Soil CO_2 Efflux in Even-aged Alder and Pine Man-made Forests in Central Korea with Special Reference to Plant Vegetation Types

Yong-Suk Kim[1,3]*, Yoon-Young Lee[2], Myong-Jong Yi[3], Yowhan Son[4] and Takayoshi Koike[5]

[1]Graduate School of Agriculture, Hokkaido Univ., Japan, [2]Division of Forest Soil Conservation, KFRI, Korea, [3]Division of Forest Resources, Kangwon Nat'l. Univ., Korea

[4]Division of Environmental Science and Ecological Engineering, Korea Univ., Korea, [5]Research Faculty of Agriculture, Hokkaido Univ., Japan

*soilys@for.agr.hokudai.ac.jp

INTRODUCTION

BACKGROUND

The high spatial variability of soil respiration results from large variations in soil physical properties, biological conditions, nutrient availability, and others (Luo and Zhou 2006). Vegetation influences significantly the accumulation and turnover of soil organic matter directly through quality and quantity of plant materials and indirectly by conditioning the pathways of biomass incorporation into the soil (Chapin et al. 2002). For example, coniferous forests had up to 10% lower rates of soil respiration than did adjacent broad-leaved forests growing on the same soil types (Raich and Tufekcioglu 2000).

OBJECTIVE

To determine reliable differences in soil respiration occur as a result of different vegetation types, we selected two even-aged plantations, alder and pine, afforested on the same soil parent material and in the same topographic position. Based on the result, we discussed the factors affecting soil CO_2 efflux under different vegetation types.

MATERIALS AND METHODS

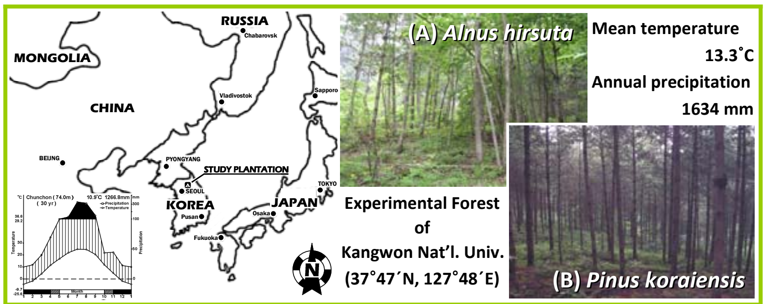


Figure 1. Alder (A) and pine (B) plantations in central Korea.

Table 1. Description of two study plantations.

Site	Altitude (m)	Slope (˚)	Stand age (yr)	Density (stem ha^{-1})	Height (m)	DBH (cm)
Alder	525	22	28	1960	12.1 (0.3)	11.1 (0.4)
Pine	510	25	28	1030	13.5 (0.2)	18.9 (0.8)

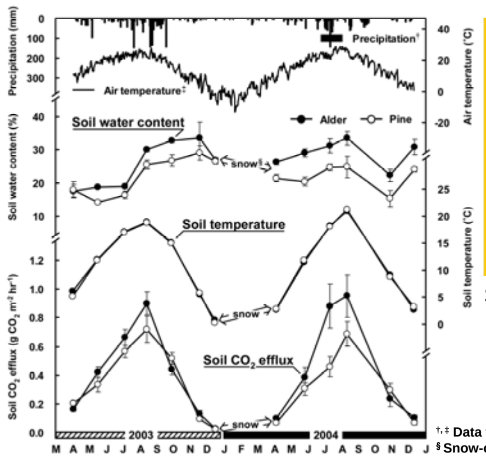
Figure 2. Field measurements

RESULTS

Table 2. Environmental conditions in two study plantations.

Environmental condition	Alder plantation	Pine plantation
Soil properties (0 - 30 cm depth)		
Soil texture	SiL	SiL
Bulk density (g m^{-3})	0.88 (0.09)‡ a	0.97 (0.04) a§
pH (1:5, H_2O)	4.9 (0.10) a	5.3 (0.10) a
Organic-C (%)	3.27 (0.35) a	2.25 (0.11) b
Total-N (%)	0.33 (0.03) a	0.26 (0.01) a
Carbon input		
Annual litter production (g C m^{-2})	316.7 (28.1) a	259.3 (5.4) a
Accumulated organic matter (g C m^{-2})	501.8 (61.6) a	573.8 (72.3) a
Decomposition parameter *k*	0.63	0.45
Soil nitrogen availability†		
NH_4^+ (mg-N bag^{-1})	3.08 (0.07) a	2.40 (0.19) b
NO_3^- (mg-N bag^{-1})	24.83 (1.57) a	11.91 (1.08) b
Total (mg-N bag^{-1})	27.91 (1.50) a	14.31 (1.25) b
Understory vegetation		
Species richness	15.7 (0.8) a	11.3 (1.4) b
Species diversity	2.3 (0.1) a	1.9 (0.1) b
Aboveground biomass (g m^{-2})	17.6 (4.5) a	8.8 (2.3) b

† Son et al., 2007. ‡ One standard errors of the mean in parentheses. § Means with different small letters indicate significant differences between the sites at a 0.05 significance level.



Mean values

Site	SWC	ST	SR
Alder	27.1 a†	11.1 a	0.43 a
Pine	22.1 b	10.5 a	0.33 b

SWC, soil water content (%); ST, soil temperature (˚C); SR, Soil CO_2 efflux (g CO_2 m^{-2} hr^{-1}). † Means with the different *small letter* indicate significant differences between study plantations at a 0.05 significance level.

Seasonal patterns of soil CO_2 efflux

- → Peaked in August
- → Similar to soil temp.
- → No yearly difference

†, ‡ Data from Chunchon National Weather Station
§ Snow-covered period.

Figure 3. Seasonal patterns of soil CO_2 efflux, soil temperature, and soil water content in two study plantations.

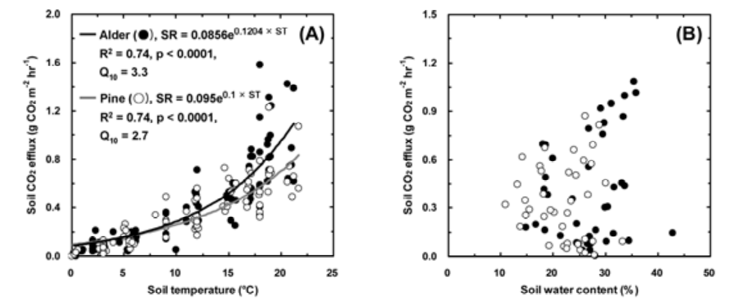
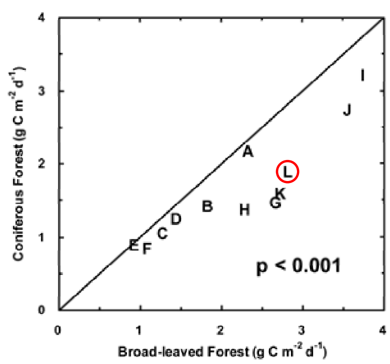


Figure 4. Relationships between soil CO_2 efflux and soil temperature (A), and soil water content (B) in two study plantations.

DISCUSSION



Sources of data: A-K, Ellis (1974); Rout and Gupta (1989); Joshi et al. (1991); Fernandez et al. (1993); Ruess et al. (1996); Longdoz et al. (2000); Curiel Yuste et al. (2004); Khomik et al. (2006); Wang et al. (2006); Wu et al. (2006); L, this study.

Soil respiration in broad-leaved forests are slightly higher than that of coniferous forests located on the same soil parent material and in the similar topographic positions.

Figure 5. Paired comparisons of soil respiration rates in paired coniferous and broad-leaved forest stands modified from Raich and Tufekcioglu (2000).

Table 3. Estimated turnover time of soil carbon in the top <30 cm of soil.

Site	Soil-C (kg m^{-2})	Soil respiration (g C m^{-2} yr^{-1})	Turnover time† (yr)
Alder	8.6 (1.5)‡	838.6 (27.3)	15
Pine	6.5 (0.3)	700.6 (18.4)	18

† Turnover time is estimated based on the assumption that 30% of soil respiration in derived from root respiration (Raich and Schlesinger 1992). ‡ One standard errors of the mean in parentheses.

In this study, mean annual soil respiration in the alder plantation is 1.3 times higher than that of the pine plantation. Although it was in the same area, environmental conditions will have been changed slowly by the different vegetation types. Two different vegetations will have led to changes in nutrient diffusion and carbon allocation to the belowground. Especially, higher soil respiration rate in the alder plantation may include respiration of symbiotic N_2 fixing microbe (e.g. *Frankia* sp.).