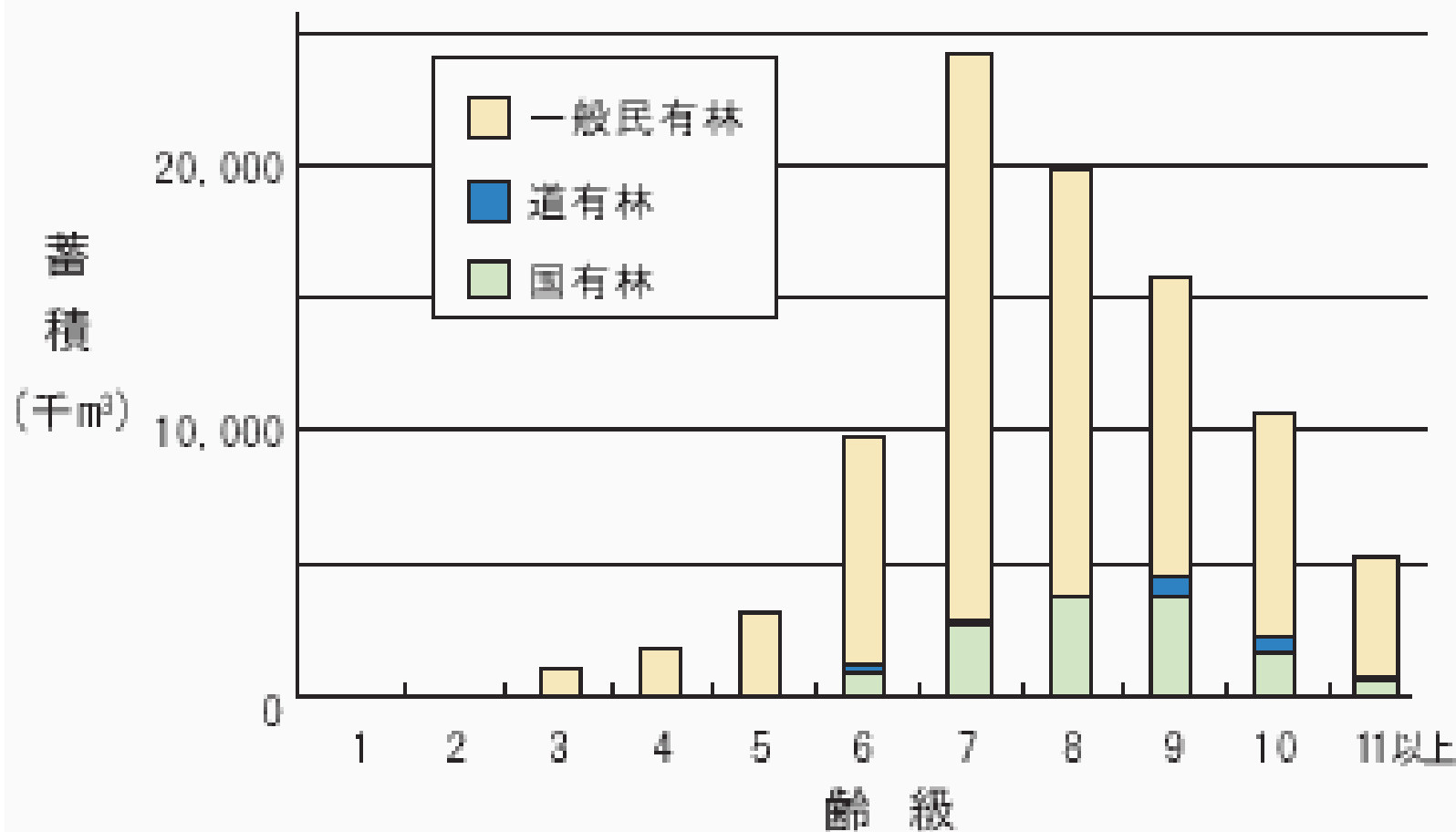


話 題

- 1 . 何故、カラマツ類に焦点をおくか
- 2 . カラマツの有用性の改良
- 3 . 変動環境とは
- 4 . 環境応答
- 5 . 高CO₂と窒素沈着の影響
 - 5 . 1 . 土壌酸性化に対する応答
 - 5 . 2 . 対流圏オゾンの驚異
- 6 . 森林機能の改良への展望

カラマツの齡級別の蓄積(2002年)



35～45年生の蓄積は多いが、25年以下が乏しい

(齡級: 一般に5カ年をひとくくり、林齡1～5年生までを 齡級)

Photosynthesis of Conifers in Relation to Annual Growth Cycles and Dry Matter Production

1. Some C₄ Characteristics in Photosynthesis of Japanese Larch (*Larix leptolepis*)

By

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(Received 9 February, 1976; revised 16 March, 1976)

Abstract

Observations that deciduous larch species can show annual increments equal to or greater than evergreen conifers, and that the saturating light intensity for photosynthesis in needles of *Larix leptolepis* was almost twice those for several evergreen conifers, led to a study of the photosynthetic mechanism in *L. leptolepis*. Several features of photosynthesis in *L. leptolepis* placed this species in an intermediate position between classical C₃ and C₄ plants. Incorporation of ¹⁴C from ¹⁴CO₂ by enzyme preparations of needles was eight times greater with PEP as substrate than with ribulose bis phosphate; a chlorophyll a/b ratio of 3.5 was obtained; needles possessed a green starch-containing endodermis but with little orientation of mesophyll cells to this "bundle sheath"; no clear ultrastructural dimorphism was observed between chloroplasts of mesophyll and endodermal cells; a CO₂-compensation point of 20 μl l⁻¹ was recorded; and the first measurable product of photosynthesis appeared to be malate rather than phosphoglyceric acid. These results are discussed in relation to the deciduous habit of *L. leptolepis* and its high productivity in comparison with other conifers.

Introduction

Timber yields from the deciduous Japanese, European and hybrid Larches (*Larix leptolepis* (Sieb. & Zucc.) Gord.; *L. decidua* Mill. and *L. x eurolepis*) compare favourably with those obtained from various species of evergreen conifers grown in British forests (Forest Management Tables 1966). A number of conifers growing in the British Isles are ap-

rates of *L. leptolepis* were found to be greater than those of two highly productive pine species, *Pinus radiata* and *P. contorta* (Sweet and Waring 1968). Thus, during summer, overall photosynthetic rates of larch trees are higher than those of many non-deciduous conifers, but it is not known whether the photosynthetic efficiency in

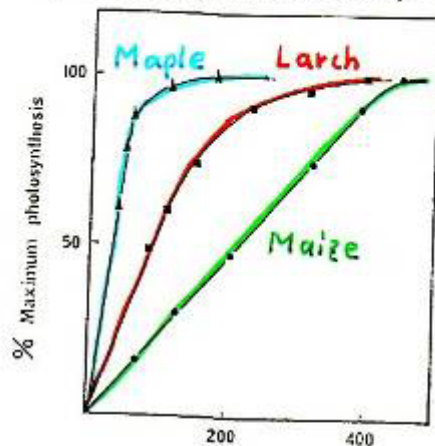
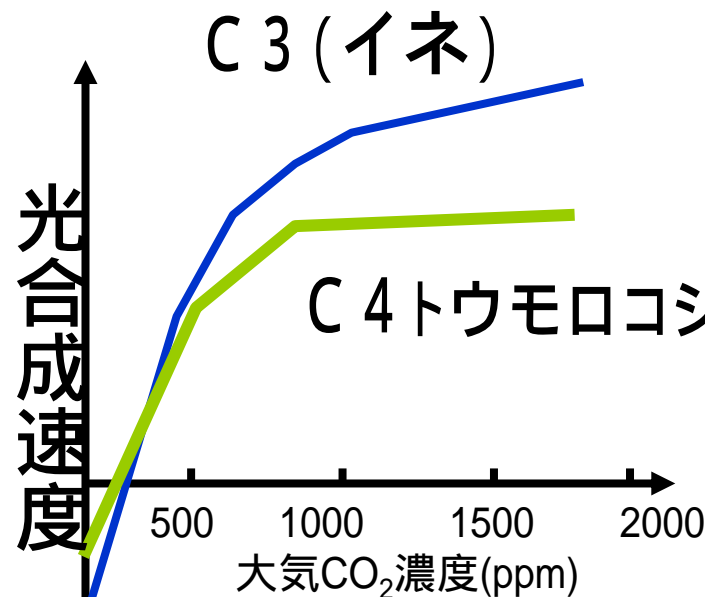


Figure 2. Comparative photosynthetic responses of individual leaves of *Acer pseudoplatanus* (▲), *Larix leptolepis* (■) and *Zea mays* (●) to increasing light intensity. Mean of 3 determinations for each species.

mechanism in *L. leptolepis* suggests that this conifer possesses features normally associated with the C₄ pathway of photosynthesis, the evidence for which is summarized in

C4植物の一種とされた



2. カラマツの有用性の改良

高い成長速度

戦前よりドイツなど欧州へ輸出

連合王国
エクセター大学
1976

period than do evergreen conifers. In fact summer growth

¹ Permanent address: Faculty of Agriculture, University College of Dublin, Glasnevin, Dublin 9, Ireland.

Re-evaluation of proposed C₄ photosynthetic characteristics in the genus *Larix*

J. H. Richards and J. A. Teeri

Richards, J. H. and Teeri, J. A. 1982. Re-evaluation of proposed C₄ photosynthetic characteristics in the genus *Larix*. – *Physiol. Plant.* 55: 117–120.

It has been suggested previously that Japanese larch (*Larix kaempferi*) exhibits characteristics of C₄ photosynthesis. To further evaluate this suggestion, stable carbon isotope ratios were determined for leaf and bark tissue of *Larix gmelini*, *L. kaempferi*, *L. laricina*, *L. lyallii*, *L. occidentalis*, and *L. sibirica*. All $\delta^{13}\text{C}$ values were more negative than –22‰. Short-term labeling with $^{14}\text{CO}_2$ showed that phosphoglyceric acid and other phosphorylated compounds were the first products of photosynthesis in *L. sibirica*. Both of these results strongly suggest that the initial fixation of atmospheric CO₂ in these six *Larix* species is accomplished solely via the C₃ photosynthetic pathway.

Additional key words – C₃ photosynthesis, $\delta^{13}\text{C}$.

J. H. Richards, Dept. of Range Science and the Ecology Center, UMC-52, Utah State Univ., Logan, UT 84322, USA; J. A. Teeri, Barnes Lab. The Univ. of Chicago, 5630 South Ingleside Avenue, Chicago, IL 60637, USA.

同位体を使った
代謝の解析から
C4植物の
可能性は否定
1982

Kazutoshi 0004
14 FEB. 1989 59



Paternal inheritance of chloroplast DNA in *Larix*

Alfred E. Szmidt, Torsten Aldén and Jan-Erik Hällgren

Department of Forest Genetics and Plant Physiology, Faculty of Forestry, Swedish University of Agricultural Sciences, S-901 83 Umeå, Sweden

Received 6 January 1987; in revised form 31 March 1987; accepted 14 April 1987

Key words: chloroplast DNA, conifers, inheritance, *Larix* hybrids, restriction analysis



初めて葉緑体の父系遺伝を
DNAレベルで解明した(1987)

Ohba, K. et al. (1971)
スギについて可能性を示唆

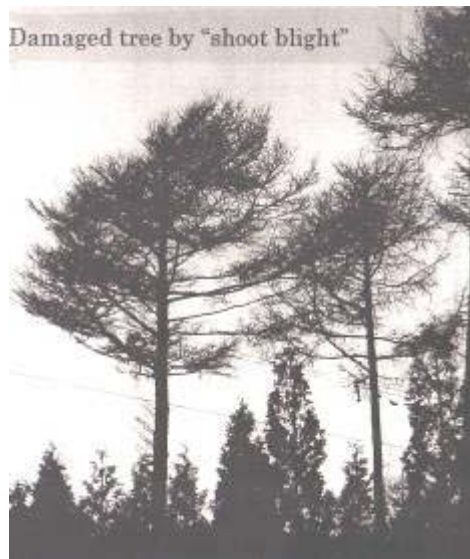
2. 品種改良への路

カラマツ先枯れ病

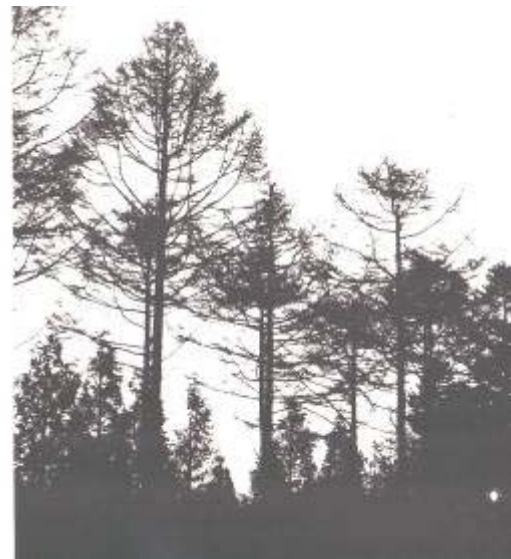


カラマツ先枯病の
薬剤防除に関する
研究(1965年
林業科学技術振興賞)

五十嵐恒夫 会長



罹病木



健全木

二代目造林もカラマツで！

1960年代 長野のカラマツ人工林
いや地(連作障害)

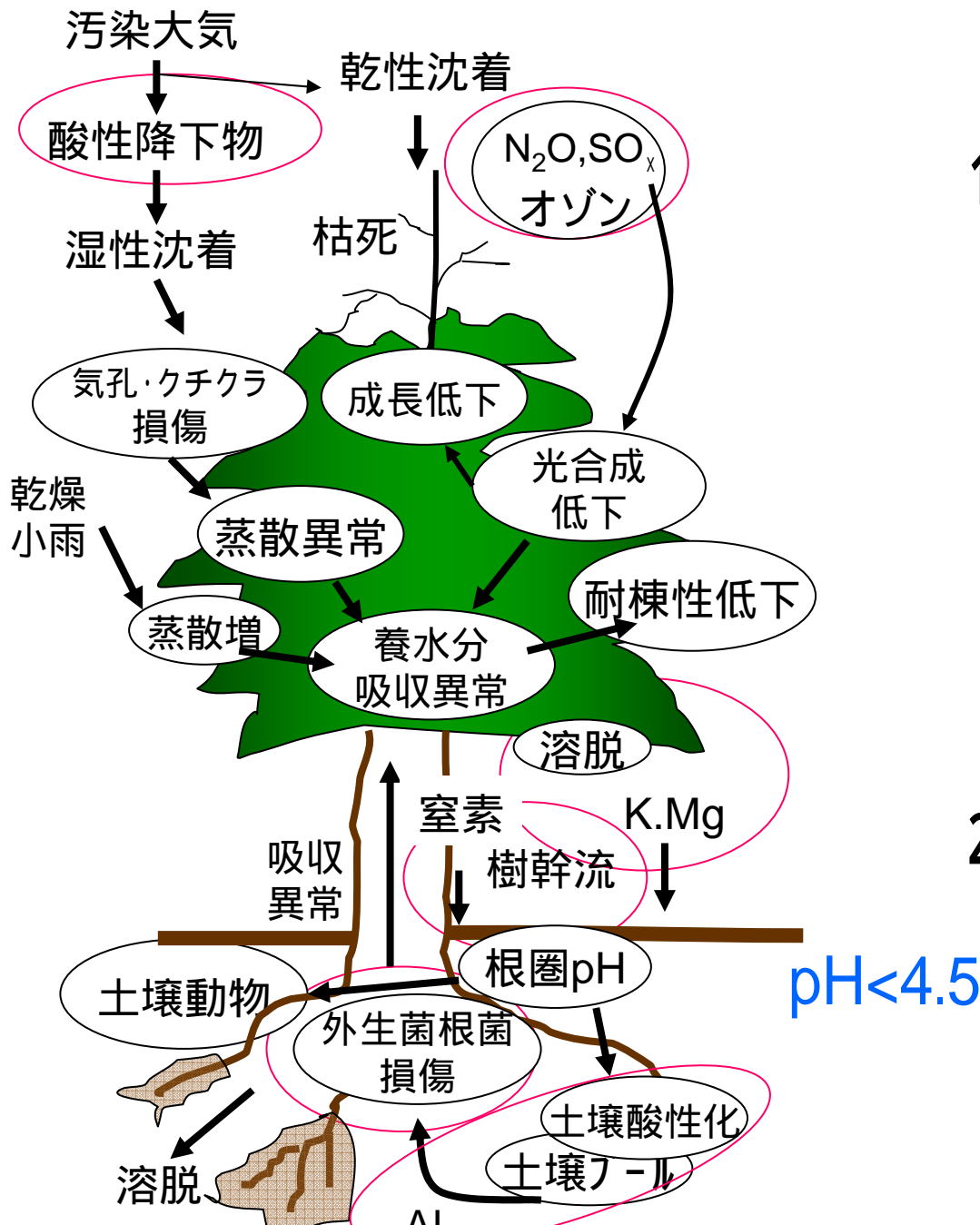


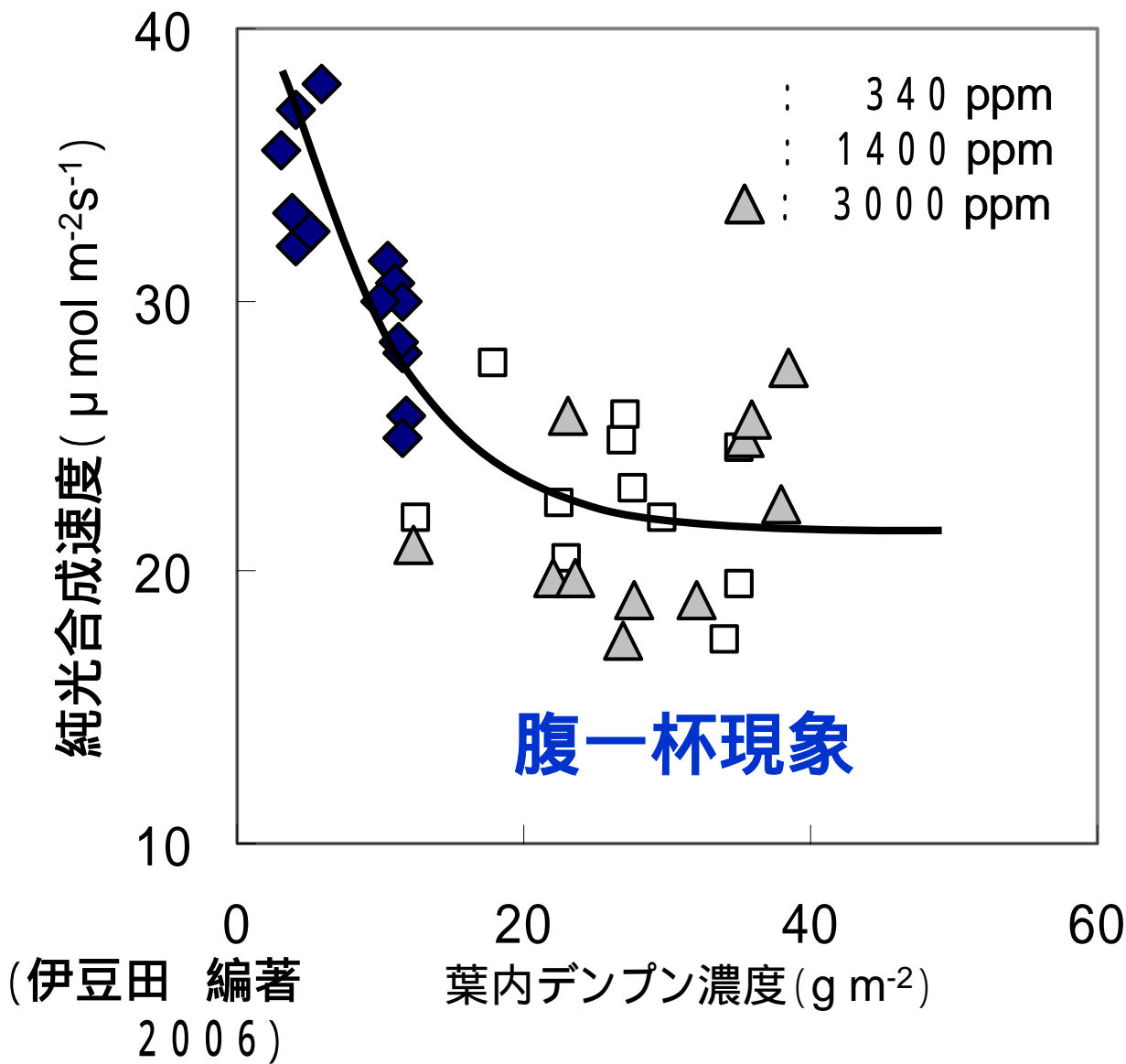
ナラタケ病が主因

<http://arugamama.cocolog-nifty.com/kaze/images/>

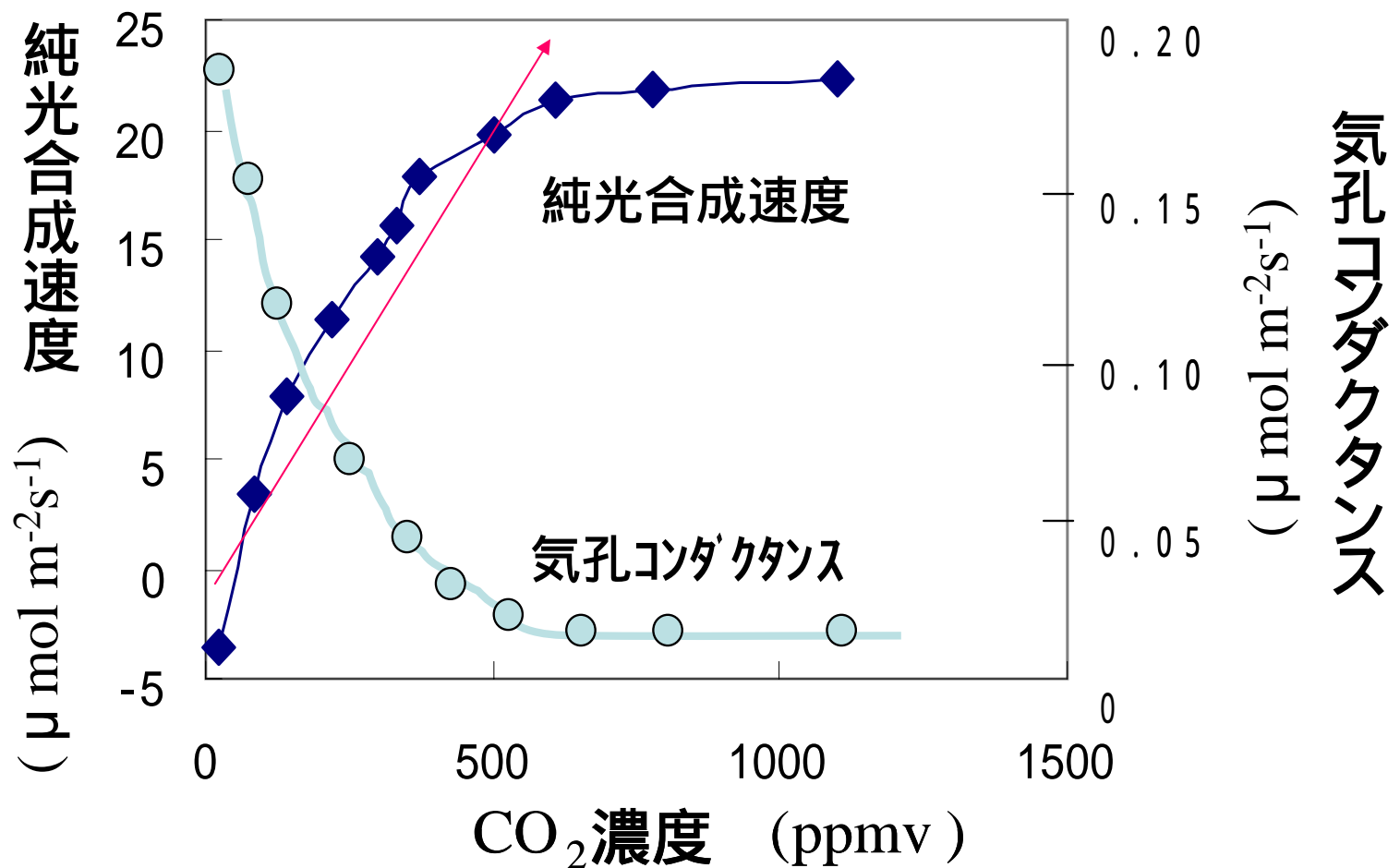
成長に40～60年以上を必要とする
林木の生産には、変動環境は無視できない！

・外生菌根菌の劣化



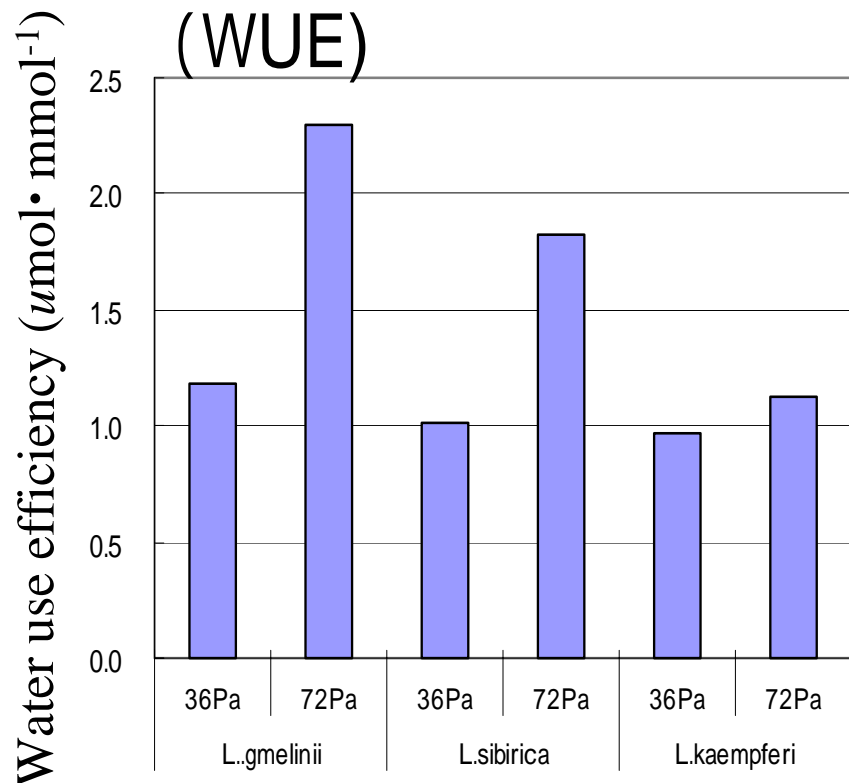


デンプンが集積すると光合成速度は低下する

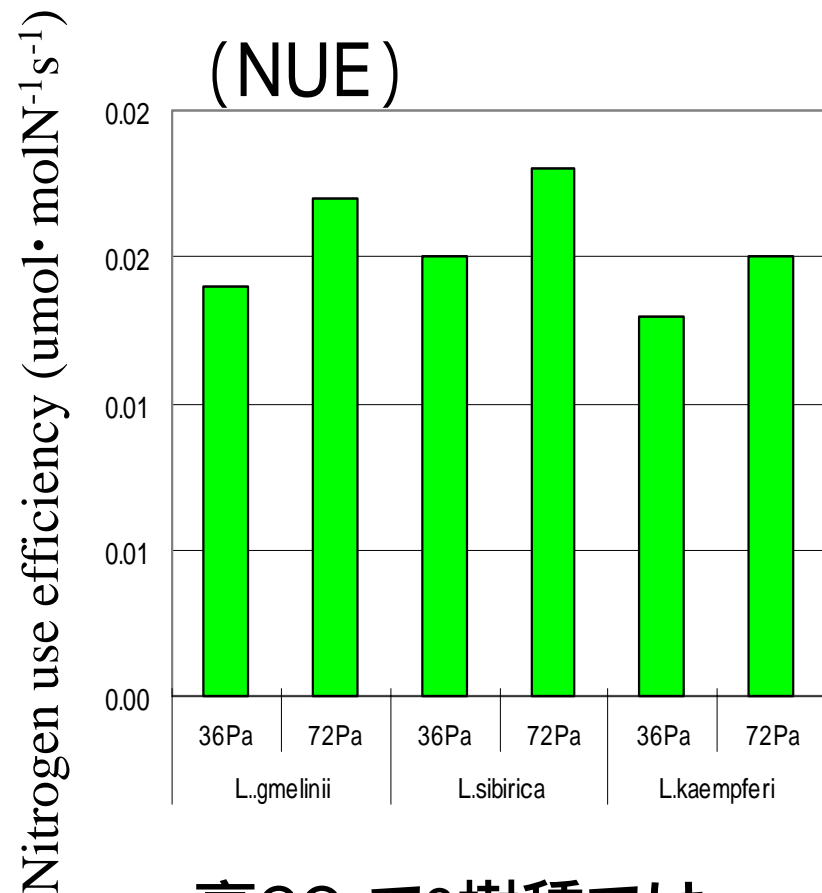


- ・高CO₂への反応は100 ~ 700ppmで直線的
 - ・気孔コンダクタンスは高CO₂で低下
- 水利用効率が上昇

水・窒素利用効率・・・育種の基礎として



水利用効率(WUE)はグイマツとシベリアカラマツは、ニホンカラマツより高CO₂で上昇が明瞭



高CO₂で3樹種では窒素利用効率(NUE)の増加が見られる。しかし、種間差は無い。



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(現在:
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森林保全生態学、
北大北方森林保全学講座出身)

Choi DS (2008)

Ecophysiological study of the growth of conifers
in Korea in acidified soil with elevated CO₂:

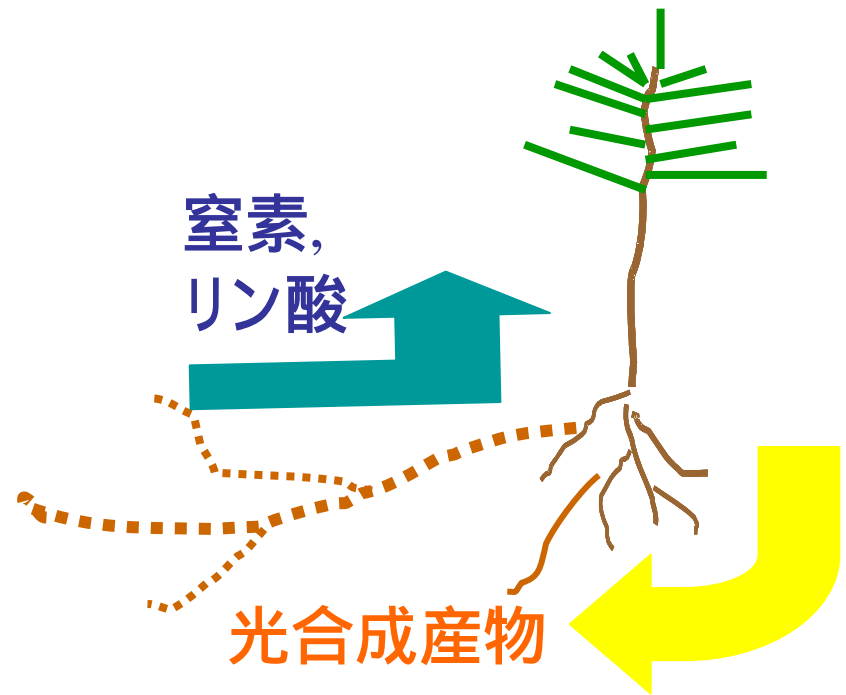
The role of ectomycorrhizal infection.

Eurasian J For Res 11: 1-39.



外生菌根菌はあたかも
細根のように機能する

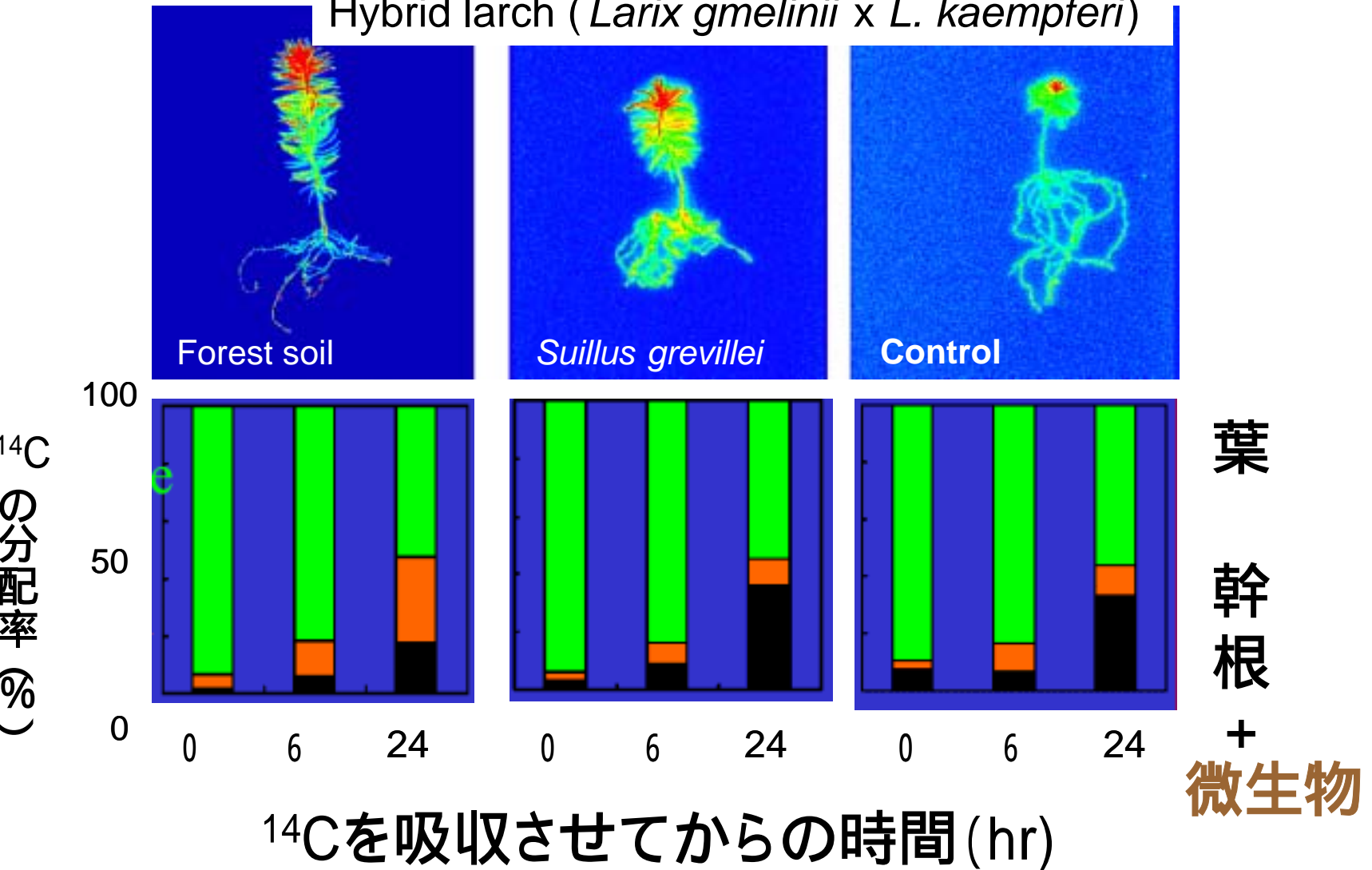
窒素、リン酸、水分を供給



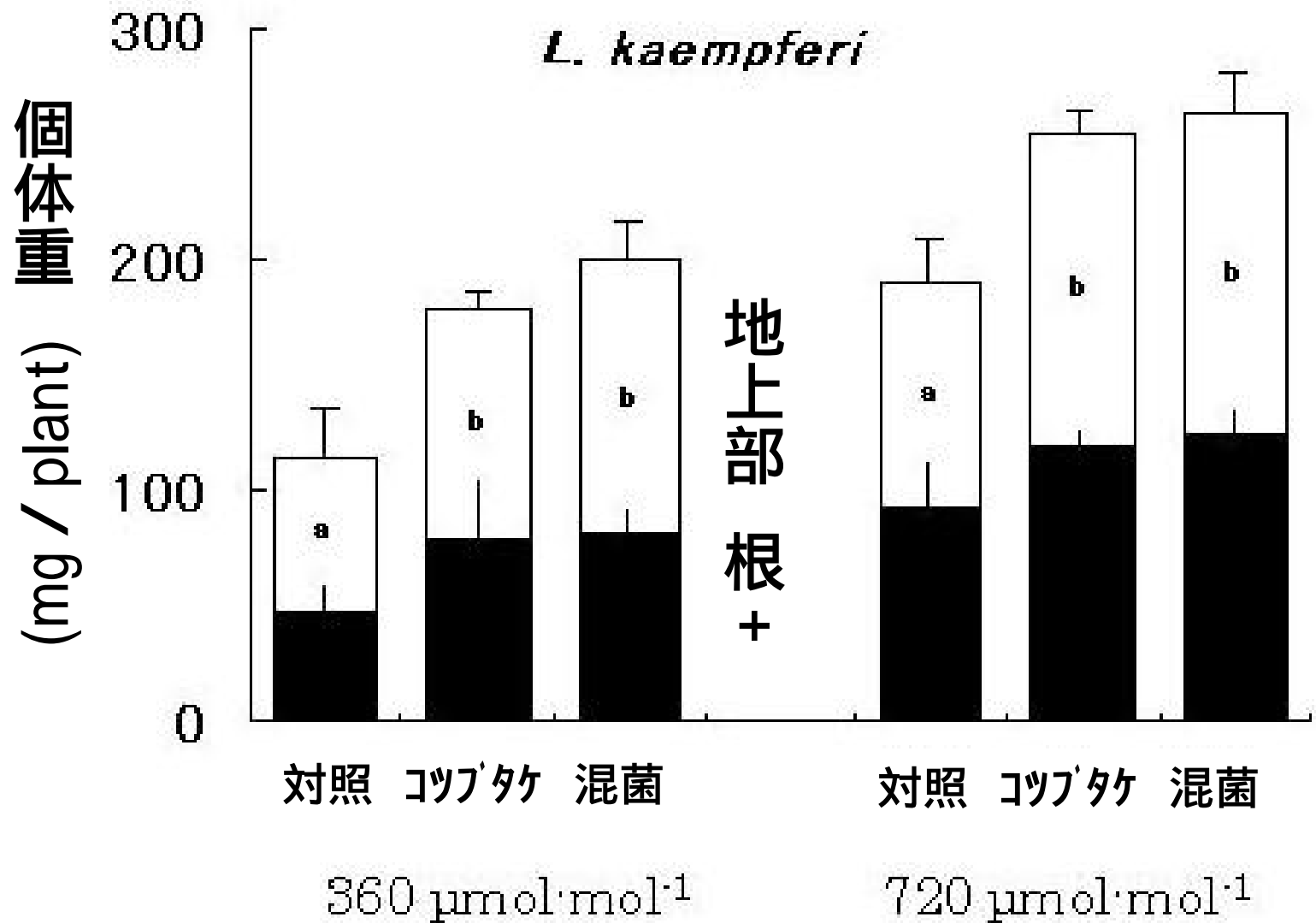
・宿主は光合成産物を
供給 (^{14}C 利用)

(Qu et al. Tree Physiol. 2004,
Choi et al. Photosynthetica 05)

Hybrid larch (*Larix gmelinii* x *L. kaempferi*)

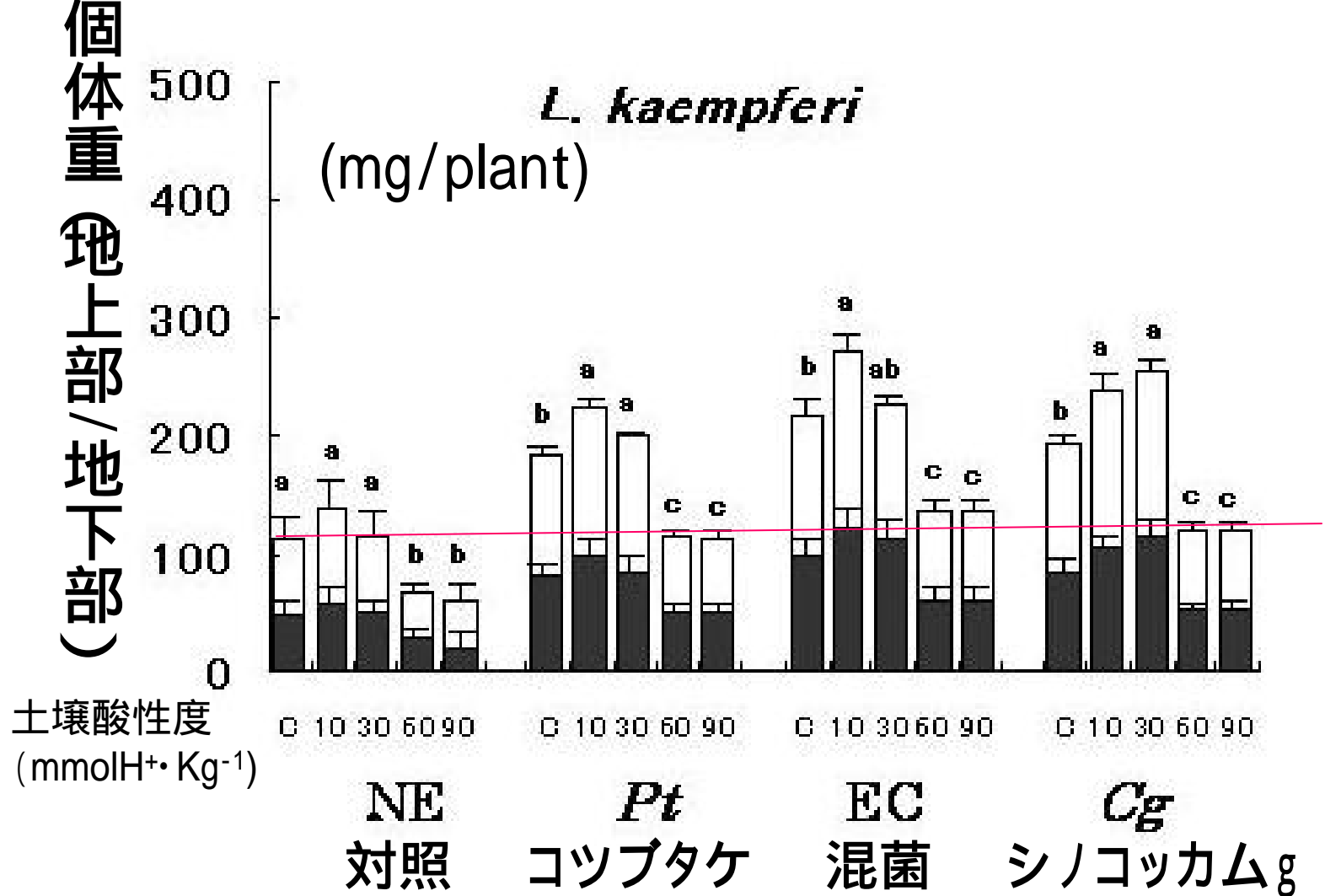


根圏への光合成産物の分配はF1で約16%

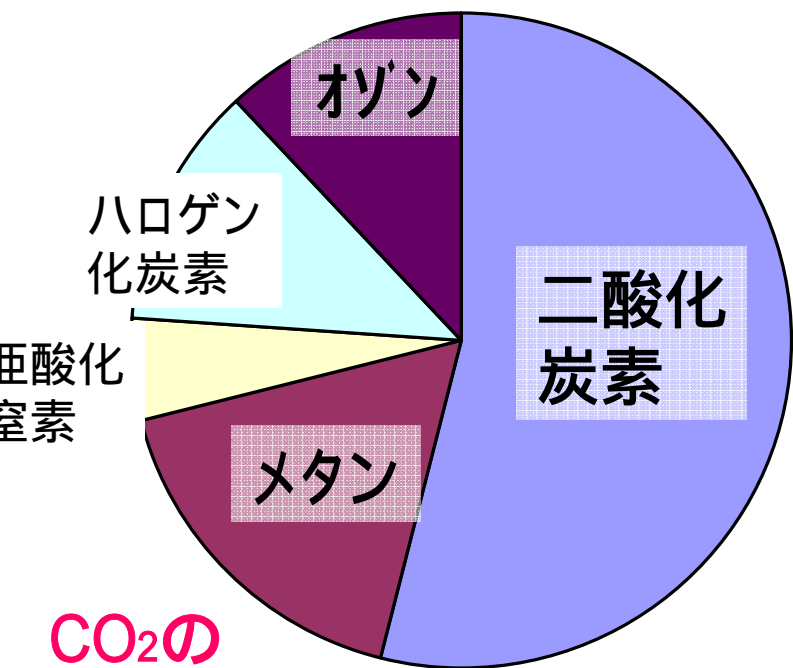


高CO₂環境でも外生菌根菌の感染によって成長増

(Choi 2008)



土壌酸性度 30 (mmolH⁺·Kg⁻¹)以下では成長が
外生菌根菌によって増加する



CO₂の
21 ~ 23 倍

推定された
温室効果ガスの寄与率

Nature 439: 187-191
July 2006

Methane emissions from
Terrestrial plants under
Aerobic conditions.

By
Keppler F, Hamilton JTG,
Bra M, Rockmann T.

嫌気条件で生産されるはずのメタン(CH₄)が
好気条件で生産されていた！

森林を増やすと
温暖化加速？

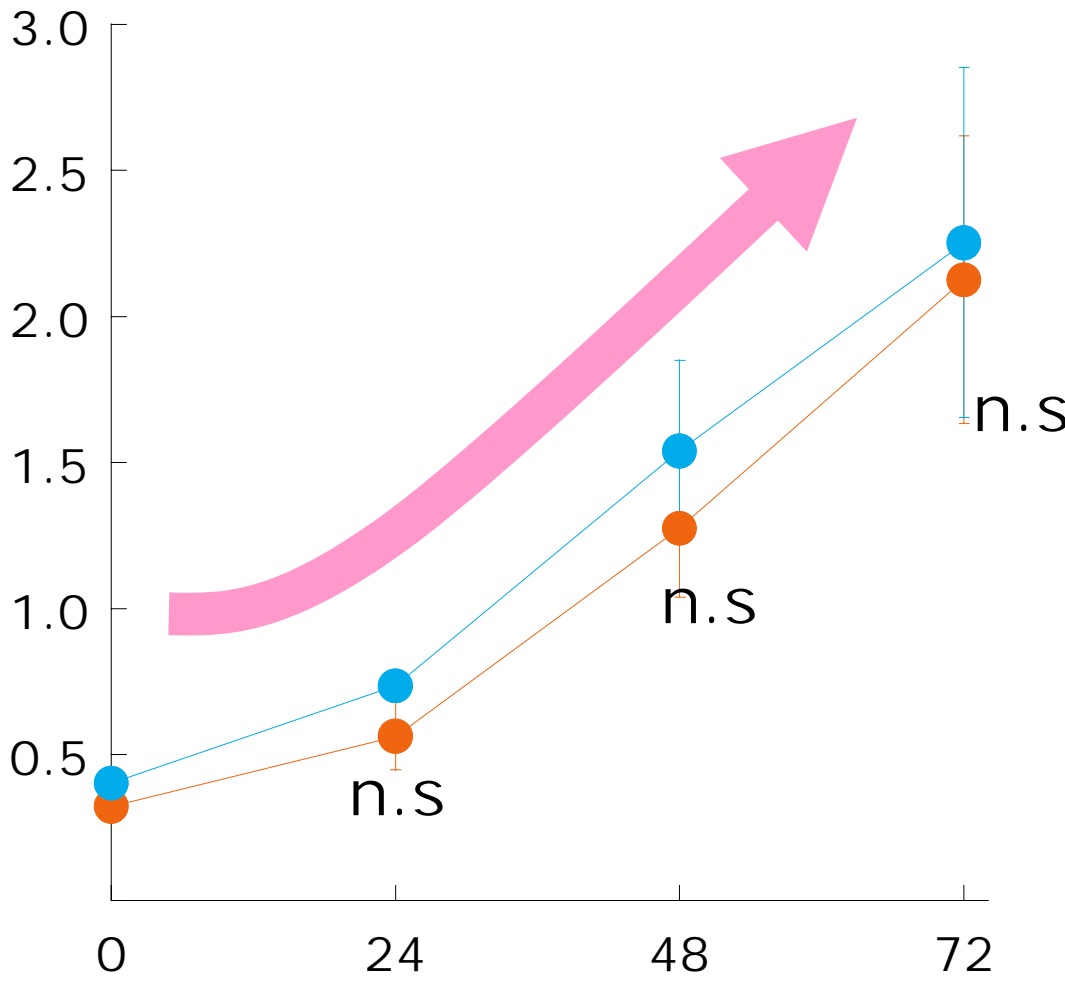
乾重当たりのメタン放出量 (カラマツ)

生育条件

500ppm

360ppm

メタン放出量 ($\text{ngCH}_4 \text{ g}^{-1}(\text{DW})$)



Kitaoka et al.
(2007)

カラマツ針葉からはメタンが好気条件で発生

Journal of Agriculture Meteorology 63: 201-206.

長伐期への可能性



Photo 1. Cross section of a Japanese larch log showing the white stringy rot caused by *Stereum sanguinolentum* at a height of 5.3 m above the ground.



Photo 2. Cross section of a Japanese larch log showing the brown cubical rot caused by *Phaeolus schweinitzii* at a height of 0.3 m above the ground.



Photo 3. Cross section of a Japanese larch log showing the brown cubical rot caused by *Sparassia crispata* at a height of 0.3 m above the ground.



Photo 4. Cross section of a Japanese larch log showing the brown cubical rot caused by *Tyromyces balaneus* at a height of 0.3 m above the ground.

814

Research Bulletin of the College Experiment Forests Vol. 42, No. 4

病虫害など生物ストレスの影響は？

(Igarashi et al. 1985)

湿度の高い場所は
長伐期は困難 Ⅱ?