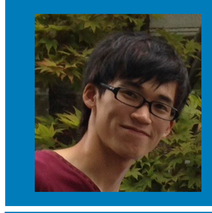
Effects of ammonium sulfate and/or ozone on the growth and photosynthesis of Japanese larch and hybrid larch F_1



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Introduction

Asia: Changes in atmospheric environment

◎ N deposition, $(NH_4)_2SO_4$ has been increasing
→ Changing soil condition, causing forest decline finally

◎ Ground-level ozone (O_3, 0~11 km), made by NOx, VOC
→ Absorbed via stomata, effects trees negatively

Japanese larch (JL), Hybrid larch F_1 (HL)

◎ Larch (*Larix* spp.): high growth, survival rate → Afforestation

◎ NH_4NO_3 decreased O_3 sensitivity of JL

◎ The mechanism of this responses are unknown
(Aber *et al*. 1989, Izuta 2001, Watanabe *et al.* 2006, Koike *et al.* 2013, Liu *et al.* 2015)

【Research subject】
The mechanism of the responses to $(NH_4)_2SO_4$ and O_3 in both larch species

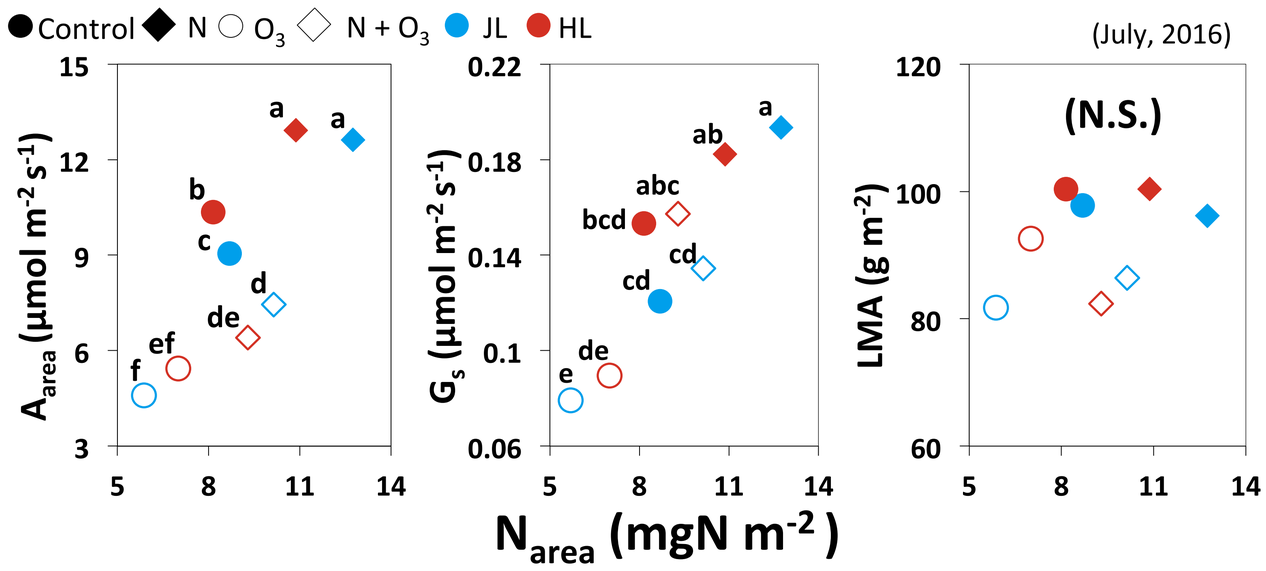
Conclusion

The responses to $(NH_4)_2SO_4$ and O_3 depend on larch species

◎The growth response
- ○ Under $(NH_4)_2SO_4$, O_3 decreased dry mass of hybrid larch F_1
- ○ Species difference may be caused by difference in biomass allocation to needle

◎The photosynthesis response
- ○ $(NH_4)_2SO_4 + O_3$ decreased PNUE of hybrid larch F_1
- ○ More O_3 may be absorbed by hybrid larch F_1

Results & Discussion ~ Leaf scale~



◎ $(NH_4)_2SO_4$ increased A_{area} in both species

◎ Under $(NH_4)_2SO_4$, O_3 decreased PNUE of HL ($p < 0.05$)

◎ $(NH_4)_2SO_4$ increased G_s: HL < JL

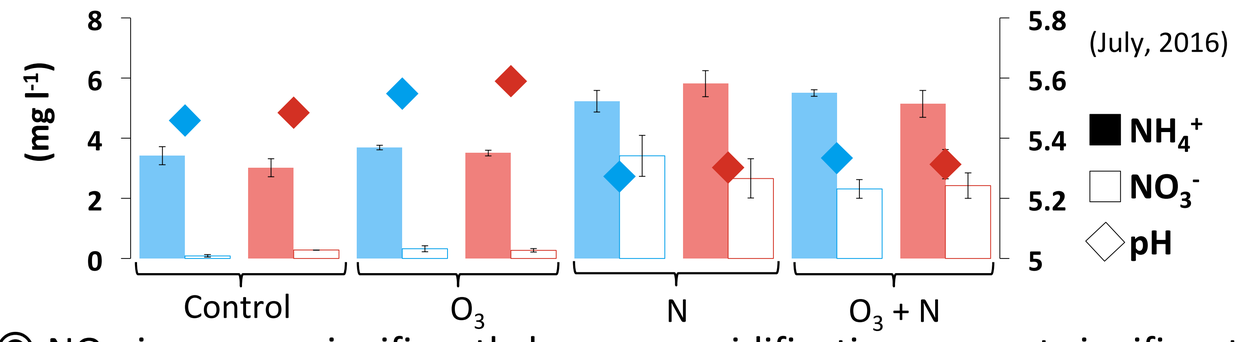
◎ Under $(NH_4)_2SO_4$, O_3 decreased G_s of only JL

→ **More O_3 may be absorbed by HL**

◎ $(NH_4)_2SO_4$ and O_3 did not significant effect LMA in both species

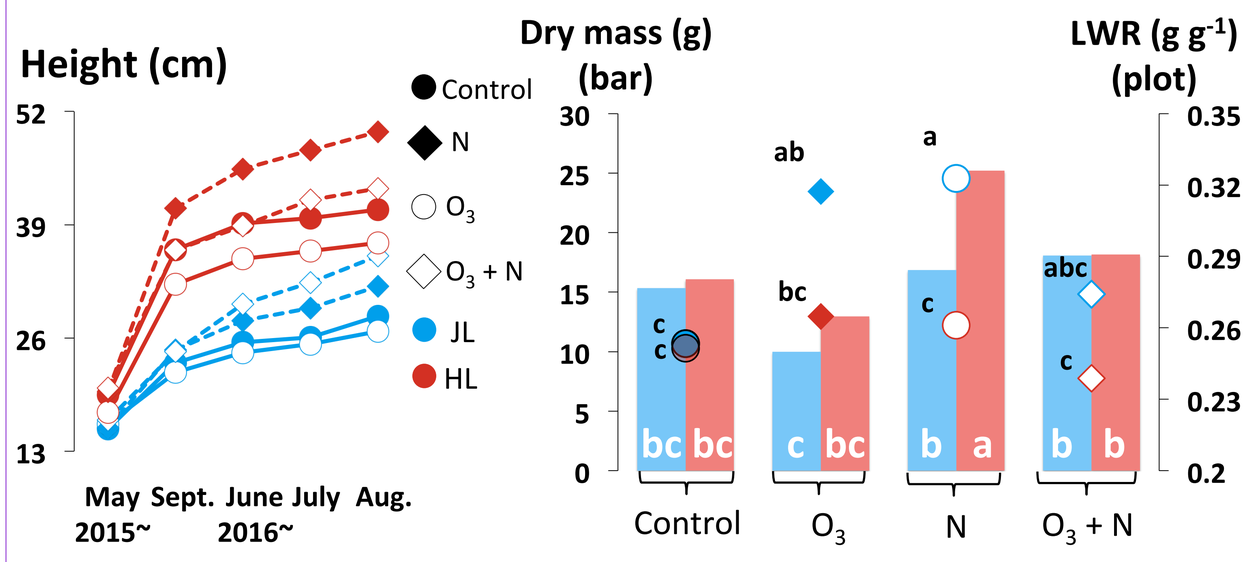
(Note) A_{area}:Assimilation rate, G_s:Stomatal conductance, LMA:Leaf mass area
PNUE: Photosynthesis nitrogen use efficiency (= A_{area} / N_{area}),
Different letters : significant differences of A_{area}, G_s and LMA, Tukey HSD, $p < 0.05$

Results & Discussion ~ Soil condition~



◎ NO_3^- increases significantly however acidification was not significant

Results & Discussion ~ Individual scale ~



◎ $(NH_4)_2SO_4$ increased height of both species (Sept., 2016)

◎ $(NH_4)_2SO_4$ and O_3 increased LWR of JL, respectively ($p < 0.05$)

◎ $(NH_4)_2SO_4$ increased dry mass of HL however not LWR

◎ Under $(NH_4)_2SO_4$, O_3 decreased dry mass of HL

→ **Species difference in the dry mass response to $(NH_4)_2SO_4$ and O_3 may depend on difference in the biomass allocation to needle**

(Note) LWR:Leaf-whole dry mass ratio, Different black (white) letters : significant differences of LWR (Dry mass), Tukey HSD, $p < 0.05$

【Estimation of coefficients by GLM】
(Response value) = (Intercept)+O_3+N+Spp.+O_3:Spp.+N:Spp.+O_3:N+ O_3:N:Spp.+(1|OTC)
(Family: Gaussian, O_3: Control/O_3, N: Control/N, Spp.: Control/Hybrid, OTC: 16)

	(Intercept)	O_3	N	Spp.	O_3 × N	O_3 × Spp.	N × Spp.	O_3 × N × Spp.
Height	12.3	-0.61	**6.48**	**8.96**	-0.20	-3.05	2.06	-2.92
Dry mass	15.3	**-5.35**	1.51	0.75	**6.58**	2.22	**7.60**	**-10.50**
LWR	0.253	**0.064**	**0.069**	-0.001	**-0.113**	**-0.051**	**-0.060**	**0.077**

(Bold letters : significant effect in GLM, $p < 0.05$)

Materials & methods

Location

Sapporo, Exp. For. Hokkaido Univ.（N43.07, E141.38, 15 m a.s.l.)

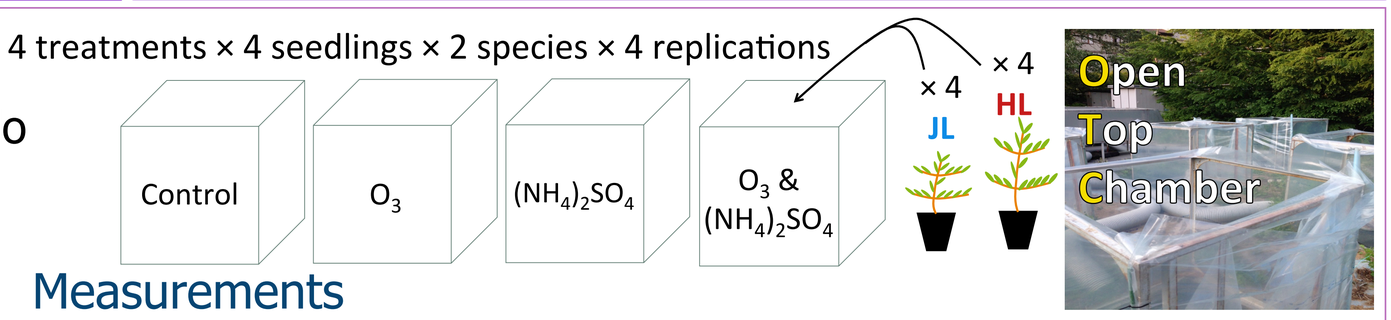
Plants and Design

2-year-old seedlings planted in 7L pots with Immature volcanic ash soil

Japanese larch (*Larix kaempferi*, JL)

Hybrid larch F_1 (*Larix gmelinii* var. *japonica* × *L. kaempferi*, HL)

Two-growing-season: May 2015 ~ Sept. 2016
O_3: 60 ppb, June ~ Oct., 2015, OTC (→)
May ~ Sept., 2016, 4 OTC per treatments
N: Total of 50kg ha^{-1} yr^{-1}, 5 times each year
– 6/11, 6/27, 7/7, 7/22, 8/1 (2016)



Measurements

- A_{area}: Assimilation rate, Gs: Stomatal conductance (light saturation & 380 CO_2)
  - LI-6400 (Li-Cor, Lincoln, USA), Image J (Wayne Rasvand, NIH), 7/23~31
- N_{area}: Needle nitrogen contents - NC analyzer (Elemntar, VarioEL lll), 7/23~31
- Soil sampling (0~5 cm) : soil pH(KCl)- pH meter (TOADKK, WM-32EP), 7/29
- Inorganic nitrogen contents- Flow injection analyzer (Aqua lab), 7/29
- Height (May, 2015 ~ Aug., 2016), Final Harvest (Sept. 2016) + Separate shoots

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