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The Effects of Eco-char Application to Urban Soil System on Soil structure and Plant Water Availability

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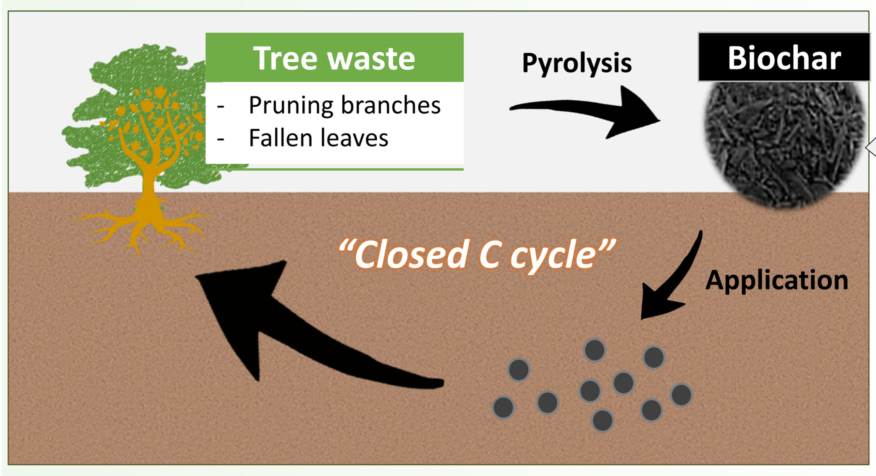
Introduction

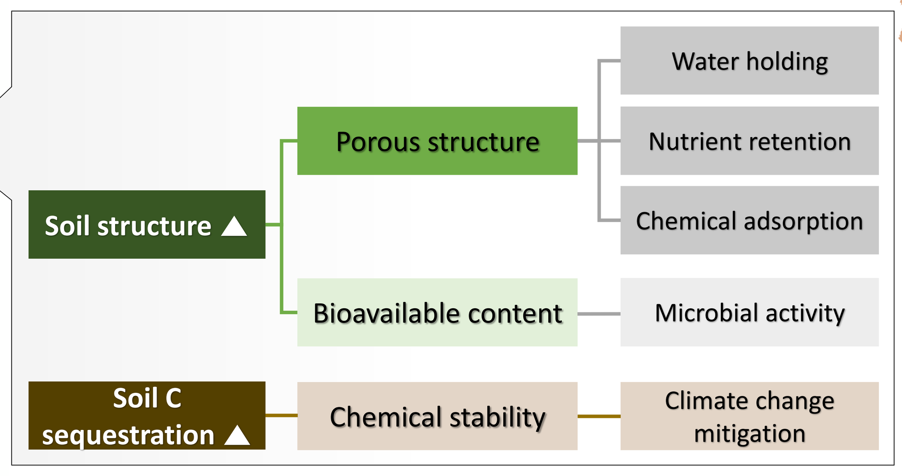
Urban roadside tree system

- Urban roadside tree system provides ecosystem services
  : carbon sink, climate change regulation, air quality improvement, etc.
- Urban trees are under severe stress such as soil compaction, runoff, contamination and drought.
- Stressful conditions for urban roadside tree system need to be alleviated by improving soil structural qualities.

Eco-char

- A new concept of biochar ⇒ ***Recycle of tree waste + Soil improvement + Climate change mitigation***

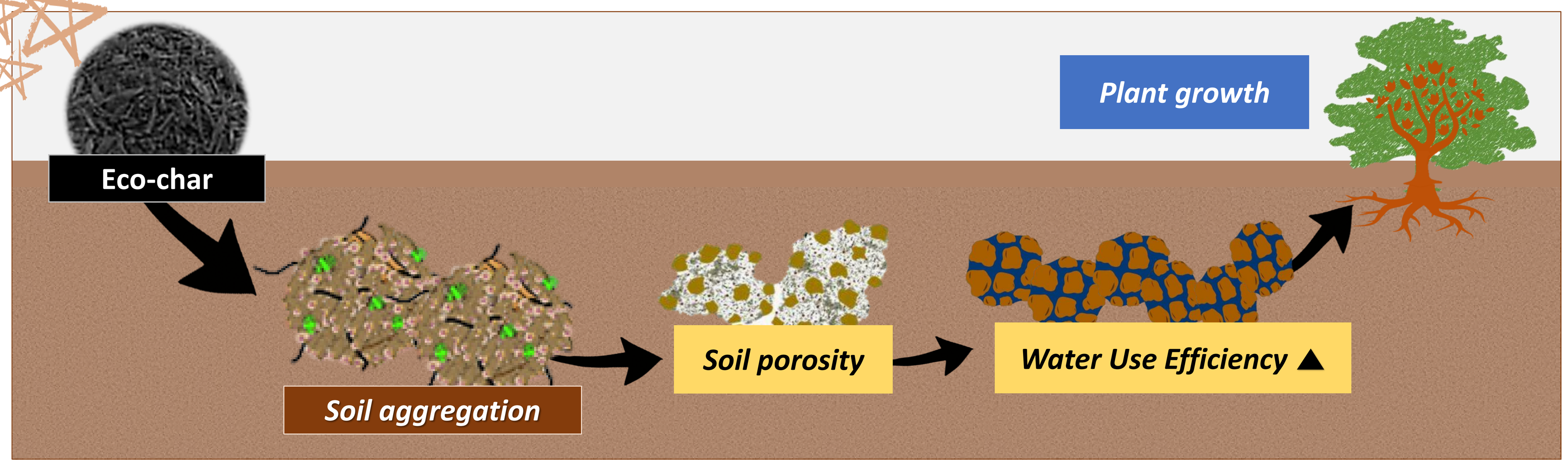




In this study, **greenhouse experiments** were conducted to focus on soil aggregation and plant water availability influenced by eco-char application to urban roadside tree system.

Objectives

1) **To investigate the role of eco-char in aggregation process**
2) **To investigate the effects of increased aggregation by eco-char amendment on plant growth**



Materials and methods

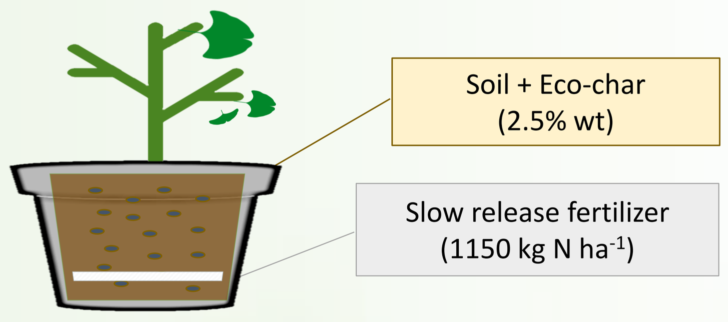
Plant, soil and eco-char preparation

Plant
- 2 year-old Ginkgo trees (*Ginkgo biolba*)
- The most common street trees in South Korea

Soil	Texture	Bulk density	pH (1:10)	TC	TN	C/N ratio
		---- g cm⁻³ ---		------g kg⁻¹ soil----		
	Sandy clay loam	1.15	6.6	2.7	0.4	6.75

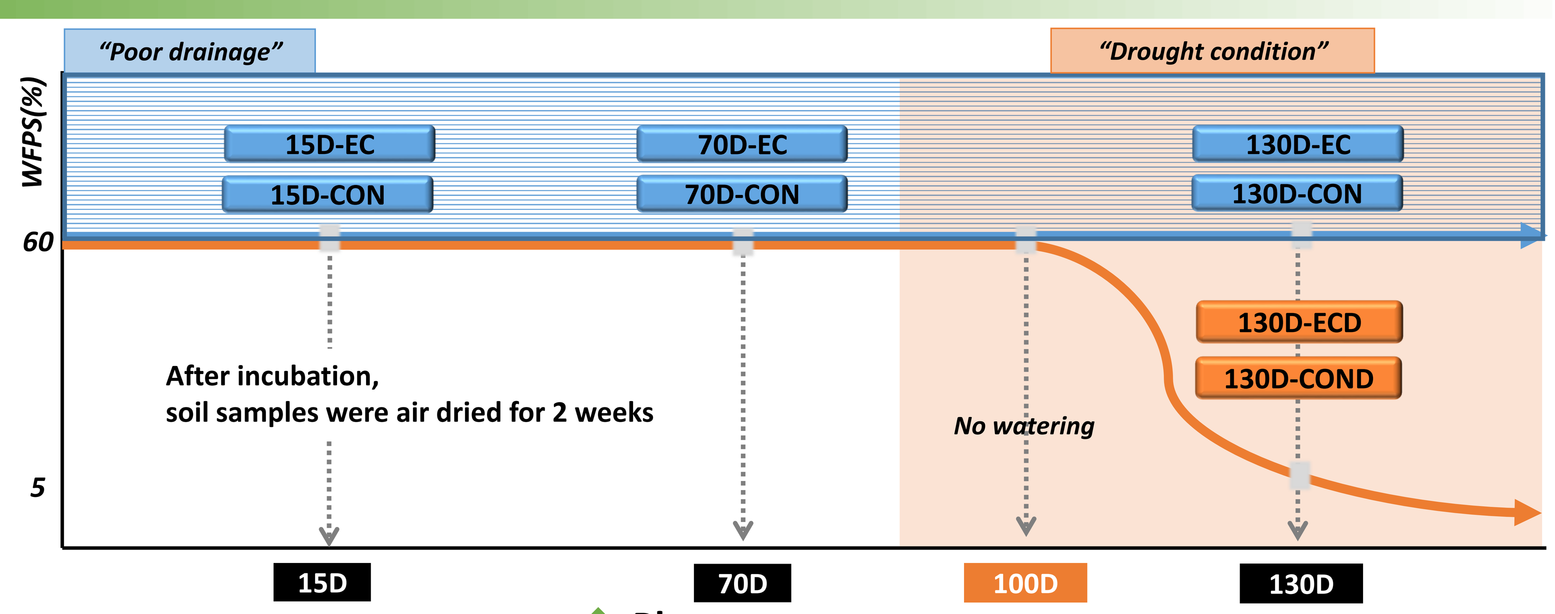
Eco-char	Bulk density	pH (1:10)	TC	TN	Hot-water extractable C (HWC)
	-----g cm⁻³----		----------------g kg⁻¹ soil------------------		
	0.43	9.56	460.6	14.1	2.65

Growth box



Treatments and Incubation

Poor drainage		Drought condition	
EC (2.5% eco-char)	CON (No add)	ECD (2.5% eco-char, Drought)	COND (No add, Drought)



Soil analysis and aggregate fractionation

Soil fractionation

- ✓ Wet sieving and density distribution
- ✓ Mass distribution of soil aggregates
- ✓ C distribution among different-sized aggregates

> 1000 μm, *250-1000 μm* → *Macro-aggregates*

53-250 μm → *Micro-aggregates*

< 53 μm → *Organo-mineral complexes*

Soil porosity

$$\text{Total porosity}\ (\%) = \left(1 - \frac{\text{Bulk density}\ (g\ cm^{-3})}{\text{Particle density}\ (g\ cm^{-3})}\right) \times 100$$

$$\textit{Theoretical porosity}\ (\%) = \{x \times p_1\} + \{(1-x) \times p_2\}$$

- *x : the mass proportion of eco-char in the EC treatment*
- p_1 *: total porosity of eco-char*
- p_2 *: total porosity of the soil (CON soil)*

Least limiting water range (LLWR)

$$\ln\theta = -4.15 + 0.69 \ln Clay + 0.4 \ln SOC + 0.27 \ln D_b + (-0.55 + 0.11 \ln Clay + 0.02 \ln SOC + 0.1 \ln D_b) \times \ln P$$

$$\ln SR = -3.67 - 0.14\ clay + 0.77\ SOC + (-0.48 - 0.12\ Clay + 0.21\ SOC) \ln\theta + (3.85 + 0.10\ Clay) \ln D_b$$

Plant assay

Plant measurements

- ✓ Leaf number, Leaf biomass
- ✓ Root, Shoot length and biomass
- ✓ Plant pictures : morphology

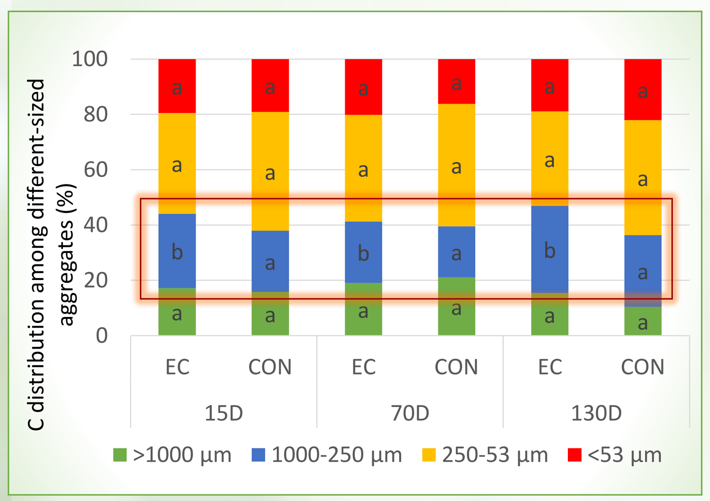
Water use efficiency (WUE)

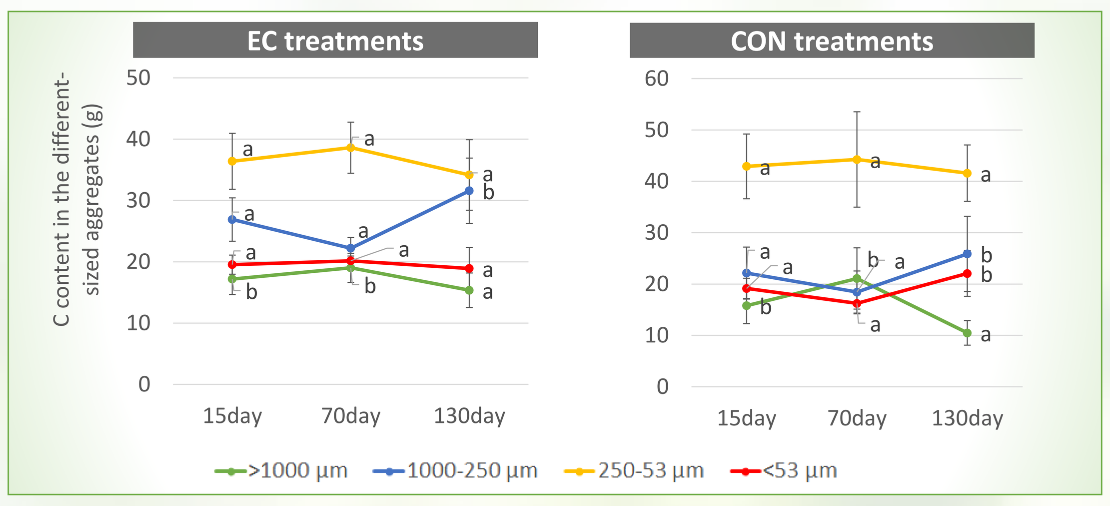
- ✓ Plant Available Water indirect index

$$\text{WUE}(\%) = \left(\frac{\text{Total biomass produced}\ (g)}{\text{Water consumed}\ (L)}\right) \times 100$$

Results and Discussion

Changes in carbon proportion of the soil aggregates





In the EC treatment, the amount of macroaggregate was increased by 10% compared to the control on average, indicating that eco-char functioned as a nucleus for macroaggregation.

In both treatments, large macroaggregates(> 1000μm) were decreased throughout incubation.
- In the EC treatment, large macroaggregate was broken into small macroaggregate.
- In the control, large macroaggregate was broken into small macroaggregate and organo-mineral complexes.
- Eco-char played a role in preventing macroaggregates from breaking down into smaller ones.

Soil porosity

		Total porosity	Theoretical porosity
		(%)	
15d	EC	60.63 (← 1.2 %)	59.92
	CON	59.62	59.62
70d	EC	36.04 (← 3.1 %)	34.96
	CON	34.03	34.03

- Due to soil compaction during poor drainage period, total porosities became lower in the 70d and 130d samples.
- Total porosity was higher in the EC treatment than the control.
- In the EC treatment, observed total porosity was greater than the theoretically calculated total porosity, indicating that eco-char addition promoted additive pore formation.

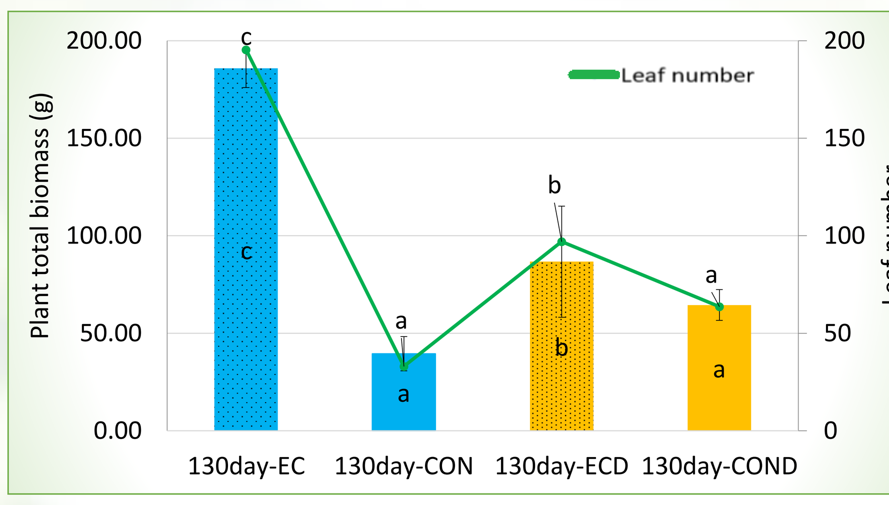
Least Limiting Water Range (LLWR)

	15d	70d	130d
	cm³/cm³		
EC	0.19[b]	-0.07[b]	-0.08[b]
CON	0.12[a]	-0.12[a]	-0.13[a]

	130d-EC	130d-CON	130d-ECD	130d-COND
cm³/cm³	-0.11[a]	-0.11[a]	0.21[b]	0.22[b]

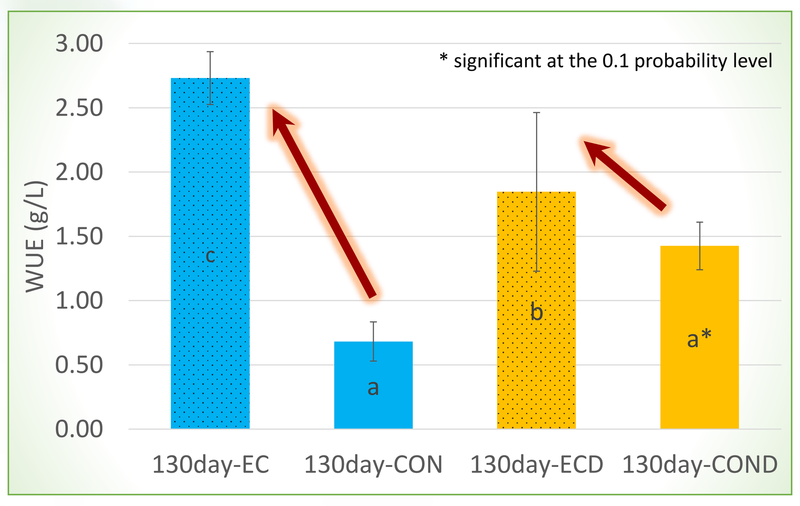
The LLWR was significantly higher in the EC treatment than that in the control, indicating that the soil environments in the EC treatment might be more favorable for plant growth.

Plant total biomass and leaf number



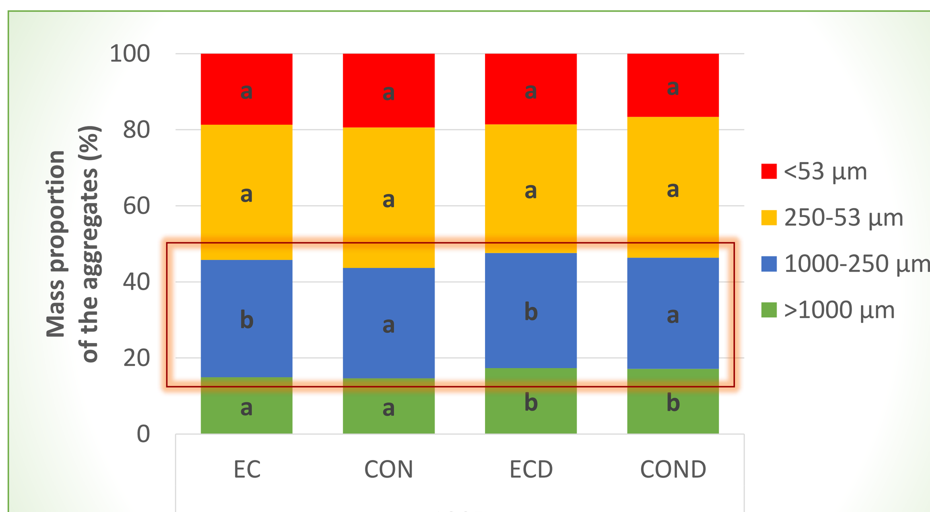
Root morphology

Water Use Efficiency (WUE)



- When eco-char was added, WUE was greatly increased during poor drainage period.
- During the drought period,
  - WUE in the COND was higher than that in CON.
  - WUE in the ECD was higher than that in COND.

Changes in mass proportion of the soil aggregates



Consistent with the increase in the amount of maccroaggregates in the eco-char addition, eco-char would as a nucleus for macroaggregation under the drought condition.

Conclusion

Summary

- ➢ **Eco-char played as a nucleus for macroaggregation, continuing macroaggregates form for a long period time.**
- ➢ **The improved porosity caused by eco-char amendment could enhance the water use efficiency, leading to the increase in plant growth.**

Further study

- ➢ **About enhanced of plant water availability, the effect of eco-char on the microbial activities will be conducted.**
- ➢ **Further study will be focused on the role of eco-char in the soil structure during the dry-wet cycle and its relation to water use efficiency.**

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