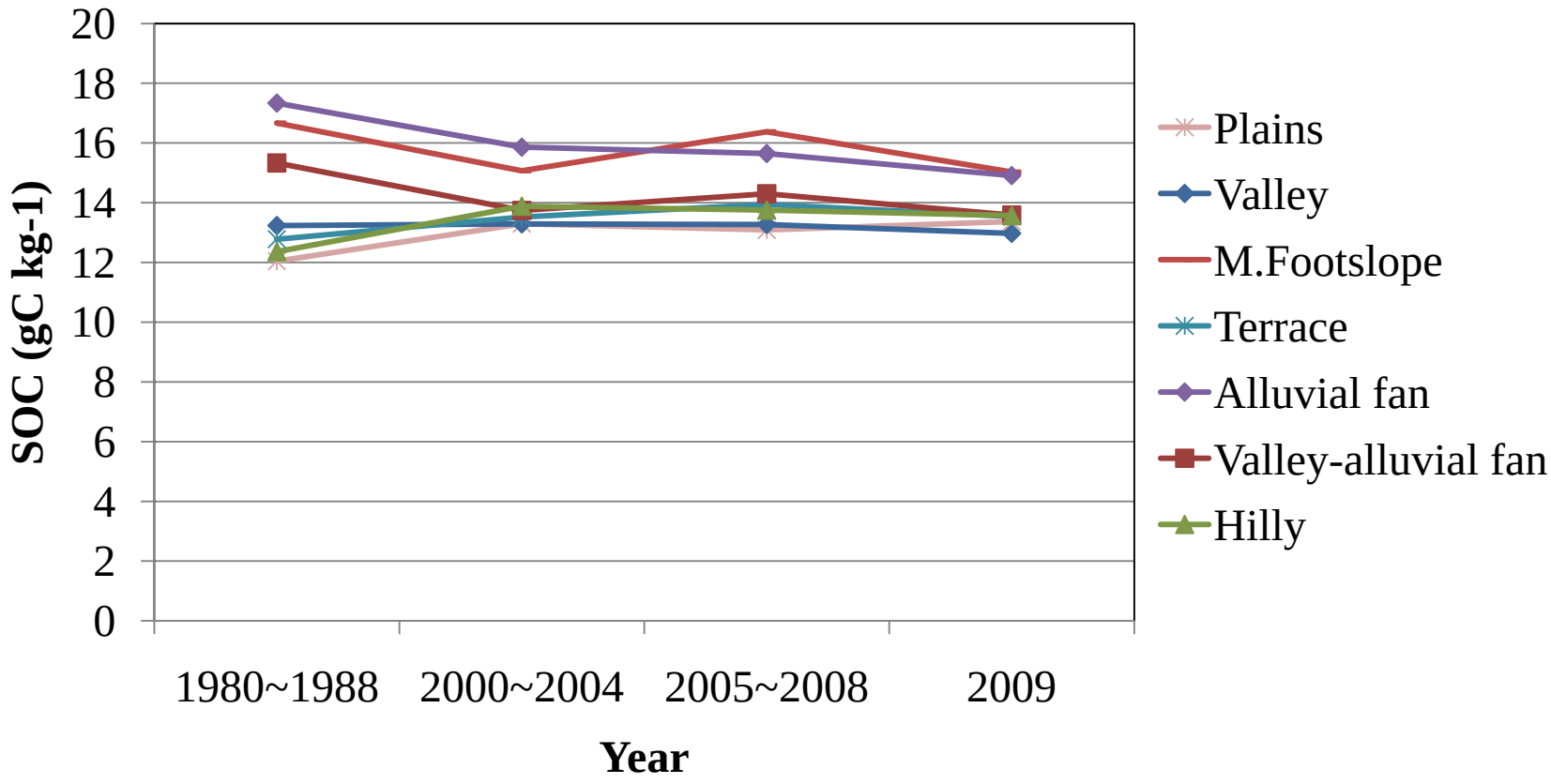


Fig. 2. Chronological changes of SOC of paddy soils located in different topography.

The effect of parent material in paddy soils

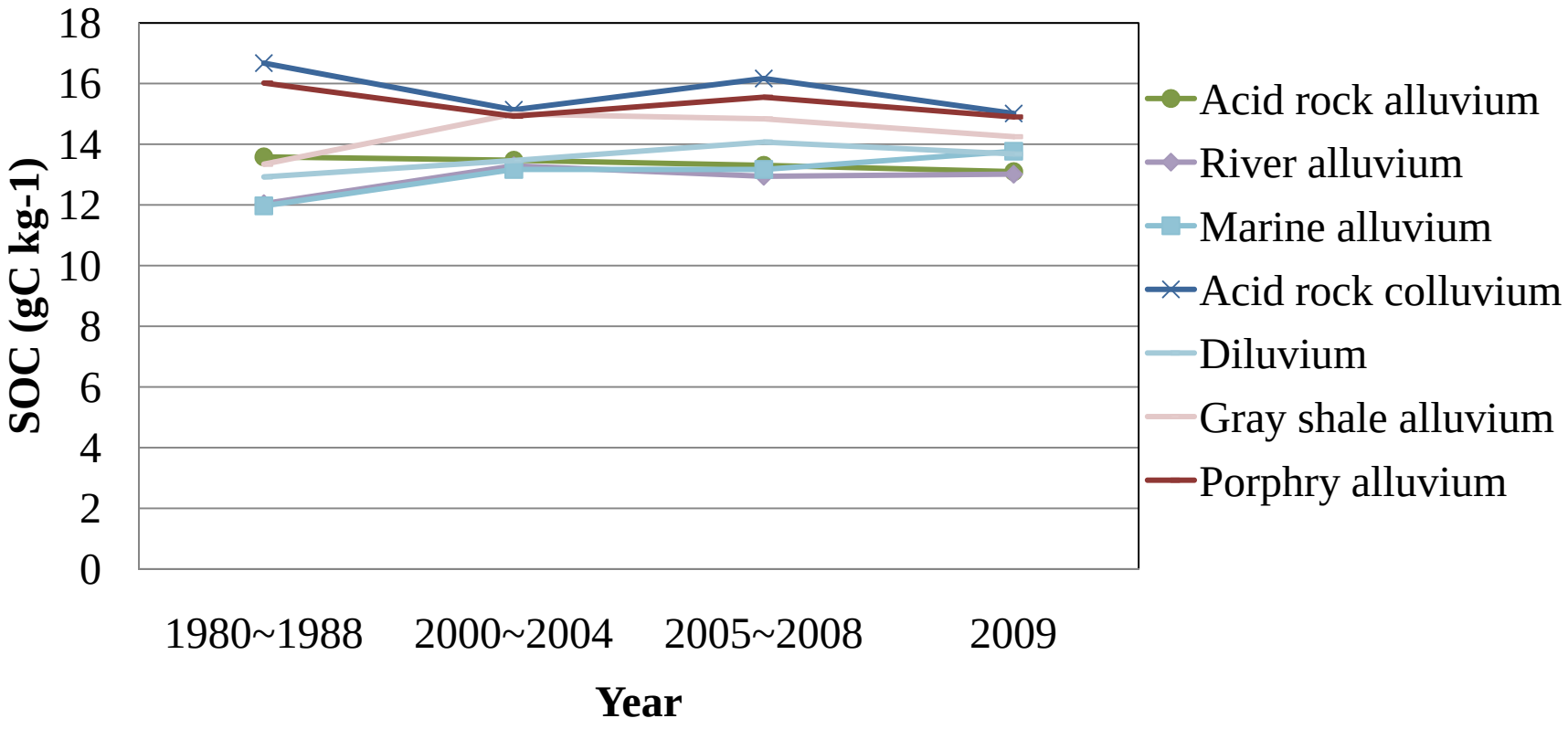


Fig. 3. Chronological changes of SOC of paddy soils by parent material.

The effect of great group in paddy soils

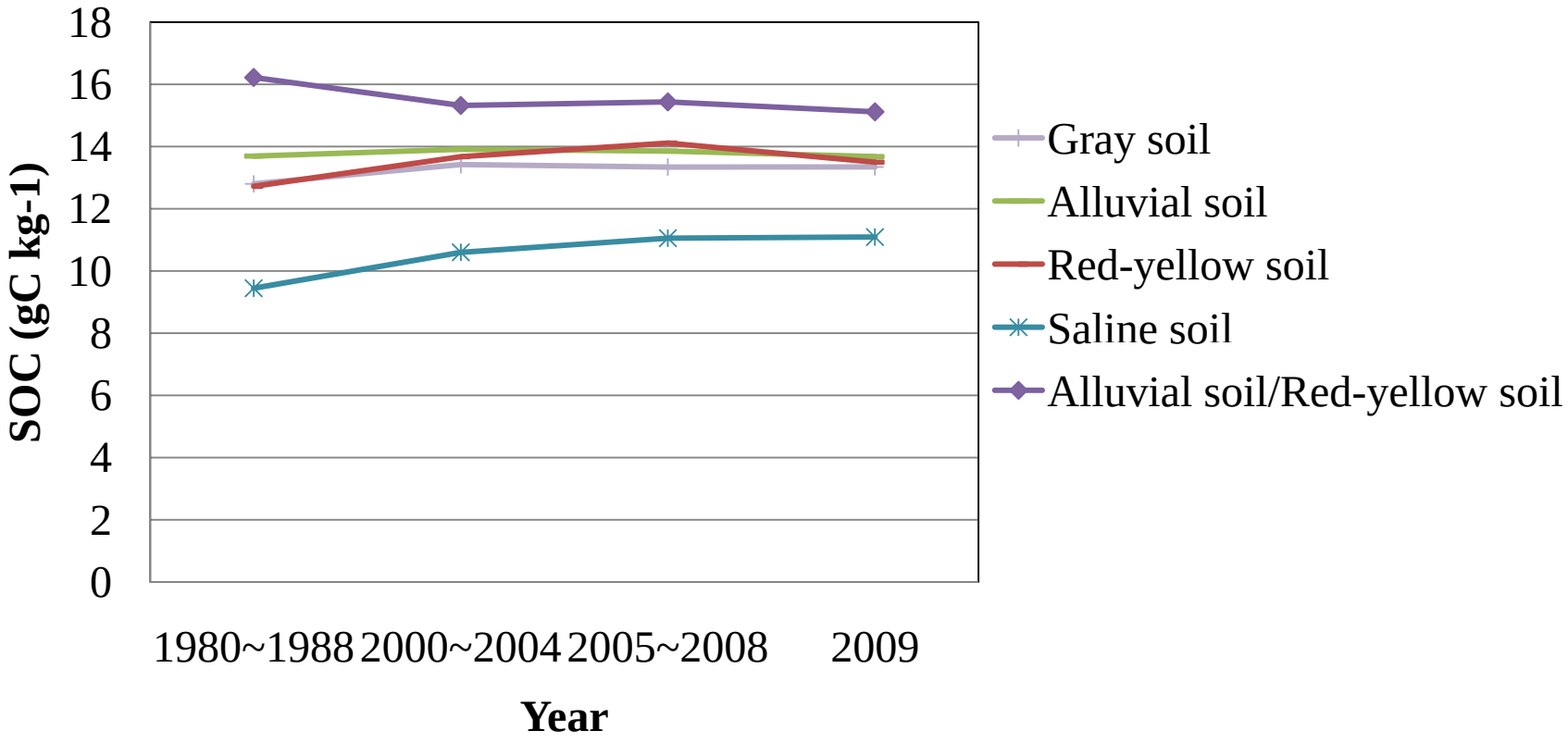
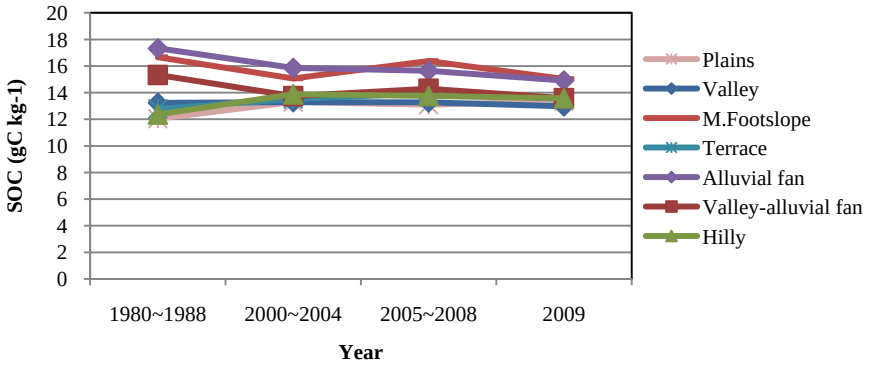
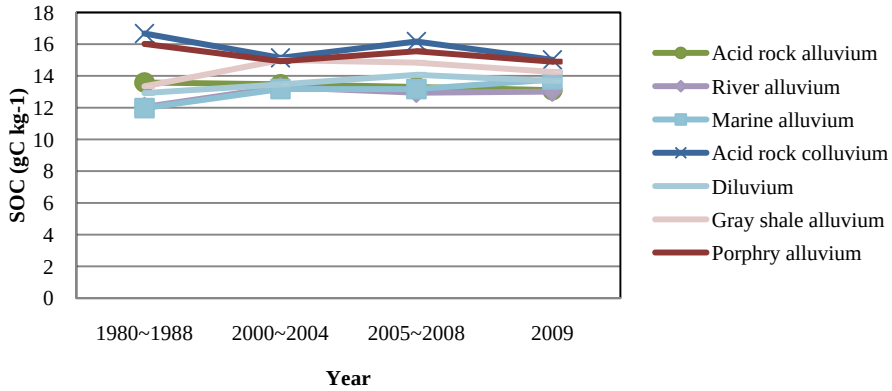
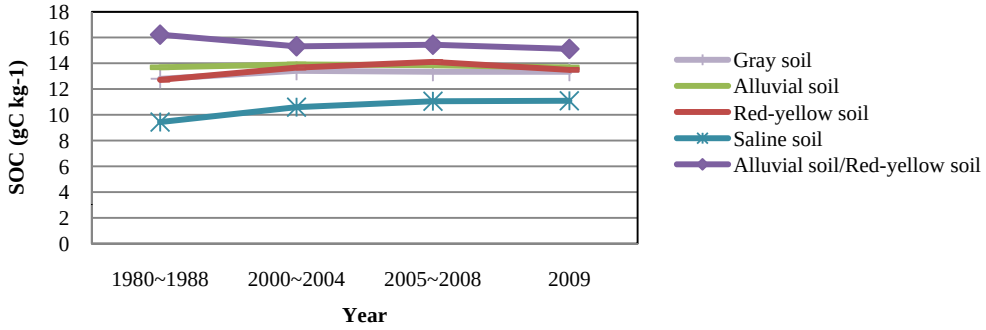


Fig. 4. Chronological changes of SOC of paddy soils by great soil group.

Paddy SOC according to site characteristic







- ✓SOC is differed from topography, parent material, etc.
- ✓But SOC pattern showed **steady-state** because of removal of rice straw

The effect of drainage in paddy soils

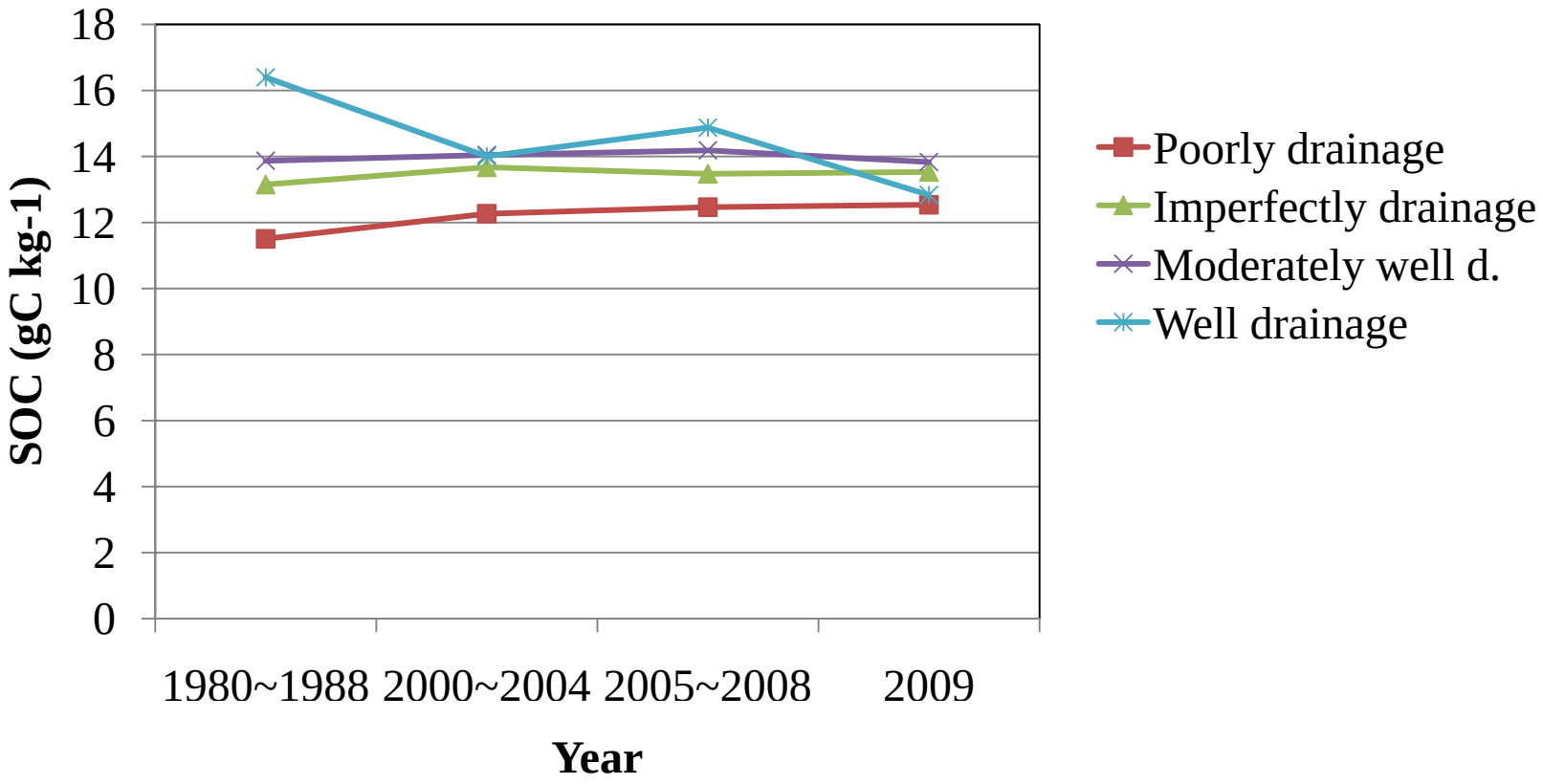


Fig. 5. Chronological changes of SOC by drainage condition of paddy soils.

The effect of gravel content in paddy soils

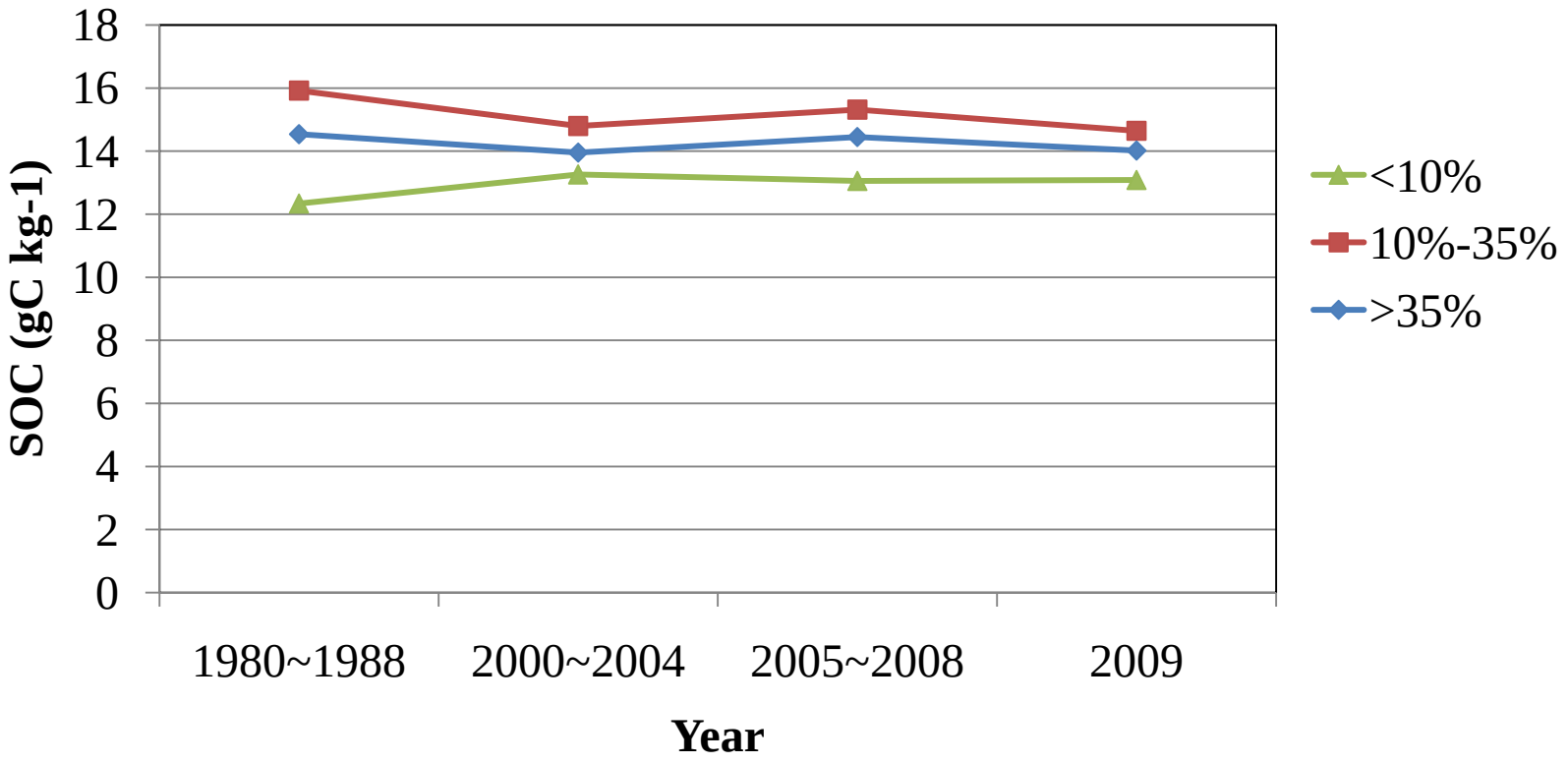


Fig. 6. Chronological changes in SOC according to gravel content of paddy soils.

The effect of soil texture in paddy soils

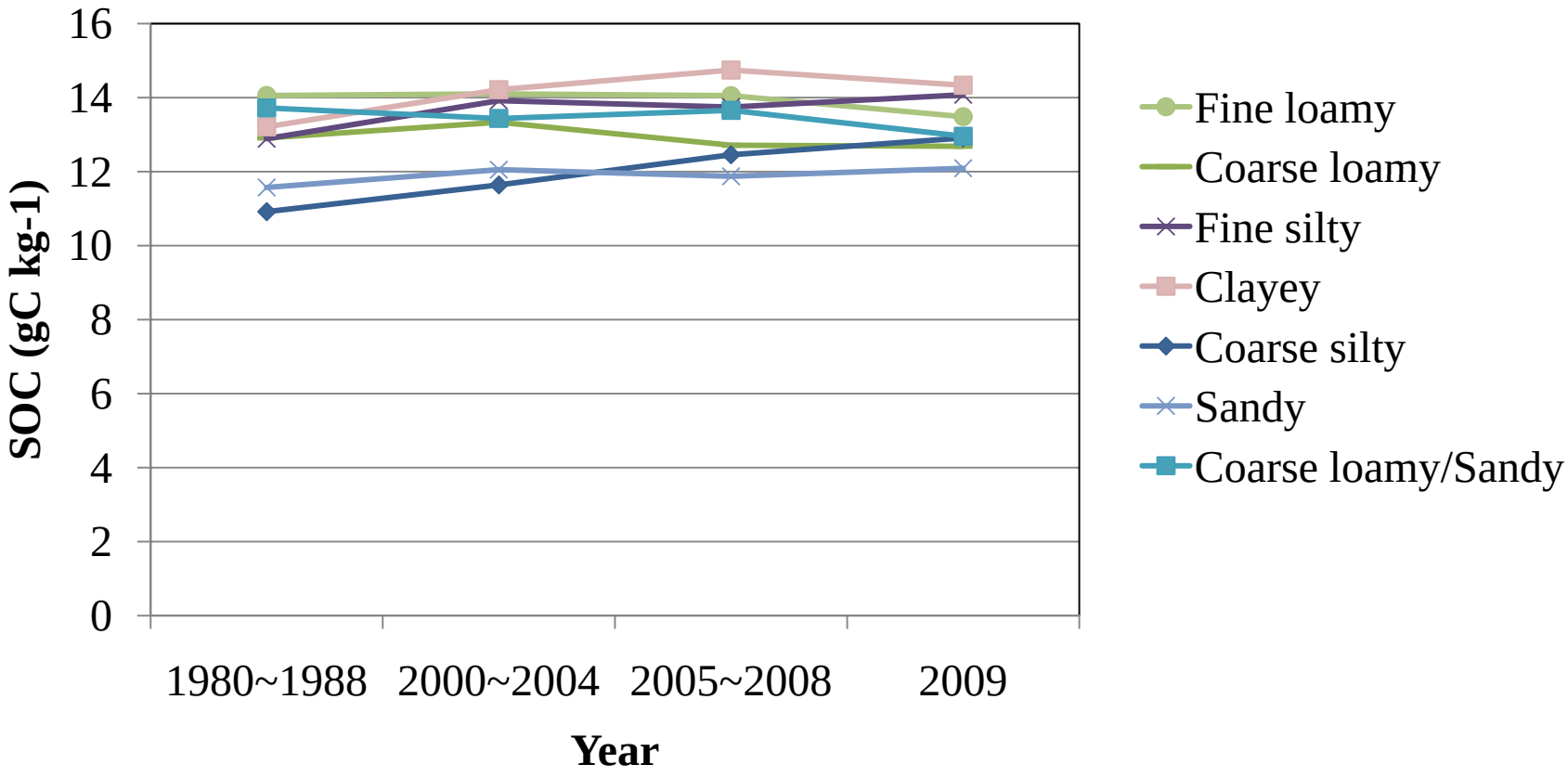


Fig. 7. Chronological changes in SOC according to soil texture of paddy soils.

The effect of effective soil depth in paddy soils

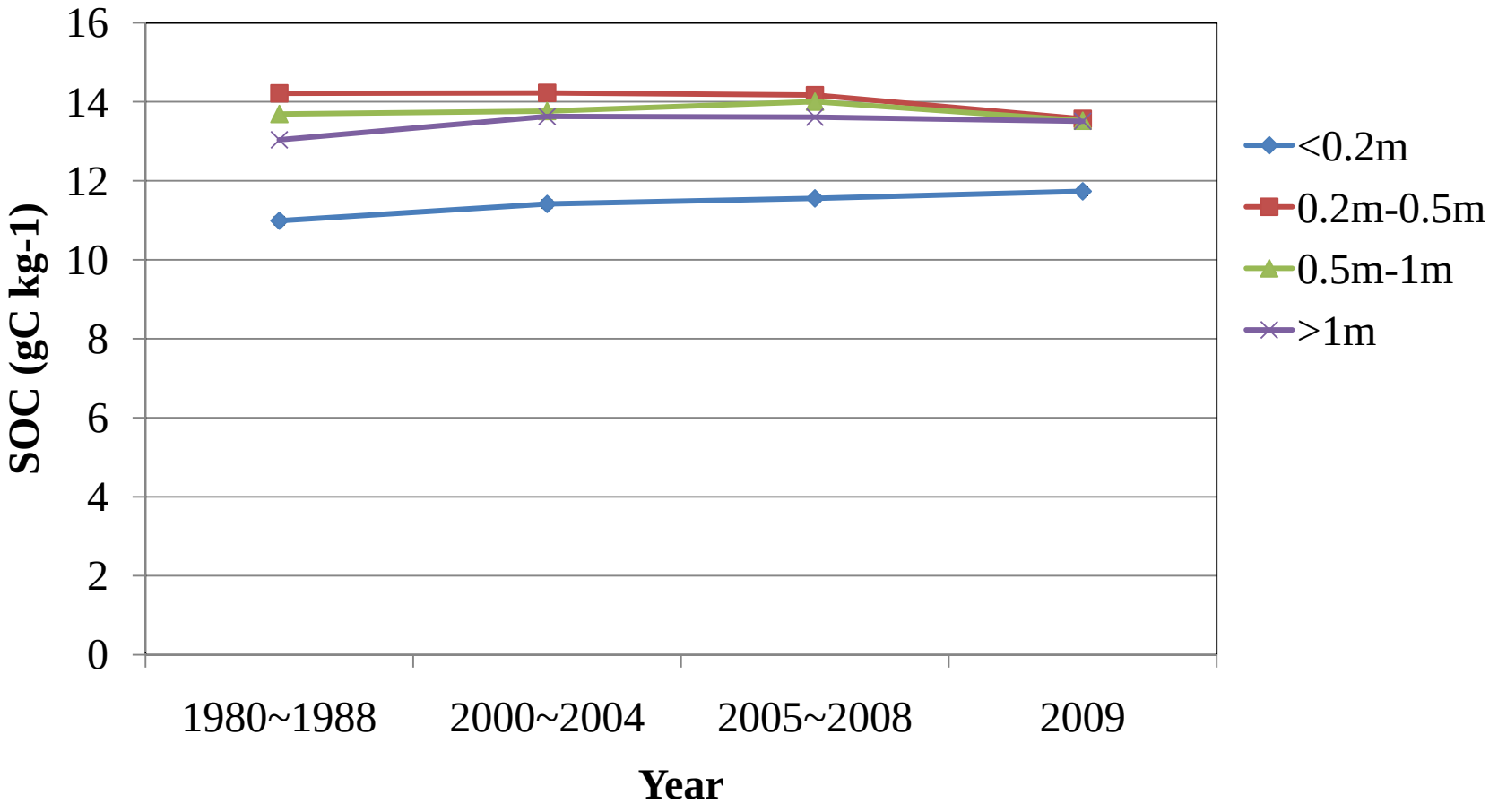
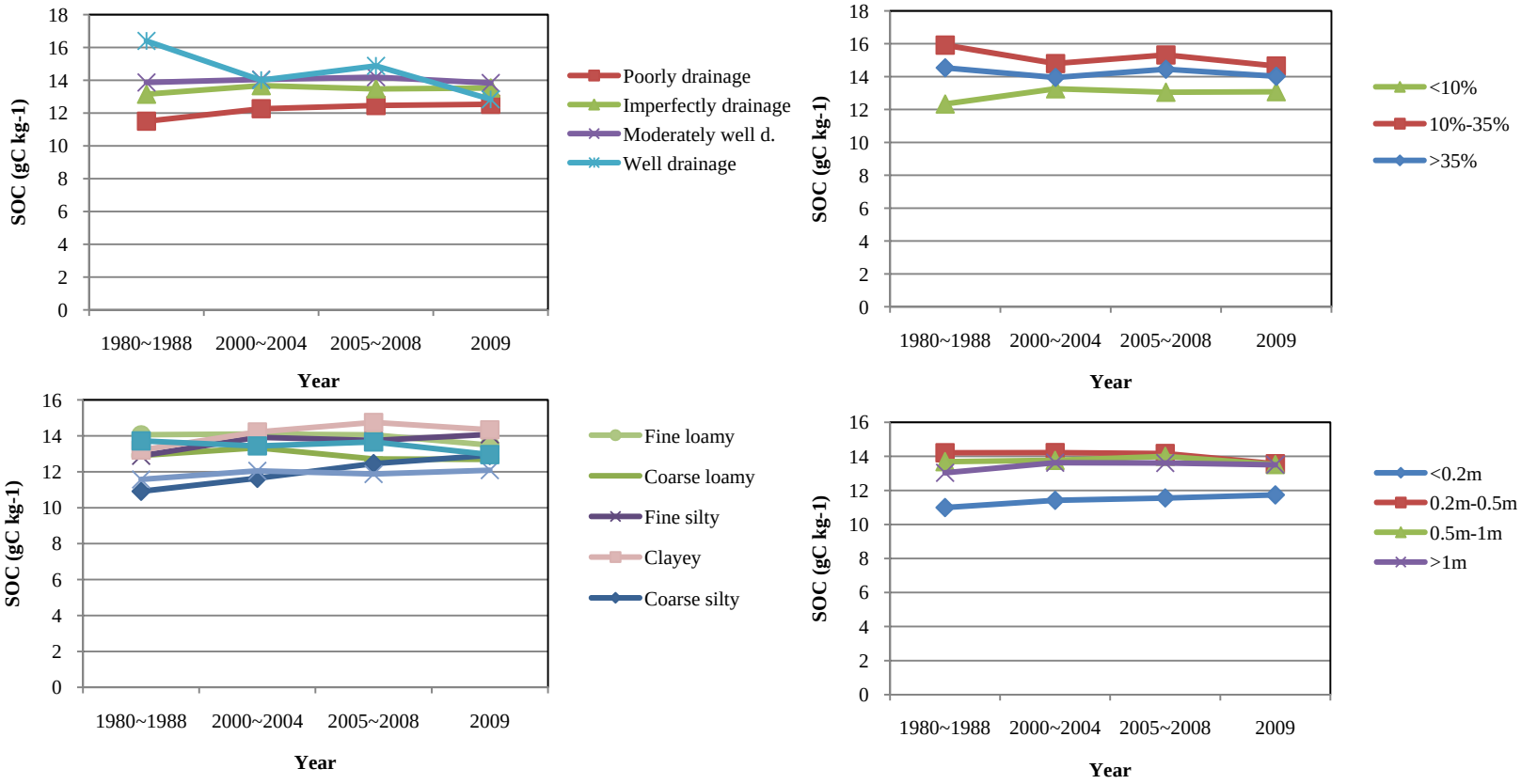


Fig. 8. Chronological changes in SOC of paddy soils according to effective soil depth.

Paddy SOC according soil properties



- ✓SOC stock is differed from soil properties.
- ✓Minimum SOC stock, SOC sequestration potential will be different from soil properties.

SOC changes by applying compost

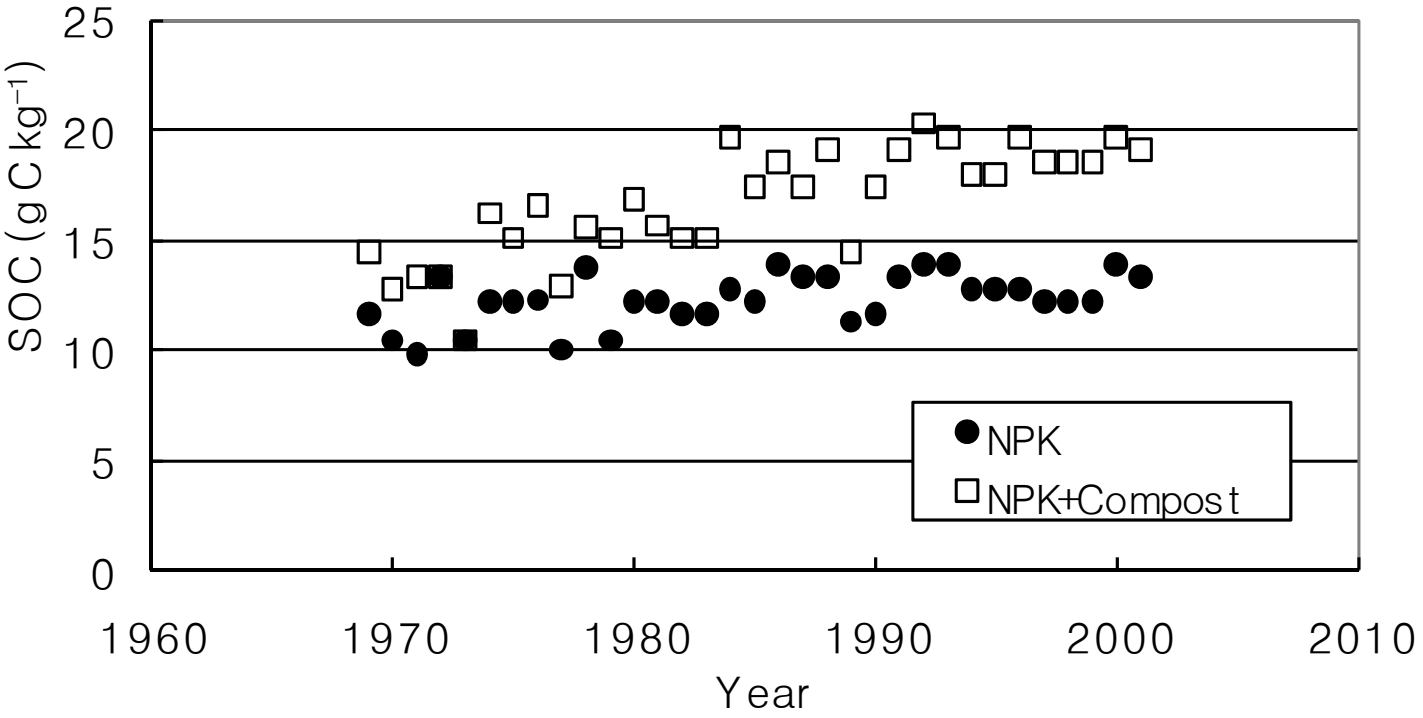


Fig. 9. SOC changes of paddy soil by applying compost 7.5 MT ha^{-1} annually.

Could SOC of paddy soils be affected by soil properties?

✓ SOC stock of paddy soil is related to soil properties.

- Rice straw has been removed to utilize for cattle food.
- SOC was low in poor drainage and sandy soil and shallow soil depth.

⇒ **Minimum SOC stock of paddy soil**

✓ SOC sequestration potential of paddy soils

- Annual application of compost made SOC of paddy soil increase: **from 13 to 20** g C kg^{-1}
- SOC sequestration potential of paddy soils will be different from soil properties.

⇒ **SOC sequestration potential depends on soil properties.**

∴ **Paddy soil could sequester the air C.**

Is SOC of upland soils related to soil properties?

The effect of topography in upland soils

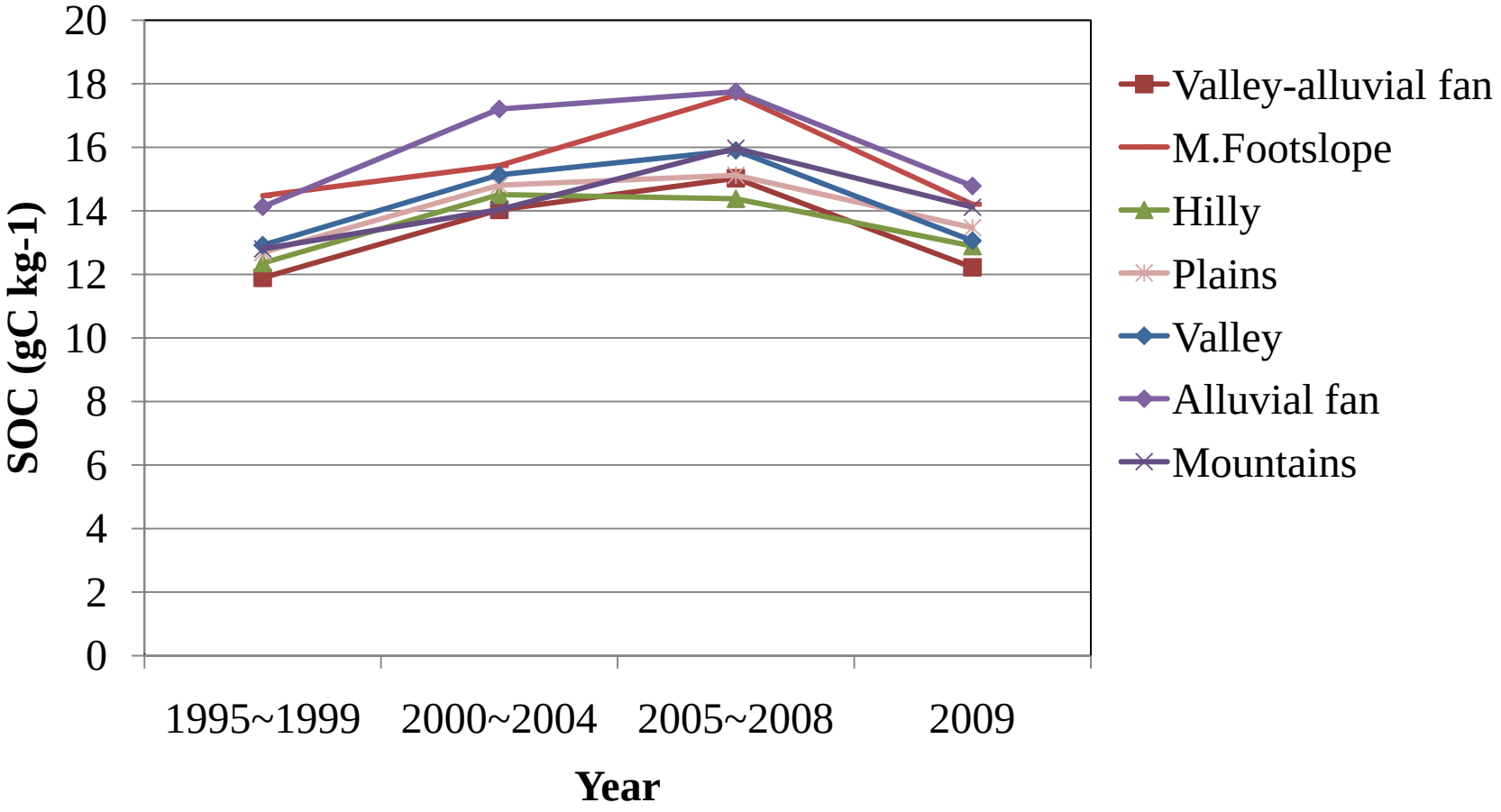


Fig. 10. Chronological changes of SOC of upland soils by topography.

The effect of parent material in upland soils

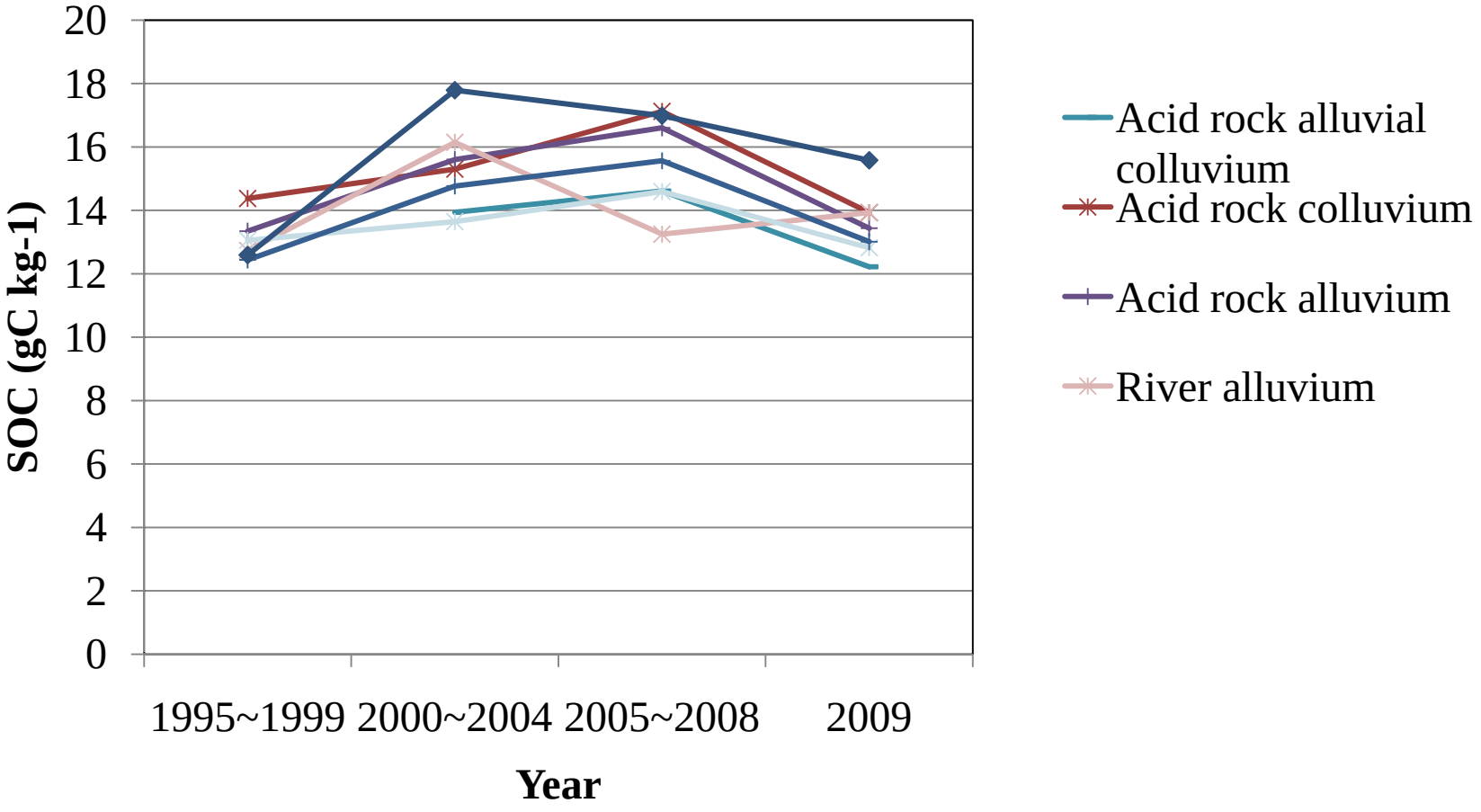


Fig. 11. Chronological changes of SOC of upland soils by parent material.

The effect of great group in upland soils

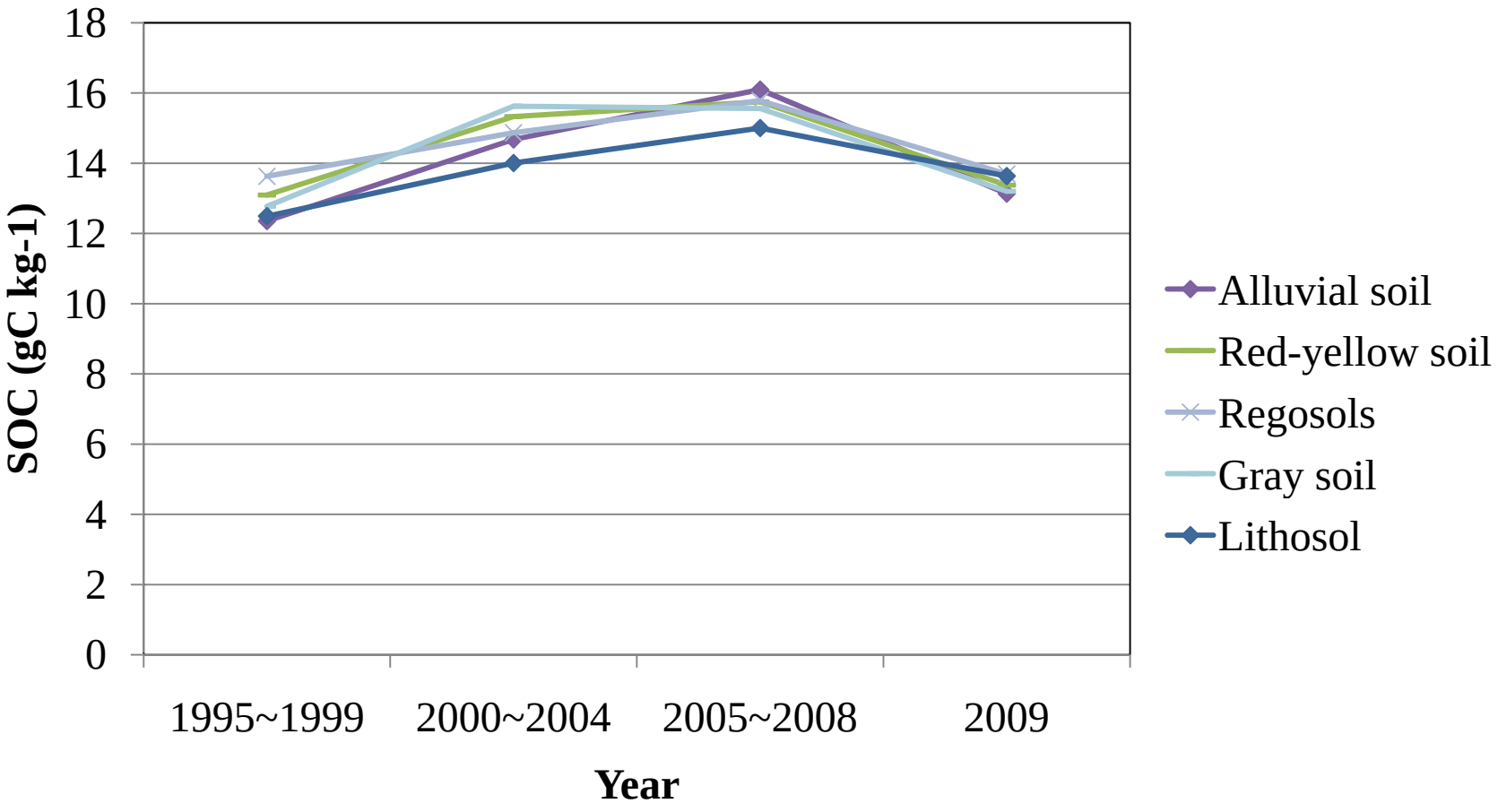
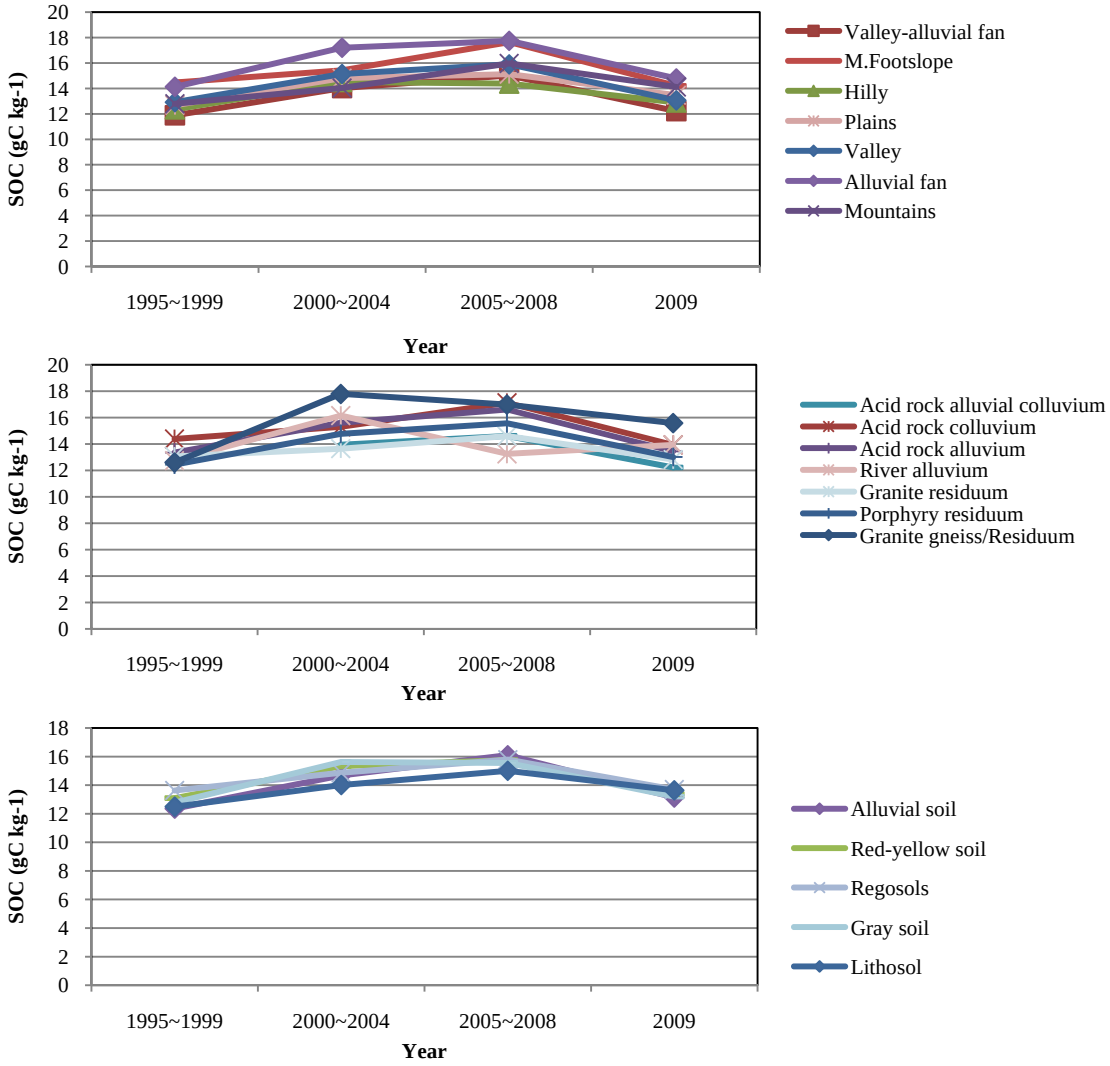


Fig. 12. Chronological changes of SOC of upland soils by great soil group.

Upland SOC according to site characteristic



- ✓Yearly difference is greater than that of topography, parent materials, etc.
- ✓C sequestration is possible in upland soil by management practices.

The effect of drainage in upland soils

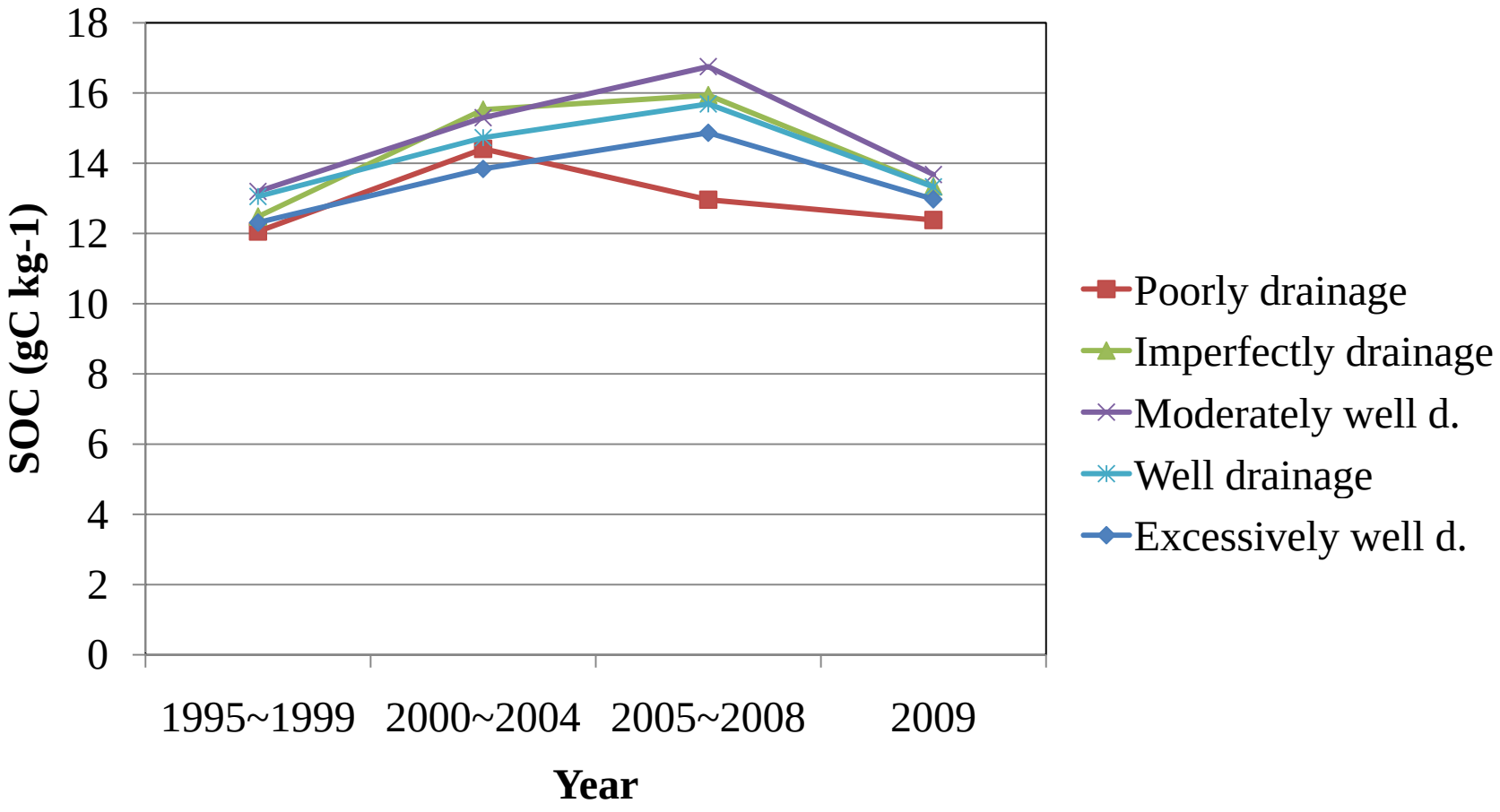


Fig. 13. Chronological changes of SOC by drainage condition of upland soils.

The effect of gravel content in upland soils

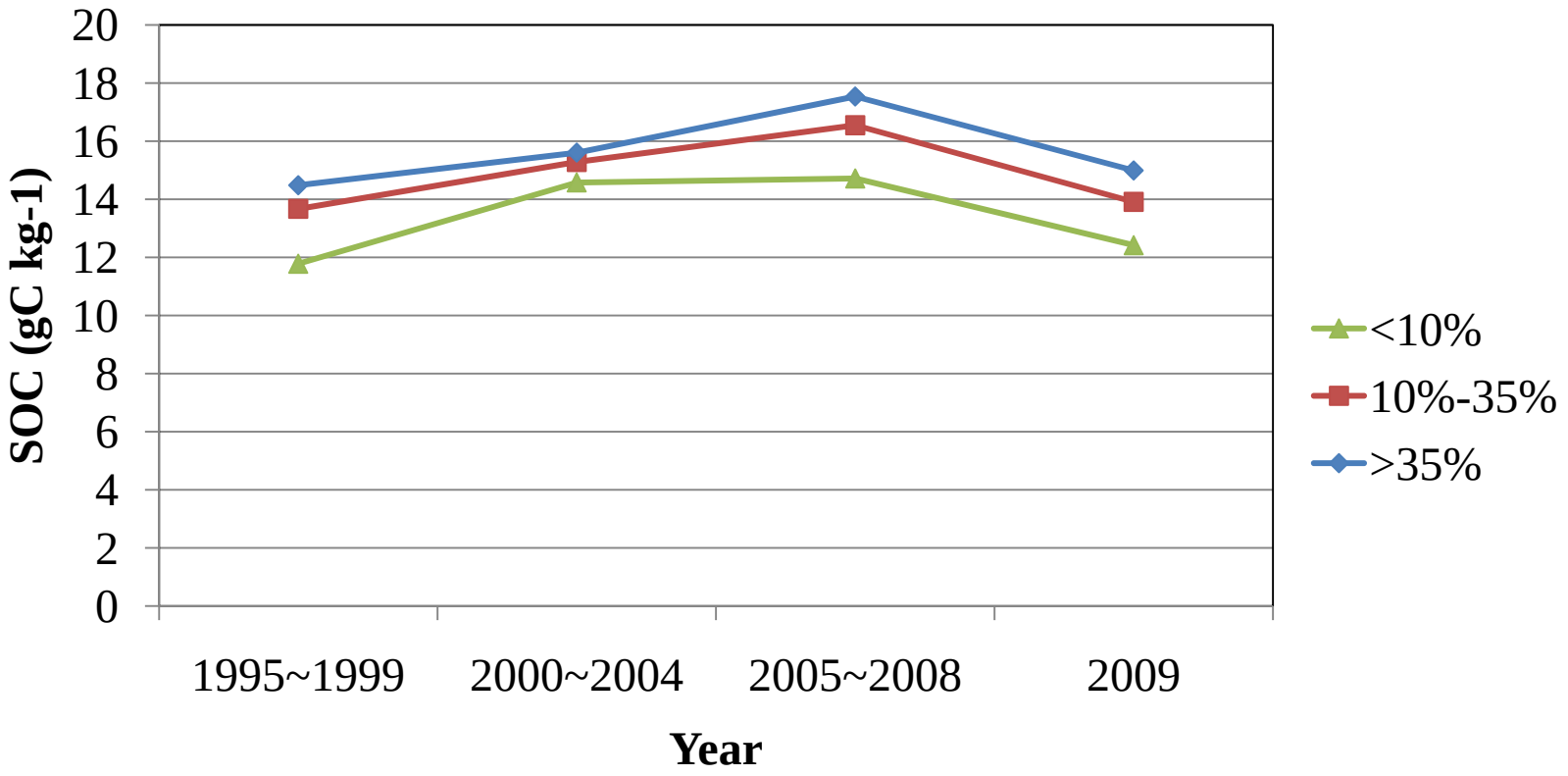


Fig. 14. Chronological changes in SOC by gravel content of upland soils.

The effect of soil texture in upland soils

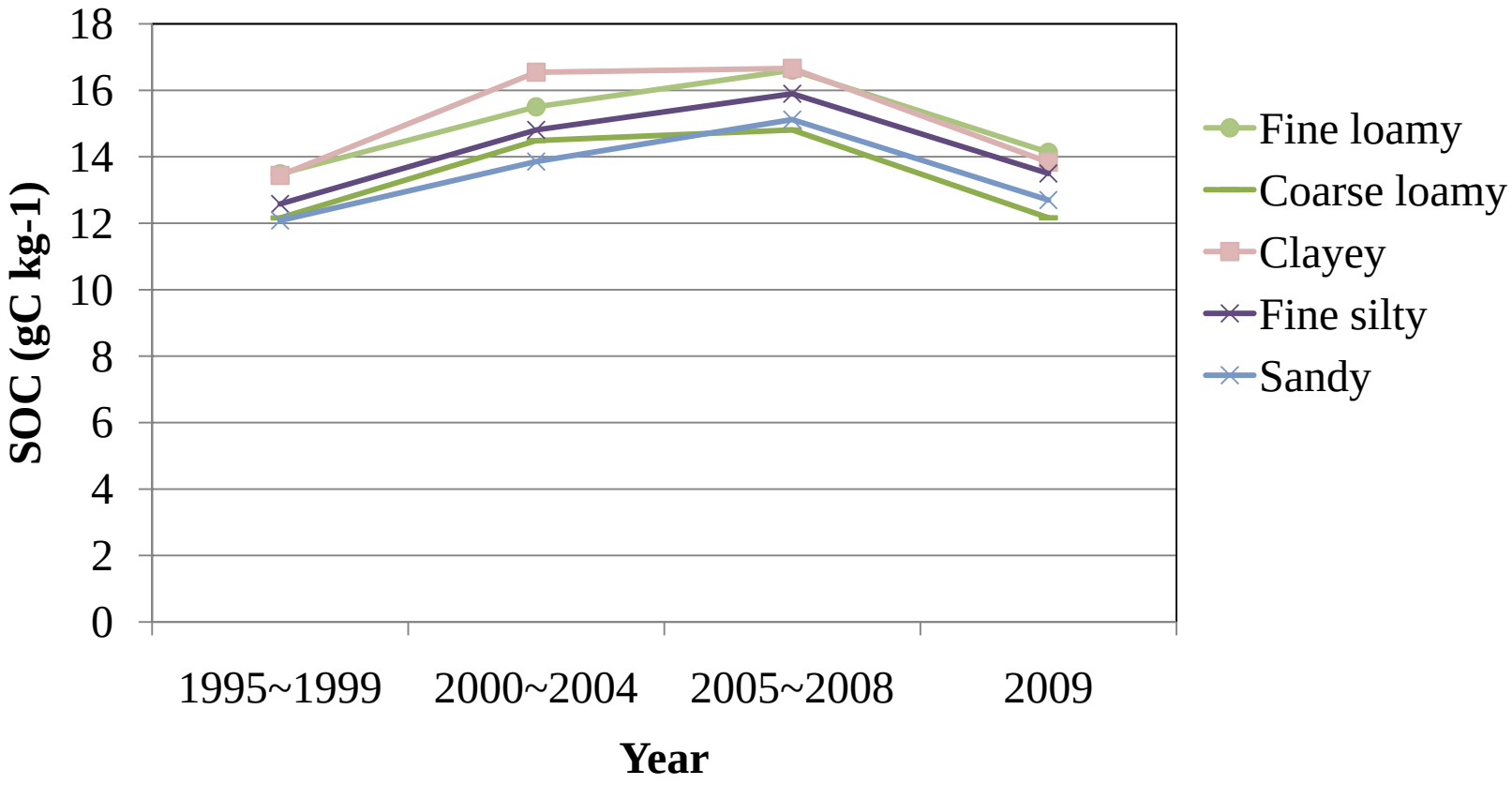


Fig. 15. Chronological changes in SOC by soil texture of upland soils.

The effect of effective soil depth in upland soils

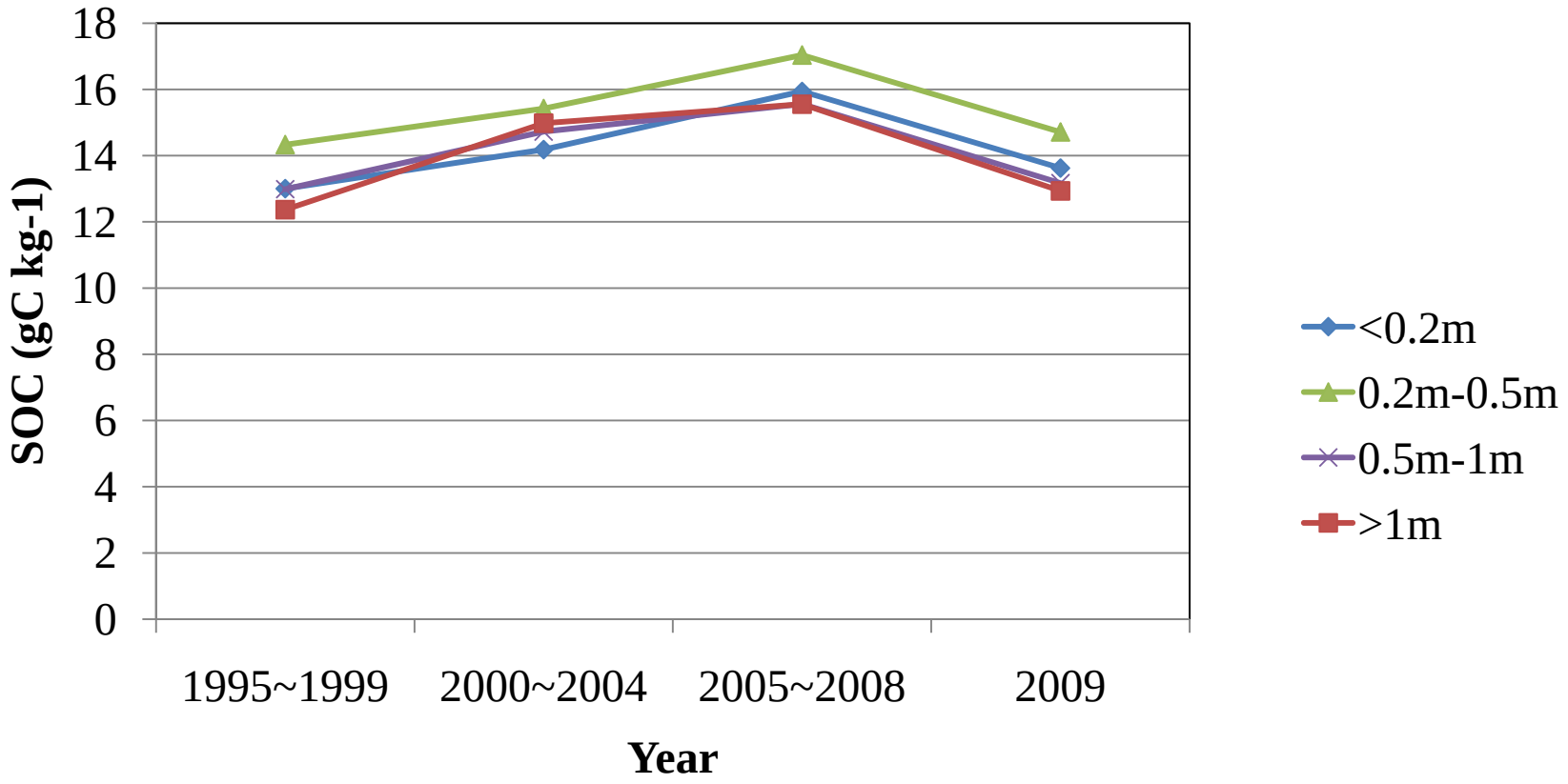
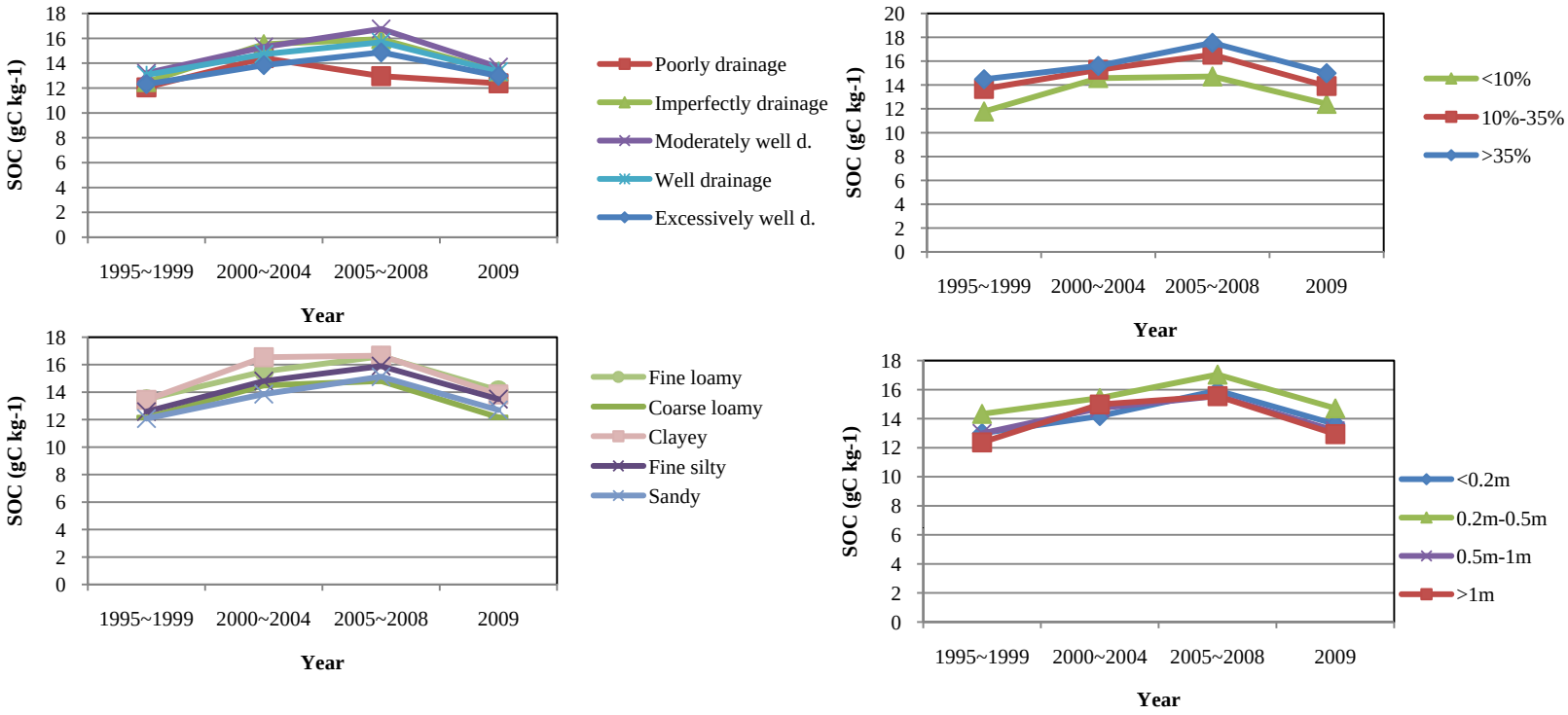


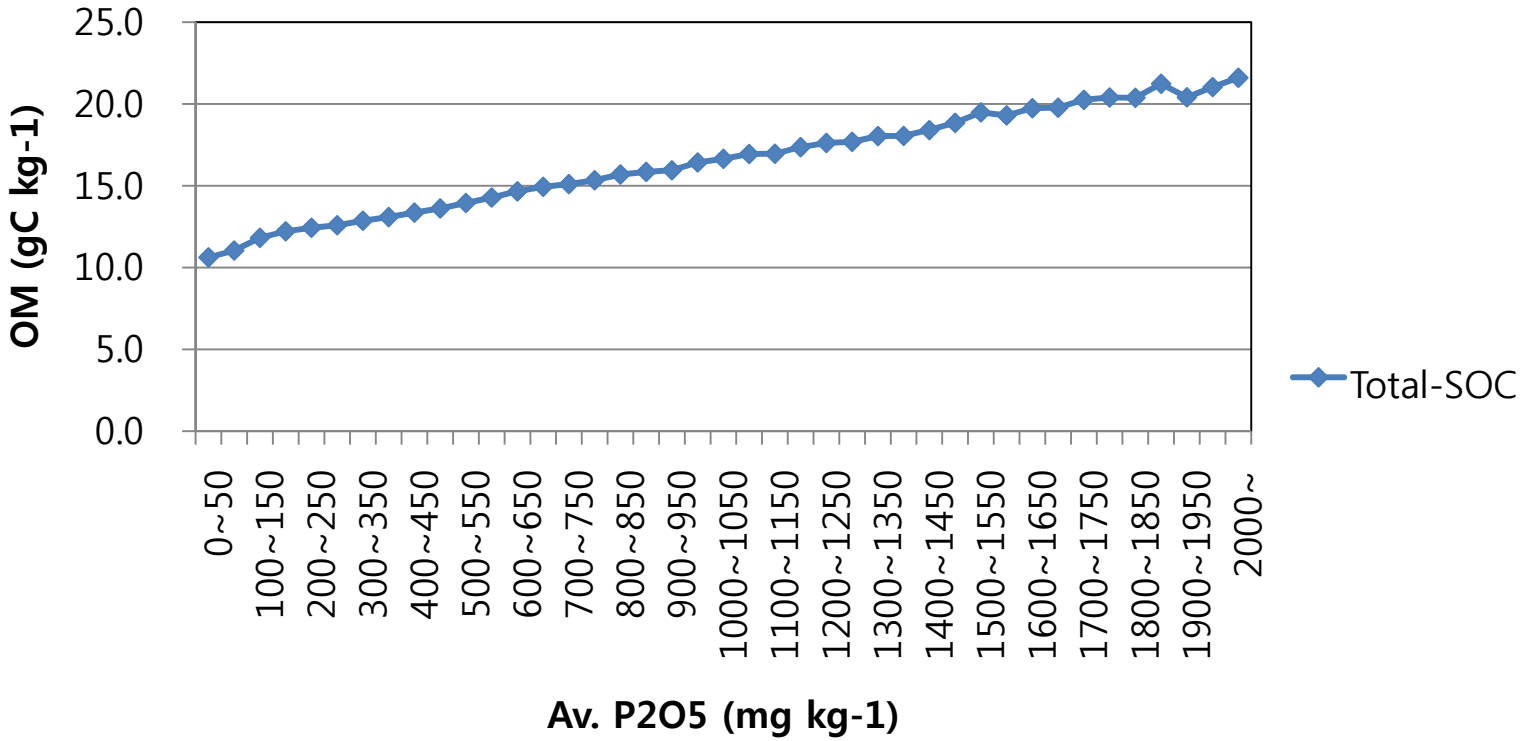
Fig. 16. Chronological changes in SOC of upland soils according to effective soil depth.

Upland SOC according soil properties



✓Yearly difference is greater than that of soil properties.

The relationships between SOC and available phosphorus.



✓SOC is governed by C input because SOC is related to available phosphorus.

Could SOC of upland soils be affected by soil properties?

✓ SOC stock of upland soil is related to soil properties.

- Yearly difference is greater than soil properties.
- SOC was low in poor drainage and sandy soil.

⇒ **SOC changes of upland soil were depended on C input.**

✓ SOC sequestration potential of upland soils

- Application of compost for beneficial crops made SOC increase
- SOC sequestration potential of upland soils will be different from soil properties.

⇒ **C sequestration potential will be higher than SOC stock in upland soil.**

∴ **Upland soil could sequester the air C.**

How much? The answer relies on C sequestration potential and execution policy.

Conclusion

- Chronological SOC change of fields was mainly depended on how much organic matter input.
- Chronological SOC change of paddy soils seemed to be close to steady-state because of removing rice straw from paddy soils.
- Chronological SOC changes of upland soils were high in the year of cultivating beneficial crops due to applying compost.
- C sequestration potential for arable land is prerequisite to increase SOC and regulate C sequestration.
- Best management practices of increasing SOC are needed to mitigate air C and to preserve soil fertility.

Thank you for your attention