International Symposium on Forest Soils:

Linking Ecosystem Processes and Management to Forest Biodiversity and Functions

Conference Program

17-20 September, 2013, Shenyang, China

International Symposium on Forest Soils

Linking Ecosystem Processes and Management to Forest Biodiversity and Functions

17-20 September, 2013

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Welcome

Dear Delegates,

It is my pleasure to welcome you, the delegates for International Symposium on Forest Soils: linking ecosystem processes and management to forest biodiversity and functions, to Shenyang, China.

The themes of this Symposium include: (1) innovative techniques used to simulate and monitor the effects of local management and climate change; (2) advances and novel approaches in research technologies; and (3) application and monitoring of these developments at local, national and global levels. Most importantly, this Symposium will promote the development of effective networks and strategies within the research community: linking ecosystem processes and management to forest biodiversity and functions, particularly in the context of climate change adaptation and mitigation at both local and global scales.

There are delegates from more than ten countries and regions, including senior forest soil ecologists and students. We really appreciate your contribution and participation.

I hope that you will enjoy your stay here and will return with a good memory of the people, the landscape, the flora and the culture.

Xingguo Han

Conference Chair

Symposium Goal and Objective

Forest soils fulfill multiple functions in single forest ecosystems and in landscapes with different ecosystems. The evolution of environmental conditions in a changing climate, adaptations of local forest management practices to sustain productivity and maintain environmental services (water quality, biodiversity and carbon sequestration) and the legacy of former land-use, all influence soil morphology and function.

The major objective of this symposium is to facilitate the development of international links, scientific exchanges and strategic alliances in forest soils and ecosystem processes, leading to fully realised, collaborative research programmes that address key research questions on the effects of local management / disturbance and climate change on forest ecosystem productivity, biodiversity and functions. The themes of this symposium will examine: (1) innovative techniques used to monitor and simulate / model the effects of local management and climate change; (2) advances and novel approaches in research technologies; and (3) application and monitoring of these developments at local, national and global levels. Most importantly, this symposium will promote the development of effective networks and strategies within the research community: linking ecosystem processes and management to forest biodiversity and functions, particularly in the context of climate change adaptation and mitigation at both local and global scales.

Organizer

Institute of Applied Ecology, Chinese Academy of Sciences (IAE, CAS)

State Key Laboratory of Forest and Soil Ecology

Co-organizer

Shenyang University

Sponsers

- International Union of Soil Science (IUSS)
- International Union of Forestry Research Organizations (IUFRO)
- Chinese Academy of Sciences (CAS)
- Griffith University (GU)
- National Natural Science Foundation of China (NNSFC)
- Shenyang Municipal Science and Technology Bureau (SMSTB)

Participants

The symposium will invite approximately eight leading scientists from the world, and ten Chinese leading scientists. The organizers also open the conference to other scientists and students (with registration). There will be approximately 60 oral presentations and up to 200 participants including scientists, students, government officials, and industry experts.

Symposium Organizer and Committees

This symposium, which is the fourth international conference on forest soil around the world, will be held in Shenyang, Liaoning province, China, September 17-20, 2013, and hosted by the Institute of Applied Ecology, Chinese Academy of Sciences.

Conference Chair

Dr. Xingguo Han (Director, Institute of Applied Ecology, CAS)

International Scientific Advisory Committee

Chair: Zhihong Xu, Griffith University, Australia

Co-Chair: Xingguo Han, Institute of Applied Ecology, CAS, China

Co-Chair: Peter Clinton, New Zealand Forestry Research Institute, New Zealand

Members:

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- Tat Smith, Canada
- Weixin Cheng, China
- Shenglei Fu, China
- Jim He, China
- Hailong Wang, China
- Chris Johnson, USA
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- Pavel Krestov, Russia
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- Guoyi Zhou, China

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Secretary: Dr. Zhe Liu (IAE, CAS)
Dr. Zhengwen Wang (IAE, CAS)

Contact:

Dr. Zhe Liu (IAE, CAS)
Tel: +86-24-83970317
Mobile phone: 13591645157
Email: liuzhe@iae.ac.cn

Dr. Zhengwen Wang (IAE, CAS)
Tel: +86-24-83970392
Mobile phone: 13897964588
Email: wangzw@iae.ac.cn

Sponsorship

中国科学院
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IUFRO

Shenyang Taoxian International Airport to Shenyang Qipanshan International Conference Center

1) It is about 40 km from Shenyang Taoxian International Airport to Shenyang Qipanshan International Conference Center.

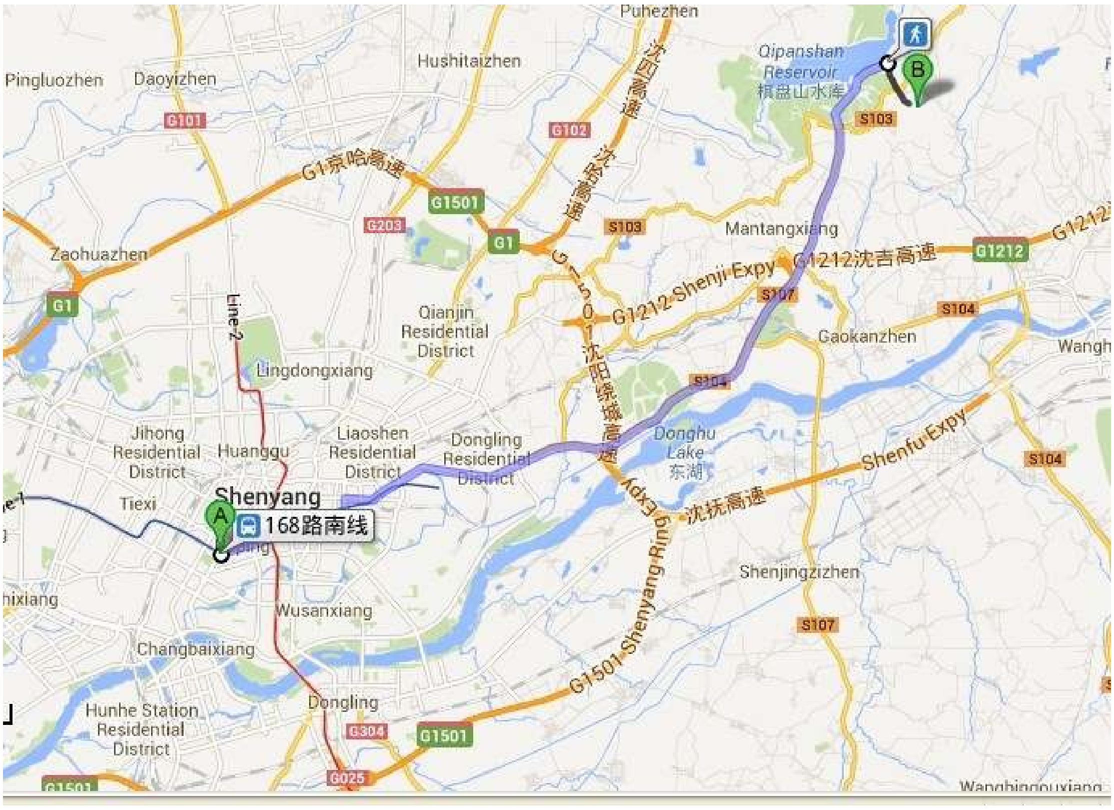
2) You can take the airport bus to Maluwan (马路湾) station first, and then take bus 168 south line to Xiuhu square or a taxi to the hotel.

Shenyang North Railway Station to Shenyang Qipanshan International Conference Center

You can take Shenfu three line to Fushun south station, and then take 168 south line to Xiuhu square and next walk to Qipanshan International Conference Center.

Shenyang Railway Station to Shenyang Qipanshan International Conference Center

You can take Subway towards Liming Guangchang and walk to two zero one(二〇一) then take 168 north line to Xiuhu square and next walk to Qipanshan International Conference Center.



Important Information

Registration and poster fixation

Registration desk will be on the first floor of the Shenyang Qipanshan International Conference Center. Upon your arrival, you can fix your posters on the Roll Up Banner with the aid of meeting staffs.

Conference room

September 17-19: Conference Hall of Shenyang Qipanshan International Conference Center

Meals

Date	Meals	Start time	Site
17-September	Breakfast	7:00am	Dining room of Shenyang Qipanshan International Conference Center
	Lunch	12:10am	Dining room of Shenyang Qipanshan International Conference Center
	Welcome Dinner	6:00pm	Dining room of Shenyang Qipanshan International Conference Center
18-September	Breakfast	7:00am	Dining room of Shenyang Qipanshan International Conference Center
	Lunch	12:10am	Dining room of Shenyang Qipanshan International Conference Center
	Dinner	5:40pm	Dining room of Shenyang Qipanshan International Conference Center
19-September	Breakfast	7:00am	Dining room of Shenyang Qipanshan International Conference Center
	Lunch	12:00am	Dining room of Shenyang Qipanshan International Conference Center
	Dinner	6:20pm	Dining room of Shenyang Qipanshan International Conference Center
20-September	Breakfast	7:00am	Dining room of Shenyang Qipanshan International Conference Center
	Lunch	12:10am	Field Trip
	Farewell Dinner	6:00pm	Dining room of Shenyang Qipanshan International Conference Center

Artistic performance

All delegates are invited to enjoy the artistic performance by students majored in drama and music at the Music Performance Hall in Shenyang University. Please be at the entrance of Shenyang Qipanshan International Conference Center at 6:30pm on the18th of September and wait to be transferred to the hall by bus. After the performance, there are buses at the exit of the hall lifting the delegates back to the Shenyang Qipanshan International Conference Center.

Poster session

The poster session will take place at the Conference Hall of Shenyang Qipanshan international conference center. Please place your poster according to the number on the Roll Up Banner provided (please see page 183 for your poster number).

Conference Field Trip

Please be at the entrance of Shenyang Qipanshan International Conference Center at 9:10am on the 20th of September waiting for bus to new campus of IAE, arboretum garden of IAE and Shenyang ecological experimental station respectively.

Scientific Program

September 16, 2013 (Monday)	
08:00-22:00	Registration
September 17, 2013 (Tuesday)	
08:30-09:30	Opening Addresses and Group Photo
09:30-09:40	Refreshment Break
Theme 1 Impacts of climate change and local management on biogeochemical cycles and biodiversity **(**Keynote Speaker: 30 Minutes for Presentation, 10 Minutes for Questions and Discussion) (Oral Presenter: 20 Minutes for Presentation, 5 Minutes for Questions and Discussion)	
Chair: Prof. **Zhihong Xu** Prof**. E Bai**	
09:40-10:20	Prof. **Charles Driscoll** (Syracuse University, USA) Northern Forest: Long-term Measurements, Experiments and Future Model Projections From the Hubbard Brook Experimental Forest, New Hampshire, USA
10:20-11:00	Prof. **E Bai** (Institute of Applied Ecology, CAS) Spatial Pattern of Nitrogen Isotope As An Indicator of Ecosystem Responses to Rainfall in Semi-arid and Arid Grasslands
11:00-11:15	**Refreshment Break**
11:15-11:40	**Qiufang Xu** (Zhejiang A & F University, China) Winter Fertilization and Mulching Affected N_2O Emissions and Ammonia Oxidizing Microbes
11:40-12:05	**Xiyun Chen** (Beijing Normal University, China) Spatial and Temporal Controls of in Situ Soil N Transformations in Subtropical Forest Ecosystems in South China
12:05-13:20	**Lunch**
Chair: Prof. **Chris Johnson** Prof. **Zhibin Luo**	
13:30-14:10	Prof. **Zhihong Xu (**Griffith University, Australia) Subtropical to Boreal Convergence of Non-linear Tree Growth Responses to Rising Atmospheric Carbon Dioxide Concentration
14:10pm-14:50	Prof. **Scott X. Chang** (University of Alberta, Canada) Agroforestry Systems for Carbon Sequestration and Reduction in Greenhouse Gas Emissions
14:50-15:15	Prof. **Maihe Li** (Swiss Federal Research Institute) Interactive Effects of Environmental Changes on C, N, and P Concentrations of Semi-arid Grassland Plants in Relation to Soil C, N, and P Contents
15:15-15:40	**Ang Wang** (Research Institute of Tropical，Chinese Academy of Forestry Forestry) Variations in 15N Natural Abundance of Plant and Soil System in Four Remote Tropical Rainforests, Southern China
15:40-16:00	**Refreshment Break**

16:00-16:25	**Xingkai Xu** (Institute of Atmospheric Physics, Chinese Academy of Sciences, China) Effects of Nitrogen Addition on Concentrations and Fluxes of Dissolved Organic Matter and Inorganic Nitrogen Under A Temperate Old-growth Forest in Northeast China
16:25-16:50	**Yoshiyuki Inagaki** (Forestry and Forest Products Research Institute,Japan) Nitrogen Stable Isotopic Composition of Leaves and Soil in Japanese Cedar and Hinoki Cypress Plantation Along a Precipitation Gradient in Shikoku District, Southern Japan
16:50-17:15	**Haohao Wu** (Institute of Atmospheric Physics, Chinese Academy of Sciences; Chang'an University, Xi'an, China) Effect of Wetting Intensity, Carbon and Nitrogen Addition on N_2O and CO_2 Fluxes From Forest Soils
17:15-17:40	**Fuke Yu** (Yunnan University, China) Impacts of Ageratina Adenophora Invasion on Soil Water, Soil Organic Matter and Soil Nitrogen in Eucalyptus Plantation
18:00	**Welcome Dinner**
September 18, 2013 (Wednesday)	
Chair: Prof. **Yunting Fang**	Prof. **Muneoki Yoh**
08:30-09:10	Prof. **Chris E. Johnson** (Syracuse University, USA) Soil Acidity and Forest Health: Results From an Experimental Wollastonite ($CaSiO_3$) Addition at Hubbard Brook, NH, USA
09:10-09:50	Prof. **ZhiBin Luo** (Northwest A&F University, China) Ecophysiological and Molecular Responses of *Populus* Species to Nitrogen Deficiency and Fertilization
09:50-10:15	**Zhang Zhou** (Research Institute of Tropical Forestry, CAF) Responses of Soil Respiration to Nitrogen and Phosphorus Additions in Tropical Mountain Rainforests in Hainan Island, China
10:15-10:40	**Kazumichi Fujii** (Forestry and Forest Products Research Institute, Japan) Effects of Forest Management on Organic Matter Cycling and Soil Acidification In a Japanese Cedar Plantation
10:40-11:00	Refreshment Break
11:00-11:25	**Xuefeng Li** (Institute of Applied Ecology, CAS) a Modified Ingrowth Core Method For Measuring Fine Root Production, Mortality and Decomposition in Forests
11:25-11:50	**Muneoki Yoh** (Tokyo University of Agriculture and Technology, Japan) Earthworm Cast As Nitrifiers' Paradise in Terrestrial Ecosystems: a Hot Spot of N_2O Production
12:00-13:20	**Lunch**

Chair: Prof. **Weixin Cheng** Prof. **Jean-Michel Carnus**	
13:30-14:10	Prof. **Thomas Robert Fox** (Virginia Tech, USA) Linking Forest Soils and Ecophysiology to Improve Our Understanding of Ecosystem Processes Affecting Forest Productivity
14:10-14:50	Prof. **Jianxin Sun** (Beijing Forestry University, China) Soil Carbon Sequestration in Terrestrial Ecosystems: Pathway & Controls
14:50-15:15	**Dongwei Liu** (Institute of Applied Ecology, CAS) Patterns of δ^{15}N of Soil Available N along a Precipitation Gradient in Northern China Grassland
15:15-15:40	**Faming Wang** (South China Botanical Garden, CAS) The Effects of N and P Addition on Soil Microbe and N Transformaitons in a Tropical Forest
15:40-16:00	**Refreshment Break**
16:00-16:25	**Kai Yang** (Institute of Applied Ecology, CAS) Long-term Nitrogen Addition Effects on Soil Organic Matter in a Larix Gmelinii Plantation in China
16:25-16:50	**Liqing Sha** (Xishuangbanna Tropical Botanical Garden, CAS) Soil transfering from high- to low-elevation forests affects nitrogen mineralization rate
16:50-17:15	**Weiwei Dai** (Institute of Applied Ecology, CAS) Modeled Effects of Climate Change on Soil N_2O Emission in Broad-leaved Korean Pine Mixed Forest, ChangBai Mountain
17:15-18:15	**Dinner**
19:30-	**Artistic performance**
September 19, 2013 (Thursday)	
Theme 3: **Linking ecosystem processes and management to forest biodiversity and functions** (Keynote Speaker: 30 Minutes for Presentation, 10 Minutes for Questions and Discussion) (Oral Presenter: 20 Minutes for Presentation, 5 Minutes for Questions and Discussion)	
Chair: Prof. **Thomas Robert Fox** Prof. **Jianxin Sun**	
08:30-09:10	Prof. **HailongWang** (Zhejiang A & F University, China) Soil Carbon Dynamics Under Typical Forests in Subtropical China
09:10-09:50	Prof. **Peter William Clinton** (New Zealand Forestry Research Institute) Future Expectations of Forest Soils: Increased Productivity, Environmental Limits; New Knowledge and Understanding
09:50-10:15	**Yongchun Li** (Zhejiang A & F University, China) Differential Responses of Ammonia Oxidizing Archaea and Bacteria to Four Main Types of Vegetation in Subtropical Area
10:15-10:40	**Jianfen Guo** (College of Geographical Science, China) Conversion of a Natural Evergreen Broadleaved Forest into Pure Plantation Forests in a Subtropical Area: Effects on Soil Respiration and Microbial Biomass

10:40-11:00	**Refreshment Break**
11:00-11:25	**Shucai Zeng** (College of Forestry, South China Agricultural University) Comparison of Soil Properties Under Introduced Eucalyptus Urophylla Plantations in Reference to Native Pinus massoniana Plantations and Natural Broadleaved Forests in South China
11:25-11:50	**Wenjie Wang** (Northeast forestry University, China) Changes in Glomalin-related Soil Protein, SOC, N and Other Soil Physic-chemical Properties During Vegetation Succession of Original Korean Pine Forests in Changbaishan Mts
12:00-13:20	**Lunch**
Chair: Prof. **Hailong Wang**	Prof. **Scott X. Chang**
13:30-14:10	Prof. **Weixin Cheng** (Institute of Applied Ecology, CAS) An Overall View of The Rhizosphere Priming Effect
14:10-14:50	Prof. **Jean-Michel Carnus** (INRA, FRANCE) Responding to Climate Change and Sustaining Production from Planted Forests - what does it mean for forest soils?
14:50-15:15	**Jianming Xue** (Scion, New Zealand) Beneficial Effect of Biosolids on Soil Fertility, Tree Growth and Carbon Sequestration of Radiata Pine Plantation on a Poor Site
15:15-15:40	**Shinji Kaneko** (Forestry and Forest Products Research Institute, Japan) Carbon Stock of Dead Wood, Litter and Mineral Soil in Japanese Forests
15:40-16:00	**Refreshment Break**
16:00-16:25	**Maokui Lyu** (Fujian Normal University, China) Effects of Forest Conversion on Carbon Mineralization and Microbial Community Composition in Top- and Subsoil Horizons in Subtropical China
16:25-16:50	**Hui Wang (**Research Institute of Forest Ecology, Environment and Protection, Chinese Academy of Forestry) Effects of Forest Management on Carbon Sequestration and Soil Stability
16:50-17:15	**Xiaohua Wan** (Fujian Normal University, China) Changes in Labile Soil Organic Matter Pools and Microbial Biomass After Reforestation of Chinese Fir Site With a Broadleaf Species
17:15-17:40	**Haiyan Ren** (Institute of Applied Ecology, CAS) ^{15}N Natural Abundance of Leaf and Soil in Response to 4- and 8-yr Nitrogen Additions in a Temperate Steppe of Northern China
17:40-18:10	**Discussion**
18:20-20:00	**Closing addresses and farewell dinner**
20:00-21:00	**Poster Session**
September 20, 2013 (Friday)	**Field Trip**

09:30-11:00	New Campus Visit of IAE
11:30-12:30	Lunch
13:30-15:30	Visiting Arboretum Garden of IAE
16:30-18:00	Shenyang Ecological Experimental Station Visit
18:00-	Dinner

September 21-23, 2013: Post-conference Tour (optional)

Changbai Mountain Tour

Keynote

Subtropical to Boreal Convergence of Non-linear Tree Growth Responses to Rising Atmospheric Carbon Dioxide Concentration………………………. …………………………….Zhihong Xu 19

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Future Expectations of Forest Soils: Increased Productivity, Environmental Limits; New Knowledge and Understanding…………………………………………Peter William Clinton 37

Linking Forest Soils and Ecophysiology to Improve Our Understanding of Ecosystem Processes Affecting Forest Productivity……………………………………………Thomas Robert Fox 41

Agroforestry Systems for Carbon Sequestration and Reduction in Greenhouse Gas Emissions……………………………………………………………………...Scott X. Chang 43

Subtropical to boreal convergence of non-linear tree growth responses to rising atmospheric carbon dioxide concentration

Zhihong Xu,[1*] Yan Xu[1] and Putranto Nugroho[1]

[1]Environmental Futures Centre & School of Biomolecular and Physical Sciences, Griffith University, Nathan, Queensland 4111, Australia.

[*]**Corresponding author**: Zhihong Xu, Environmental Futures Centre, Griffith University, Nathan, Queensland 4111, Australia (telephone: +61-7-37353822; fax: +61-7-37357773; e-mail: zhihong.xu@griffith.edu.au)

Keywords: atmospheric carbon dioxide, climate change, plant photosynthesis, tipping points, tree growth, water limitation, forest ecosystems

Abstract

Tree water use efficiency (WUE), the ratio of tree biomass produced to amount of water used during a growing season, is increased in the past century under climate change, but this increased WUE does not translate into enhanced tree growth across the globe. The impact of climate change, particularly complex atmospheric carbon dioxide (CO_2), temperature and water interactions, on plant photosynthesis, tree WUE and growth remains elusive. Plant photosynthesis is an important biological process, subject to atmospheric CO_2 or water limitation. There is a subtropical to boreal convergence towards an optimum temperature for leaf photosynthesis within forest canopies.

Here we show for the first time that tree growth of beech and oak in four temperate forest ecosystems of central Europe (Belgium) responded non-linearly to rising atmospheric CO_2 and water limitation due to increasing mean annual temperature and decreasing summer rainfall during 1840s–1990s. We have advanced and tested the atmospheric CO_2 - water limitation model which can adequately reconcile the changing relationship between tree WUE and growth under climate change for the past century in central Europe. It is the CO_2 limitation and then CO_2-induced water limitation, not rising temperature itself, that control tree growth under climate change, although both rising atmospheric CO_2 and increasing water limitation enhance tree WUE. The tipping points of atmospheric CO_2 for tree growth occurred 30-40 years ago, and thereafter tree growth decreased with rising atmospheric CO_2. This resulted in decreasing forest CO_2 assimilation and increasing atmospheric CO_2, leading to accelerated global warming and increasing water limitation in central Europe.

We have further tested the atmospheric CO_2 - water limitation model in the other subtropical, temperate and boreal forest ecosystems of Australia, China, Sweden and USA, using tree ring stable isotope (^{13}C, ^{15}N and ^{18}O) composition and growth data as well as climate data in the past 50-200 years. We have noted the subtropical to boreal convergence of non-linear responses of tree growth to rising atmospheric CO_2, for different tree species across the diversified forest ecosystems. The significance and implications of these key research findings will be discussed in the context of forest ecosystem carbon dynamics and intensifying future climate change, particularly global warming and increasing water limitation for many forest ecosystems in the world.

Ecophysiological and Molecular Responses of *Populus* Species to Nitrogen Deficiency and Fertilization

Zhi-Bin Luo [a*], Jie Luo [b], Hong Li [c], Mengchun Li [b]

[a] College of Forestry and State Key Laboratory of Crop Stress Biology in Arid Areas, Northwest A&F University, Yangling, Shaanxi, 712100, P. R. China
[b] College of Life Sciences, Northwest A&F University, Yangling, Shaanxi, 712100, P. R. China
[c] Key Laboratory of Applied Entomology, College of Plant Protection, Northwest A&F University, Yangling, Shaanxi 712100, P.R. China
* phone: +86 29 87080178; Fax: +86 29 87082216; E-mail: luozbbill@163.com

Keywords: Amino acids, ammonium transporters, carbohydrates, gene expression, nitrate transporters, net flux, plasma membrane H^+-ATPase, poplar, stable carbon isotope

Poplar plants are cultivated as woody crops, which are often planted on marginal land where soil nutrients are limited. Occasionally, some poplar plantations are fertilized by addition of ammonium (NH_4^+) and/or nitrate (NO_3^-) to improve yields. However, little is known about ecophysiological and molecular responses of *Populus* species to nitrogen (N) deficiency/fertilization. In this talk, net NH_4^+/NO_3^- fluxes in association with H^+ fluxes in roots of *P. popularis* (Pp), N uptake and assimilation of Pp and *P. alba* × *P. glandulosa* (Pg) in acclimation to low N availability, and how N-fertilization affects the growth, carbon and N physiology, and wood properties of Pp and Pg will be reported based on our recent studies (Li *et al.*, 2012; Luo *et al.*, 2013).

Net NH_4^+/NO_3^- fluxes in association with H^+ fluxes were measured non-invasively by using scanning ion-selective electrode technique in fine roots of Pp. Spatial variability of NH_4^+ and NO_3^- fluxes was found along root tips of Pp. The maximal net uptake of NH_4^+ and NO_3^- occurred, respectively, at 10 and 15 mm from poplar root tips. Net NH_4^+ uptake was induced by ca. 48% with provision of NO_3^- together, but net NO_3^- uptake was inhibited by ca. 39% with the presence of NH_4^+ in poplar roots. Furthermore, inactivation of plasma membrane (PM) H^+-ATPases by orthovanadate markedly inhibited net NH_4^+/NO_3^- uptake and even led to net NH_4^+ release with NO_3^- co-provision. Linear correlations were observed between net NH_4^+/NO_3^- and H^+ fluxes in poplar roots except that no correlation was found between net NH_4^+ and H^+ fluxes in roots exposed to NH_4Cl and 0 mM vanadate. These results indicate that root tips play a key role in NH_4^+/NO_3^- uptake and that net NH_4^+/NO_3^- fluxes and the interaction of net fluxes of both ions are tightly associated with H^+ fluxes in poplar roots.

To investigate nitrogen (N) uptake and assimilation of two contrasting *Populus* species in acclimation to low N availability, saplings of Pp occurring on nutrient-poor sites and Pg growing on fertile soils were exposed to 10, 100 or 1000 μM NH_4NO_3. Lower net influxes of NH_4^+ and NO_3^- at the root surface, higher stable N isotope composition ($\delta^{15}N$) in roots and more responsiveness of transcriptional regulation of 18 genes involved in N uptake and assimilation in roots/leaves of Pp compared to those of Pg are found under limiting N supply. Low N treatments decreased net influxes of NH_4^+ and NO_3^-, concentrations of root NH_4^+ and foliar NO_3^-, foliar glutamate dehydrogenase activities, total N and soluble protein concentrations in roots and leaves, and transcript levels of most ammonium (*AMTs*) and nitrate (*NRTs*) transporters in leaves and genes involved in N assimilation in roots and leaves, whereas increased fine root surface area, foliar starch, $\delta^{15}N$ in roots and leaves, and transcript abundance of several *AMTs* and *NRTs* in roots. These results indicate that Pp and Pg have different response patterns and slow down processes of N acquisition and assimilation in acclimation to limiting N availability.

To investigate how N-fertilization affects the growth, carbon and nitrogen (N) physiology, and wood properties of poplars with contrasting growth characteristics, slow- (Pp) and fast-growing (Pg) poplar saplings were exposed to different N levels. Aboveground biomass, leaf area, photosynthetic rates (***A***), instantaneous photosynthetic nitrogen use efficiency ($PNUE_{\mathrm{i}}$), chlorophyll and foliar sugar concentrations were higher in Pg than in Pp. Foliar nitrate reductase (NR) activities and root glutamate synthase (GOGAT) activities were higher in Pg than in Pp as were the N amount and NUE of new shoots. Lignin contents and calorific values of Pg wood were less than that of Pp wood. N-fertilization reduced root biomass of Pg more than of Pp, but increased leaf biomass, leaf area, ***A*** and $PNUE_i$ of Pg more than of Pp. Among thirteen genes involved in the transport of ammonium or nitrate or in N assimilation, transcripts showed more pronounced changes to N-fertilization in Pg than in Pp. Increases in NR activities and N contents due to N-fertilization were larger in Pg than in Pp. In both species, N-fertilization resulted in lower calorific values as well as shorter and wider vessel elements/fibers. These results suggest that growth, carbon and N physiology, and wood properties are more sensitive to increasing N availability in fast-growing poplars than in slow-growing ones, which is probably due to prioritized resource allocation to leaves and accelerated N physiological processes in fast-growing poplars under higher N levels.

Acknowledgements

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Luo J, Qin JJ, He FF, Li H, Liu TX, Polle A, Peng CH, Luo ZB. 2013. Net fluxes of ammonium and nitrate in association with H^+ fluxes in fine roots of *Populus popularis*. *Planta (Berlin)* **237**, 919-931.

Luo J, Li H, Liu TX, Polle A, Peng C, Luo ZB. 2013. Nitrogen metabolism of two contrasting poplar species in acclimation to limiting nitrogen availability. (Submitted)

Effects of changing climate on the structure and function of the Northern Forest: long-term measurements, experiments and future model projections from the Hubbard Brook Experimental Forest, New Hampshire, USA

Charles Driscoll[a*], Peter Groffman[b], John Campbell[c], Afshin Pourmokhtarian[a], Pamela Templer[d], Timothy Fahey[e]

[a]Department of Civil and Environmental Engineering, Syracuse University, Syracuse, NY 13244, USA; [b]Cary Institute of Ecosystem Studies, Millbrook, NY 12545, USA; [c]USDA Forest Service, Northeastern Research Station, Durham, NH 03824, USA; [d]Department of Biology, Boston University, Boston, MA 02215, USA; and [e]Department of Natural Resources, Cornell University, Ithaca, NY 14853, USA

*Telephone No. 315-443-3434; Fax No. 315-443-1243; and Email: ctdrisco@syr.edu

Keywords: downscaling, global change, global circulation models, hydrochemical model projections, hydrology, Long Term Ecological Research, long-term measurements, snow manipulation experiments

Abstract: Long-term measurements and research is summarized on the effects of changing climate on the structure and function of a Northern Forest at the Hubbard Brook Experimental Forest (HBR) in New Hampshire, USA. HBR is a U.S. Forest Service intensive research site and a member of the National Science Foundation Long-Term Ecological Research (LTER) network. Long-term measurements, experiments and model calculations have been conducted to assess past climate and to project the future impacts of changing climate.

The Hubbard Brook Experimental Forest (HBR), New Hampshire, USA

The 3,037-ha HBR valley is located in the White Mountain National Forest (43°56'N, 71°45'W). The climate is humid continental with short, cool summers and long, cold winters. Mean air temperature (1955 – 2000) is 19 °C in July and -9 °C in January (Campbell et al. 2009). Annual precipitation averages approximately 140 cm, and a continuous snowpack usually develops early each winter to a depth of approximately 1.5 m (Campbell et al. 2009).

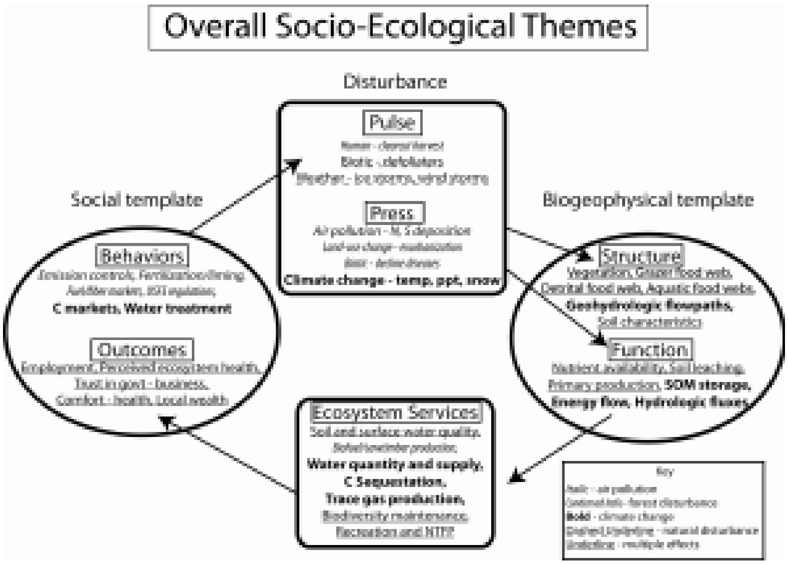

Figure 1. The response of the structure and function of the Northern Forest ecosystem to pulse and press drivers, associated effects on Ecosystem Services (ES), and the feedback to societal outcomes and activities. Note that the disturbance drivers are coded by font and underlining to correspond to air pollution, forest disturbance and climate change. Effects of these drivers are also shown in these same fonts and underlining

Vegetation is dominated by northern hardwood forests, i.e., American beech (*Fagus grandifolia*), sugar maple (*Acer saccharum*) and yellow birch (*Betula alleghaniensis)* that grade into red spruce (*Picea rubens)* and balsam fir (*Abies balsamea*) along a spatially and temporally dynamic ecotone at higher elevations (Schwarz et al. 2003). Soils are 75–100 cm deep, acidic (pH ~4.0 in the surface organic horizons) typic and aquic Haplorthods developed from unsorted basal tills. The HBR was subjected to logging from 1880 to 1920 and then a salvage logging following a hurricane in 1938.

Research Themes

The long-term record from the HBR provides clear evidence of a changing climate in the northeastern U.S. Over the nearly 60 years of record, annual average temperature at HBR has increased by about 1.5^{o}C. This increase has been more pronounced in winter than summer. Over the same period, total annual precipitation has increased significantly, by about 5.5mm/yr. Surprisingly, the changes in these two key drivers have been accompanied by a slight reduction in annual evapotranspiration. The warming winter climate has resulted in a significant reduction in the depth and duration of the snowpack (Campbell et al. 2011), with likely consequences for the frequency and extent of soil freezing (Henry 2008). Although we cannot conclusively ascribe recent extreme climatic events at HBR (e.g., ice storm, drought) to climate change, they are in accord with expectations of climate change projections for this region (Hayhoe et al. 2007). Marked decreases in extreme cold temperatures may have implications for insect pests such as the hemlock wooly adelgid. We have also seen an increased frequency of high-discharge events and a decreased frequency of low-flow events due to the long-term increases in precipitation at HBR. We would anticipate that these trends will continue and probably accelerate in coming years (Meehl et al. 2000).

How will ecosystem structure and function and the provision of ecosystem services in the Northern Forest respond to changing climate (Figure 1)? The HBR valley lies at the interface between the broadleaf deciduous forest biome and the evergreen needleleaf biome. Climate change responses appear to be occurring in this ecotone (Beckage et al. 2008), but we anticipate that complex feedbacks between vegetation and environment will influence ecosystem dynamics. Although elevation might be considered as a spatial surrogate for changing climate (Fukami and Wardle 2005), the elevation gradient at HBR encompasses a complex hydrogeologic and biogeochemical template over which physical conditions and soil resources exhibit complex patterns. Projecting the responses of vegetation dynamics and productivity, heterotroph populations and food webs, and nutrient cycling and hydrology to climate change and other interconnected drivers such as air pollution and land disturbance presents a challenge requiring a new level of ecosystem study in a large landscape context (Figure 1). We anticipate that a variety of possible feedbacks could lead to “tipping-point” behaviors in ecosystem structure and function, and our proposed conceptual model of the landscape ecosystem may be particularly relevant for identifying these phenomena. Evaluating and testing the mechanisms that underlie ecosystem responses to climate change at the HBR will also allow us to translate patterns and processes to the regional scale (Groffman et al. 2012).

Building on earlier observations of the role of winter climate and soil freezing in controlling landscape and temporal patterns in ecosystem pattern and process, we have conducted a series of plot-level manipulations to evaluate mechanisms of response involving such key features as damage to fine roots (Cleavitt et al. 2008), soil aggregation (Steinweg et al. 2008), microbial production of trace gases (Groffman et al. 2006), microbial retention of N and S (Campbell et al. 2009) and herbivory by moose (Christenson 2007). A key factor in nutrient dynamic responses to soil freezing is direct physiological impairment of root nutrient uptake function, but the extrapolation of this response across large landscapes remains uncertain and is the subject of ongoing research. Our insights on winter climate are summarized in regional syntheses (Campbell et al. 2009; Campbell et al. 2005).

We use statistically downscaled atmosphere-ocean general circulation model output as input to the model PnET-BGC to examine how the Northern Forest might respond to future climate and interactions with atmospheric deposition. Reconstructions of past climate and atmospheric deposition allow us to hindcast hydrologic and biogeochemical conditions prior to the Industrial Revolution. Comparisons of model predictions with measured observations enable us to test theory and, where theory is inadequate, to design process studies to improve understanding. Model forecasts project future hydrochemistry in HBR watersheds under changing conditions of temperature, precipitation, and solar radiation with and without CO_2 effects on forest vegetation. An important hypothesis that has emerged from this work suggests that forest fertilization associated with rising CO_2 could offset the effects of accelerated N cycling and acidification caused by future increases in temperatures (Pourmokhtarian et al. 2012).

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Soil acidity and forest health: Results from an experimental wollastonite (CaSiO3) addition at Hubbard Brook, NH, USA

Chris E. Johnson[a,*], Charles T. Driscoll[a], Joel D. Blum[a]

[a] Syracuse University, Syracuse, NY, 13244, USA; [b] University of Michigan, Ann Arbor, MI, 48109, USA

[*] Phone: +1 315 443 4425; Fax: +1 443 1243; E-mail: cejohns@syr.edu

Keywords: acid rain, aluminum, base cations, calcium, cation exchange capacity, exchangeable cations, watershed, wollastonite.

Abstract The abstract should be **in English** and within **two-page limit**. Please follow the format and style described in this template.

Introduction

Acidic deposition, primarily in the form of sulfuric and nitric acid, has resulted in the acidification of soils and surface waters of the northeastern United States, and many other regions of the world. There is a growing consensus that this acidification has resulted in the depletion of available calcium from many base-poor soils. Soil calcium depletion may partly explain the sluggish response of surface waters in the northeastern United States to recent decreases in acidic deposition, and may also be related to declining forest health in the region. This study extends results reported in Cho et al. (2010, 2012) and is part of an ecosystem-level investigation of the response of vegetation, soils, fauna, and drainage waters to Ca amendment using wollastonite. Our main research hypotheses related to soils were:

H1. Wollastonite addition increases the exchangeable Ca in forest floor and upper mineral soil horizons.

H2. Increasing exchangeable Ca is balanced by a compensatory decline in exchangeable Al.

H3. Timing of soil chemical changes reflect a downward migration of Ca released from the added wollastonite.

Materials and methods

This work was carried out at the Hubbard Brook Experimental Forest (HBEF) in New Hampshire, USA (Likens and Bormann 1995). Annual precipitation is 1295 mm and monthly mean temperatures range from -9 °C (Jan) to 19 °C (July). The forest at Hubbard Brook is predominantly hardwoods (beech, maple, birch) with some conifers (red spruce, balsam fir) at higher elevations. Predominant soil types are Spodosols (Typic Haplorthods) and Inceptisols (Typic Dystrochrepts), which are acidic ($pH_w \sim 3.5 - 4.0$ in O horizon) and coarse-grained (loamy sands).

In October, 1999, Watershed 1 at the HBEF was amended with 1015 kg/ha of Ca in the form of powdered and pelletized wollastonite ($CaSiO_3$). The aim of this long-term experiment is to replace Ca believed to have been leached from the soil in the 20th century by acid rain. Wollastonite was used instead of lime or other more common Ca amendments because the natural geochemical source of Ca in the region is principally silicate minerals. Soil samples were collected from 75-100 sites in July, 1998 (pre-treatment), 2000, 2002, 2006, and 2010. The Oi and Oe horizons (L and F) were collected together as a single sample. After sampling the Oa (H) horizon, soil cores were collected from the upper 10-cm of mineral soil. All samples were air-dried and sieved (5-mm for O horizons, 2-mm for mineral soils). Oi+Oe samples were ground in a Wiley mill. The "total" concentrations of Al, Ca, Mg, K, Na were measured by ashing overnight (500 °C), then digesting the residue in concentrated HNO_3. Exchangeable cations (Al, Ca, Mg, K, Na) were measured in 1 M NH_4Cl extracts, exchangeable acidity (assumed to be Al+H) was measured in 1 M KCl extracts, and exchangeable H was computed by difference. The effective cation exchange capacity (CEC_e) was computes as the sum: Exch. Acidity + Ca + Mg + K + Na. Effective base saturation (BS_e) was estimated as the percentage of CEC_e satisfied by basic cations. Soil pH was measured in deionized water (pH_w) and 0.01 M $CaCl_2$ (pH_s). Chemical analyses of extracts were performed using ICP-OES.

Results and discussion

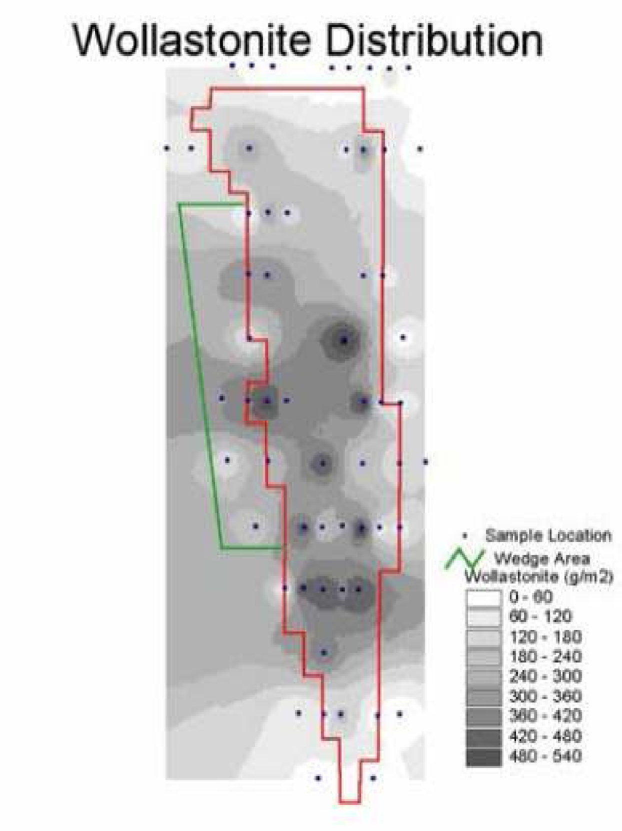

Figure 1 Spatial pattern of wollastonite deposition on watershed 1 at the Hubbard Brook Experimental Forest, October 1999.

Mass Balance for Added Wollastonite

The wollastonite loading for the watershed was 1015 kg Ca/ha. Measurements from collectors indicated that the wollastonite was fairly evenly distributed (Peters et al. 2005; Figure 1). Measured "total" Ca pools in the O horizons and the upper mineral soil indicate that most of the added Ca due to wollastonite addition could be accounted for in the Oi+Oe horizons in the year after application (2000; Figure 2). Some of the added wollastonite was probably not dissolved by the 5M HNO_3 used for our digestions. As hypothesized, there has been a progressive downward migration of Ca in the soil, with the Oa horizon pool increasing in 2002 and the mineral soil pool increasing in 2006 (Figure 2). Of the 1015 kg/ha of Ca added as wollastonite, at least 480 kg/ha are no longer in the forest floor or the upper mineral soil. Possible fates include: uptake in forest vegetation, migration to mineral soil, and export as stream water.

Soil Chemical Changes

The goal of this experiment was to replace exchangeable Ca believed to have been depleted from the soil by decades of acid deposition. Our data suggest that the experiment was successful in this regard. Exchangeable Ca increased in all horizons after wollastonite application (Figure 3). Exchangeable acidity decreased in the Oi+Oe and Oa horizons after wollastonite application. As with the "total" Ca, patterns in the increases in exchangeable Ca and decreases in exchangeable acidity reflect a progressive downward migration of Ca in the soil, as hypothesized. Chemical changes were detected in the Oi+Oe horizon in 2000, the year after treatment, while changes did not occur until 2002 in the Oa

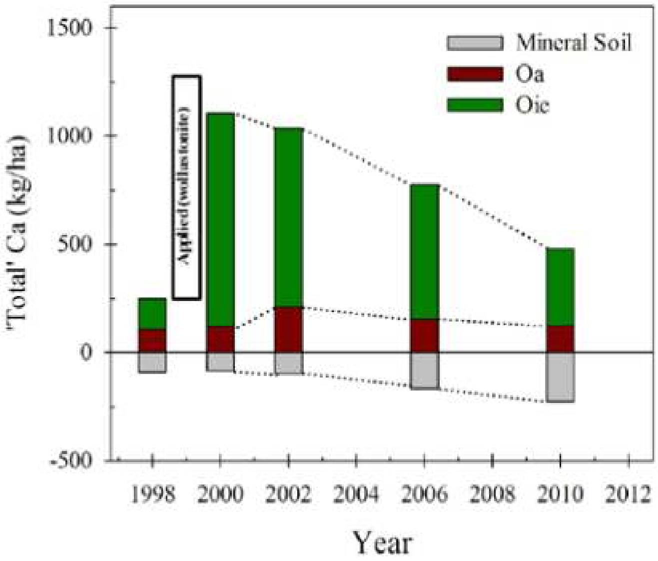

Figure 2 Changes in "total" Ca, measured in 5M HNO_3 digests, after wollastonite addition to watershed 1 at the HBEF

horizon, and 2006 in the mineral soil (Figure 3). The increases in exchangeable Ca were not fully compensated by decreases in exchangeable Al and/or H (Figure 3). As a result, CEC_e increased in the Oi+Oe and Oa horizons.

Conclusions

Our data support the interpretations of Nezat et al. (2010), who proposed three stages to explain increases in stream water Ca concentration. They attributed the initial (first-year) increase in stream Ca to the dissolution of wollastonite pellets deposited in the stream channel. Elevated stream Ca concentrations in years 2 and 3 were attributed to Ca reaching the stream from the hyporheic zone, corresponding to the penetration of Ca into the Oa horizons. The penetration of Ca into mineral soils that we observed after 2002 (Year 3) coincides with their "infiltration" stage, in which wollastonite-derived Ca is believed to reach the stream from soil sources.

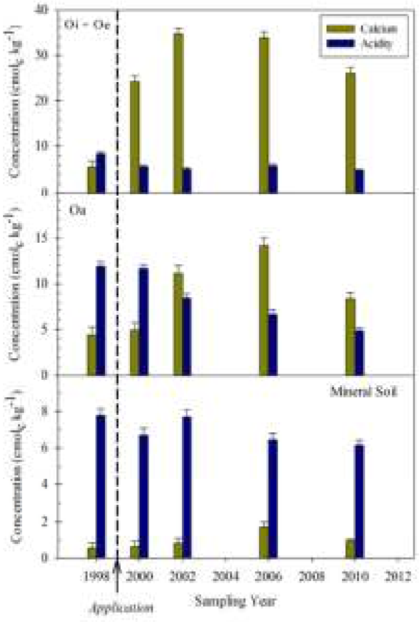

Figure 3 Changes in exchangeable Ca and exchangeable acidity after wollastonite addition to watershed 1 at the HBEF. Error bars indicate one standard error.

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Spatial pattern of nitrogen isotope as an indicator of ecosystem responses to rainfall in semi-arid and arid grasslands

Edith Bai[a], Chao Wang, Dongwei Liu, Yunting Fang, Ping Jiang, Wentao Luo, Xingguo Han

[a] State Key Laboratory of Forest and Soil Ecology, Institute of Applied Ecology, Chinese Academy of Sciences, Shenyang, 110016, China
[*] Phone: +86 24 83970570; Fax: +86 24 83970570; E-mail: baie@iae.ac.cn

Keywords: Arid and semi-arid, precipitation, nutrient limitation, water limitation, stable nitrogen isotope

Introduction

Nitrogen (N) as an essential element is usually limited for plant growth, maintenance, and reproduction in terrestrial ecosystem. However, in arid and semi-arid grassland ecosystems, previous studies suggested that despite low N mineralization rate and N availability, N losses tended to be high in these areas compared to mesic areas (Austin *et al.* 2004).The potential reasons include lower plant N uptake and microbial N immobilization and bigger impacts of precipitation pulses in arid and semi-arid areas (Dijkstra *et al.* 2012). Collins *et al.* (2008) proposed that soil microbes can be activated by precipitation at lower threshold compared to plant N uptake, resulting in more responses of soil microbial processes than plant metabolism by small rainfall events. Therefore, the uncoupled N processing between plants and microbes would cause significant N losses from leaching and gaseous pathways in these areas (Austin *et al.* 2004). However, whether the thresholds exist is still under debate and questions remain on whether N is a limiting factor of primary production in water-limited areas (Harpole *et al.* 2007).

Natural abundance of N isotopes ($\delta^{15}N$) can provide insights into large-scale N dynamics of terrestrial ecosystems and has become an efficient tool to understand ecosystem N cycling (Houlton *et al.* 2006). Here, we seek to use N isotopes to gain insights into N status in water-limited grasslands. In semi-arid and arid regions, due to the water limitation, N utilization by plants and microbes may be more sensitive to the change of water availability than in other regions (Austin 2011). Qualification of spatial variability of soil and plant $\delta^{15}N$ across a precipitation gradient affords an opportunity to evaluate soil-plant interactions and responses of plants and microbes to changing water availability. Here we chose a west-east transect across the grasslands in northern China, which was 3200 km long and covered a MAP gradient from 34 mm to 436 mm. This transect provides a natural precipitation gradient to examine large-scale spatial patterns of soil and plant $\delta^{15}N$. Especially, few previous studies have been carried out in such areas with less than 200 mm MAP (Handley *et al.* 1999; Craine *et al.* 2009). The main objectives of this study were: 1) to investigate the spatial patterns of soil and plant $\delta^{15}N$ along a large-scale precipitation gradient; 2) to analyze the effects of precipitation on soil and plant $\delta^{15}N$; and 3) to understand the interactions between water and N and how they affect plants and microbes in arid and semi-arid regions.

Materials and methods

This study was conducted along the west-east grasslands transect across Gansu province and Inner Mongolia, northern China. Along the west-east grassland transect, one site was set about every 50 km during July-August, 2012 and in total there were 50 sites. At each site, a 50 m × 50 m plot was selected and five 1 m × 1 m sampling plots were set within the plot. In each 1 m × 1 m plot, after removing floor litter, ten random soil samples (0-10 cm) were collected using a soil core (2.5 cm diameter), and were mixed together into one sample. Soil samples were air-dried right after sampling and then stored in a plastic bag for later measurements.

Three dominant grass genera and one shrub genus were selected for isotope analyses: (1) *Stipa*, (2) *Leymus*, (3) *Cleistogenes*, and (4) *Caragana*.

Samples were analyzed for C, N content and N stable isotope ratios at the Stable Isotope Faculty of University of California, Davis. The nitrogen stable isotope abundance of samples relative to the standard was expressed as the following:

$\delta^{15}N = (R_{sample} / R_{standard} - 1) \times 1000$

where R_{sample} is the ^{15}N / ^{14}N ratio of a sample and $R_{standard}$ is the ^{15}N / ^{14}N ratio of the standard (atmospheric N_2).

Results and discussion

Soil $\delta^{15}N$ increased with increasing MAP in areas with MAP < 200 mm, but decreased in areas with 200 mm < MAP < 500 mm. Variations of foliar $\delta^{15}N$, soil total N, and soil C: N provided further evidence of a threshold at MAP = 200 mm for precipitation effects. Results indicated that soil microbes can be activated by precipitation even when MAP < 200 mm while plant N uptake can only be activated when MAP > 200 mm. In areas with MAP < 200 mm, productivity was limited by water, but not nitrogen, although soil N is low.

Our finding of the breakpoint at MAP = 200 mm supports the prediction by the Threshold-Delay Nutrient Dynamics (TDND) model made by Collins *et al*., which described that a threshold exits in the response of plant metabolism to rainfall. MAP = 200 mm happen to be the commonly used boundary between arid and semi-arid regions in China and other regions such as the Sahara Desert. While whether this is a coincidence needs to be further explored, our study pointed to the potential different plant-microbe interactions and different resource limitation mechanism between arid and semi-arid areas. The simple theoretical model of ecosystem N response to precipitation in arid and semi-arid grasslands may be applied to other dry ecosystems, but may be with a different MAP threshold value at different ecosystems. Therefore, this study provides fundamental experimental inputs for future process-based modeling of nutrient cycling in arid and semi-arid areas.

Our results also point to the particularity of the extreme conditions and the importance of more understanding of these conditions. If future climate change leads to higher aridity in dry areas, the uncoupled plant and microbial response may cause more N losses and higher ecosystem vulnerability. While in the areas of this study, annual and summer rainfall has been found to increase in northwestern China and decrease in northeastern China, hence the arid areas may become less limited by water and more limited by N. Nevertheless, a better mechanic link between precipitation dynamics and ecosystem N cycling is vital to understand how dry land will respond to interactions among multiple global change phenomena.

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Responding to Climate Change and Sustaining Production from Planted Forests - what does it mean for forest soils?

Carnus Jean-Michel [1], Augusto Laurent [2], Bakker Mark [3], Trichet Pierre [4]

[1] INRA Bordeaux-Aquitaine Research Centre UAR 911, Cestas Pierroton, 33610, France
[2] INRA Bordeaux-Aquitaine Research Centre UMR1220 TCME, Villenave d'Ornon, 33882, France
[3] Bordeaux Sciences Agro UMR1220 TCME, Gradignan, 33175, France
[4] INRA Bordeaux-Aquitaine Research Centre UR 1263 EPHYSE, Cestas Pierroton, 33610, France

[1] Phone: +33 5 57 12 28 65; Fax: +33 5 56 68 02 23; E-mail: carnus@pierroton.inra.fr

Keywords: climate change adaptation, planted forest management, sustainable intensification, biomass harvesting, soil productivity.

Abstract: The demands placed on the forest sector, and particularly on planted forests resources, will increase in the next decades both in terms of timber production and other products such as bioenergy and biochemicals. With limited land availability globally, sustainable intensification in the management of planted forests will be required, thus potentially preserving and reducing pressure on natural forests and agricultural lands for food production. In parallel, climatic conditions will change dramatically in many parts of the world and adaptation strategies need to be implemented and deployed rapidly for planted forests given their role in climate change mitigation through long term carbon sequestration in wood-based products and fossil fuel substitution from forest bioenergy systems. Responses to rapid climate changes and to increasing wood and biomass market demands will include a range of planted forest management options and intensification strategies with various impacts on soil fertility, site productivity and the wider environment. By combining regional approaches such as foresight study for development of future forest scenarios and elaboration of strategies for adaptation to climate change with experimental and modeling research work on impacts of forest intensification on environmental balance, forest management and planning options can be defined at regional scale and assessed for their impacts on soil sustainability. Results show that some intensification options will have limited effects on biogeochemical cycles and can be considered in regional adaptation strategies of planted forests.

Keynote speaker

Soil carbon sequestration in terrestrial ecosystems: pathway & controls

Osbert Jianxin Sun
Institute of Forestry and Climate Change Research, Beijing Forestry University, Beijing 100083
Ministry of Education Key Laboratory for Silviculture and Conservation, Beijing Forestry University, Beijing 100083
Email: sunjianx@bjfu.edu.cn

Abstract

As the largest organic carbon pool in terrestrial ecosystems, any fluctuation in soil organic carbon would greatly impact on the atmospheric greenhouse gas concentrations. Soil organic carbon originates mainly from remains and tissues of various organisms, in particular plant litter. After entering into the soil, most organic carbon are mineralized through activities of soil animals, micro-organisms, and/or other detritivores, and are emitted into the atmosphere as CO_2 or methane; a small proportion are stored in soil for a longer term after being transformed into more stable forms of soil organic carbon such as humus or protected by physical, chemical and/or physiochemical processes. Because of the differences in the origin and impacts by complex interactions between biotic and abiotic factors, organic carbons in soil occur in various forms and vary in their physiochemical properties and rates of turnover. Soil organic carbon can be differentiated either as labile carbon and recalcitrant carbon based on the decomposability, or as hydrophilic carbon and hydrophobic carbon based on the water dissolvability. In accordance to the degree of physical protection by mineral soil, soil organic carbon may also be identified as light fraction carbon or heavy fraction carbon. In terms of chemical composition, soil organic carbon consists of various types of carbon compounds including carbohydrates, polymers, carboxylic acids, aromatic compounds, amino acids, and amines, etc. Differences in the composition of soil organic carbon may affect the soil microbial structure and activity. Moreover, the processes of soil carbon sequestration are affected by climate, vegetation type, land use, soil texture and structure, and soil fauna and microbial communities. It should be recognized that soil organic carbon varies greatly in composition and its dynamics are affected by various factors and complex processes. Therefore, elucidation of the processes and potential in soil carbon sequestration remains a great challenge in studies of terrestrial ecosystem carbon cycles.

An overall view of the rhizosphere priming effect

Weixin Cheng
Institute of Applied Ecology, Chinese Academy of Sciences, Shenyang, China; and Environmental Studies Department, University of California, Santa Cruz, California 95064, USA. E-mail: chengwx@iae.ac.cn

Keywords: Soil organic C, decomposition, plant-soil interactions, nitrogen mineralization, elevated CO_2, ^{13}C isotope, rhizosphere method.

Abstract: Rhizosphere interactions, at the global scale, may control as much as 50% of the total CO_2 released from terrestrial ecosystems and regulate virtually all aspects of nutrient cycling. One crucial component of these rhizosphere interactions is the rhizosphere priming effect (**RPE**) which is defined as the stimulation or suppression of soil organic matter decomposition by live roots and associated rhizosphere organisms when compared to SOM decomposition from rootless soils under the same environmental conditions. Current results indicate that the RPE can enhance soil organic matter decomposition up to 380% or reduce it by 50%, depending on actual plant-soil conditions. Furthermore, global increases in atmospheric CO_2 concentration and surface temperature can significantly alter the magnitude of the RPE, which may play into future climate change. Therefore, incorporating the RPE into future ecosystem models is needed for accurately forecasting potential responses of terrestrial ecosystems to global environmental change. Overall, collective evidence indicates that the RPE is emerging as a crucial mechanism in terrestrial ecosystems, which warrants substantial future research and model development.

Significance of rhizosphere processes

Roots of higher plants, a key functional component of belowground systems and one of the main soil-forming agents, interact with virtually all soil components. Processes that are largely controlled or directly influenced by roots are often referred to as rhizosphere processes. These processes may include exudation, water uptake, nutrient mobilization, rhizosphere-associated soil organic matter (SOM) decomposition, and rhizosphere respiration. The substrates of rhizosphere respiration come from recently fixed C through photosynthesis, whereas SOM decomposition is primarily a function of soil heterotrophic activities utilizing solely original soil carbon. The two processes act simultaneously and are also linked through rhizosphere interactions. Therefore, plant roots and their interactions with soil components are at the center of many ecosystem processes. Rhizosphere processes regulate flows of energy, water, nutrients, and carbon in most terrestrial ecosystems. These processes have increasingly been recognized to significantly affect ecosystem productivity, plant community structure and diversity. At the global scale, approximately 70% of the photosynthetically-fixed energy in terrestrial ecosystems is channeled to soil via litter and roots; between one-thirds and two-thirds of this energy is allocated directly to roots and the rhizosphere. Despite the recognized importance of rhizosphere processes, our understanding of these processes remains inceptive, because methodological difficulties have largely prevented systematic investigations.

Rhizosphere priming under elevated CO_2

Results from CO_2-enrichment experiments suggest that RPEs are crucial in regulating soil organic C storage and N mobilization. Based on commonly reported findings of higher NPP and greater organic C inputs belowground under elevated CO_2, a significant increase in soil organic carbon storage is generally expected. However, several studies provide opposing evidence, with soil organic carbon storage declining when ecosystems are exposed to elevated CO_2. For example, Heath et al. (2005) reported that young trees grown under elevated CO_2 significantly increased total soil respiration while simultaneously reducing soil sequestration of root-derived C. Another study using Populus deltoides (Trueman & Gonzalez-Meler 2005) showed that rhizosphere C input significantly increased under elevated CO2, but a concurrent increase in SOM decomposition resulted in a net loss of soil C 10-20x greater than under ambient CO_2. Carney et al. (2007) and Langley et al. (2009) also found that six years of elevated CO_2 significantly reduced soil C storage in a scrub-oak ecosystem despite higher plant growth and likely higher rhizosphere C input. All these studies point to the RPE as a likely mechanism causing soil C loss and enhanced N mineralization when ecosystems are exposed to elevated atmospheric CO_2 concentrations; therefore, it is imperative to gauge the potential role of RPEs in ecosystem responses to elevated CO_2 and other global change drivers.

Factors influencing the rhizosphere priming effect

Results from laboratory studies using isotopic methods indicate that the magnitude of the RPE is responsive to changes in both biotic and abiotic conditions including plant species, plant phenology, aboveground plant biomass, photosynthetic activity, nutrient level, soil water content, atmospheric CO_2 concentration, root N content, and soil warming (see Cheng et al., 2013). Clearly, the rhizosphere priming effect can be controlled and influenced by plant, soil and environmental variables.

The rhizosphere priming effect on nitrogen mineralization

Rhizosphere regulation of soil N dynamics has received considerable recent attention. In their synthesis, Frank & Groffman (2009) emphasized the crucial role of RPEs on N mineralization and strongly encouraged the incorporation of rhizosphere-mediated processes into N cycling studies. They further stressed the urgent need for field methods of assessing N availability that include the rhizosphere component. In his commentary, Phillips (2007) also noted that assessing the effects of rhizosphere priming on soil N availability is critical for elevated CO_2 research. The importance of rhizosphere N dynamics was also mentioned in a synthesis on changing paradigms of N mineralization (Schimel & Bennett 2004). Laboratory experiments indicate that gross N mineralization rates in the rhizosphere can be an order of magnitude higher than in the bulk soil (Herman et al. 2006). High N mineralization rates in the rhizosphere are often associated with enhanced microbial decomposition of soil organic matter (de Graaff et al. 2009) and faunal grazing (Clarholm 1985, Bonkowski 2004). A greenhouse experiment showed that gross N mineralization rates of intact soil-root systems were positively correlated with rhizosphere-primed soil organic C decomposition rates across combinations of tree species and soil types (Dijkstra et al. 2009).

^{13}C Natural Abundance Tracer Method

Studies of rhizosphere processes have been restricted by the limitation of existing methods. Carbon dioxide released by a system of living roots and soil has two main origins: (1) plant-derived rhizosphere respiration (the sum of root respiration and rhizo-microbial respiration), and (2) microbial respiration of original soil C. These two C sources can be separated using isotope techniques. Total rhizosphere respiration and original soil C decomposition have been quantified by continuous ^{14}C labeling (e.g., Liljeroth et al. 1994) or pulse labeling (e.g., Cheng et al. 1993) under lab conditions. However, because of safety concerns ^{14}C-labeling is difficult to be used widely. Instead, a ^{13}C natural abundance tracer method for measuring total rhizosphere respiration and SOC decomposition has been developed (Cheng 1996, Qian et al. 1997). This natural tracer method is safe, but requires a large difference in ^{13}C natural abundance between the SOM-derived C and the root-derived C, which restricts its use to two kinds of plant-soil couplings: C3 plants grown in soils developed under C4 vegetation ("C4 soils"); or C4 plants grown in soils developed under C3 vegetation ("C3 soils"). The principle of the ^{13}C natural tracer method is based on the difference in ^{13}C:^{12}C ratio (reported in $\delta^{13}C$ values) between plants with C3 versus C4 photosynthetic pathways. C3 plants are more depleted in ^{13}C and have a mean $\delta^{13}C$ of -27‰ while C4 plants have a mean $\delta^{13}C$ of -12‰. The $\delta^{13}C$ values of accumulated SOM roughly reflect the original source of plant carbon. If C3 plants are grown in a C4-derived soil, new carbon entering the soil via roots of the C3 plants will have a different $\delta^{13}C$ value than the $\delta^{13}C$ value of the original soil C. We can use the following equation to partition soil-derived C4 carbon from plant-derived C3 carbon (Cheng 1996): $C3 = Ct\,(\delta t - \delta 4)/\,(\delta 3 - \delta 4)$; where $Ct=C3+C4$ and is the total amount of carbon, C3 is the amount of carbon derived from C3 plants, C4 is the amount of carbon derived from C4 soil, δt is the $\delta^{13}C$ value of the Ct carbon, $\delta 3$ is the $\delta^{13}C$ value of the C3 plant carbon, and $\delta 4$ is the $\delta^{13}C$ value of the C4 soil carbon. This method is highly recommended for partitioning rhizosphere C fluxes in several recent syntheses (e.g., Kuzyakov 2006, Subke et al. 2006, Paterson et al. 2009).

Continuous labeling using ^{13}C-depleted CO_2

Although the above-mentioned natural tracer method is safe and inexpensive, it requires a large difference in ^{13}C natural abundance between the SOM-derived C and the root-derived C, which restricts its use to two kinds of plant-soil couplings: C3 plants grow in soils developed under C4 plant-dominated vegetation ("C4 soils"); or C4 plants grow in soils developed under C3 plant-dominated vegetation ("C3 soils"). This method, therefore, cannot be used with most natural plant-soil couplings, which are typically C3 plants in C3 soils or C4 plants in C4 soils. In order to study the RPE with natural plant-soil couplings, a continuous labeling chamber system using commercially available, inexpensive CO_2 produced from natural gas (^{13}C-depleted, having $\delta^{13}C$ values from -40‰ to -55‰) was developed (Cheng & Dijkstra 2007). Plants grown inside this labeling system become highly ^{13}C-depleted. The difference between the $\delta^{13}C$ values of plant-derived C and soil-derived C in this continuous labeling system is much larger than in the natural ^{13}C tracer method, but the principle of two end-member separation between the plant-derived C and the soil derived C is the same. The principle of this continuous labeling method is basically the same as that used in elevated CO_2 experiments (e.g., Andrews et al. 1999) except that the CO_2 concentration is maintained at the ambient level. This labeling method has been tested both in a growth chamber and in a greenhouse.

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Soil carbon dynamics under typical forests in subtropical China

Xinzhang Song[a,b], Hailong Wang[a,b*], Mark O. Kimberley[c], Zhiting Zhang[d]
[a] Zhejiang Provincial Key Laboratory of Carbon Cycling in Forest Ecosystems and Carbon Sequestration, Zhejiang A＆F University, Lin’an, Zhejiang Province, 311300, China; [b] The Nurturing Station for the State Key Laboratory of Subtropical Silviculture, Zhejiang A＆F University, Lin’an, Zhejiang Province, 311300, China; [c] Scion, Private Bag 3020, Rotorua 3046, New Zealand; [d] Hebei North College, Zhangjiakou, Hebei Province, 075000, China
[*] Phone: +86 571 63705212; Fax: +86 571 63740889; E-mail: nzhailongwang@gmail.com

Keywords: bamboo, carbon sequestration, Chinese fir, plantation forest, soil organic carbon.

Introduction

In terrestrial ecosystems, the soil typically contains a greater carbon pool than the combined total contained in the vegetation and atmosphere. As land-use change can significantly affect soil carbon dynamics, accounting for this is crucial for understanding the terrestrial carbon cycle. The objective of this review paper is to illustrate how forest community succession and anthropogenic management practices can affect soil organic carbon dynamics and soil respiration.

Materials and methods

We synthesized from the literature information on soil carbon and respiration for five subtropical forest ecosystems, namely evergreen broadleaved forests, mixed needle- and broad-leaved forests, masson pine (*Pinus massoniana*) forests, Chinese fir (*Cunninghamia lanceolata*) forests, and Moso bamboo (*Phyllostachys pubescens*) forests. The forest ecosystems were compared for topsoil soil organic carbon (SOC) content, annual soil respiration (Rs) rate, and temperature sensitivity (Q_{10}).

Results and discussion

Based on published information from 55 studies of Chinese subtropical forest ecosystems, we obtained 71 estimates of SOC content, 56 estimates of annual forest soil CO_2 flux and 41 estimates of Q_{10}. Evergreen broadleaved forest had the highest SOC content (33.14 ± 4.92 g kg^{-1}), followed in order by mixed needle- and broad-leaved forest (26.43 ± 5.83 g kg^{-1}), Moso bamboo forest (25.31 ± 2.64 g kg^{-1}), Chinese fir forest (18.44 ± 1.16 g kg^{-1}), and masson pine forest (15.75 ± 2.10 g kg^{-1}) which had only half the SOC of evergreen broadleaved forest. The annual soil respiration rate was highest in evergreen broadleaved forest (46.80 ± 3.03 t CO_2 ha^{-1} yr^{-1}), followed by Moso bamboo forest (43.52 ± 4.52 t co_2 ha^{-1} yr^{-1}) mixed needle- and broad-leaved forest (35.57 ± 3.15 t CO_2 ha^{-1} yr^{-1}), masson pine forest (28.77 ± 5.18 t CO_2 ha^{-1} yr^{-1}), and Chinese fir forest (24.08 ± 3.26 t CO_2 ha^{-1} yr^{-1}). The Q_{10} value was highest in evergreen broadleaved forest and lowest in Chinese fir forest, but there was no significant difference between the five forest ecosystems ($P > 0.05$). There was no significant correlation between either SOC and Rs, or SOC and Q_{10} value ($P > 0.05$). Our findings imply that when evergreen broadleaved forest is converted to any of the other forest types, the SOC content will decline sharply, especially when converted to Chinese fir or masson pine forest. In the longer term, it is expected that such forest conversion will lead to a decrease in the soil respiration rate.

Conclusion

This study contributes to a better understanding of the affects of forest land-use and land-cover change and management practices on the carbon cycle in subtropical China.

Future expectations of forest soils: increased productivity, environmental limits, new knowledge and understanding.

Peter W. Clinton[a]

[a]Forest Environment and Economics, Scion, Forestry Rd, University of Canterbury, PO Box 29-237, Fendalton, Christchurch 8540, New Zealand. Telephone +64 3 364-2949, Fax +64 3 364 2812; Email Peter.Clinton@Scionresearch.com

Keywords:
Forest soils, Productivity gap, Mycorrhizae, Plant growth promotion

Future expectations of forest soils

There is increasing demand for timber and non-timber products and services (food, fibre, carbon sequestration, clean water, recreation, biodiversity, erosion mitigation) from both planted and natural forests. To meet this demand, forest managers need to evaluate management practices and strategies for the efficient use of resources and provision of timber and non-timber benefits over time. Sustainable management is essential if the worlds' forests are to continue to meet societies' expectations of forests, including bioenergy and increased contribution to human health and well-being.

While the interdependence of plant-soil interactions is well recognised, particularly in the areas of energy dynamics and nutrient cycling, new advances in molecular biology and plant and microbial science are creating an opportunity to further explore these interactions in a more rigorous fashion in order to inform forest management. The effect of soil properties and processes on cambial activity in plants is one area where this convergence of scientific disciplines may provide important insights and potentially ensure forests continue to provide a diversity of values. Identifying links between forest soil properties and processes and human health is proposed as an emerging area (Donovan et al. 2013).

Increasing productivity

There is an increasing recognition of the productivity gap (Mueller et al. 2012) in the agricultural sector and the need to close this to increase the supply of products. In the light of the future demands on forests, there is also the need to identify the extent of the productivity gap for forests. Due to the long-term nature of the forest cycle there is the potential to manipulate both the productivity of existing forests and also future forests that will be planted following the harvest of current forests.

The manipulation of forest soils offers many possible options for increasing the productivity and value of mid rotation stands. Simply put, achieving larger logs, and more of them with better wood characteristics will increase both the value and productivity of existing forests. One way to do this is to increase the sophistication of fertiliser use in forestry (Smethurst 2010) and to bring it into line with state-of-the-art fertiliser technology while adopting a systems biology approach to match plant nutrition with forest soil resources. If we recognise that as well as being nutrients, P, B and particularly N can act as signals, regulating plant gene expression, physiology and growth and development (Gutierrez 2012; Smaill et al. 2011) we could aim to transform fertiliser use in forestry. As an example B has been identified as an important factor in quorum sensing (Chen et al. 2002), the process by which microbes communicate. So applying B to a B-deficient soil should not only address plant needs in terms of overcoming B deficiency and improving growth, but also address microbial demands for improving communication. As a result of increased microbial communication, there may be more microbial activity that ultimately benefits plant growth. Not only may plant growth be improved, but the quality of the resulting wood may also be improved as B acts to increase pectin cross linking in cell walls that improves cell wall strength (O'Neill et al. 2004) and plants may be more healthy due to improved plant immune system responses (Ruuhola et al. 2011) due to improved microbial activity impacting on the plant immune system. The results of these sorts of studies will be important as they will demonstrate the need to look at a whole of soil-plant response and not just focus on a measure of plant growth when it comes to adding value to mid rotation stands.

Environmental limits

The ability of environments to buffer the impacts of intensification of forest management will become increasingly important. One of the goals of the New Zealand Forest Owners' science and innovation plan is to improve productivity (double it) and consistency of wood in a sustainable way. To do this, new innovative approaches will be required such as novel biological agents to promote plant growth and manipulation of sites, including nutrient amendments, to increase carrying capacity. As well as increasing productivity these approaches will need to maximise wood quality and operate within environmental limits imposed by regulators and markets. On this latter aspect, local regulators are imposing limits on catchment nutrient loadings that will restrict current and future fertiliser use, particularly N and P (Davis et al. 2012). At the same time, international certification processes such as forest stewardship council certification are challenging the use of a range of chemicals, including some Cu and B-based compounds used in forest management. More research is required to avoid unnecessary restriction on forest productivity, but also to ensure environmental quality is not compromised.

The predictability and magnitude of tree fertiliser response needs to be greatly improved to increase the efficiency of fertiliser use. This requires response models and systems models that consider a whole of plant responses to applied nutrients and competition for resources that limit tree growth. Increased fertiliser costs, coupled with more stringent requirements around nutrient inputs, mean that greater efficiency of and value from fertiliser application will become increasingly important.

Also the extent to which microbial activity can be manipulated is a key question (Smaill et al. 2010), particularly in order to increase the availability and effectiveness of soil resources and the certainty with which this can be achieved. What processes ought we focus on - increased weathering, increased N and P availability, enhanced plant growth promotion, or enhanced plant immune system response (e.g. Berendsen et al. 2012)?

What we don't know very well is to what extent fertilisers influence soil microbial communities, both positively and negatively? There has been concern that fertilisers make soil microbes lazy in terms of gene expression and can even reduce mycorrhizal effectiveness or change the nature of species involved in the symbiotic relationship. Looking ahead, are there new compounds that will have positive effects on microbial communities, stimulating greater microbial activity and enhancing plant growth?

New knowledge and understanding

When thinking about future forests and new plantings we can anticipate the impacts of new genetics; new species choices; local, national and international policies; and climate change realities that will have many and varied influences on the supply of timber and non-timber products and services from forests. The ability of forest soils to accommodate all these potential changes will be the key to any successful strategy.

Current efforts are focused on improving the genetics of existing species for superior tree growth and wood characteristics with a much lesser focus on other important plant traits such as roots, which are the main interface between plants and soil resources such as nutrients and water. Do we know enough about the interactions between tree roots and forest soils, in particular mechanisms that enable plants to access important soil resources while avoiding environmental issues such as leaching of nitrogen? A lot of effort is spent on selecting plant traits (e.g. White et al. 2013) while leaving nature to determine the make- up of the soil microbial community. There is little effort on selecting and breeding soil microbes to improve the use of soil resources or enhance plant growth. Is this something that needs addressing to get more out of forest soils with fewer inputs?

I have raised the issue that we need to understand the role of microbes in signalling soil conditions to plants and to plant cambia. Ultimately we want to understand the role of soil microbes in communicating soil conditions. Then we can influence plant growth in order to improve wood quality by manipulating the activity of belowground microbial communities using appropriate amendments that could include rhizobia and or mycorrhizal fungi.

Finally, we also need to know more about the role of forest soils in the health of forests and how this links to the health of humans and our well-being.

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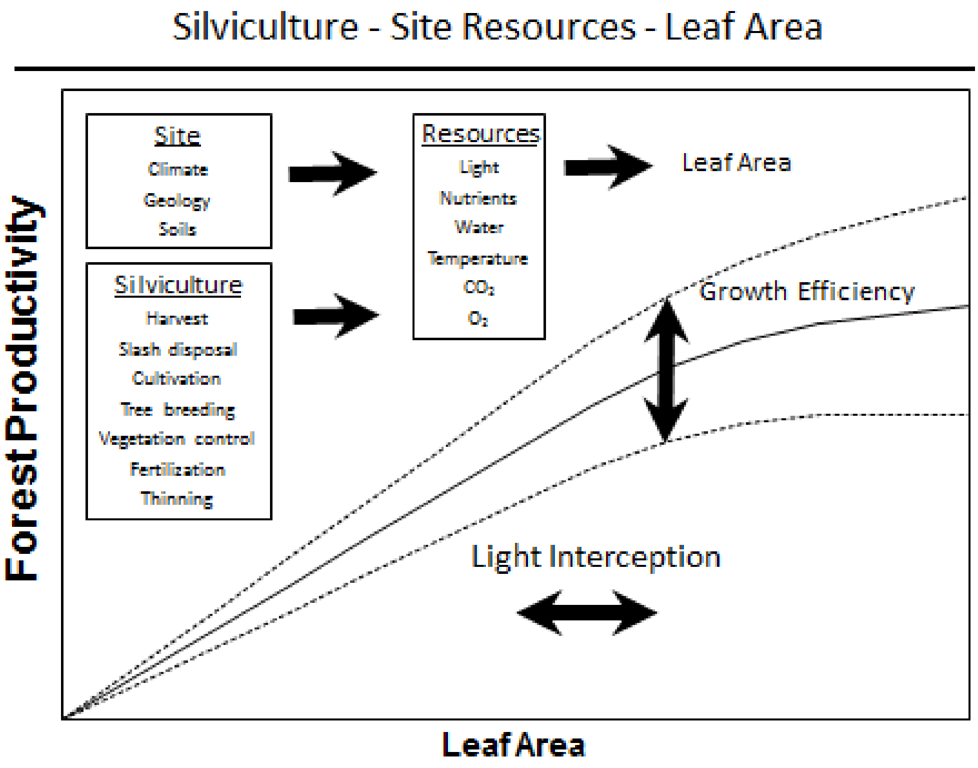
Linking Forest Soils and Ecophysiology to Improve Understanding of Ecosystem Processes Affecting Forest Productivity

Thomas R. Fox[a*]
[a]Department of Forest Resources and Environmental Conservation, Virginia Polytechnic Institute and State University, 228 Cheatham Hall, Blacksburg, VA 24061, USA
*Telephone No. +001-540-231-8862; Fax No. +001-540-231-3330; and E-mail: trfox@vt.edu

Keywords: leaf area index, silviculture, site quality, PAR, growth efficiency, soil nutrient availability, soil water availability, climate

Abstract Forest productivity is determined by the amount of carbon fixed through photosynthesis, the carbon lost through respiration, and the allocation of carbon to above-ground and below-ground tree components. Forest growth is directly related to the amount of photosynthetically active radiation (PAR) intercepted by the tree canopy. Leaf area index (LAI), measured as the m^2 of leaf surface area per m^2 of ground surface areas, is a commonly used measure related to intercepted PAR in forests and is thus also directly related to forest productivity. Light interception and associated tree growth initially increases linearly as leaf area increases. The slope of the line relating leaf area and growth is growth efficiency, which varies with climate, species, genotype, soil properties, and silvicultural treatments. Growth efficiency tends to decline as leaf area increases due to self-shading of leaves in the lower canopy. Leaf area index determines the amount of PAR intercepted and growth efficiency determines the rate that intercepted PAR is converted into biomass.



Site quality is determined by the climate and soil properties that affect the amount of PAR, water and nutrients available to support tree growth at specific site. Leaf area index and growth efficiency are strongly affected by soil properties that affect nutrient and water availability. Silvicultural practices such as species and genotype deployment, site preparation, planting density, weed control, fertilization, thinning and pruning impact forest growth and yield primarily through their impact on leaf area and growth efficiency.

Linking ecophyiology and forest soils to improve plantation silviculture

In order to develop innovative solutions to the complex problems facing foresters throughout the world, translational research must link empirical research with an improved understanding of ecosystem processes. This paper reviews the results of a comprehensive translational research program focused on southern pine plantations conducted by the Forest Productivity Cooperative. In pine plantations in the southern United States, improved silvicultural practices over the last 50 years have more than doubled productivity and reduced rotation lengths by over 50%. Until recently the ecophysiological basis for these changes was poorly understood. Soil nutrient and water availability varies spatially across the landscape and temporally through the rotation. This made it difficult for managers to develop silvicultural regimes that were well adapted for the various climatic regimes and soil types that occur in the southern U.S. It also decreased the efficiency of research efforts because empirical field trials evaluating a wide variety of silvicultural treatments were required and multiple sites across the region. The development of land classification systems based on climate, geology, and soil physical and chemical properties now describe the spatial heterogeneity of nutrient and water availability. Models of biogeochemical process in soils and forest ecosystems can be coupled with models of tree nutrient and water use to describe the temporal pattern of water and nutrient supply and demand on the various landscape units across the region. It is now clear how silvicultural treatments influence resource availability that affects leaf area and growth efficiency that in turn determines the growth response of plantations to the various treatments. Silvicultural regimes can then be designed and implemented to optimize the growth of forest plantations across the landscape. Incorporating these advances into geographic information systems enables foresters to efficiently develop and implement site-specific silvicultural systems that can meet complex landowner objectives.

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Agroforestry systems for carbon sequestration and reduction in greenhouse gas emissions

Scott X. Chang[a,*]
[a] Department of Renewable Resources, University of Alberta, Edmonton, Alberta, Canada T6G 2E3
[*] Phone: +1 780 492-6375; Fax: +1 780 492-1767; E-mail: Scott.Chang@ualberta.ca

Keywords: Carbon cycling, greenhouse gas emissions, agroforestry systems, land-use, global change, policy development.

Abstract Agroforestry systems as a form of land-use have been practiced around the world for millennia and have recently been promoted as one that provides many beneficial environmental and economic services such as reduction of soil erosion, abatement of pollution and diversification of farm income. In addition, agroforestry systems have been shown to be an effective land-use system for long-term carbon (C) storage as well as for the reduction of greenhouse gas emissions, particularly as compared with traditional agricultural systems such as annual cropping. Agroforestry as a land-use system may not be readily adopted by landowners as many lack the experience with growing trees on farm and trees can be a nuisance for the operation of large farm equipment. The economics of incorporating trees on farm also may not be very attractive due to the long-term nature of growing trees. Policies recognizing the ecological services, the C benefit in off-setting greenhouse gas emissions in particular, should be developed for agroforestry systems to promote this land-use system.

Introduction

Agroforestry systems as a form of land-use have been practiced around the world for millennia (Nair 1993). Agroforestry is a collective name for land-use systems where woody perennials such as trees, shrubs, palms, and so on and agricultural crops and/or animals are deliberately used on the same land management unit in some form of spatial arrangement or temporal sequence; there are both ecological and economical interactions between the different components (Lundgren and Raintree 1982). Some of the most common agroforestry systems are shelterbelt systems, riparian forests, silvopastural systems, and alley cropping, among others (Nair 1993).

Agroforestry systems have been promoted as a land-use system that provides many beneficial environmental and economic services such as reduction of soil erosion, abatement of pollution and diversification of farm income (Young 1997). In addition, agroforestry systems have been shown to be an effective land-use system for long-term carbon (C) storage as well as for the reduction of greenhouse gas emissions, particularly as compared with traditional agricultural systems such as annual cropping (Stavi and Lal 2013). However, the State of the World's Forests 2005 declared that studies on the environmental and ecological benefits of agroforestry are far fewer than those related to economic benefits, and studies seeking to materialize such monetary benefits are scarce (FAO 2005).

Much more research is therefore required to understand the role of agroforestry systems in increasing ecosystem C storage and rate of C accumulation. Even though C sequestration/storage is only one of forest ecosystem services that are not valued by markets, but this is one of the first such values that people are trying to create a global market (Douglas and Simula 2010). If a global market for C can be established, a mechanism for promoting a greener economy can be formed.

Agroforestry and C sequestration

Agroforestry systems have frequently been demonstrated to have a higher capacity to sequester C in the form of soil organic C (SOC) and C stored in plant biomass (Benbi et al. 2012; Mutuo et al. 2005). In the humid tropics, the potential of tree-based agroforestry systems to sequester C in vegetation can be more than 70 Mg C ha^{-1}, and up to 25 Mg ha^{-1} in the top 20 cm of soil, while in degraded soils of the sub-humid tropics, improved fallow agroforestry practices have been found to increase top soil C stocks up to 1.6 Mg C ha^{-1} yr^{-1} above continuous maize cropping (Mutuo et al. 2005). Earlier estimates indicate that the C sequestration potential of agroforestry systems is between 12 and 228 Mg ha^{-1} (median: 95 Mg ha^{-1}) 1.1–2.2 Pg C could be stored in agroforestry systems over the next 50 years, based on 585–1215×10^{6} ha of suitable land for the development of such systems (Albrecht and Kandji 2003). However, the distribution of SOC in pools with different stability in the ecosystem may be affected by land-use practices. For example, about 56–60% of the total organic C in an agroforestry system (poplar-based agroforestry involving wheat-legume rotation) occurred as labile and very labile C compared to 37% under a rice-wheat rotation in semi-arid India (Benbi et al. 2012). Therefore, the complete picture of ecosystem C sequestration, including the amount and long-term stability, should be considered in evaluating efficacy of agroforestry systems for C sequestration.

Agroforestry and greenhouse gas emissions

Research on the effects of agroforestry systems on greenhouse gas emissions is limited. There are a large number of factors involved in affecting the net greenhouse gas balance of different land-use systems. For example, the type and rate of fertilizer application, the type and composition of plant species used, soil type, climatic conditions in different land-use systems. While it is expected that greenhouse gas emissions will generally be higher in annual production systems due to the more frequent disturbances such as tillage and greater rates of fertilizer nitrogen application, greenhouse gas emission rates may actually be higher in an agroforestry system. For example, rates of greenhouse gas emissions were greater in a coffee-based agroforestry system with a N-fixing legume tree species that shades coffee trees and a monocultural coffee plantation system, both heavily fertilized (Hergoualc'h et al. 2012). Yet, others found no significant difference between agroforestry systems and the control in terms of greenhouse gas emissions (Verchot et al. 2008). Ruminant-based systems (e.g., silvopastoral systems) and rice paddy agrisilvicultural systems are recognized as likely sources of greenhouse gases such as CH_4 (Dixon 1995) and when legume residues are added to improved fallow systems in the sub-humid tropics N_2O and CO_2 emissions increased (Mutuo et al. 2005). As such, caution needs to be exercised when claim greenhouse gas offsetting benefits of agroforestry system when only changes in C storage is evaluated.

A case study of agroforestry systems for C sequestration in western Canada

Several projects were initiated in Canada in 2011 with funding from the Agricultural Greenhouse Gas Program (AGGP) of the Agriculture and Agri-Food Canada to study C sequestration in agroforestry systems across Canada. The project in Alberta in western Canada is evaluating three different agroforestry systems (shelterbelt, hedgerow and grazed aspen forest) in relation to neighboring annual cropping systems. Our initial research investigated the distribution of SOC in particle-size and density fractions under the above different land-use systems. Results showed that average SOC content was greater in the agroforestry than in their respective agricultural fields, with greater retention of SOC in silt- and clay-sized fractions. Soil organic C increment in agroforestry can be attributed in part to greater deposition of litter from the tree components and reduced frequency of disturbance. In general, results demonstrated the potential of agroforestry as a C sequestration strategy.

Policy development for promoting agroforestry practices

Agroforestry as a land-use system may not be readily adopted by landowners as many lack the experience with growing trees on farm and trees can be a nuisance for the operation of large farm equipment. The economics of incorporating trees on farm also may not be very attractive due to the long-term nature of growing trees. Policies recognizing the ecological services, the C benefit in off-setting greenhouse gas emissions in particular, should be developed for agroforestry systems to promote this land-use system.

Conclusions

Agroforestry systems are effective land-use systems for C sequestration and mitigation of greenhouse gas emissions; however, factors that may negate the effectiveness the system for such function should be carefully considered. Policy development is urgently needed to increase the adoption of this beneficial land management practice by landowners across the globe.

Acknowledgements

Funding from the AGGP (Agricultural Greenhouse Gas Program) of Agriculture and Agri-Food Canada and NSERC (Natural Science and Engineering Research Council of Canada) and contributions from graduate students and collaborators in various research projects are gratefully acknowledged.

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Interactive effects of environmental changes on C, N, and P concentrations of semi-arid grassland plants in relation to soil C, N, and P contents

Mai-He Li[a, b, *], Xue Wang [b], Zhu-Wen Xu [b], Yong Jiang [b]

[a] Forest dynamics, Swiss Federal Research Institute WSL, CH-8903 Birmensdorf, Switzerland; [b] State Key Laboratory of Forest and Soil Ecology, Institute of Applied Ecology, Shenyang 110164, China.
* Phone: +41 44 7392491; Fax: +41 44 739 2215; E-mail: maihe.li@wsl.ch

To understand the carbon- and nitrogen-physiological mechanisms underlying replacement and extinction of plant species found in semi-arid grasslands (Xu *et al.*, 2012) under rapid environmental changes, we investigated non-structural carbohydrate (NSC = soluble sugars + starch), nitrogen (N), and phosphorus (P) status in 3 dominant plant species (*Agropyron cristatum, Stipa krylovii, Artemisia frigida*) in a semi-arid grassland community in Duolun (41°46′- 42°39′N, 115°55′- 116°54′E;1324 m a.s.l., mean annual precipitation of 385.5 mm; mean annual temperature of 1.8℃), Inner Mongolia, China. The community has been treated by water (ambient vs. 180 mm water addition between June and August), N (ambient N deposition vs. N addition of 10 g m^2/year), and P (0 vs. P addition of 10 g m^2/year) for 8 years (2005-2012).

N and P addition increased N and P concentration in plants, respectively, implying that the grassland may suffer from N and P shortage. However, correlation analysis did not find any clear relationships between plant C, N concentrations and soil C, N contents, except that plant P concentrations were significantly correlated with soil P contents regardless of plant species.

Levels of NSC concentration reflect the balance between carbon gain (photosynthesis) and loss (growth and maintenance respiration) within a plant, and represent a plant's capital for growth after dormancy and act as a buffer for insufficient source activity (photosynthesis) due to adverse weather conditions or loss of foliage (Körner, 2003; Li *et al.*, 2008). Water, N, and P addition decreased plant NSC concentration, which may be caused by an increased NSC use (more production of photoassimilates, but more used for plant structural growth) and a dilution effect, as showed that water, N, and P addition significantly increased their size of the 3 plant species (Xu *et al*. unpublished data).

Agropyron was found to be sensitive to water, N, and P treatment, whereas *Stipa* was sensitive to N and P but *Artemisia* was sensitive to N only. Grasses (*A. cristatum, S. krylovii*) seemed to use water more effectively within the semi-arid grassland community, showing that grasses had much higher δ^{13}C values (less negative) than the forb (*Artemisia frigid*) (Fig. 1).

Our results showed significant interactive effects of treatments with plant species (P<0.05 for water x species, N x species, and P x species), indicating species-specific responses of plant physiology to environmental changes. Such different responses may lead to changes in competitive ability among plant species under global environmental change, which may result in plant replacement and extinction in grassland ecosystems reported by Xu et al. (2012).

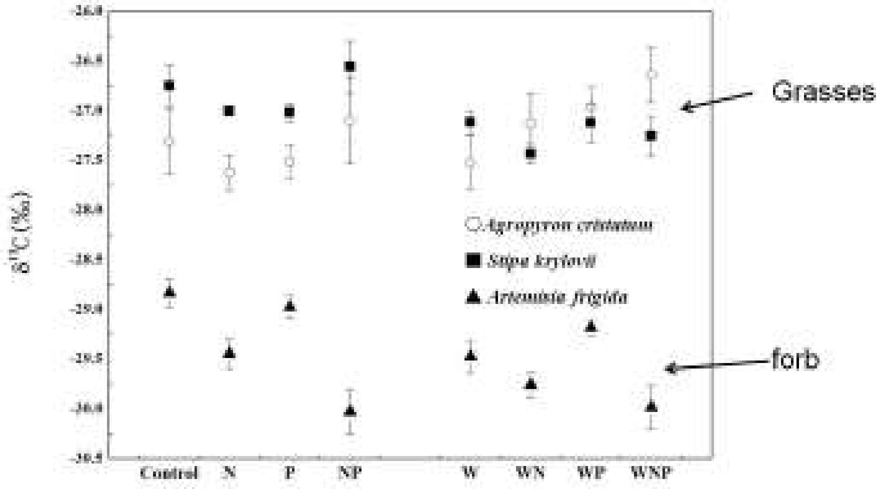

Figure 1. Responses of δ^{13}C values (±1SD, *n*=3) of three dominant plant species (*Agropyron cristatum, Stipa krylovii, Artemisia frigida*) in a semi-arid grassland community to 8-year water (W), N, P addition, and their combination (NP=N+P, WN=W+N, WP=W+P, WNP=W+N+P). Note treatments: water (ambient vs. 180 mm water addition between June and August), N (ambient N deposition vs. N addition of 10 g m^2/year), and P (0 vs. P addition of 10 g m^2/year.

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Winter fertilization and mulching affected N_2O emissions and ammonia oxidizing microbes.

Xu Qiufang[a] *, Guo Shuai[a], Li Songhao[a], Li Yongchun[a], Qin Hua[a] Shen Zhenming[b]
[a] Zhejiang Provincial Key Laboratory of Carbon Cycling in Forest Ecosystems and Carbon Sequestration, School of Environmental and Resource Sciences, Zhejiang A & F University, Lin'an, 311300, Zhejiang, China;
[b] Lin'an Forestry Technology Service General Station, Lin'an, 311300, Zhejiang, China)
* Phone: +86 571 63740882; Fax: +86 571 63740882; E-mail addresses: xuqiufang@zafu.edu.cn

Keywords: winter mulching, fertilization, N_2O emissions flux, soil AOA and AOB community, PCR-DGGE, Real-Time PCR.

Introduction Heavy winter mulching to increase soil temperature and winter fertilization are widely used techniques for intensive management of *Phyllostachys praecox* forests to increase bamboo shoot production and economic return for landowners in subtropical China. However, heavy winter mulching and winter fertilization may increase in N_2O emissions. The purpose of this paper was to find a proper fertilizer management eliminating the N_2O emissions by conducting an experiment *in situ*. We also inspect the effects of mulching and fertilization practice on the N_2O producing related microbial communities: ammonia oxidizing bacteria (AOB) and ammonia oxidizing archaea (AOA).

Materials and methods

Two experiments were conducted, the rate of fertilizer based on same amount of N fertilizer (360 kg N ha^{-1}) for all treatments except non-fertilizer treatment (CK2) (1) the first experiment studied the effect of mulching with the same amount of N fertilizer applied as urea respectively receiving no mulching (CK1) or mulching (treatment 2); and (2) the second experiment studied the effect of different fertilizer under mulching practice, including CK2 (no fertilizer applied), treatment 1 applied fertilizer as a compound fertilizer (N: P_2O_5: K_2O ratio of 16:16:16), treatment 2 applied N as urea, and treatment 3 applied fertilizer as urea and DMPP. The N_2O emissions flux was measured by collecting gas sample every 10 days interval with the static chamber method, and soil samples were collected at 20 days and 70 days after mulching and fertilization (in respective No.2 No.7 gas sampling time), as well as at the end of experiment (140 days). The community structure and functional gene abundance of soil AOB and AOA were measured by using PCR-DGGE and RT-PCR.

Results and discussion

The results from the first experiment showed that N_2O emissions rate were much higher in the mulched than un-mulched plots in which N_2O emissions rate kept at low emission level during the 5 months experiment period. The second experiment revealed that the highest N_2O emission rates were observed in the urea treatment along the experiment period. The similar trend that emission rate kept at low level until No 4 sampling time and gradually increased and reached the peak in No 10 sampling time and then decreased deeply till the end of experiment (No 13 time), were observed for all the treatments except treatment 3 with DMPP, in which a very low emission rate was observed during the earlier 8 sampling times, and sharp emission rate start from No 9 sampling time and sustained the similar level until No 12 time and declined deeply in No 13 sampling time. Some of AOB species were stimulated by mulching practice while 2 species restricted, however those major species kept unchanged. Higher species richness and gene abundance was observed in treatment 2 with urea fertilizer. Most of AOB species were restricted by DMPP when 20 days and 70 days after mulching and fertilization, but at the end of mulching practice (140 days) some major AOB species recovered and even more abundance than the other treatments. Soil AOB with DMPP presented different community structure from other treatments and showing the highest gene abundance. Both mulching practice and fertilization depressed some of AOA species, and relative higher species richness was observed in compound fertilizer than urea treatment. DMPP did not affect AOA as severely as AOB, some dominant AOA species kept unchanged. Although AOA gene abundance for DMPP was listed at lowest level but the difference from others was not as larger as AOB gene.

Conclusions

It was found that mulching practice greatly increased N_2O emission and altered comminutes of soil AOB and AOA. The highest N_2O emission rates were observed in the urea treatment along the experiment period but DMPP can efficiently reduce N_2O emission by restriction activity of soil AOB and AOA.

Short-term effects of harvesting on spatial heterogeneity of soil nitrogen in secondary forests in Northeast China

Jiacun Gu [a], Zhengquan Wang [a*], Youzhi Han [b]
[a] School of Forestry, Northeast Forestry University, Harbin, 150040, China; [b] School of Forestry, Shanxi Agriculture University, Taigu, 030801,China
[*] Phone: +86-451-82190614; Fax: +86-451-82191044; E-mail: wzqsilv@126.com

Keywords: semivariogram, soil available nitrogen, spatial heterogeneity, spatial correlation

Abstract We investigated the effects of harvesting methods (i.e. selective cutting, clear cutting and no cutting) on the availability, spatial heterogeneity and spatial correlations of different forms of soil nitrogen in secondary forests in Northeast China over 3 years. Semivariogram analysis was applied to quantify changes of spatial heterogeneity for topsoil (0-10 cm) nitrogen. The results showed that, harvesting markedly altered the dynamics of availability, and spatial heterogeneity of soil nitrogen. Availabilities of nitrate (excluding clear cutting plot), ammonium, total nitrogen and total available nitrogen showed similar temporal patterns in selective cutting and clear cutting plots in 3 years. The temporal patterns or magnitudes in variation for parameters of semivariogram differed from harvesting and control plots. Magnitude of spatial heterogeneity (sill) for nitrogen variables, except nitrate in clear cutting plot, expressed a similar increase-then-decline pattern under two different harvesting methods. However, the dynamics of other parameters (nuggets, range and structural variance ratio) were influenced by combination of harvesting method and nitrogen forms. Spatial correlation among nitrogen variables were enhanced by harvesting, but independent of harvesting methods. Our study suggest changes of vegetation exerts a strong impacts on the availability, spatial heterogeneity and correlations of soil nitrogen variables, however, the responses of different forms of nitrogen to harvesting methods were various.

Introduction

Soil resources heterogeneity is a ubiquitous characteristic in ecosystems, from forests (Lechowicz and Bell, 1991; Gallardo, 2003), shrubs (Jackson and Caldwell, 1993a, b), grasslands (Western et al., 2004), old fields (Robertson et al., 1993), croplands (François et al., 2000), to desert (Schlesinger et al., 1996).

Plants play an important role in forming and developing of soil resources and its spatial heterogeneity. Recent studies have shown that plants exert great impacts on the soil nutrients availability and spatial distribution by means of crown interception (Schlesinger et al., 1996), stem flow (Falkengren-Grerup 1989), root uptake (Sarah et al., 2003), quantity and quality of litters input (Gonzalez and Zak, 1994), and even community succession (Gross et al., 1995). Based on such a paradigm, vegetation changes altering related biotic and abiotic processes unavoidably result in a shift in spatial heterogeneity of soil nutrients.

Soil nitrogen, especially in the temperate region, is known as the most crucial limiting nutrient in ecosystems (Chapin 1980) Therefore, the relationship between spatial variation of soil nitrogen and vegetation characteristics has been extensively documented (Gross et al., 1995; Guo et al., 2004). However, few studies have investigated the effects of disturbance on soil nitrogen heterogeneity in forest ecosystems. In a harvesting and girdling experiment conducted in slash pine (*Pinus elliottii* Engelm) forest, Guo et al. (2004) demonstrated that gross concentration of soil available nitrogen (NH_4^+ and NO_3^-) returned to undisturbed level after 4 years of vegetation restoration, but its spatial structure did not show predictable trends. Since translocation and transformation of different forms of nitrogen are governed by complex physical, chemical, and biological processes. Therefore, it can be inferred that soil nitrogen and its spatial distribution may respond differently to different disturbance regimes.

In Northeast China, selective cutting and clear cutting are the most commonly used silvicultural practices. Selective cutting removes “big trees” (DBH> 8 cm in this study), whereas clear cutting removes all trees in the field. In this study, we were to examine **three hypotheses** about soil nitrogen dynamics:

(1) Harvesting may alter the availability and spatial heterogeneity of nitrogen variables (ammonium, nitrate, total nitrogen, total available nitrogen) because of the markedly change in vegetation structure and composition, but they may return to the pre-harvesting level quickly as vegetation regenerates and recovers.

(2) Following disturbance, availability and spatial heterogeneity of soil nitrogen may change, and the rate of change in soil nitrogen may vary with nitrogen forms and harvesting methods (selective cutting vs. clear cutting).

(3) For the significance of resources congruence to plant individual growth, species regeneration (Carlton and Bazzaz, 1998; Guo et al., 2004), the effects of harvesting in different methods on the spatial correlation between nitrogen variables were also investigated. However, the effects may differ between the two harvesting methods and among the nitrogen forms were anticipated.

Materials and methods

Study site

Our study site was located on a low flat hill area at 340 m in altitude, at the Maoershan Forest Research Station of the Northeast Forestry University in northeastern China (45°21′- 45°25′N, 127°30′- 127°34′E). The climate is of continental monsoon with the mean July maximum, January minimum, annual temperature of 20.9℃, -19.6℃, and 2.8℃, respectively.

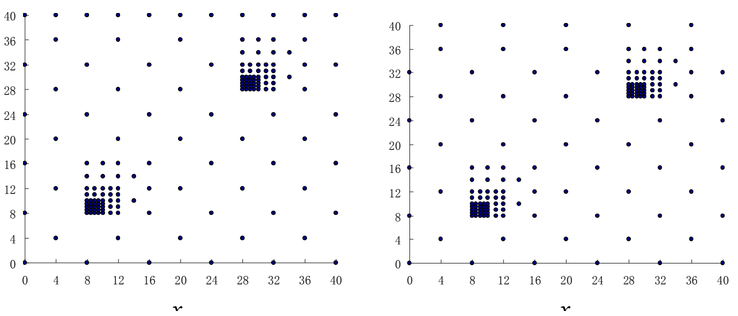
Vegetation of the site at the time of the study was a secondary hardwood forest, established after the original vegetation of Korea pine (*Pinus koraiensis*) forest being harvested destructively during World War Ⅱ.

Experiment design

In May of 2001, three 40 × 40 m plots with similar stand structure were selected, with 15 m buffer zones on each side of a plot to ensure that any two plots should be separated by at least 30 m. Each plot was assigned a treatment: Plot A as control (i.e. no harvesting), Plot B as selective cutting (i.e. randomly harvesting 50% of basal area, DBH> 8 cm), and Plot C as clear cutting (i.e. removal of all trees). Nested grid systems for soil sampling were set up in the three plots as shown in the diagrams of Figure 1. This sampling design ensured a full range of lag distance from 0.5 m to 56 m, and yielded 160, 154, and 154 sampling points in Plot A, B, and C, respectively.

Topsoil (0-10cm) was sampled at each predetermined point (Fig. 1) on August 14 of 2001 before harvesting, and on August 28 of 2002 and August 26 of 2003 after harvesting. Total nitrogen (N_{total}, %), ammonium (NH_4^+), nitrate (NO_3^-), and total available nitrogen (N_{avail}, sum of ammonium and nitrate) concentration were determined concurrently.

Fig. 1 Diagrams of the nested grid systems for soil sampling in the three plots: the left diagram for plot A (control) and the right diagram for plot B (selective cutting) and plot C (clear cutting). The X and Y coordinates in the Diagrams were in the unit of m. The nested grid system had a 4 m interval grid in the 40×40 m plot, within which two randomly selected subplots of 8×8 m were further divided by the overlapping 2, 1, and 0.5 m interval grids. Sampling took place only at the grid points diagonally. This sampling design yielded 160, 154, and 154 sampling points for plot A, B, and C, respectively.



Data analysis

Descriptive analysis for each nitrogen variable was performed by classic statistics. Geostatisical semivariograms were calculated with the GS$^+$ software version 5.1 (Gamma Design, Plainwell, Mich, USA). In this study, all semivariograms were fitted to a spherical model. We focused on four important parameters: (1) sill (C_0+C), which represents maximum variance of systematic or characteristic variable; (2) nugget (C_0) which results from either a random error or spatial dependence less than the minimum distance analyzed; (3) range, which is the distance at which the sill is achieved and represents the average maximum of distances over which two samples are correlated; (4) structural variance ratio [$C/(C_0+C)$], which indicates the degree of spatial heterogeneity affected by autocorrelation. Moreover, spearman rank correlation coefficient among soil total nitrogen, ammonium and nitratewere calculated through SPSS 13.0 for windows (SPSS Inc. Chicago, USA), to test whether harvesting exert effect on spatial correlation between different forms of soil nitrogen.

Results and discussion

Temporal changes of soil nitrogen availability

Availability of soil nitrogen variables increased greatly after harvesting, except for nitrate in selective cutting plot (B). Guo et al. (2004) and Antos et al. (2003) also found a similar temporal pattern for soil nitrogen variables in slash pine plantation and old growth, respectively.

Temporal changes of spatial heterogeneity for soil nitrogen

Temporal dynamics of spatial heterogeneity in nitrogen variables was altered by harvesting, when comparing parameters of semivarograms in 2002 and 2003 to that of 2001. Sills for all nitrogen variables in harvested plots, except nitrate in plot C, increased in the first year following harvesting then decreased in the second year. These suggested that harvesting had a positive impact on magnitudes of spatial heterogeneity in soil nitrogen. In addition, structural variance ratio [$C/(C_0+C)$] for all nitrogen variables in plot C increased after harvesting and then declined, indicating that effect of structural variability (spatial autocorrelation) on soil nitrogen spatial distribution was enhanced by clear cutting, and herbs vegetation recovery had a negative impact on that.

Changes due to harvesting in spatial correlation between nitrogen variables

Spatial correlation between different soil nitrogen variables were stimulated by harvesting, however, there were no large differences between selective and clear cutting. One possible reason was that: following the harvesting operation, dominant plants altered from relatively high and big crown tree to low, small leaf herbs in plot C (clear cutting), or created many small area forest gaps in plot B (selective cutting), which stimulated many shade-intolerant herb species invasion and regeneration.

Conclusions

Harvesting practices in the secondary forest markedly altered the availability of soil nitrogen. Availabilities of nitrate (excluding clear cutting plot), ammonium, N_{total} and N_{avail} in two harvesting plots increased in the first year following disturbance, then all showed similar temporal patterns under selective cutting and clear cutting methods in the next year. Spatial heterogeneity of soil nitrogen variables, characterized by parameters of semivariogram, was altered by harvesting. The temporal patterns or magnitudes in variation of parameters in harvesting plots were differed from control. However, the dynamics of other parameters (nuggets, range, etc.) were influenced by combination of harvesting method and nitrogen variables. Harvesting had a potentially positive impact on spatial correlation among different forms of nitrogen, however, no obvious different impacts between selective and clear cutting were observed.

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Soil carbon dynamics under typical forests in subtropical China

Xinzhang Song[a,b], Hailong Wang [a,b*], Mark O. Kimberley[c], Zhiting Zhang[d]
[a] Zhejiang Provincial Key Laboratory of Carbon Cycling in Forest Ecosystems and Carbon Sequestration, Zhejiang A&F University, Lin’ an, Zhejiang Province, 311300, China; [b] The Nurturing Station for the State Key Laboratory of Subtropical Silviculture, Zhejiang A&F University, Lin’ an, Zhejiang Province, 311300, China; [c] Scion, Private Bag 3020, Rotorua 3046, New Zealand; [d] Hebei North College, Zhangjiakou, Hebei Province, 075000, China
[*] Phone: +86 571 63705212; Fax: +86 571 63740889; E-mail: nzhailongwang@gmail.com

Keywords: bamboo, carbon sequestration, Chinese fir, plantation forest, soil organic carbon.

Introduction

In terrestrial ecosystems, the soil typically contains a greater carbon pool than the combined total contained in the vegetation and atmosphere. As land-use change can significantly affect soil carbon dynamics, accounting for this is crucial for understanding the terrestrial carbon cycle. The objective of this review paper is to illustrate how forest community succession and anthropogenic management practices can affect soil organic carbon dynamics and soil respiration.

Materials and methods

We synthesized from the literature information on soil carbon and respiration for five subtropical forest ecosystems, namely evergreen broadleaved forests, mixed needle- and broad-leaved forests, masson pine (*Pinus massoniana*) forests, Chinese fir (*Cunninghamia lanceolata*) forests, and Moso bamboo (*Phyllostachys pubescens*) forests. The forest ecosystems were compared for topsoil soil organic carbon (SOC) content, annual soil respiration (Rs) rate, and temperature sensitivity (Q_{10}).

Results and discussion

Based on published information from 55 studies of Chinese subtropical forest ecosystems, we obtained 71 estimates of SOC content, 56 estimates of annual forest soil CO_2 flux and 41 estimates of Q_{10}. Evergreen broadleaved forest had the highest SOC content (33.14 ± 4.92 g kg^{-1}), followed in order by mixed needle- and broad-leaved forest (26.43 ± 5.83 g kg^{-1}), Moso bamboo forest (25.31 ± 2.64 g kg^{-1}), Chinese fir forest (18.44 ± 1.16 g kg^{-1}), and masson pine forest (15.75 ± 2.10 g kg^{-1}) which had only half the SOC of evergreen broadleaved forest. The annual soil respiration rate was highest in evergreen broadleaved forest (46.80 ± 3.03 t CO_2 ha^{-1} yr^{-1}), followed by Moso bamboo forest (43.52 ± 4.52 t co_2 ha^{-1} yr^{-1}) mixed needle- and broad-leaved forest (35.57 ± 3.15 t CO_2 ha^{-1} yr^{-1}), masson pine forest (28.77 ± 5.18 t CO_2 ha^{-1} yr^{-1}), and Chinese fir forest (24.08 ± 3.26 t CO_2 ha^{-1} yr^{-1}). The Q_{10} value was highest in evergreen broadleaved forest and lowest in Chinese fir forest, but there was no significant difference between the five forest ecosystems ($P > 0.05$). There was no significant correlation between either SOC and Rs, or SOC and Q_{10} value ($P > 0.05$). Our findings imply that when evergreen broadleaved forest is converted to any of the other forest types, the SOC content will decline sharply, especially when converted to Chinese fir or masson pine forest. In the longer term, it is expected that such forest conversion will lead to a decrease in the soil respiration rate.

Conclusion

This study contributes to a better understanding of the affects of forest land-use and land-cover change and management practices on the carbon cycle in subtropical China.

Effect of nitrogen and sulfur addition on soil CO_2 emission in a subtropical red soil forestland

Jianling Fan*, Yehong Xu, Weixin Ding
Institute of Soil Science, Chinese Academy of Sciences, Nanjing, 210008, China
* Phone: +86 25 86881526; Fax: +86 25 86881000; E-mail: jlfan@issas.ac.cn

Keywords: carbon sequestration, N deposition, S deposition, soil respiration, subtropical forestland.

Abstract Excessive nitrogen (N) and sulfur (S) deposition have been demonstrated to have many adverse impacts on the environment and human health. A field experiment was conducted to estimate the effect of simulated N and S deposition on soil CO_2 emission in a typical subtropical red soil forestland in southeastern China. Static chamber and gas chromatography techniques were used to quantify the soil CO_2 emission, under six treatments using three N levels (0, 40, 80 kg ha^{-1} a^{-1}) combined with two S levels (0 and 45 kg ha^{-1} a^{-1}). In treatments without S addition, one split block was introduced by removing forest detritus. Results showed that soil CO_2 emission exhibited a strong seasonal pattern, where the highest fluxes were found in the summer (June to September) with an average of 92.85 mg C m^{-2} h^{-1} while the lowest fluxes in the winter (December to March) with an average of 18.41 mg C m^{-2} h^{-1}. Soil CO_2 emission fluxes showed significant positive exponential relationship ($P < 0.001$) with soil moisture and soil temperature at different depth (5, 10, 15 cm). The temperature sensitivity (Q_{10}) was reduced by N and S addition, which may be due to low labile organic C of test soil (Ni et al., 2012). Under the detritus removal treatments, N addition significantly increased annual cumulative soil basal respiration from 3.43 Mg C ha^{-1} in control to 4.62 and 4.44 Mg C ha^{-1} in 40 and 80 kg N ha^{-1} addition treatments, respectively. However, N addition treatments showed higher but not significant annual cumulative CO_2 emission than control under treatments with litter. The difference of annual cumulative CO_2 emission between treatments with and without litter represents the litter decomposition rate. Nitrogen addition significantly decreased litter decomposition from 1.75 Mg C ha^{-1} yr^{-1} in control to 0.60 and 1.19 Mg C ha^{-1} yr^{-1} in 40 and 80 kg N ha^{-1} addition treatments, respectively. CO_2 emission from litter decomposition accounted to 34% of cumulative CO_2 emission in control, while the corresponding values were 12% and 21% for treatments with 40 and 80 kg N ha^{-1} addition. This may be mainly due to the decrease of soil microbial biomass, activity and extracellular enzyme secretion in response to N addition (Frey et al., 2004; Fang et al., 2007), which may decrease soil organic carbon (SOC) decomposition and induced dissolved organic carbon (DOC) export from the ecosystems (DeForest et al., 2004; Waldrop & Zak, 2006). These results suggested that N addition could significantly promote soil basal respiration but inhibit litter decomposition, which resulted in no significant difference for CO_2 emission among treatments. Furthermore, annual cumulative CO_2 emissions were significantly lower with S additions than without S addition, indicating that S addition suppressed CO_2 emission from red soil forestland. This could be attributed to the decrease of soil pH under S deposition, which could influence microbial community and activity and inhibit the activities of urease, invertase, and acid phosphatase (Pennanen et al., 1998; Waldrop et al., 2004; Zhu et al., 2009). A significant interaction between N and S addition on CO_2 emission was found. Our results suggested that soil CO_2 emission would be restrained under high N and S deposition condition in subtropical red soil forestland.

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Afforestation and slope position effects on ecosystem nutrient pools and carbon stability in various soil aggregates in a red soil hilly land

Jing Fan, Fu-Sheng Chen*
College of Forestry, Jiangxi Agricultural University, Nanchang, 330045, China
* Phone: +86 791 83813243; Fax: +86 791 83813243; E-mail: chenfush@yahoo.com

Keywords: biogeochemistry, land use change, organic carbon stability, soil aggregates, Subtropical China

Abstract The dynamic of interaction among soil aggregates, nutrients and carbon stability following afforestation is not fully understood. The slope position effect on this process is often neglected, but may dominate the topsoil properties due to serious erosion in red soil hilly region of southern China. Two 19-year old Masson pine (*Pinus massoniana*) forest plantations and their neighboring secondary shrubs were selected to study nutrients and carbon stocks in soils and at ecosystem level using excavating, harvesting and modeling methods, and carbon stability in various aggregates and bulk soil using dry sieving and closed-jars alkali-absorption methods. The afforestation did not alter soil C and P stocks, and decreased N stock at 0–75 cm depth, but increased ecosystem C, N and P stocks from 53, 11.6, 1.51 t ha^{-1} to 111, 12.1 1.90 t ha^{-1}, respectively due to tree biomass accumulation. The organic C mineralization potential was much lower in larger aggregates than in smaller aggregates, thus aggregate formation was helpful to improve soil organic C stability, which preferably explained the slope position effect with higher mean weight diameter of aggregates and organic C stability at lower and middle positions than upper position in forest plantations. The shift from shrubs to forests increased organic C stability in various aggregates and bulk soils, which was closely related with the decrease in soil N concentration, and was also influenced by soil bulk density, aggregate components, C/N and N/P ratios. Additionally, slope position significantly affected all variables measured in this study, thus the further research needs pay attention to physical erosion and deposition process when exploring afforestion effect on soil biogeochemistry cycling in the red soil hilly region.

Introduction

Afforestation and reforestation are popular means of improving ecological functionality while combating poverty in degraded hilly and mountainous ecosystems (Li, 2004). Maturing forests serve as a sink of atmospheric carbon, making forest establishment a popular mechanism for global carbon offsets. Carbon cycling is closely coupled to N and P dynamics in forest ecosystems. Soil organic carbon accumulation is strongly affected by erosion and deposition dynamics that are sensitive to slope position (Wei et al., 2010). In particular, soil aggregation and aggregate turnover are key dynamics in soil biogeochemical cycling, and the sensitivity of aggregates to slope position has been shown to impact organic carbon sequestration (Tang et al., 2010). Thus, soil aggregates are a useful focal point for exploring the impact of slope position on the ecological behavior of recently established forests.

Subtropical China provides a particularly good context for evaluating the benefits of forest establishment on barren hills. To evaluate the benefits of leaving upper slopes undisturbed during reforestation, we took advantage of a natural experiment created by undisturbed shrubland located on a steeply sloping hill within a 20-year-old plantation. We compared the effect of slope position on the nutrient and carbon cycling properties of recently-established forests and their neighboring secondary shrubs. In particular, our aims were to: 1) compare the distribution, stability, and nutrient content of soil aggregates at different slope positions under forest and shrub cover; 2) determine whether differences in carbon and nutrient accumulation dynamics between forests and shrubland differ by slope position; 3) quantify the relative magnitude of carbon, N, and P stocks under forests and shrubs.

Materials and methods

The study area is located at Qianyanzhou Experimental Station of Red Soil and Hilly Land, CAS, which lies in Taihe County, Jiangxi Province of Southern China (26°44' N, 115°04' E). The study site consists of a strip of undisturbed shrubs surrounded by Masson pine (*Pinus massoniana*) located in the middle of a 250 m wide 25 ° slope. The pine was established in 1991 with 1.5 m×2 m spacing. We divided the slope into 3 areas of approximately equal size corresponding to the upper, middle, and lower slope positions. Within each slope position we selected pairs of 10 m × 10 m shrub and forest plots.

In July of 2010, we selected 3 random locations from each plot. At each location, we used a steel corer to obtain intact 15 cm × 15 cm × 15 cm soil blocks at 5 depths to 75 cm. These blocks were placed in aluminium specimen boxes and used for aggregate grading and nutrient quantification. From 50 cm × 50 cm pits surrounding each of these cores we excavated 5 soil layers 15 cm deep to measure root biomass and soil properties. The biomasses of main stems, lateral branches and leaves were estimated based on allometric regression models. In addition, mixed plant samples in shrubs and mixed floor vegetation samples in forests were collected from the entire plot. Following the procedures provided by Kemper and Rosenau (1986), soil subsamples were kept sealed with hard plastic box at 4 °C in order to maintain a suitable moisture level at which soils can be easily sieved for aggregate fractionation (Sainju, 2006). Meanwhile, carbon mineralization potential was evaluated using bulk soil and samples from each aggregate size class drawn from the topsoil layer (0-15 cm). Paired T tests were used to compare differences between secondary shrubs and forest plantations.

Results and discussion

Soil total N was higher in shrubs than in forests, higher at upper (1.36±0.14 g kg^{-1}) and lower (1.39±0.13 g kg^{-1}) positions than middle position (1.13±0.13 g kg^{-1}), and decreased with increasing soil depth. Soil C/N was lower in shrubs than in forests, and N/P was in reverse. but total P and C/P were not significantly different ($P<0.05$). Slope position in general affected the nutrient distribution pattern along the hilly slope mainly due to the accumulation of runoff and depositions from upper towards middle, and finally in lower slopes, but slope position effect also depended on land use type and nutrient element characteristics (Fu et al., 2004).

Average organic C concentration in soil aggregates was not significantly different between two land use types. The amount of CO_2 emission in various soil aggregates generally decreased with incubation days, and the first one third (1–24 days) of the whole incubation period occupied 57–65% and 50–62% of the total accumulative amount of CO_2 emission in shrubs and forests, respectively. The total amount of CO_2 emission was influenced by main factors of slope position and aggregate size, but not by their interaction in both land use types (Fig. 1). In shrubs, the total amount of CO_2 emission was lower in the larger aggregates (>5 mm, 2–5 mm and 1–2 mm) than in the smaller aggregates (0.5–1 mm and 0.25–0.5 mm) and silt and clay soils (<0.25 mm) (Fig. 1A). In contrast, the total amount of CO_2 emission generally increased with deceasing aggregate size in forests. The average amount of CO_2 emission in various aggregates was not significantly different at three slope positions, but that in bulk soil was slightly higher in upper and middle positions than in lower position (Fig. 1B). The quality of soil organic C might be the key factor to differ the soil organic C stability between two land use types (Six et al., 2000). Fortunately, we found the C/N and C/P ratios in soil aggregates were generally higher in forests than shrubs. The root and foliar litters driven by forest rebuilding were generally higher C/N and C/P ratios than those of soil. Thus, we deduced that new organic matter was usually more stable than the old organic matter (Schmidt et al., 2011). Soil N and P dynamics have been generally neglected, especially the C-N and C-P interactions, which would be very important to regulate the long-term terrestrial C sequestration (Li et al., 2012). In our study, compared with shrubs, the higher C/N and lower N/P could generally explain the decreases in CO_2 emission amount in bulk soil and the aggregates in forests possibly due to N limitation. The stability of soil organic C could be caused by the enhanced soil aggregation that provided microenvironments for constructing physical protection and absorbing particle organic matter (Six et al., 2000).

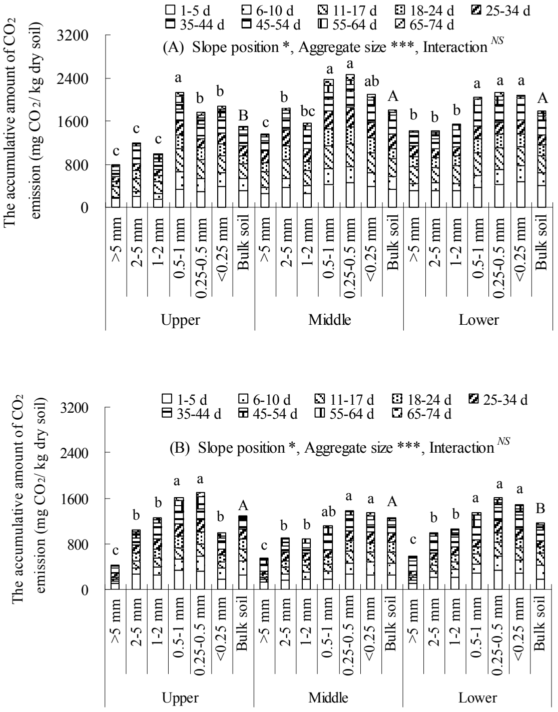

Fig. 1. Topsoil organic C mineralization potential varied with slope position and aggregates in secondary shrubs (A) and forest plantations (B) in a hilly red soil land of subtropical China. Note: Error bars represent standard error. *NS* not significant, * *P*<0.05, *** *P*<0.001. Small letters indicate significant differences among different aggregates within a slope position and capital letters indicate significant differences among three slope position for bulk soil at 0.05 level.

Conclusions

Soil aggregation and organic C stability were significantly improved at the forest plantation of 19 year-old, compared to secondary shrubs. The main factor driven lower soil organic mineralization potential in forests than in shrubs was not the aggregation formation, but might be the decrease in soil N concentrations, and N limitation with the higher C/N and lower N/P in early forest plantations. We predict that soil organic C accumulation will be accelerated since the increase of litter input and decrease in soil organic C decomposition after afforestation on the shrubs.

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A transcriptomic network underlies microstructural and physiological responses to cadmium in *Populus* × *canescens*

Jiali He[a], Hong Li[b], Jie Luo[a], Zhi-Bin Luo [c*]

[a] College of Life Sciences, Northwest A&F University, Yangling, Shaanxi, 712100, P. R. China

[b] Key Laboratory of Applied Entomology, College of Plant Protection, Northwest A&F University, Yangling, Shaanxi 712100, P.R. China

[c] College of Forestry and State Key Laboratory of Crop Stress Biology in Arid Areas, Northwest A&F University, Yangling, Shaanxi, 712100, P. R. China

* phone: +86 29 87080178; Fax: +86 29 87082216; E-mail: luozbbill@163.com

Keywords: Poplar, phloem, cadmium, carbohydrates, oxidative stress, transcriptome, energy-dispersive X-ray microanalysis

Bark tissue of *Populus* × *canescens* can hyperaccumulate cadmium (Cd) (He *et al*., 2011, 2013), but microstructural, transcriptomic and physiological response mechanisms are poorly understood. Histochemical assays, transmission electron microscopic observations, energy-dispersive X-ray microanalysis, transcriptomic and physiological analyses have been performed to enhance our understanding of Cd accumulation and detoxification in P. × canescens. Cd was allocated to the phloem of the bark and subcellular Cd compartmentalization occurred mainly in vacuoles of phloem cells. Transcripts involved in microstructural alteration, changes in nutrition and primary metabolism, and stimulation of stress responses showed significantly differential expression in the bark of *P.* × *canescens* exposed to Cd. About 48% of the differentially regulated transcripts formed a co-regulation network in which 43 hub genes played a central role both in cross talk among distinct biological processes and in coordinating the transcriptomic regulation in the bark of *P.* × *canescens* in response to Cd. The Cd transcriptome in the bark of *P.* × *canescens* was mirrored by physiological readouts. Cd accumulation led to decreased total N, P, Ca and increased S in the bark. Cd inhibited photosynthesis, resulting in decreased carbohydrate levels. Cd induced oxidative stress and non-enzymatic antioxidants including free proline, soluble phenolics, ascorbate and thiol compounds. These results suggest that an orchestrated microstructural, transcriptomic and physiological regulation may sustain Cd hyperaccumulation in *P.* × *canescens* bark and provide new insights into engineering woody plants for phytoremediation.

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Variations in ^{15}N natural abundance of plant and soil system in four remote tropical rainforests, southern China

Ang Wang[1], Yun-Ting Fang[2*], De-Xiang Chen[1], Keisuke Koba[3], Akiko Makabe[3], Yi-De Li[1], Tu-Shou Luo[1], Muneoki Yoh[3]
[1]Research Institute of Tropical Forestry, Chinese Academy of Forestry, Guangzhou 510520, China; and [2] State Key Laboratory of Forest and Soil Ecology, Institute of Applied Ecology, Chinese Academy of Sciences, Shenyang 110164, China; and [3] Graduate School of Agriculture, Tokyo University of Agriculture and Technology, Saiwai-cho 3-5-8, Fuchu, Tokyo 183-8509, Japan
*Corresponding author: Yunting Fang: State Key Laboratory of Forest and Soil Ecology, Institute of Applied Ecology, Chinese Academy of Sciences, Shenyang 110164, China E-mail: fangyt@iae.ac.cn Tel: +86 24 8397 0541

Keywords: Foliar δ^{15}N; Nitrogen availability; Nitrogen status; Southern China; Tropical forests

Abstract Foliar δ^{15}N can provide an integrated index of the openness of ecosystem N cycling (i.e., the ratio of N input or output relative to the standing N pool) (Amundson et al. 2003) and has the potential to reveal spatial and temporal patterns of N cycling as well as how N cycling is altered by disturbances (Robinson 2001; Craine et al. 2009).Therefore, with the globalization of nitrogen (N) deposition, there is increasing concern on ecosystem N status and about the impact of excess N on ecosystems and a number of studies have been conducted to exploit δ^{15}N (natural abundance of ^{15}N) as a “nature” means to evaluate the dynamics of ecosystem N cycling and to assess N saturation at both regional and global scales (Robinson 2001; Pardo et al. 2006; Craine et al. 2009; Fang et al. 2011).

Compared to temperate and boreal forests, tropical and subtropical forests in general are considered to be richer in N, so that plants are expected to be more enriched in ^{15}N therein (Martinelli et al. 1999). However, recent research found that some tropical forests do not always have positive values. A previous study by Fang et al. (2011) shows that both foliage and 0-10 cm mineral soil δ^{15}N (on average -3.8‰ and 0.9‰ for foliage and soil, respectively) are much lower in the 14 subtropical forests in southern China than the averages of tropical forests (3.7‰ and 9.0‰ for foliage and soil, respectively) but close to those of temperate forests (-2.8‰ and 2.0‰) compiled by Martinelli et al. (1999). Negative values for plants are also reported in other tropical regions, e.g., south-eastern Brazil (Scarano et al. 2001), but the reasons have not been stated.

Foliar δ^{15}N varies broadly with different species. Some studies have reported that conifers tend to have lower δ^{15}N than hardwoods (Pardo et al. 2007a; Templer et al. 2007) although others reported no difference (Gebauer and Dietrich 1993). Also, in several studies, strong and consistent patterns of the relative foliar δ^{15}N value by species have been reported (Templer 2007). Meanwhile, the magnitude of variation in value of foliar δ^{15}N among species at a given site seems to be dependent on ecosystem N status (N cycling, forest floor and foliar chemistry). Nadelhoffer et al. (1996) hypothesized that foliar δ^{15}N should have a large range in N-limited conditions such as tundra ecosystems than in N rich conditions such in tropics, Pardo et al. (2006) found that a similar level of variability in foliar δ^{15}N values within species in 21 temperate forests. However, an ever wider range of foliar δ^{15}N (over 10‰) is observed in some tropical forests (Ricardo et al. 2011) while not observed in others (e.g., Houlton et al. 2007).

Nevertheless, previous studies on ecosystem δ^{15}N is based primarily on research from North America, Europe, South America, Australia, and Africa (e.g., Martinelli et al. 1999; Amundson et al. 2003; Pardo et al. 2006; Craine et al. 2009). Limited studies exist over a large area of Eastern Asia (Fang et al. 2012b). With increasing concerns over the impacts of elevated N deposition in this region on tropical and subtropical forests, it is important to understand current ecosystem N status. As mentioned above, low foliar δ^{15}N values are also reported for the tropical forests in southern China (Fang et al. 2011), in Borneo of Malaysia (-4.8‰ to 0.02‰, Kitayama and Iwamoto 2001) and for a subtropical forest in Guandaushi of Taiwan (-6‰ to -2.2‰, Liu et al. 2006). Thus it is critically important to explore why foliar δ^{15}N values is often reported to be negative in order to assess ecosystem N status at a regional scale.

In this study, we presented δ^{15}N of plant and soil in four remote typical tropical rainforests (one primary and three secondary) of southern China. We aimed to examine if (1) foliar δ^{15}N in the study forests is negative as observed in other eastern Asia sites; (2) variation in δ^{15}N among different species is smaller compared to that in many N-limited temperate and boreal ecosystems; and (3) the primary forest is N richer than the younger secondary forests and thereby is more ^{15}N enriched. Our results show that foliar δ^{15}N ranged from -5.1‰ to 1.3‰ for 39 plant species with different growth strategies and mycorrhizal types, of which 35 species was negative. Negative values may be caused by increased uptake of ^{15}N-depleted N sources, e.g., soil nitrate (-11.4‰ to -3.2‰ in the study forest) and atmospheric ammonia/ammonium. The variation in foliar δ^{15}N among species (by about 6‰) was smaller than that observed in many N-limited ecosystems, which is typically about or over 10‰. The primary forest had large N-capital in aboveground pool than the secondary forests. However, soil N variables did not display consistent pattern between primary and secondary forests. Overall, the difference in δ^{15}N for all ecosystem N variables was small among forests, except for soil nitrate which was significantly different between the primary and secondary forests.

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Effects of nitrogen addition on concentrations and fluxes of dissolved organic matter and inorganic nitrogen under a temperate old-growth forest in northeast China

Xu Xingkai[a*], **Han Lin**[a,b], **Luo Xianbao**[a,b]

[a]State Key Laboratory of Atmospheric Boundary Layer Physics and Atmospheric Chemistry, Institute of Atmospheric Physics, Chinese Academy of Sciences, Beijing 100029, China; [b]Graduate School of Chinese Academy of Sciences, Beijing 100049, China

[*] Phone: +86 010 8205510; Fax: +86 10 62041393; E-mail: xingkai_xu@mail.iap.ac.cn

Key words: Dissolved organic carbon and nitrogen, Forest soil, Inorganic nitrogen, Leaching, Nitrogen mineralization

Abstract Soil solutions at 15 cm and 60 cm under a mature broadleaf and Korean pine mixed forest (>200 years old) at Changbai mountain, northeast China, were sampled using porous ceramic cups from July 2006 to October 2008, to study the effects of nitrogen (N) addition on concentrations and fluxes of dissolved organic matter and inorganic N. The soil net N mineralization and wet atmospheric deposition of N and dissolved organic carbon (C) under forest canopy were also measured. The addition of N sources such as $(NH_4)_2SO_4$, NH_4Cl and KNO_3 at rates of 2.25 and 4.5 g N/m^2 each year tended to increase concentrations and fluxes of inorganic N and dissolved organic N in soil solutions at 15 cm and 60 cm depths and soil net N mineralization, and it reduced leaching losses of soil dissolved organic C. The concentration ratios of dissolved organic C to dissolved organic N and special UV absorbance values in the soil solutions at both depths were mostly smaller under the N-fertilized forest plots than under non-fertilized plots. Soil net N mineralization under the N-fertilized forest plots can contribute to the leaching losses of inorganic N from the soil. Our observations indicate that N inputs to temperate forest floors can affect the status of N and C processes in underlying forest soils.

Introduction

Soil solution chemistry can be considered a sensitive indicator of biogeochemical processes under forest stands, responding quickly to disturbances or stresses like nitrogen input (e.g. McDowell et al., 2004; Pregitzer et al., 2004; Michel et al., 2006). The addition of N sources to temperate forest floors can usually increase N leaching as DON and inorganic N from forest topsoils (e.g. McDowell et al., 1998; Michalzik et al., 2001; Pregitzer et al., 2004). The N inputs from forest topsoils can increase the activities of soil microorganisms and the mineralization of carbon (C) in underlying soils, thus releasing CO_2 into soil solution (Xu et al., 2009). However, there were contrasting results regarding N effects on DON and DOC dynamics in forest soil solution (McDowell et al., 1998, 2004; Magill and Aber, 2000; Pregitzer et al., 2004; Michel et al., 2006). Furthermore, these earlier studies mainly focused on the dynamics of DOC, DON and inorganic N concentrations in forest soil solutions sampled using zero-tension lysimeters rather than using suction cups. There has been so far limited knowledge about the concentrations and fluxes of dissolved organic matter and inorganic N in soil solutions at the various depths under N-fertilized forest stands, especially in northeast Asia.

In this study, soil solutions at 15 cm and 60 cm under a Korean pine and broadleaf mixed forest (>200 years old) at Changbai mountain, northeast China, was sampled using porous ceramic cups from July 2006 to October 2008, to study the effects of N addition on the concentrations and fluxes of DOM and inorganic N. The soil net N mineralization and wet atmospheric depositions of N and dissolved organic C under forest canopy were also measured. The objectives of this work were to 1) study the effects of N addition on the concentrations and fluxes of DOM and inorganic N in forest soil solution; and 2) to assess the contribution of soil net N mineralization and wet atmospheric C and N depositions to these fluxes. The results would improve our understanding of N and C processes in underlying forest soils due to the increase in atmospheric N inputs.

2. Materials and methods

2.1. Forest stand site and soil properties

Field experiment was located under a mature broadleaf and Korean pine mixed forest (*Pinus koraiensis* mainly mixed with hardwood trees such as *Tilia amurensis, Fraxinus mandsburica* and *Quercus mongolica*, >200 years old, altitude 738 m above sea level) nearby the National Research Station of Changbai Mountain Forestry Ecology, northeast China (128°6′E, 42°24′N). The area around the mountain is a temperate, continental climate, with a long-term cold winter and warm summer. The annual mean temperature is approximately 4.1°C, and precipitation averages approximately 855 mm at the bottom of the mountain, with more than 80% of rainfall from May to August. The dark brown forest soil belongs to Andosols (Food and Agriculture Organization soil classification), and the depth of litters and A-horizons is approximately 3-5 cm and 10 cm, respectively. The main properties of the soils at the various depths and groundwater table levels were reported by Xu et al. (2007, 2009).

2.2. Effects of N addition on soil solution chemistry under forest stand

Twenty-eight individual plots with 3 m x 3 m each were selected on the flatness under the mixed forest stand. Aqueous solutions of N sources such as $(NH_4)_2SO_4$, NH_4Cl and KNO_3 were respectively sprayed on the ground within four individual plots in equal monthly doses at rates of 2.25 and 4.5 g per m^2 each year, during the growing season from June to October in 2006-2008, corresponding with 5.0 mm rainfall each; tap water was added only to the control. The N addition experiments at high and low doses started from July 2006 and June 2007, respectively. According to the depth of A-horizons and the distribution of tree roots in underlying soil, two sets of porous ceramic suction cups (3.1 cm in diameter and 7 cm in height) were installed at 15 cm and 60 cm depths, respectively, to collect soil solutions of organic layers and beyond root zones (Vandenbruwane et al., 2008). To eliminate the disturbance of soil, soil auger with a diameter of 3.3 cm was used to establish the holes down to 15 cm and 60 cm depths, respectively, and the suction cups connected to PVC tubes were fixed closely inside the holes. The pressure inside each tube within a week at water-filled pore space more than 70% or within 24 hours after heavy rainfall was brought to approximately -70 kP_a by a portable vacuum/pressure pump (Mityvac4010, Missouri, USA). Over the years from July 2006 to October 2008, soil solutions were sampled via the stopcock attached to each tube to avoid degassing, using 100-ml plastic syringes equipped with a stopcock, and the volume of soil solution was measured simultaneously. Considering initial effects of installing the suction cups, the early two collections were discarded. These samples were rapidly transported to the laboratory and were frozen prior to analysis. Concentrations of DOC and total N in soil solutions were measured using a TOC/TN-analyzer (Shimadzu TOC-V_{CSH}/TN, Kyoto, Japan). Both NH_4^+-N and NO_3^--N concentrations of solutions were measured colorimetrically via the nitroprusside and hydrazine-reduction methods, respectively. Concentrations of dissolved organic N (DON) were calculated as the differences between total N and mineral N (NH_4^+-N and NO_3^--N) concentrations.

2.3. Measurement of wet atmospheric C and N deposition and soil net N mineralization under forest canopy

Monthly wet atmospheric C and N depositions under forest canopy were sampled at an irregular interval dependent on intensity of precipitation using self-made rainfall collections during the whole experimental period. Dynamics of net N mineralization fluxes of the soil at 15 cm depth under all the experimental plots were measured in 2006-2008 using in-situ resin-core incubation method.

2.4. Calculation and statistical analysis

Wet atmospheric C and N depositions, and fluxes of dissolved organic matter and inorganic N in the soil solution were calculated via multiplying corresponding volume mean concentrations of solution C and N forms by amount of water flux. Means and standard errors of soil solution chemistry for each sampling date were calculated. Correlation coefficients between the tested properties of soil solutions at 15 cm and 60 cm depths were calculated using SPSS software for Windows. The multivariate tests and paired-sample T tests were performed using SPSS software for Windows to compare the differences in concentrations and fluxes of DOC, DON, NH_4^+ and NO_3^- in soil solutions between treatment, sampling date and soil depth.

3. Results and discussion

3.1. Effect of N addition on concentrations of DOC, DON and inorganic N in soil solution

NH_4^+-N concentrations in the soil solutions at 15 cm and 60 cm depths under N-fertilized and non-fertilized plots were mostly below 0.2 μg N ml^{-1}, which were much smaller than NO_3^--N concentrations in soil solutions (Fig. 1). The addition of N increased concentrations of NH_4^+-N, NO_3^--N and DON in the soil solutions at both depths (Fig. 1). Thus, the export of inorganic N and DON from such forest stand was significantly increased by addition of N.

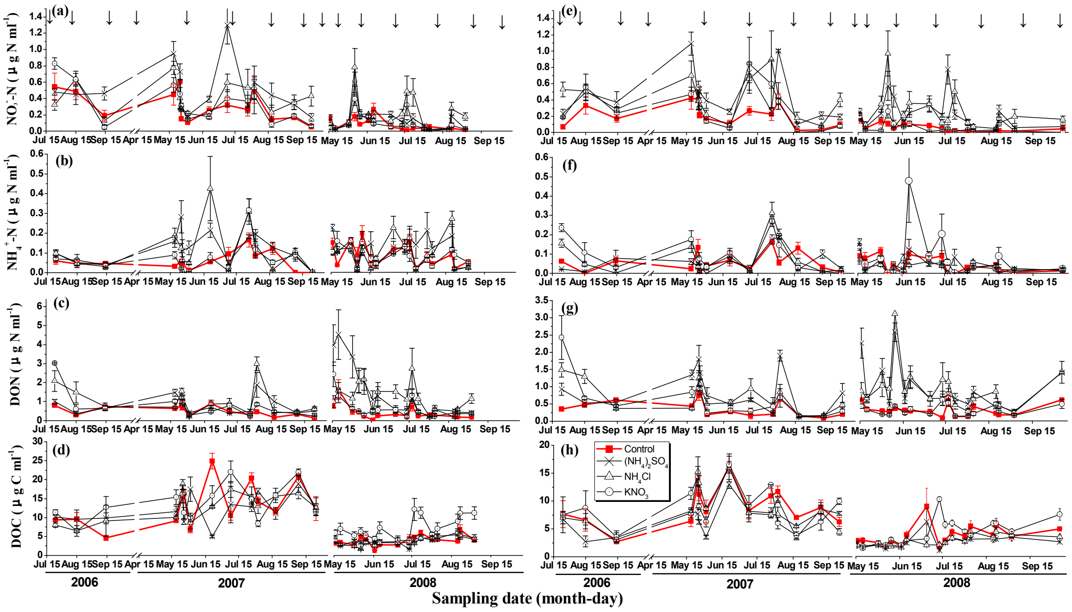

Figure 1 Dynamics of dissolved organic matter and inorganic N concentrations in forest soil solutions in 2006-2008 upon addition of N at a rate of 4.5 g /m^2 each year. a-d: soil solution at 15 cm depth; e-h: soil solution at 60 cm depth. Arrows indicate date of N addition.

The DOC concentrations in soil solutions at 15 cm depth (1.2 to 27.8 μg C ml^{-1}) throughout the period of the experiment were significantly larger than those at 60 cm depth (1.1-16.5 μg C ml^{-1}) (Fig. 1d,h). The addition of N sources such as $(NH_4)_2SO_4$ and NH_4Cl tended to decrease DOC concentrations in the soil solutions at 60 cm depth (Fig. 1h) and showed a small change in concentrations at 15 cm depth (Fig. 1d). DOC concentrations in the soil solutions decreased with increasing soil depth under all the experimental plots to a greater degree than did DON, especially under N-fertilized plots. This phenomenon may decrease rates of DOC to DON concentrations in soil solutions at both depths upon N addition. Our observations indicated that the mechanisms for DOC dynamics under N-fertilized forest stands on a plot-scale differed from those for DON.

3.2. Effect of N addition on fluxes of DOC, DON and inorganic N in soil solution

Monthly DOC fluxes in soil solutions at 15 cm depth (0.2 to 25.0 g C m^{-2}) throughout the period of the experiment were significantly larger than those at 60 cm depth (0.1-16.3 g C m^{-2}). The addition of N sources such as $(NH_4)_2SO_4$ and NH_4Cl tended to decrease monthly DOC fluxes in soil solutions at 60 cm depth and showed a small change in fluxes at 15 cm depth. Probably, there was high amount of DOC retained in underlying mineral soils (15-60 cm) under N-fertilized forest plots. The addition of N increased fluxes of NH_4^+-N and NO_3^--N and DON in the soil solutions at both depths and tended to decrease the proportion of DON in total N fluxes.

3.3. Effect of N addition on special UV absorbance of forest soil solution

There was a relatively small special UV absorbance of forest soil solution at 60 cm depth under all experimental plots in 2007-2008 compared to the soil solution at 15 cm depth. This indicated that DOM leached from deep soil layers is characterized by high decomposability. The addition of N tended to decrease special UV absorbance of soil solutions at 15 cm and 60 cm depths, especially at the latter. Probably, N inputs to forest floors can affect the stability of DOM in soil solution.

3.4 Contribution of N inputs and soil net N mineralization to N fluxes in soil solution

In combination with previous published studies, our experimental data can be used to assess the contribution of N inputs and soil net N mineralization to N fluxes in soil solution under forest ecosystems.

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Increased Nitrogen deposition from Qinghai-Tibet Plateau to Yangtze River Delta

Yuepeng Pan
LAPC, Institute of Atmospheric Physics, Chinese Academy of Sciences, Beijing 100029, PR China.
*To whom correspondence should be addressed. E-mail: pyp@dq.cern.ac.cn (Y. Pan).

Abstract

In response to the growing concern on the potential effects of atmospheric deposition on the sensitive ecosystems, since 2013 we have established a monitoring network in Qinghai-Tibet Plateau and Yangtze River Delta, where particularly susceptible to severe air pollution. Wet and dry deposition was collected using an automatic wet-dry sampler. The presentation will focus on the new results of atmospheric deposition of reactive nitrogen species in rain, particles and gases.

Introduction /Results and discussion

From 2008 to 2010, we conducted various measurements of atmospheric deposition in Northern China. The major results and conclusions are as follows:

(1) Over the 3 year period, 26% of precipitation events were more acid than pH 5.60 and these acidic events occurred in summer and autumn. The annual volume-weighted mean (VWM) pH value of precipitation was lower than 5.60 at most sites, which indicated the acidification of precipitation was not optimistic. The primary ions in precipitation were NH_4^+, Ca^{2+}, SO_4^{2-} and NO_3^-, with 10-sites-average concentrations of 221, 216, 216 and 80 μeq L^{-1}, respectively. The ratio of SO_4^{2-} to NO_3^- was 2.7; suggesting SO_4^{2-} was the dominant acid component.

(2) The deposited particles were neutral in general and the pH value increased from rural area to industrial and coastal sites. It is not surprising to note that the annual VWM pH value of precipitation was higher than 5.60 at three urban sites (Beijing and Tianjin mega cities) and one coastal site near the Bohai Bay, considering the fact that high buffer capacity of alkaline component, gas NH_3 and mineral aerosols, at these sites compared to other places.

(3) The 10-sites annual total deposition amounts for sulfur and nitrogen compounds were 60 and 65 kg N/S ha^{-1} yr^{-1}, respectively. Total deposition amounts of sulfur and nitrogen in North China were 5-10 times higher than those in CASTNet and EMEP, as well as EANET sites in Japan, which indicated that the increasing emissions of air pollutants in North China resulted in high atmospheric depositions. Integrated assessment of acidic deposition and potential environmental consequences in North China are needed.

More details can be found in the following papers.

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Effect of wetting intensity, carbon and nitrogen addition on N_2O and CO_2 fluxes from forest soils

Wu Haohao[a,b], **Wang Lu**[a,c], **Xu Xingkai**[a,*], **Li Tuansheng**[b], **Duan Cuntao**[a]

[a] State Key Laboratory of Atmospheric Boundary Layer Physics and Atmospheric Chemistry, Institute of Atmospheric Physics, Chinese Academy of Sciences, Beijing, 100029, China; [b] College of Earth Science and Resources, Chang'an University, Xi'an 710054, China; [c] Graduate University of Chinese Academy of Sciences, Beijing 100049, China

[*] Phone: +86 010 8205510; Fax: +86 10 62041393; E-mail: xingkai_xu@mail.iap.ac.cn

Keywords: Forest soil, Nitrous oxide, Carbon dioxide, Wetting intensity, Glucose, Nitrate, Ammonia, Microbial biomass.

Abstract Incubation experiments were done to study the effect of carbon (glucose) and nitrogen (NH_4Cl and KNO_3) addition on nitrous oxide (N_2O) and carbon dioxide (CO_2) fluxes from a mature broadleaf and Korean pine mixed forest(BKPF) soils and adjacent white birch forest (WBF) soils under two wetting intensities (55% and 80% WFPS). The results showed that nitrogen (N) addition enhanced soil N_2O emission and dissolve organic nitrogen (DON) content, but decreased CO_2 fluxes from the both soils, regardless of the types of N added ($P<0.05$). Glucose addition promoted N_2O and CO_2 fluxes from the both soils, especially at the early stage of incubation. Moreover, the addition of glucose increased microbial biomass carbon (C) and the ratio of microbial biomass C and N in the soils, and thus probably changed the microorganism compositions in the soils. Compared to the BKPF soils, N_2O fluxes from the WBF soils were more sensitive to glucose addition. Stepwise regression analysis showed that relationships existed between fluxes of wetting-induced N_2O and CO_2 and soil properties.

Introduction

Nitrous oxide and carbon dioxide are major greenhouse gases (GHG), which can arise global climate change. The increasing frequency of periodic droughts in northern regions followed by heavy rainfalls is expected for this current century(Kim et al, 2012), including the Changbai mountain area which is affected by East Asian monsoon. A few researches have reported the effect of wetting intensity on GHG fluxes (Xu et al. 2012), while wetting-induced GHG fluxes can also be deeply influenced by supply of soluble organic C and available N in soils. Based on this, incubation experiments were made to study the effect of C and N addition on N_2O and CO_2 fluxes from two different forest soils in Changbai mountain area under different wetting intensity. The related mechanisms were also analyzed in combination with the variations of soil properties prior to and after incubation. The results would improve our understanding of N_2O and CO_2 fluxes from forest soils during wetting processes and their respective responses to addition of C and N.

Materials and methods

Soil samples (0-10 cm) were collected from a mature broadleaf and Korean pine mixed forest (BKPF) and adjacent white birch forest (WBF) (42°24′ N, 128°6′ E) in October 2012, respectively; both forest stands were characterized by different microclimatic and soil conditions. The soil samples from each forest were mixed thoroughly, and sieved through a 2-mm sieve. A factorial design with two tree species (BKPF and WBF), two wetting intensity (55% and 80% WFPS), nutrients addition (glucose, namely Glu 6.4 C g/m^2, NH_4Cl 4.5 N g/m^2, KNO_3 4.5 N g/m^2, Glu+NH_4Cl, Glu+KNO_3) was established; no nutrient addition was considered as control. All treatments were carried out in triplicate, giving a total of 72 packed soil cores. The soil cores were incubated at 10 °C, and gas sampling was performed at 6, 12, 24, 37, 49, 75, 95, 119, 143, 167, 191, 215, 239, 263, 287, 311, 335 and 359 h after the incubation. Soil properties including pH, NH_4^+-N, NO_3^--N, dissolved organic N (DON), dissolved organic C (DOC), microbial biomass C and N prior to and after incubation were analyzed as mentioned by Xu et al (2007). Multivariate analysis of variance was done to determine the effects of wetting intensity, C and N addition as fixed factors and their interaction on the fluxes of N_2O and CO_2 from the two forest soils upon wetting, along with soil properties, separately. Least significant differences (LSD) were calculated at the 5% level to assess differences among treatments in either flux of N_2O and CO_2 for each sampling date during incubation. Stepwise regression analysis was performed to assess soil properties that affect the emissions of N_2O and CO_2 from each soils. Significant effects were determined at $P<0.05$.

Results and discussion

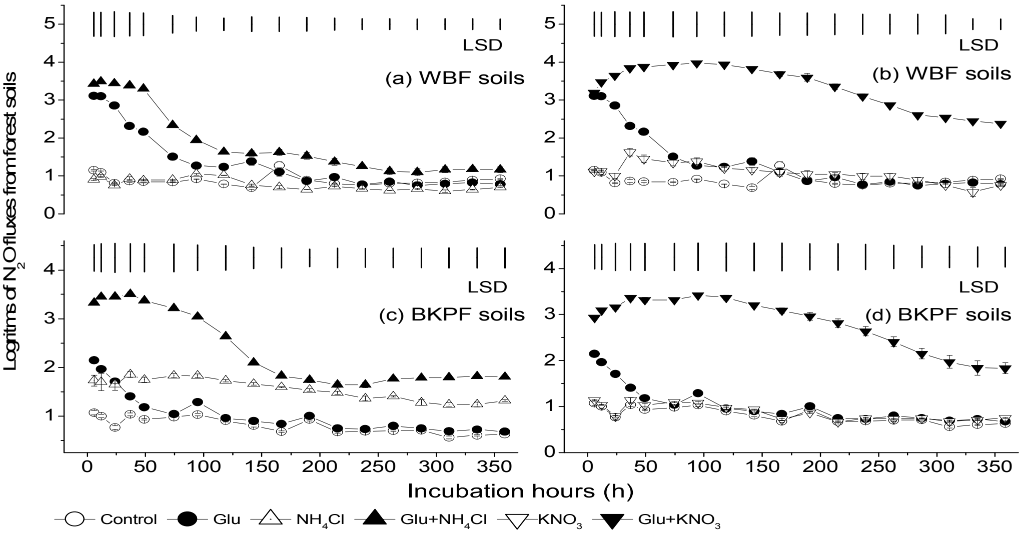
1. Effect of wetting intensity, carbon and nitrogen addition on N_2O fluxes from forest soils

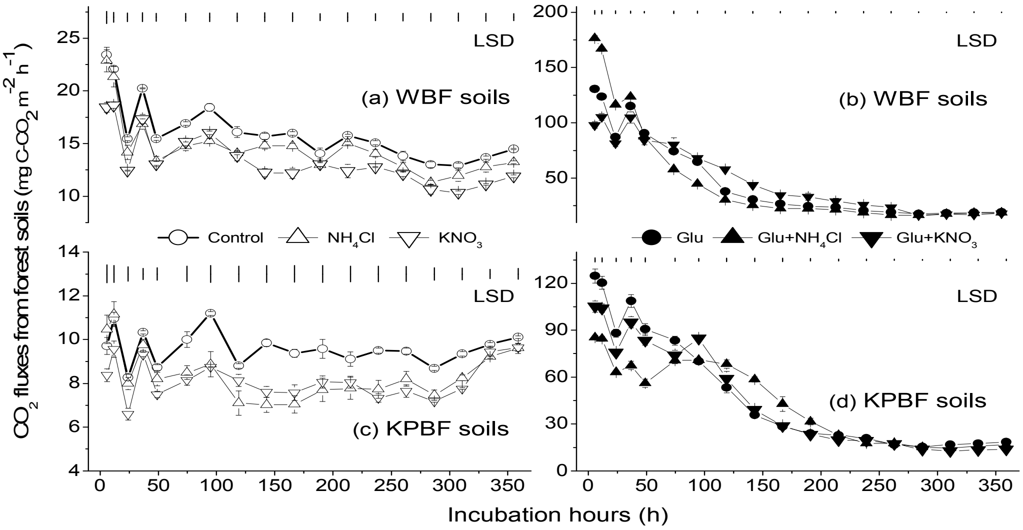
Figure 1 shows temporal changes in logarithms of N_2O fluxes from WBF and BKPF soils during incubation following addition of C and N under high wetting conditions, and data under low wetting conditions were not shown. Compared to the control, addition of glucose could significantly enhance N_2O emissions from both soils during the early stage (2-4 days) of the incubation ($P<0.05$), and then had little difference till the end. The promotion effect of carbon combined with N addition on N_2O fluxes from the soils under high wetting intensity was significant during the whole incubation period compared to the Glu treatment, especially at the early stage, while remarkable variations in N_2O fluxes ($P<0.05$) were observed between N types (NH_4Cl and KNO_3). We also studied cumulative N_2O fluxes and rates of N_2O emission from the both soils during incubation, which were well affected by wetting intensity and nutrients addition differently.

2. Effect of wetting intensity, carbon and nitrogen addition on CO_2 fluxes from forest soils

Figure 2 shows temporal changes in CO_2 fluxes from WBF and BKPF soils during incubation following addition of C and N under high wetting intensity, and data under low wetting conditions were not shown. The inhibition effect of N addition on CO_2 fluxes from WBF soils was significant during the whole incubation period, while for the KPBF soils, the effect disappeared at 335 h after the incubation ($P<0.05$) (Fig. 2a,c). The fluxes of CO_2 from the both soils were significantly enhanced after glucose addition during the whole incubation period ($P<0.05$). CO_2 emissions from WBF soils decreased with increasing wetting intensity, which was different from CO_2 fluxes from BKPF soils following wetting (data not shown). We also studied cumulative CO_2 fluxes and the rates of CO_2 emission during incubation.

Fig.1 Changes in logarithms of N_2O fluxes from WBF soils and BKPF soils during incubation upon addition of C and N under high





wetting intensity

Fig.2 Dynamics of CO_2 fluxes from WBF soils and BKPF soils during incubation upon addition of C and N under high wetting intensity

3. Relationships between fluxes of wetting-induced N_2O and CO_2 and soil properties

We studied the effect of wetting intensity, C and N addition on soil properties at the end of incubation (data not shown). Cumulative fluxes of N_2O and CO_2 from WBF soils during the whole incubation period were both influenced mainly by the ratio of microbial biomass C and N. Cumulative N_2O and CO_2 fluxes from BKPF soils were influenced mainly by WFPS and microbial biomass C respectively.

Conclusions

Wetting intensity, C and N addition could affect fluxes of N_2O and CO_2 from both soils, as well as the soil properties. Further studies should be focused on the change in wetting-induced microbial dynamics and its relationships to both N_2O and CO_2 fluxes from forest soils.

Acknowledgements

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Theme 1

Long-term nitrogen addition effects on soil organic matter in a *Larix gmelinii* plantation in China

Kai Yang [a], Jiaojun Zhu [a, *], Zhengquan Wang [b]

[a] State Key Laboratory of Forest and Soil Ecology, Qingyuan Experimental Station of Forest Ecology, Institute of Applied Ecology, Chinese Academy of Sciences, Shenyang 110164, P.R. China
[b] School of Forestry, Northeast Forestry University, Harbin, 150040, P.R. China
* Phone: 86-24-83970342, Fax: 86-24-83970300, E-mail: jiaojunzhu@iae.ac.cn

Keywords: Larch plantation; Nitrogen addition; Microbial biomass; Soil organic matter stability

Abstract

Sustained inputs of nitrogen (N) via atmospheric deposition or N fertilizers, important global change drivers, are likely to change soil organic matter quantity and quality and ultimately affect soil C storage. Although many fertilization studies have focused on plant growth, the response of soil organic matter to increased N availability remains unclear. In order to understand the influence of N addition on soil organic matter quantity and quality in the larch (*Larix gmelinii*) plantation, a continuous nine-year N addition in the larch plantation was conducted in northeast China. Results showed that soil C concentration increased 5.7% in the 0-10 cm soil layer in N fertilized plots compared to control (no N addition) plots, and this increased soil C concentration was mainly in heavy fraction C, suggesting stabilization of soil C compounds in heavier associated fraction in the N fertilized plots. In contrast, soil C mineralization, and microbial biomass C and N decreased in response to N fertilization and corresponded to declines in soil $\delta^{15}N$. It appeared that N addition decreased microbially-mediated processes as well as soil nutrient cycling in the larch plantation. This was supported by Fourier transform infrared spectroscopy analysis because aliphatic and carboxylic compounds were less abundant in the N fertilized plots. Overall, long-term N addition in the larch plantation may increase C storage in soil. However, our results indicated that N addition leads to a decline in soil quality in the larch plantation.

International Symposium on Forest Soils

Nitrogen stable isotopic composition of leaves and soil in Japanese cedar and hinoki cypress plantation along a precipitation gradient in Shikoku district, southern Japan

Yoshiyuki Inagaki[a,*], Hidehisa Fukata[b] & Keisuke Koba[c] ...
[a] Forestry and Forest Products Research Instituite, Tsukuba, Ibaraki, 305-8687, Japan;
[b]Kochi Prefectural Forestry Technology Research Center, Kami, Kochi, 782-0078, Japan, and
[c]Faculty of Agriculture, Tokyo University of Agriculture and Technology, Fuchu, Tokyo, 183-8509, Japan
[*] Phone: +81 29 8298230; Fax: +81 298743720; E-mail: yinagaki@affrc.go.jp

Keywords: conifer plantation, precipitation, nitrogen stable isotope, soil, leaves

Abstract

δ^{15}N in leaves and soil were investigated in Japanese cedar (*Cryptomeria japonica*) and hinoki cypress (*Chamaecyparis obtusa*) plantations along a precipitation gradient in Shikoku district, southern Japan. Eight areas were selected from Setouchi region (annual precipitation, 1500-2000mm) and Pacific region (2500-4000mm). A pair of Japanese cedar and hinoki cypress forests was selected in each area. Leaves, roots, organic layer and surface soil at 5cm depth were collected at each forest and analyzed for δ^{15}N. Relationship between δ^{15}N pattern and soil processes was evaluated. δ^{15}N in leaves and roots was not different between Setouchi and Pacific region whereas δ^{15}N in surface soil was higher in Pacific region than in Setouchi region for both forest types. The enrichment factor from soil to leaves (δ^{15}N leaf − δ^{15}N soil) was lower in Pacific region than in Setouchi region. The enrichment factor was correlated with nitrification rate in surface soil positively and C/N ratio of decomposing leaves after 2 years negatively. The mechanism explaining this relationship was discussed.

Introduction

Natural abundance of nitrogen stable isotope is a powerful tool for understanding a long-term ecosystem processes (Craine et al 2007; Takebayashi et al 2010; Fang et al in press). In the global scale δ^{15}N in leaves was negatively correlated with mean annual precipitation (Craine et al 2007). However, the relationship between δ^{15}N and precipitation was not clear in East Asia (Fang et al in press). The reason for the lack of clear relationship is not known but the information about relationship between δ^{15}N and soil processes for the same species along a climate gradient would provide valuable insights about nitrogen dynamics in the region. In Japanese forest soils, decomposition of organic horizon is rapid (Inagaki et al 2011) and this character would be important process shaping δ^{15}N in leaves and soil. In this study relationship between δ^{15}N pattern and soil processes were evaluated for conifer plantations along a precipitation gradient in Shikoku district, southern Japan.

Materials and methods

The pattern of δ^{15}N in plant and soil is evaluated in Japanese cedar and hinoki cypressplantations along a precipitation gradient in Shikoku Island. Eight areas were selected from Setouchi region (annual precipitation, 1500-2000mm) and Pacific region (2500-4000mm). In each area, a pair of Japanese cedar and hinoki cypress forests was selected. In each stand, leaves, roots, organic layer and surface soil at 5cm depth were collected and analyzed for C and N concentration, and δ^{15}N. Soil nitrification rate of the surface soil was determined by the 30-d laboratory incubation. Decomposition of fresh leaves was measured by litterbag method for 2 years. Carbon and nitrogen content in the leaves was analyzed.

Results and discussion

δ^{15}N in leaves and roots was not different between Setouchi and Pacific region whereas δ^{15}N in surface soil was higher in Pacific region than in Setouchi region for both forest types. Thus, enrichment factor from soil to leaves (δ^{15}N leaf-δ^{15}N soil) was lower in high precipitation area. The enrichment factor was correlated with nitrification rate in surface soil positively and C/N ratio of decomposing leaves after 2 years negatively (Fig. 1). These results indicate that depletion of leaf δ^{15}N is greater where nitrification rate is low and leaves decompose with high C/N ratio. Leaves with high C/N ratio would release nitrogen more rapidly than leaves with low C/N ratio. Therefore, plants can utilize nitrogen released from decomposing leaves in the organic horizon rather than mineralized N in surface soil. The results suggest plants in Setouchi region utilize nitrate in the surface soil but plants in Pacific region utilize nitrogen released from organic horizon. The shifts of nitrogen sources along a precipitation gradient can be reasonably explained by the patterns of δ^{15}N in leaves and soil.

Conclusions

The δ^{15}N enrichment factor was different between the two regions. The enrichment factor was correlated with soil nitrification rate and C/N ratio of decomposing leaves. The results suggest plants in Setouchi region utilize nitrate in the surface soil but plants in Pacific region utilize nitrogen released from organic horizon. The measurement of soil processes and pattern of δ^{15}N can provide valuable insights about nitrogen sources along a precipitation gradient.

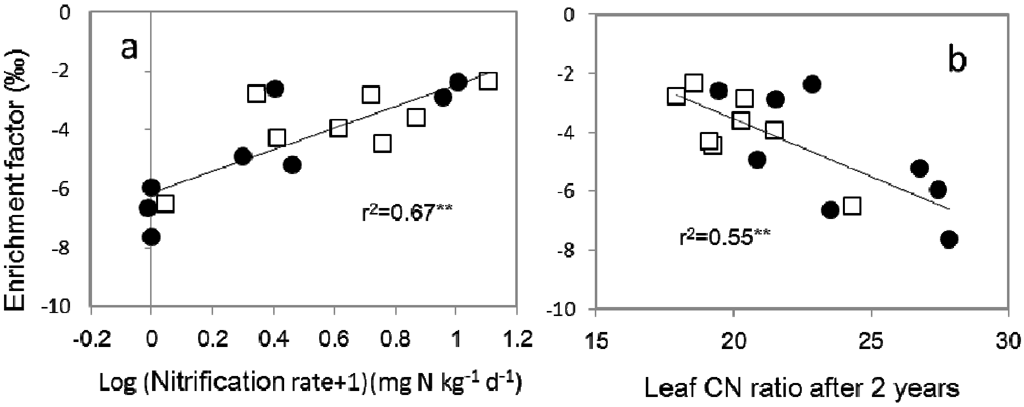

Fig. 1 Relationship between enrichment factor (δ^{15}N leaf − δ^{15}N soil) and soil nitrification rate (a) and C/N ratio of decomposing leaves after 2 years (b) in Japanese cedar (open square) and hinoki cypress (closed circle)
** *P* <0.01

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Impacts of *Ageratina adenophora* invasion on soil water, soil organic matter and soil nitrogen in *Eucalyptus* plantation

Fuke Yu[a], Xinhui Huang[b,*], Changqun Duan[a], Shuzhuang He[a], Guosheng Zhang[a], Chang'e Liu[a], Denggao Fu[a]
[a]Institute of Environmental Sciences and Ecological Restoration, School of Life Sciences, Yunnan University, Kunming 650091, P. R. China; and [b]College of Environmental Science and Engineering, Southwest Forestry University, Kunming 650224, P. R. China.
*Telephone: +86-871-65090855; Fax: +86-871-65090855; and E-mail: ylhxh2001@163.com, frank-yu@163.com

Keywords: *Ageratina adenophora*, biological invasion, *Eucalyptus* plantation, soil water, soil organic matter, soil nitrogen.

Abstract *Eucalyptus* tree-*Ageratina adenophora* compound system is considered as a new invasion in Yunnan, southwest China in recent years. In this paper, the impacts of *A. adenophora* invasion on soil water, soil organic matter, soil nitrogen in *E.* plantation were investigated, based on the exploration of its causes, the assessment of its risk and the prediction of its succession. The results showed that the invasion had a different impact on four different physical-chemical indexes of soil in *E.* plantation, characterized with a certain complexity. Its impact on soil water was featured with seasonal difference, namely, during the dry season, the soil water concentration increased significantly (excluding the severely invasive sample on shadowy slope), while, in the rainy season, the soil water concentration decreased significantly. Meanwhile, its impact on soil organic matters and soil nitrogen was related to seasons, exposure and invasive degrees of *A. adenophora*, but there was no unified rule for them, which should be studied further. It's expected to provide a theoretical basis for the sustainable operation and scientific management of *E.* plantation under the condition of *A. adenophora* invasion.

Introduction

A. adenophora, an herbal plant, belongs to *Eupatorium* Genus of Compositae Family, originated from Mexico and Costa Rica in Central America, now it is a typical vicious invasive weed worldwide, which is widely distributed in more than 30 countries and regions in tropical and subtropical areas (Xie et al, 2001). In the 1940s, it was introduced into Lincang, the a boundary county in Yunnan China, from Myanmar, now, it has been widely spread to Yunnan, Guizhou, Sichuan, Chongqing, Guangxi, even further to Taiwan (Xie et al, 2001), and it continues to spread further eastward and northward at an annual speed of 20 km (Wang & Wang, 2006). Its invasion could produce many ecological impacts, such as changes in soil quality (Kourtev et al, 2002; Niu et al, 2007), the exclusion of local species (Stinson et al, 2006; Mangla et al, 2008), damages to regional biodiversity (Wang et al, 2010; Pritekel et al, 2006), which has brought about enormous economic losses (Xu et al, 2006; Zhu et al, 2005). Meanwhile, due to the covertness of its invasive impacts on soil quality, along with lack of in-depth researches and deficiency in the understanding of its occurrence mechanism and influential factors, there is a major technological challenge on the cause exploration and risk assessment of its invasion.

Recently, in parts of Yunnan such as Kunming, Chuxiong, Pu'er, etc., it was found that in *E.* plantation with rare local species, *A. adenophora* could not only survive but widely spread, thus *E.* tree-*A. adenophora* compound system appeared (Huang et at, 2013). Behind such phenomenon lied some major scientific issues, e.g., what's the essential reason for such a compound system? What ecological impacts would it produce, and how would it go in succession? Based on its great significance, a series of studies had been done. In this paper, the impact of *A. adenophora* invasion on soil water, soil organic matter, soil nitrogen in *E.* plantation would be mainly explored.

Materials and methods

A brief introduction to the research area

Humashan Hill in Kunming, Yunnan was selected as the research site, with its geographical coordination of 25°06′76″N and 102°76′51″E and an altitude of about 1,920m above sea level. It goes from eastward to westward, characterized with obvious dry and wet seasons. From mid May to mid October, it's the rainy season, while from the late October to early May, the dry season, with an annual average temperature around 16℃ and 850-950 mm of annual rainfall. The soil in the research site is characterized with red earth, with *E. globules* plantation as its main vegetation with the invasion of *A. adenophora*.

Sample sites selecting

Different water and thermal condition of the sunny side and shadowy side of Humashan Hill and different invasive degrees of *A. adenophora* into *E.* plantation were taken into consideration, thus 4 sample sites with an area of 10m×10m with a similar altitude were selected in *E.* plantation on the sunny and shadowy side of the Hill respectively, marked with SIS (severely invasive sample, an invasive coverage of 51%~70%, treatment 1), MIS (moderately invasive sample, an invasive coverage of 31%~50%, treatment 2), LIS (lightly invasive sample, an invasive coverage of 11%~30%, treatment 3) and WIS (weakly invasive sample, an invasive coverage below 10%, CK) respectively. These sample sites are used for soil samples collecting.

Soil sample collecting and the test of its physical-chemical indexes

In September, 2011 (the rainy season) and April, 2012 (the dry season), soils were collected twice as samples for the test of physical and chemical indexes. The specific test indexes and methods were shown as below: water concentration was measured by the Oven Drying Method; the concentration of organic matter was measured by Oxidation-Reduction Titration; the concentration of total nitrogen (TN) was measured with Potassium

Dichromate-Sulfuric Acid Digestion and distillation; the concentration of alkali-hydrolyzale nitrogen (AN) was measured with NaOH-hydrolyzation diffusion.

Results and discussions

The impact of *A. adenophora* invasion on soil water in *E.* plantation

The impact of the invasion of *A. adenophora* on soil water in *E.* plantation varied greatly with the change of seasons. In the dry season, the invasion of *A. adenophora* raised the water concentration of the invasive samples (excluding the severely invasive sample in shadowy slope) (compared to CK); on the contrary, in the rainy season, it reduced the water concentration of the samples (compared to CK). Such rule was possible related to the water use characteristics of *A. adenophora*. However, the relation between soil water concentration and invasion degree is not linear.

The impact of *A. adenophora* invasion on soil organic matters in *E.* plantation

The impact of the invasion of *A. adenophora* on soil organic matters in *E.* plantation was related to seasons, exposure and the invasive degrees. During the dry season, on the sunny slope, soil organic matters increased significantly in all samples with the invasion of *A. adenophora* to a different extent (compared to CK), among which, the soil organic matters increased significantly in MIS; by contrast, on the shadowy slope, in SIS and LIS, though soil organic matters increased, there was no significant change, on the contrary, in MIS, the organic matters decreased significantly (compared to CK). During the rainy season, on the sunny slope, in SIS and LIS, soil organic matters increased significantly, by contrast, in MIS, soil organic matters decreased significantly (compared to CK); while on the shadowy slope, in SIS and LIS, soil organic matters were characterized with no significant difference, by contrast, in MIS, soil organic matters increased significantly (compared to CK). These vibrations were possibly due to the change in the process of humification and mineralization of soil organic matters under the condition of the invasion of *A. adenophora.*

The impact of *A. adenophora* invasion on soil nitrogen in *E.* plantation

The impact of the invasion of *A. adenophora* on soil nitrogen in *E.* plantation was related to seasons, exposure, and invasive degrees.

Take soil TN for instance, during the dry season, on the sunny slope, in MIS, the concentration of soil TN increased significantly, while the concentration of soil TN in SIS and LIS decreased significantly (compared to CK); by contrast, on the shadowy slope, in SIS, soil TN was characterized with no significant increase, while in MIS and LIS, soil TN was characterized with significant decrease (compared to CK). During the rainy season, on the sunny side, in SIS and LIS, soil TN was characterized with significant increase, while in MIS, soil TN was characterized with significant decrease (compared to CK); on the shadowy side, in all samples, soil TN increase to a certain degree, while in MIS, soil TN was characterized with no significant increase (compared to CK).

Take soil AN for another instance, during the dry season, in the sunny samples, the concentration of soil AN in SIS and MIS decreased significantly, while there was no significant change in LIS (compared to CK); by contrast, in the shadowy samples, in SIS, soil AN increased significantly, while in MIS and LIS, soil AN decreased significant (compared to CK). During the rainy season, on the sunny slope, in all samples, soil AN increased, while there was no significant increase in MIS (compared to CK); by contrast, in all the shadowy samples, soil AN increased significantly, while there was no significant difference between the samples (compared with CK).

Conclusions

The impacts of the invasion of *A. adenophora* on four different physical-chemical indexes of soil in *E.* plantation were characterized with great differences and a certain complexity as well. Its impact on soil water was featured with seasonal difference, namely, in the dry season, soil water concentration increased significantly (excluding the severely invasive sample in shadowy slope), while in the rainy season, soil water concentration decreased significantly. Its impact on soil organic matters, soil nitrogen was related to seasons, exposure and invasive degrees of *A. adenophora*, whereas, there was no unified rule suitable for all of them, thus its influential mechanism required for further study.

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Soil transfering from high- to low-elevation forests affects nitrogen mineralization rate

Sha Liiqng [a,b]*, Gao Jianmei [a]

[a] Key Laboratory of Tropical Forest Ecology, Xishuangbanna Tropical Botanical Garden, Chinese Academy of Sciences, Kunming 650223, China; [b] Ailaoshan Station for Subtropical Forest Ecosystem Studies, Chinese Academy of Sciences, Jingdong 676200, Yunnan, China

[*] Phone: +86 871 65112637; Fax: +86 871 65160916; E-mail: shalq@xtbg.ac.cn

Keywords: global warming, nitrogen mineralization, nitrification, nitrogen loss.

Introductions:

N frequently limits the net primary productivity of terrestrial ecosytems, and soil N transformations have been shown to be fairly responsive to temperature changes. Global warming will increase soil temperature and influnce soil nitrogen cycling.

Materials and methods

By using resin core method, the intact soils of evergreen broad-leaved forest at high elevation (2450m) were transferred to and incubated in secondary forest at medium elevation (1950m), and in artificial plantation at low elevation (1650m) in the Ailao Mountains. N minerarization rate, nitrification rate and N loss were measured.

Results and discussion

Elevation had significant effects on net mineralization rate, net nitrification rate, and leached amount of soil nitrogen ($P<0.01$), being most obvious in early rainy season. At high elevation, soil nitrogen net mineralization and net nitrification rates were -5.81 and -4.18 $\text{mg N}\cdot\text{kg}^{-1}\cdot 60\ \text{d-}^{1}$, respectively; while at medium and low elevation, they were 20.92 and 44.15 $\text{mg N}\cdot\text{kg}^{-1}\cdot 60\ \text{d}^{-1}$, and 17.07 and 20.38 $\text{mg N}\cdot\text{kg}^{-1}\cdot 60\ \text{d}^{-1}$, and the amount of leached nitrogen was increased by 0.37 and 2.77 times, respectively. Due to increase of soil denitrification in mid and late rainy seasons, soil nitrogen net mineralization and net nitrification rates decreased, with the net mineralization rate peaked in mid rainy season and decreased in late rainy season.

Conclusions

Future climate warming could accelerate soil nitrogen transformation rate and cause the gaseous nitrogen loss in the montane evergreen broadleaved forest in Ailao Mountains.

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Earthworm cast as nitrifiers' paradise in terrestrial ecosystems: a hot spot of N_2O production

Takamaru Kobayashi[a], Keisuke Koba[a], Nobuhiro Kaneko[b], Muneoki Yoh[a,*]
[a] Tokyo University of Agriculture and Technology, Tokyo 183-8509, Japan;
[b] Yokohama National University, Yokohama, 240-8501, Japan
[*] Phone: +81 42 3675900; Fax: +81 42 3675900; E-mail: yoh@cc.tuat.ac.jp

Keywords: nitrogen cycling, hot spot, earthworm, N_2O emission

Abstract Soil fauna can be an agent to create a 'hot spot' of N_2O production in soil but its quantitative importance has been poorly understood. Here, we studied total dose of N_2O production and the nitrogen cycling in casts from earthworm. Casts in different size collected from earthworms were incubated for two weeks till the processes virtually ceased. Overall, large quantity of NH_4^+ initially contained in fresh casts was totally oxidized to NO_3^- via nitrification, which was principally responsible for active N_2O production during this period. Denitrification also took place in casts, leading to N loss and partly contributing to N_2O production, especially in larger casts (>8mm). N_2O production was 28-fold to 229-fold intensive in casts relative to the soil. According to our preliminary estimate, casts from earthworm contribute to about 7% of the global N_2O flux from natural soils.

Introduction

Nitrous oxide (N_2O) is a biogenic gas in the atmosphere having potent greenhouse effect and an effect to deplete stratospheric ozone. N_2O emission from soil is generally attributed to two microbial process; nitrification and denitrification. It has been reported that these processes do not occur uniformly soil systems (e.g., Parkin, 1987). It is likely that such a spatial heterogeneity and the mechanism to create it may be fundamental to N_2O emission in terrestrial environment.

It is known that earthworm contributes to N_2O production and related processes in soil. A few studies exist that measured N_2O emission from casts (Svensson et al., 1986; Elliott et al., 1990; Mathies et al., 1999; Majeed et al., 2013), but all of them measured N_2O emission only at a certain point in time after cast collection. Little knowledge has been available on the quantitative importance of earthworm cast as a source of N_2O emission and associated nitrogen processes, due partly to technical difficulties associated with small sample sizes.

Here, we discuss the total amount of N_2O emission from earthworm cast and the dominant process responsible for N_2O production throughout the time course after excretion. The results suggest that earthworm cast, which contains disproportionately high concentration of NH_4^+, serves as a hot spot of N_2O production, nitrification, and occasionally denitrification.

Materials and methods

Earthworm, soil, and litter were collected from forest sites in Kamakura, Japan. One earthworm and 100g of 2mm-sieved soil were put in each plastic box for the pre-incubation. After 24 hours, cast was collected; aggregate that couldn't pass 4mm sieve after pre-incubation was defined as casts. In some experiment, cast was further separated into two fraction, >8mm and 4-8mm. About 3.5g of collected casts or soil (control) was incubated in a 30ml glass vial till the processes came to an end, during which replicates were destructively sampled to measure nitrogen components. NO_3^- was measured using a denitrifier method (Christensen and Tiedje, 1988). N_2O production rate was measured using an ECD-GC. The rate of nitrification and denitrification in casts was also measured using two levels of acetylene (10 Pa and 10 kPa), which repress nitrification and N_2O reduction, respectively (Davidson et al., 1986).

Results and discussion

Cast excreted from earthworm contained strikingly high concentration of NH_4^+, which contrasted with the soil of only trace NH_4^+. NH_4^+ concentration in casts decreased sharply with time and came to a trace level after 2 weeks. NO_3^- concentration of the casts increased largely during the incubation, while little change in NO_3^- concentration in the soil. Initial NH_4^+ concentration and increase in NO_3^- was larger in the >8mm casts than the 4-8mm casts. N_2O production in casts was much higher than the soil; 0.570 μgN/g/day for >8mm casts and 0.480 μgN/g/day for 4-8mm casts on the 1-day as against 0.004 μgN/g/day on average in the soil. N_2O production continued till 14th day, when NH_4^+ was exhausted. The total amount of N_2O production during the 14 days was 7.72 μgN/g for >8mm casts, 1.65 μgN/g for 4-8mm casts, and 0.034μgN/g for the soil; N_2O production was 229-fold or 49-fold intensive in casts relative to the soil.

In 4-8mm cast, the increase in NO_3^- was almost equivalent to the decrease in NH_4^+ during the incubation, indicating negligible process other than NH_4^+ oxidation to NO_3^- by nitrification. In > 8 mm cast, the amount of NO_3^- increase was 72 % of NH_4^+ decrease, suggesting possible simultaneous NO_3^- reduction through denitrification. It is likely that larger particle could develop more anaerobic site to promote denitrification. An experiment using C_2H_2 to measure nitrification and denitrification processes demonstrated that N_2O from nitrification, N_2O from denitrification, and N_2 from denitrification was 0.72 μgN/g/day, 0.46 μgN/g/day, and 4.25 μgN/g/day, respectively, for the >8mm casts on the 1 day of incubation. Based on the initial concentration of NH_4^+ of casts and soil samples, the ratio of cumulative N_2O production relative to NH_4^+ consumption are 0.033, 0.031 and 0.026, being within a range of the N_2O yield in nitrification process.

It has been considered so far that the N_2O emission from casts is mainly due to denitrification (Elliott et al., 1990; Elliott et al., 1991; Majeed et al., 2013). In contrast, our results indicated that nitrification is rather the process dominantly responsible for N_2O production in casts but with a simultaneous partial contribution of denitrification. Based on simple assumptions of average earthworm density, colonization coverage of land, and the above N_2O production rate similar to those adopted by Drake et al. (2006), we preliminarily calculate the global N_2O production from earthworm casts to be 1.0×10^9 kgN/year, which is at the same order as the overall N_2O flux from natural soils of 6.6×10^9 kgN/year (IPCC, 2007).

Conclusions

It is important to remember that dung is also excreted from other soil fauna and earthworm consists of only a part of the total biomass. Earthworm cast, and generally dung from soil animals, would serve as nitrifiers' paradise, where nitrifiers are exceptionally vitalized through plentiful NH_4^+; otherwise, they hardly could find their substrate and their niche in forests. It is thus likely that soil animals would play a pivotal role for N_2O emission and the nitrogen cycling (especially beyond nitrification) in terrestrial environments.

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Responses of soil respiration to nitrogen and phosphorus additions in tropical mountain rainforests in Hainan Island, China

Zhang Zhou[a,b*], **Lai Jiang**[a], **Jingyun Fang**[a], **Yide Li**[b], **Dexiang Chen**[b]
[a]Department of Ecology, College of Urban and Environmental Sciences, Peking University, Beijing 100871, China; and [b]Research Institute of Tropical Forestry, Chinese Academy of Forestry, Guangzhou 510520, China
*Telephone No. +86-20-87032619; and E-mail: zhouzhang@pku.edu.cn

Keywords: carbon cycle, soil respiration, nitrogen, phosphorus, tropical mountain rainforest

Abstract

Enhanced sequestration of plant-carbon (C) inputs to soil may alleviate rising atmospheric CO_2 concentrations and related climate change but how this sequestration will respond to anthropogenic nitrogen (N) and phosphorous (P) deposition is uncertain. We conducted a 2 year field manipulative experiment of N and P addition in two tropical mountain rainforests in China. The objectives of the study were to test the following hypotheses: (1) soil respiration would be stimulated by P treatment and N+P treatment due to P-poor tropical soil; (2) N and P additions would alter the temperature sensitivity of soil respiration, basal soil respiration and the contributions of different components to total soil respiration; (3) Primary forest and secondary forest would have different responses of soil respiration to N treatment. Our results showed that soil respiration exhibited a strong seasonal pattern, with the highest rates found in the wet season and the lowest rates in the dry season. Soil respiration rates showed a significant positive relationship with soil temperature, whereas soil moisture only affected soil respiration at dry season. In the control plots, annual accumulative soil respiration in primary forest (15.6-16.4 Mg C ha^{-1} yr^{-1}) was significantly higher than that of secondary forest (14.1-15.0 Mg C ha^{-1} yr^{-1}). Annual mean soil respiration rate in the primary rainforest was 32-38% higher in N+P plots and 12-18% higher in P plots than in the control plots, and the differences between the control and N treatment did not differ significantly. In secondary rainforest, annual mean soil respiration rate was 28-32% higher in N+P plots, 14-15% higher in N plots and 7 % higher in P plots than in the control plots. In the primary forest, N and P additions increased the attribution of autotrophic respiration to total soil respiration, and decreased the proportion of litter respiration to total soil respiration; however, N and P additions increased the attribution of heterotrophic respiration or litter respiration to total soil respiration in the secondary forest. N and P additions in both forests decreased the temperature sensitivity of soil respiration, and increased basal soil respiration. Our results suggest that N and P addition drove substantial soil CO_2 losses to the atmosphere in the tropical mountain rainforests, but the increasing trends may depend on the rate and duration of N deposition and P addition.

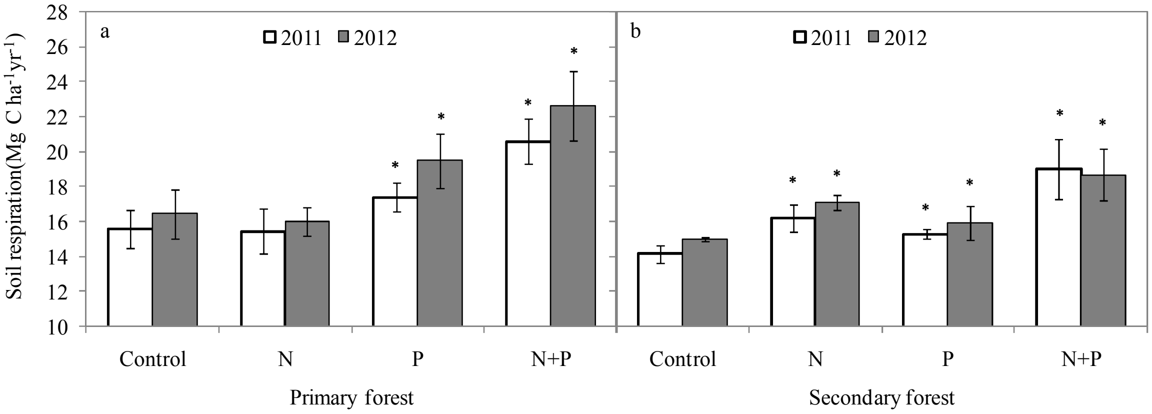

Figure: Comparisons of mean soil respiration rate among N and P treatments in tropical mountain rainforests. Bars indicate ± 1 SE, N=3. Different stars denote significant difference ($P < 0.05$) between control plots and fertilization treatments plots.

Introduction

Tropical forests contain about 40% of the global terrestrial biomass carbon stock (Field et al. 1998; Phillips et al. 1998; Pan et al. 2011) and contribute 67% of the global annual total soil flux (Bond-Lamberty et al. 2010). It is widely accepted that the biogeochemical cycle of tropical rainforests is very important, but the role of nutrients in regulating C cycling in this ecosystem is poorly understood. Many studies have shown that N availability directly controls terrestrial C uptake and losses in temperate and boreal forest ecosystems (Elser et al. 2007; Vitousek et al. 2010), but the nature and extent of nutrient limitation on C storage in tropical ecosystems are still poorly understood (Cleveland & Townsend 2006). However, it is very important to understand how the C cycle in tropical forests may respond to global environmental change. This study was to determine how increases in N and P availability could affect soil respiration and how such changes might alter tropical rain forest C balance.

Materials and methods

The site: located in the Jianfengling National Natural Reserve(18º 23´~18º 50´ N, 108º 36´~109º 05´ E) in Hainan Island, China . Temperature, humidity, and rainfall average 19.5℃, 88%, and 1600~2600 mm per year, respectively. The vegetation is a tropical intact mountain rainforest dominated by Lauraceae and Fagaceae, secondary forest naturally developed on the intact forest which cut down in 1960s-1970s, dominated by Rubiaceae, Fagaceae and Myrtaceae.

Soil Fertilization: In both primary forest and secondary forest, 4 treatments × 3 block replications = 12 plots; each plot 20m × 20m. Fertilization experiments applied monthly begun from Sep. 2010, according to the following 4 treatments: Control, no fertilizer; 50 kg of N ha^{-1}yr^{-1} as ammonium nitrate; P addition, 50 kg of P ha^{-1}yr^{-1} as simple superphosphate; N+P, 50 kg of P ha^{-1}yr^{-1} and 50 kg of N ha^{-1}yr^{-1}.

In Situ Soil Respiration Analyses: Soil respiration was measured from 2011to 2012 by using a Li-8100 automated soil CO$_2$ flux system (LI-COR Inc., Lincoln, NE, USA). All measurements occurred between 8:30 AM and 12:30 PM, and simultaneous surface soil temperature and soil moisture were determined at 10cm soil depth in each plot. We used treching to divide autotrophic respiration and heterotrophic respiration, using aboveground litter removal to get litter respiration.

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Effects of forest management on organic matter cycling and soil acidification in a Japanese cedar plantation

Kazumichi Fujii[a,b*], **Shinya Funakawa**[a], **Takashi Kosaki**[c]
[a] Graduate School of Agriculture, Kyoto University, Kyoto 606-8502, Japan; [b] Forestry and Forest Products Research Institute, Tsukuba 305-8687, Japan; [c] Department of Tourism Science, Tokyo Metropolitan University, Tokyo 192-0364, Japan
[*] Phone: +81-29-829-8228; Fax: +81-29-873-1542.; E-mail: fkazumichi@affrc.go.jp

Keywords: dissolved organic carbon, nitrification, soil acidification, soil organic matter.

Abstract In Japanese cedar plantations, forest management strategies to minimize soil degradation including acidification need to be established. Both clear-cutting and stem girdling (removal of bark and phloem) have strong influences on organic matter cycling and these managements are hypothesized to increase soil acidification by the decreased plant uptake and increased nitrification. To evaluate the effects of clear-cutting or stem girdling on soil organic matter cycling and acidification processes, soil C budgets and proton budgets were analyzed for clearcut, girdling, and control treatments in a Japanese cedar plantation. The downward fluxes of nitrate leaching out of the soil profile were greatest in the clearcut treatment (4.7 N kg ha^{-1} yr^{-1}), compared to the girdling and control treatments (0.4 and 0.9 N kg ha^{-1} yr^{-1}, respectively). Soil acidification was mainly caused by cation plant uptake in control forest, whereas acidification was induced by net mineralization of soil organic N and subsequent nitrification in the clearcut soil. In girdling treatment, translocation of basic cations from canopy and organic layer to the mineral soil horizon contributed to soil alkalization. The processes of management-induced acidification are similar to the other reports, but their magnitude appeared to be small in Japanese cedar plantation at least within a few years after managements.

Introduction

In forest ecosystems, soil acidification is a natural process, accelerated by intensive forest management (e.g., clearcutting). In Japanese cedar plantations, forest management strategies to minimize soil degradation need to be established. Both clear-cutting and stem girdling (removal of bark and phloem) have strong influences on organic matter cycling and these managements are hypothesized to increase soil acidification due to the decreased plant uptake and increased nitrification.

Materials and methods

To evaluate the effects of clear-cutting or stem girdling on soil organic matter cycling and acidification processes, soil C budgets of heterotrophic respiration and C input and the dominant acidifying processes were analyzed for clearcut, girdling, and control treatments in a Japanese cedar plantation in Wakayama prefecture, Japan (MAT: 15.3°C, MAP: 2876 mm yr^{-1}). The proton budgets in soils were quantified by measuring fluxes of solute leaching and vegetation uptake (Fujii et al., 2012). The heterotrophic soil respiration was estimated by measuring CO_2 emission from the trenched soil with a closed-chamber method (Fujii et al., 2009). The fluxes of solute leaching were estimated by collecting soil solution with tension-free lysimeters (Fujii et al., 2008).

Results and discussion

The soil C budgets showed that the greater fluxes of heterotrophic soil respiration (3.1 to 3.5 t C ha^{-1} yr^{-1}), compared to C input, resulted in loss of soil organic matter in clearcut treatment. The heterotrophic soil respiration and litter input were almost balanced in control forest. In girdling treatment, the rates of heterotrophic soil respiration increased from the first year to the second year due to the increased soil moisture (Fig. 1). The high concentrations of nitrate in surface soil solution was observed after dry-wet cycles in clearcut and girdling treatment, whereas the peak was observed after litterfall in control forest soil (Fig. 1). The downward fluxes of nitrate leaching out of the soil profile were greatest in the clearcut treatment (4.7 N kg ha^{-1} yr^{-1}), compared to the girdling and control treatments (0.4 and 0.9 N kg ha^{-1} yr^{-1}, respectively). Soil acidification was caused by organic acid dissociation and cation plant uptake at moderate rate (2.4 $kmol_c$ ha^{-1} yr^{-1}) in control forest, whereas acidification was induced by net mineralization of soil organic N induced at lower rate (0.11 $kmol_c$ ha^{-1} yr^{-1}) in clearcut treatment. In girdling treatment, translocation of basic cations from canopy and organic layer to the mineral soil horizon was greater than proton generation by nitrification, which contributed to soil alkalization (0.1 to 0.6 kmolc ha^{-1} yr^{-1}). Proton budgets showed that, along with net removal of basic cations by timber harvesting, nitrification can increase soil acidification in clearcut forest soil. The processes of clearcutting-induced acidification are similar to the other reports, but the magnitude appeared to be small in Japanese cedar plantation at least within a few years after management.

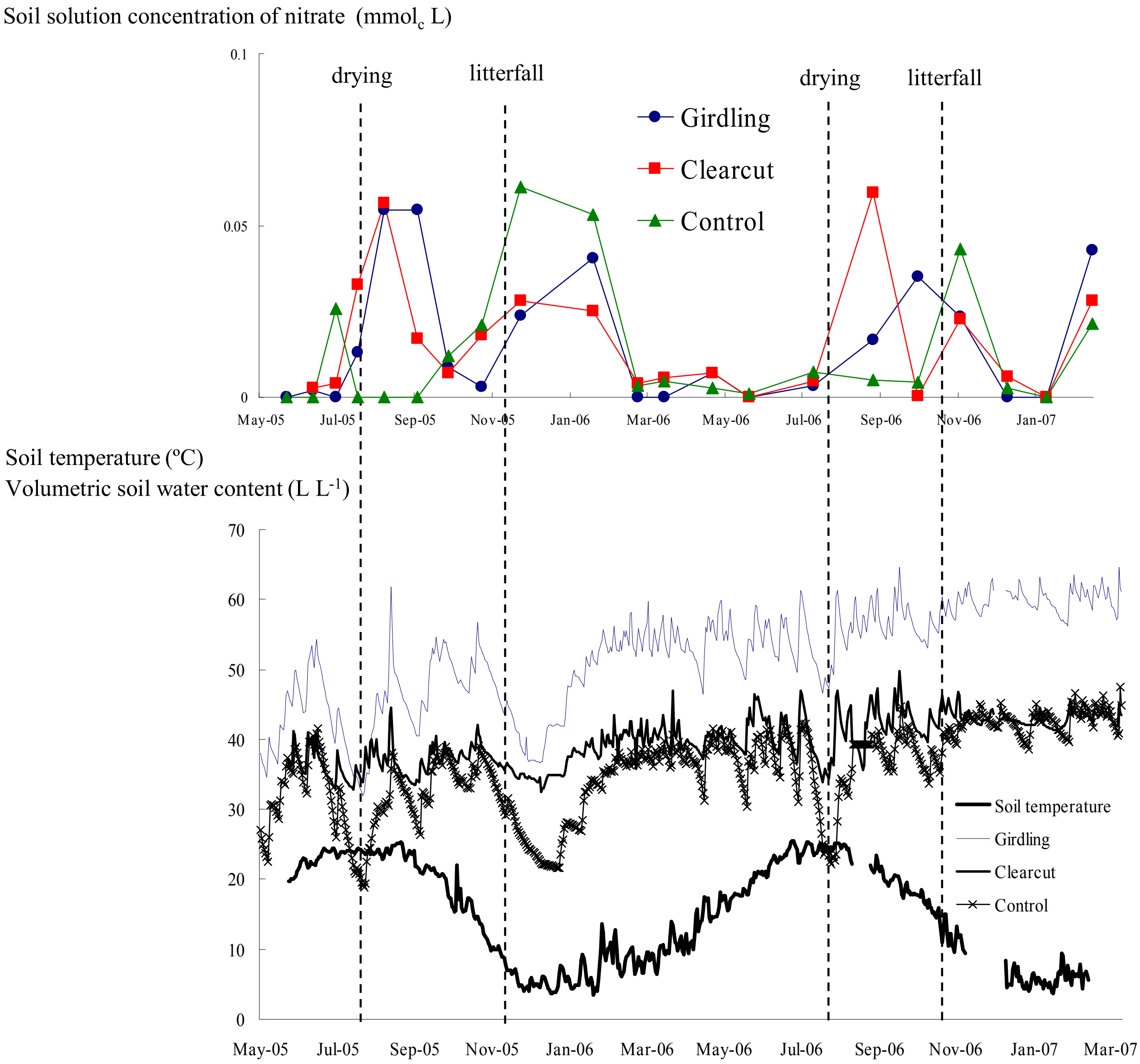

Fig. 1 Fluctuation of soil temperature, volumetric soil water content and nitrate concentrations of surface soil solution.

Conclusions

The C fluxes of organic matter cycling and proton budgets are drastically changed by forest managements within a few years. The clearcutting can increase organic matter decomposition and induce slow acidification of soils through mineralization of organic N and nitrification. The girdling results in decline of tree growth and soil alkalization through translocation of basic cations from canopy and organic layer to the mineral soil horizon. Both clear-cutting and stem girdling have strong influences on organic matter cycling and soil acidification in a Japanese cedar forest. The rates of soil acidification appeared to be low in Japanese cedar plantation at least within a few years after management. Quantification of proton budgets in the soils under different forest managements can be useful for improving the site-specific strategies of forest management.

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The Effects of N and P Addition on Soil Microbe and N Transformaitons in a Tropical Forest

Faming Wang[a,*], Jian Li , Bi Zou, Zhian Li.

[a] Key Laboratory of Vegetation Restoration and Management of Degraded Ecosystems, South China Botanical Garden, Chinese Academy of Sciences, Guangzhou 510160, PR China;

*Address correspondence to Zhian Li, Email: lizan@scbg.ac.cn; Phone: 0086-20-37252631; Fax: 0086-20-37252615

Keywords: Tropical Forest, N transformation, Soil Microbial community, N addition, P addition.

Introduction

Biogeochemical cycling of nitrogen (N) is greatly altered by anthropogenic activities, with global cycling rates estimated to have increased by approximately 100% since mid-1900s. Elevated nitrogen (N) deposition in humid tropical regions may exacerbate phosphorus (P) deficiency in forests on highly weathered soils. However, it is not clear how P availability affects soil microbes and soil N transformations, or how P processes interact with N deposition in tropical forests.

In this study, we examined the effects of N and P additions on soil microbes and soil N transformation in a restored tropical forest in 3 yrs. We hypotheses that 1) soil N transformation would be changed by nutrients addition; 2) N and P addition would change the composition of soil microbial community; 3) the changed soil microbial community would partly explain the variation of soil N transformation rates.

Materials and methods

In 2007, four treatments were established in five replicates each: Control, N-addition, P-addition, and NP-addition. Each of the 20 plots were 10 m * 10 m were established and surrounded by a 5-m wide buffer strip. Plots size and fertilizer level were similar to those in the experiment in Costa Rica by Cleveland and Townsend (2006). Field plots and treatments were laid out randomly. Applications of N and P were made as NH_4NO_3 and NaH_2PO_4 solutions sprayed in two monthly portions below the canopy with a backpack sprayer starting from September 2009 and continuing through December 2012. Fertilizer was weighed and mixed with 25 L of water for each plot. Each control plot received 25 L of water without fertilizer.

Soil sampling was conducted in August 2009 (No treatment applied), February 2011, Augeust 2011, June, 2012 and December 2012. Soil microbial community was measured by Phospholipid fatty acid (PLFA) analysis. Soil N transformation was measured by in situ methods described by Wang *et al.* (2010) Soil N_2O emission was measured from October 2010 to September 2012 with once a month.

Results and discussion

Although soil available N was greatly enhanced by nutrients addition, soil N transformation, including nitrification and N mineralization, was not significantly affected by N and P addition in the 4 yrs experiment. Soil PLFAs analysis found that in the first 3 yrs after N and P addition, soil microbial activities and composition did not greatly response to nutrients addition. However, in the last sampling in December, 2012, we found that P addition greatly enhanced soil total PLFAs, fungal PLFAs and bacterial PLFAs. N addition did not significantly affect soil PLFAs in any samplings in the 4 yrs. This result indicated that this restored tropical forest might be a P limiting ecosystem, and the response of soil microbe to P addition have a time lag. Contrary to other nutrient addition experiment, we did not observed any negative effects of N addition on soil microbes (Liu *et al.*, 2013) and also no effect of N addition on soil nitrification and N mineralization processes, which indicated that this site is not a N-P co-limiting or N-limiting ecosystem. In according with soil nitrification patterns, nutrients addition did not greatly changed N_2O emission.

Conclusions

Nutrients addition did not changed soil N transformation process in this tropical forest. But P addition greatly enhanced soil microbial activities, indicating P-limited ecosystem. We also found that the response of soil microbes to P addition have a time lag effect.

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The interreaction of N_2O and CH_4 fluxes from forest and grassland soils

Hui XU, Guan Xiong CHEN

Institute of Applied Ecology, Chinese Academy of Sciences, Shenyang 110016, China
Phone: +86 24 83970369; Fax: +86 24 83970300; E-mail: xuhui@iae.ac.cn

Keywords: Methane, Nitrous oxide, flux, Interrelation, soil

The methane (CH_4) and nitrous oxide (N_2O) are two important greenhouse gases next to CO_2. Their global warming potentials are 25 and 298 times than that of CO_2. Moreover, N_2O and CH_4 are two forms of N or C in their cycles. Soil microbial processes are involved in their emission/consumption from terrestrial ecosystems. In general, it is well known now that the nitrification/denitrification are contributors to N_2O emission. While, methanogenesis/methanotrophic oxidation are contributors to CH_4 emission/consumption. However, till now, there was no report on direct interrelation between the CH_4 and N_2O fluxes or between the soil microbial groups for CH_4 and N_2O emission/consumption.

In this study, the *In situ* measurements of CH_4 and N_2O fluxes were conducted at 2 sites of forest ecosystem and 1 site of grassland ecosystem. The forest experimental site I is located in a broadleaf-Korean pine mixed forest in Changbai Mountain Biosphere Reserve (42°24'N, 128°28'E), Jilin Province, China. The forest experiment site II is located in a beech-spruce mixed forest of Sorø (55°26'N, 11°30'E), Denmark. The grassland experiment site III (44°1'N, 123°1'E) is located in Jilin province, China. The flux measurements were conducted with the closed chamber method. Soil temperature, soil water content and soil available nitrogen were measured synchronously. SPSS software was used for statistical analysis of the correlations between N_2O and CH_4 fluxes and the environmental factors.

The results showed that there were both positive and negative relationships between the CH_4 and N_2O fluxes (Table 1). Two significant positive correlations between CH_4 flux and N_2O flux were found (Equation No. 3 & 4), while four significant negative correlations between CH_4 flux and N_2O flux were found (Equation No. 1, 2 & 6). At the same measuring period, correlations between N_2O flux and soil water content were also observed (Equation No. 5 and 7) in this study. The correlation between CH_4 flux and soil NH_4^+ concentration was also found.

The above correlations, not only existed between gases' fluxes, but also between gas' flux and soil water content, indicating that these correlations did not happen by coincidence. At the site III, a shift of correlation between CH_4 flux and N_2O flux from positive one in Spring/Autumn to negative one in Summer was observed.

Based on the *in situ* measurement of CH_4 and N_2O fluxes, this paper reported a novel phenomenon: There were interrelations between CH_4 and N_2O emission/consumption in forest and grassland soils. The correlations between fluxes of these two gases implied there was interaction among nitrification/denitrification and methanogenesis/methanotrophic oxidation. The results also implied that soil water content seemed to be one of the key controlling factors for this interreaction.

An interesting question for this interaction is: Why the correlation between N_2O flux and soil water content was changed from positive to negative? What is the controlling factor(s) for this shift or the underlying mechanism of this interreaction?

Table 1. The relationship between N_2O and CH_4 fluxes from forest and grassland soils.

No.	Correlation between N_2O and CH_4 fluxes	Period (day/month)
1	$\mathrm{Log}F_{N2O} = -0.742\ \mathrm{Log}F_{CH4} + 2.113$ ($r = -0.704$，$n = 13$，$P<0.01$)	June 1994 to Oct. 1995 at site I
2	$\mathrm{Log}F_{N2O} = -1.441\mathrm{Log}F_{CH4} + 1.595$ ($r = -0.722$，$n = 9$，$P<0.05$)	Oct. 1996 at site II
3	$\mathrm{Log}F_{N2O} = +0.899\ \mathrm{Log}F_{CH4} - 1.067$ ($r = 0.537$，$n = 38$，$P<0.001$)	August to Oct. 1996 at site II.
4	$E_{N2O} = +0.190\ F_{CH4} + 2.52$ ($r^2 = 0.604$, $n = 16$, Sig. $F= 0.004$)	May ~ July and Sept ~ Oct, 2004 at site III
5	$E_{N2O} = +0.759$ Water $- 1.848$ ($r^2 = 0.520$, $n = 16$, Sig. $F = 0.026$)	May ~ July and Sept ~ Oct, 2004 at site III
6	$E_{N2O} = -0.174\ F_{CH4} + 27.3$ ($r^2 = 0.581$, $n = 8$, Sig. $F= 0.028$)	July ~ Sept, 2004 at site III
7	$E_{N2O} = -3.177$ Water $+ 50.277$ ($r^2 = 0.306$, $n =9$, Sig. $F = 0.028$)	July ~ Sept, 2004 at site III

In the Table, F_{N2O} was N_2O flux ($\mu g N_2O\text{-}N \cdot m^{-2}h^{-1}$); F_{CH4} was CH_4flux ($\mu g CH_4\text{-}C \cdot m^{-2}h^{-1}$); Water was the soil water content (% w/w)

Patterns of $\delta^{15}N$ of Soil Available N along a Precipitation Gradient in Northern China Grassland

Dongwei Liu[1, 2], Yunting Fang[1*], Chao Wang[1, 2], Edith Bai[1], Ying Tu[1], Haiyan Ren[1], Xiaobo Wang[1]

[1]State Key Laboratory of Forest and Soil Ecology, Instituted of Applied Ecology, Chinese Academy of Sciences, Shenyang 110164, China；

[2]College of Sources and Environment, University of Chinese Academy of Sciences, Beijing, China

[*] Phone: +86-24-8397054; E-mail: fangyt@iae.ac.cn

Keywords: isotope, climate, nitrogen cycle, nitrogen availability, inorganic N, grassland

Abstract

The stable nitrogen isotope ($\delta^{15}N$) patterns of soil and leaf decrease with increasing mean annual precipitation (MAP) have been found both in regional and global scale. However, the mechanisms for these patterns are not clear. A potential mechanism is that nitrogen (N) losses relative to pool sizes are greater at drier sites and, because the N lost (via volatilization, denitrification, and leaching) is typically depleted in ^{15}N, this leads to ^{15}N-enrichment of soil and plants in the drier sites. If so, we expect to see that soil available N should be more enriched in ^{15}N in drier sites. The study aims to explore the regional pattern of $\delta^{15}N$ of soil available N (0-10cm) and their relationships with climate along an approximately 3300 km grassland transect in northern China. We hypothesized precipitation was the dominant factor to influence the soil N cycling and $\delta^{15}N$ of both nitrate (NO_3^-) and ammonium (NH_4^+) should decline with increasing precipitation. Results indicated that $\delta^{15}N$ of soil NO_3^- increased with the MAP increasing at the regions where MAP < 200mm, and declined with the MAP increasing at MAP > 200mm. The MAP accounted for 46.0% and 31.6% of the variation of the ^{15}N of soil NO_3^- values across the two distinguished regions, respectively. Nitrate concentration displayed a decreased trend with the MAP increasing, and the extremely higher soil NO_3^- concentration at sites with MAP < 100mm may be caused by atmospheric deposition, which in turn may change the pattern of soil $\delta^{15}N$ with MAP. The pattern of $\delta^{18}O$ of soil NO_3^- with MAP should be applied to confirm the uncertainty. Ammonium concentration initially exhibited increasing and then decreasing trend with MAP at the breakpoint of 200mm. The measurement for $\delta^{15}N$ of soil NH_4^+ is in progress.

Introduction

Nitrogen (N) isotope is popularly considered as an integrator of N cycling in terrestrial ecosystems (Amundson et al., 2003), and has potential to reveal spatial and temporal patterns of N cycling and the response of N cycle to disturbances at the ecosystem scale (Bai et al., 2013). A pattern of decreased soil and leaf $\delta^{15}N$ with increasing mean annual precipitation (MAP) at a global scale has been demonstrated for more two decades(Reference). However, the mechanism of this pattern has not been unraveled yet.

There is a potential explanation for the pattern of $\delta^{15}N$ of soil and leaf decreasing as MAP increasing is that N losses relative to pool sizes are greater at drier sites and, because the N lost (via volatilization, denitrification, and leaching) is typically depleted in ^{15}N, this leads to ^{15}N-enrichment of soil and plants in the drier sites. If this explanation is true, we expect that $\delta^{15}N$ of both nitrate and ammonium will decline with the precipitation increasing. To test our expectation, we chose Chinese Northern Grassland as the survey objective, which is typical grassland transect changing with precipitation amount, to explore the regional pattern of ^{15}N abundance of soil available N along an approximately 3300 km Grassland transect and their relationships with climate. As the research is ongoing, here we show the preliminary results.

Materials and methods

Soil samples were obtained from 36 sites along a 3300km west-east transect (39.9-50.1°N, 87.4-120.5°E), extending from Wushitala in Xinjiang province to Eerguna in Inner Mongolian (Fig. 1). This transect covered a MAP gradient from 30 to 500mm, and MAT gradient from -5 to 10℃. Vegetation types of this transect were mainly desert grassland, typical steppe grassland and meadow grassland from west to east. Sampling was preformed from July to August in 2012. Soil samples at each site were obtained from five 1 m×1m plots in a 50 m×50m quarter. There were total 180 soil samples along the whole transect.10g fresh soil sample was extracted with 2M KCl solution (KCL: soil=5:1) on the day. Chemical methods for soil inorganic nitrogen were: colorimetric method based on diazotization-coupling reaction for NO_3^-, indophenol method for NH_4^+, and persulfate oxidation followed by colorimetry for DON. The $\delta^{15}N$ of NO_3^- was analyzed by using the (VCl_3+NaN_3) method. The $\delta^{15}N$ of NH_4^+ was determined by hypobromite oxidation followed by sodium azide reduction. Persulfate oxidationof total dissolved N to NO_3^- in 2 M KCl soil extraction coupled with the (VCl_3+NaN_3) method allowed successful analysis of DON.

Results

The nitrate $\delta^{15}N$ values of 0-10cm soil was significantly correlated with MAP (Fig. 2), indicating that MAP is an important determinant of ecosystem $\delta^{15}N$. The relationship between MAP and nitrate $\delta^{15}N$ for the MAP less than 200mm was different from MAP more than 200mm. Soil nitrate $\delta^{15}N$ values increased with MAP in which was less than 200mm while decreased with MAP in which was more than 200mm. Along the whole west-east transect, soil nitrate $\delta^{15}N$ values at the 0-10cm changed from 1.6‰ to 13.3‰. Soil nitrate $\delta^{15}N$ values in the MAP more than 200mm varied the same as the whole transect, and the correlation between MAP and soil nitrate $\delta^{15}N$ values accounted for 46.0% of total variation. The trend of nitrate $\delta^{15}N$ with MAP was similar to soil $\delta^{15}N$. The regression slope of nitrate $\delta^{15}N$ at MAP >200mm was much higher than the slope value of soil $\delta^{15}N$ (0.052 versus 0.014). On the part of MAP<200mm, the regression slope of nitrate was lower than the slope value of soil $\delta^{15}N$ (-0.026 versus -0.010). This results suggested that nitrate $\delta^{15}N$ was more sensitive to MAP at <200mm region than soil $\delta^{15}N$. In terms of ^{15}N of soil nitrate, the results for the region with MAP of > 200 mm support our expectation that ^{15}N of soil available N decreases with increasing MAP. However, the results for the region with MAP < 200 mm show an opposite pattern, which we propose that increased nitrate deposition at the dry end of transect may contribute the low ^{15}N of bulk soil and soil nitrate, but it requires further confirm.

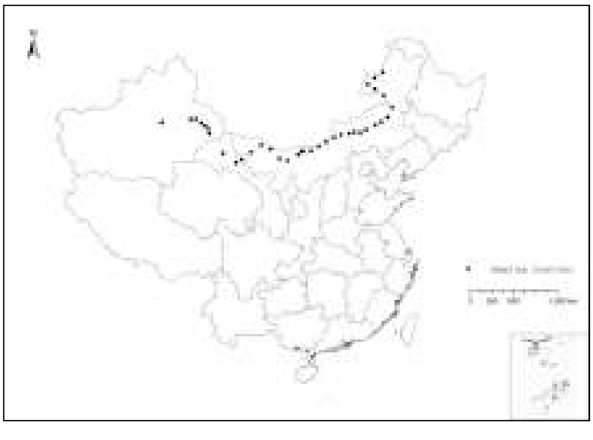

Fig. 1 A 3300km long west-east transect in the northern China, extending from Wushitala in Xinjiang province to Eerguna in Inner Mongolian. A total of 36 sites (black filled cycles) were chose along the transect.

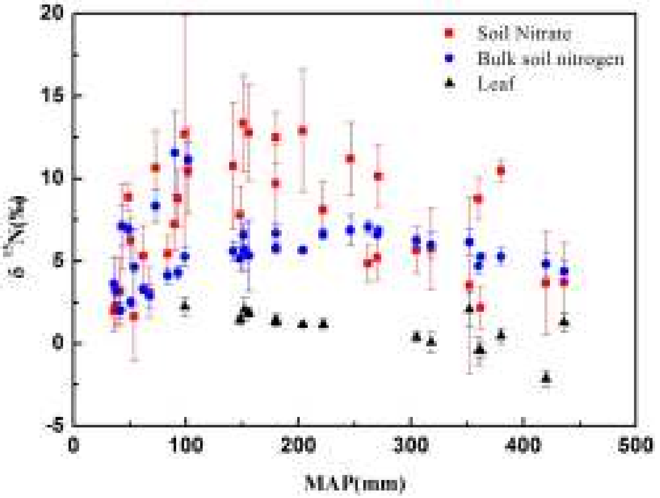

Fig. 2 Relationship between MAP and site averagedδ^{15}N values (‰) of NO_3^-, bulk soil N and leaf. Error bars are ±SD

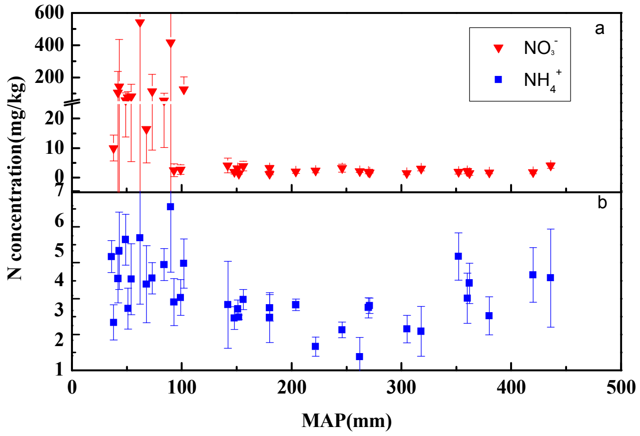

Fig. 3 Relationship between MAP and site averaged N concentration (mg/kg). Error bars are ±SD.

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Spatial and temporal controls of *in situ* soil N transformations in subtropical forest ecosystems in south China

Chen Xi Yun & Jan Mulder

Abstract

Eastern Asia, China in particular, is becoming the third hot spot of atmospheric N deposition. So far, little is known about the N dynamics and the response to increasing N deposition in subtropical forest ecosystems in China with elevated atmospheric N deposition rates. Here, we present *in situ* net N transformation rates from May 2002 to May 2003 in two selected subtropical forests (TSP and CJT) in South China. Annual *in situ* net N mineralization rates in the upper 15 cm of soil ranged from 0.22-0.85 mg N kg-1 soil day-1, 68% of the mineralized N nitrified. The seasonal variation of *in situ* net N transformation rates has been related to the seasonality of soil temperature and soil water potential with warm and wet summer and greatest N mineralization rate. Whereas, the spatial variation of *in situ* net N transformation rates correlates significantly with substrate factors. Meanwhile, soil NH4+-N availability is a limiting factor for annual averaged mineralization and nitrification rates. With principal component analysis, the variables of climate and soil property are synthesized into substrate index and micro-environmental index. Regression of PC scores on annual average net N mineralization rates confirms that the substrate index dominantly responsible for spatial variation of N mineralization. The difference in controls of the temporal and spatial variation of net N transformation rates is related to differences of spatial and temporal scales included in the datasets analyzed, being the inter-annual variations at plot scale for the spatial variation series but annual variations at site scale for the temporal variation series. This highlights the importance of the suitable combination of the scale of time and space for the interpretation of the controls on *in situ* N transformation rates. Principal component analysis (PCA) can be used as a data-fusion method to integrate the multi-variant measurements from the field. Combing PCA and multi-regression analysis may allow assessment of the relative importance of micro-environmental and substrate factors on controlling of N transformation rates.

Modeled effects of climate change on soil N_2O emission in broad-leaved Korean pine mixed forest, ChangBai Mountain

Weiwei Dai*, Edith Bai
State Key Laboratory of Forest and Soil Ecology, Institute of Applied Ecology, Chinese Academy of Sciences, Shenyang, 110164, China
Phone: +86-24-83970572; E-mail: daiweiwei@iae.ac.cn

Keywords: Climate change, DayCent**,** denitrification, nitrification, soil N_2O emission

Abstract Soil-emitted N_2O contributes to two-thirds of global N_2O emissions, and is sensitive to climate change. We used DayCent model to project soil N_2O emissions in broad-leaved Korean pine mixed forest, ChangBai Mountain under various climate change scenarios. Results indicated that N deposition is the dominant stimulant for soil N_2O emission, warming and increased precipitation increase soil N_2O emission to a lesser degree, while doubled atmospheric CO_2 concentration decreases soil N_2O emission. Our results also showed that increased temperature and precipitation together have the largest positive interactive effect on soil N_2O emission while simultaneously increasing N deposition and atmospheric CO_2 concentration gives the largest negative interactive effect. Uncertainty about the effect of climate change on soil C-N cycling still exists, and long-term field experiments are needed to fill these knowledge gaps and to help improve model projections.

Introduction

Soil-emitted N_2O, mainly from nitrification and denitrification, contributes to approximately two-thirds of global N_2O emissions (Thomson et al. 2012), and is sensitive to climate change (Brown et al. 2012). Climate change affects soil N_2O emissions by modifying the biological and non-biological conditions that control nitrification and denitrification. We used a process-based biogeochemical model, DayCent, to project soil N_2O emissions in broad-leaved Korean pine mixed forest, ChangBai Mountain under various climate change scenarios.

Materials and methods

The study site locates in northeastern China (127°38'E, 41°42'N), and is characterized by a typical temperate climate. Mean annual temperature is 2.1°C and mean annual precipitation is 745 mm. The broad-leaved Korean pine forest is the dominant forest type in northeastern China. ChangBai Mountain is an active volcano, with the last large-scale eruption dated to around 1215 a.

Daily climate data from 1958 to 2012 were used as the input. The model was run from 1243 to 2012 under ambient climate conditions, and different climate changes were simulated from 2013 to 2100. In addition to the ambient climate condition (control), the following projected climate changes (Galloway et al. 2004, IPCC 2007) as well as their complete combinations (treatment) were simulated in DayCent: (1) annual precipitation gradually increase 9%, denoted as P; (2) atmospheric CO_2 concentration gradually increase from 350 p.p.m. to 700 p.p.m., denoted as C; (3) both daily maximum and minimum temperatures gradually increase 3℃, denoted as T; and (4) the N deposition gradually increase from current level of 23 kg N/ha/yr to 50 kg N/ha/yr, denoted as N. The model was calibrated using monitored net primary production (NPP), net ecosystem exchange (NEE), heterotrophic respiration, soil water content, soil NO_3^- and NH_4^+ concentration, and soil N_2O emissions.

Data Analysis

For each scenario, annual soil N_2O emissions from 2091 to 2100 were averaged and used for subsequent analysis. The percent change was calculated as $100\% \times (N_2O_{Treatment} - N_2O_{Control}) / N_2O_{Control}$. For a single climate factor, its effect is calculated as $N_2O_{Treatment}$ - $N_2O_{Control}$, and the interactive effect of multiple factors is calculated in the way as follows: interactive effect of T×P =($N_2O_{T\times P}$ - $N_2O_{Control}$) – (N_2O_T - $N_2O_{Control}$) – (N_2O_P - $N_2O_{Control}$).

Results and discussion

DayCent projects that from 2091 to 2100 the average soil N_2O emission is 1972.17 g N/ha/yr under ambient climate condition. Among the simulated four climate change factors, N deposition is the dominant stimulant for soil N_2O emission (+61.54%), warming (+11.70%) and increased precipitation (+6.66%) increase soil N_2O emission to a lesser degree, while doubled atmospheric CO_2 concentration decreases soil N_2O emission (-13.98%). Soil N_2O emission is predicted to increase under most climate change scenarios except for scenarios of C (-13.98%), P×C (-6.06%), and T×C (-0.02%). Our results also showed that increased temperature and precipitation together have the largest positive interactive effect on soil N_2O emission (78.42 g N/ha/yr) while simultaneously increasing N deposition and atmospheric CO_2 concentration gives the largest negative interactive effect (-117.53 g N/ha/yr).

As modeled in DayCent, N_2O from nitrification is a function of soil NH_4^+ concentration, water-filled pore space (WFPS), temperature, pH, and texture, while N_2O from denitrification is a function of soil NO_3^- concentration, WFPS, heterotrophic respiration, and texture (Parton et al. 2001). N addition increases soil NH_4^+ and NO_3^- concentration (Lu et al. 2011), and stimulates both nitrification and denitrification. Elevated atmospheric CO_2 concentration may reduce soil inorganic N concentration by accumulating more N in plant biomass (Luo et al. 2004). On the other hand, it usually increases soil moisture and labile C input (Dijkstra et al. 2012), which may stimulate denitrification. Warming increases N mineralization and nitrification by increasing microbial activity. However, decreased soil moisture associated with warming may have positive and negative effects on nitrification and denitrification (Bai et al. 2013). Increased precipitation may increase soil moisture and WFPS, and it may also increase soil NO_3^- loss via leaching. Given the many controlling factors in soil N_2O production, uncertainty still exists regarding the direction and the degree to which climate factor(s) affect soil N_2O emission.

Conclusions

Climate change alters soil N_2O emission by impacting its controlling factors. Our modeling results indicate that increased N deposition would greatly stimulate soil N_2O emission, while elevated atmospheric CO_2 concentration may depress this effect. Uncertainty about the effect of climate change on soil C-N cycling still exists, and long-term field experiments are needed to fill these knowledge gaps and to help improve model projections.

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A modified ingrowth core method for measuring fine root production, mortality and decomposition in forests

Author: Xuefeng Li
Address: 72 Wenhua Road, Shenyang City, China; Postal code: 110016
Affiliation: Institute of Applied Ecology, Chinese Academy of Sciences
E-mail: lisnowmount@163.com
Tel: 0086-024-83970443; Fax: 0086-024-83970300

Summary The ingrowth core method is widely used to assess fine root (diameter < 2mm) production but has many inherent deficiencies. In this study, we modified this method by adopting mini ingrowth cores (diameter 1.2cm), extending sample intervals to a growing season, and developing new models to quantify the concurrent production, mortality and decomposition, and applied them to a secondary Mongolian oak (*Quercus mongolica*) forest. Annual fine root production, mortality and decomposition estimated by our method were 2.10±0.23 t ha^{-1}, 1.78±0.20 t ha^{-1} and 0.85±0.13 t ha^{-1}, respectively, and 33.3% of the production was decomposed in growing season. The production estimate using our method was significantly higher than those using two long-term ingrowth core (sample interval > 2 months) methods. However, it was significantly lower than that using the short-term ingrowth core (sample interval < 2 months) method, presumably due to the lower root competition and less decomposition occurring in the short-term cores. The fine root estimates using our method in the growing season were generally higher than those using the forward and continuous inflow methods but lower than those using the backward method proposed by Osawa and Aizawa (2012). Our method reduces the disturbances in roots and soil, minimizes the sampling frequency, and improves the quantification of fine root decomposition during the sample intervals. These modifications overcome the limitations associated with the previous ingrowth core methods. Our method provides an improved alternative for estimating fine root production, mortality and decomposition.

Key words**:** ingrowth core; fine root; production; mortality; decomposition

Net fluxes of ammonium and nitrate in association with H^+ fluxes in fine roots of *Populus popularis*

Jie Luo [1], Jingjing Qin [1], Fangfang He [1], Hong Li [2], Zhi-Bin Luo [1, 3*]

[1] College of Life Sciences, Northwest Agriculture & Forestry University, Yangling, Shaanxi, 712100, P. R. China
[2] Key Laboratory of Applied Entomology, College of Plant Protection, Northwest Agriculture & Forestry University, Yangling, Shaanxi, 712100, P. R. China
[3] Key Laboratory of Environment and Ecology in Western China of Ministry of Education，College of Forestry, Northwest Agriculture & Forestry University, Yangling, Shaanxi, 712100, P. R. China
Fax: +86-29 87092262, e-mail: luozbbill@163.com

Keywords: Efflux • Fertilizer • Influx • Ion uptake • Poplar • Proton

Poplar plants are cultivated as woody crops, which are often fertilized by addition of ammonium (NH_4^+) and/or nitrate (NO_3^-) to improve yields. However, little is known about net NH_4^+/NO_3^- fluxes and their relation with H^+ fluxes in poplar roots. In this study, net NH_4^+/NO_3^- fluxes in association with H^+ fluxes were measured non-invasively by using scanning ion-selective electrode technique in fine roots of *Populus popularis*. Spatial variability of NH_4^+ and NO_3^- fluxes was found along root tips of *P. popularis*. The maximal net uptake of NH_4^+ and NO_3^- occurred, respectively, at 10 and 15 mm from poplar root tips. Net NH_4^+ uptake was induced by ca. 48% with provision of NO_3^- together, but net NO_3^- uptake was inhibited by ca. 39% with the presence of NH_4^+ in poplar roots. Furthermore, inactivation of plasma membrane (PM) H^+-ATPases by orthovanadate markedly inhibited net NH_4^+/NO_3^- uptake and even led to net NH_4^+ release with NO_3^- co-provision. Linear correlations were observed between net NH_4^+/NO_3^- and H^+ fluxes in poplar roots except that no correlation was found between net NH_4^+ and H^+ fluxes in roots exposed to NH_4Cl and 0 mM vanadate. These results indicate that root tips play a key role in NH_4^+/NO_3^- uptake and that net NH_4^+/NO_3^- fluxes and the interaction of net fluxes of both ions are tightly associated with H^+ fluxes in poplar roots.

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Accumulated glomalin soil-related protein under elevated CO_2 and nitrogen deposition enhance soil carbon stock

Zhang Jing[a,b] Tang Xuli[a]* Liu Juxiu[a] Tong Lin[a,b]

[a]South China Botanical Garden, Chinese Academy of Sciences, Guangzhou 510650; [b] University of Chinese Academy of Sciences, Beijing 100049

*Phone: 15626262507; E-mail: xltang@scib.ac.cn zhangj@scib.ac.cn

Keywords: elevated CO_2, N deposition, glomalin soil-related protein, Soil organic carbon

Abstract

Introduction: Symbiotic arbuscular mycorrhizal fungi (AMF) produce a recalcitrant AM-specific glycoprotein, glomalin-related soil protein (GRSP, Wright & Upadyaya 1996), which can improve soil structure(Comis 2002), fix heavy metal in soils(Cornejo 2008), and proven to be a substantial contributor to soil carbon(Comis 2002;Lovelock 2004). In this study, GRSP and SOC were measured in modeled ecosystem under CO_2 enrichment and nitrogen deposition with the respect to access potential influence of environmental change on GRSP and soil carbon. Based on previous studies we hypothesized that (1)Elevated atmospheric CO_2 promoted plant growth and increased biomass allocation to belowground (Zhao et al 2012), carbon allocated to mycorrhizal fungi will linearly increased with increasing belowground carbon allocation (Hobbie 2006), therefore, AMF growth may facilitated with CO_2 enrichment, as the unique product of AMF, GRSP will increase under elevated CO_2. (2) N addition stimulated aboveground biomass accumulation, with decreasing root: shoot ratio (Duan et al 2009), suggested that AMF growth restrained with extra nitrogen fertilization and accordingly decrease GRSP stock. (3) GRSP has no significant change to high CO_2 and N deposition in the N restriction area (Maria et al 2008). But high N deposition in our study site leads to higher N availability (Ren et al 2000; Mo 2006), suggested that it's non-essential to develop too much AM to obtain available N in our study site plant, so GRSP stock will decrease.

Materials and methods

The experiment was carried out in ten open-top chambers. Each cylindrical chamber had a diameter of 3 m, a 3-m high above-ground section and a 0.7-m belowground section. The open chambers were located in an open space where they all were exposed to full light and rain. Chambers were exposed to different treatments since April 2005, including three replications under high CO_2 and high N treatment (CN), three chambers under high CO_2 treatment (CC), two chambers with high N treatment (NN), and two chambers as control (CK) under ambient CO_2 and N deposition. The high CO_2 treatments were achieved by supplying additional CO_2 from a tank until a concentration of ca. 700 ppm CO_2 was reached in the chambers. The high N addition treatments were achieved by spraying NH_4NO_3 weekly with total amount of at 100 kg N ha^{-1}year^{-1}. No other fertilizer was used. All the chambers were planted with 48 randomly located labeled seedlings with eight seedlings for six native species, and the most widely spread tree species in southern China. After 5years treatment, soil samples were collected in January, 2010. Glomalin extractions were conducted as described by Wright & Updahyaya (1996).

Results

1 Mean level of easily extractable GRSP (EE-GRSP) and total GRSP(T-GRSP) in the top 10cm were 0.74±0.097 mg·cm^{-3}(0.3515t C ha^{-1}) and 1.32±0.16 mg·cm^{-3} (0.627t C ha^{-1}), accounting for approximately 3.0% and 5.6% of SOC, respectively.

2 In CN, CC and NN treatment, the contents of EE-GRSP were 0.80±0.038, 0.71±0.11, 0.86±0.12 mg·cm^{-3}, is 1.07,0.95,1.16 times more than CK, respectively. And T-GRSP were 1.54±0.20, 1.78±0.30, 1.72±0.26 mg·cm^{-3}, increasing 16.7%, 35.0% and30.0%, respectively, compared to CK.

3 EE-GRSP account for 3.12%,2.24% and 2.74% of SOC, and T-GRSP achieved 5.97%， 5.71% and 5.45%, respectively in the CN,CC and NN treatment. In the CC treatment, EE-GRSP/SOC significantly lower than CK ($p=0.001$), but there were no statistical differences between T-GRSP/SOC.

4 In CN,CC and NN treatments, EE-GRSP/T-GRSP were 52.54%， 40.22%， 50.51%,respectively.They all lower than CK (CK=56.72%).The ratio of EE-GRSP to T-GRSP derived from CC treatment was significantly lower than that from CK. Above results suggested that CO_2 enrichment and N addition accumulate T-GRSP in subtropical forest ecosystem.

Conclusion

Elevated atmospheric CO_2 and increasing N deposition increased T-GRSP in subtropical forest ecosystem. Compared to CK, EE-GRSP and T-GRSP were increased accordingly under all treatments, expect for under CC treatment which was found EE-GRSP decreased with increasing T-GRSP. Our results indicated that regional environmental changes as CO_2 enrichment and N deposition accumulate GRSP and consequently enhance soil carbon sequestration in subtropical forest ecosystem. Linear relationship between T-GRSP and SOC found in this study also suggested that T-GRSP is an indicator for SOC dynamics under influence of environmental changes.

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Direct relationship between stream nitrate concentration and nitrogen leaching in forest areas in the central part of Japan

Hideshige Toda, Yuko Noritake, and Takashi Kunito
Faculty of Science, Shinshu University, Matsumoto, Nagano 3908621, Japan
Phone: +81-263-37-2460; Fax: +81-263-37-2460; E-mail: h-toda@shinshu-u.ac.jp

Keywords: nitrate concentration, nitogen leaching, forest area, central part of Japan

Abstract Nitrogen leaching rates, potential N mineralization rates, and C and N contents in leaf litters and surface soils were analyzed in 8 forest watersheds (west of Tokyo) with different nitrate concentration in their streams. Nitrate concentration in the stream waters ranged from 0.1 to 1.4 mg N/L. There is a significant positive relationship between nitrogen leaching rates measured by using ion exchange resin bags buried at 40cm depth and stream nitrate concentrations. The potential N mineralization rates significantly negatively correlated with C/N ratio in surface soils, and positively correlated with N leaching rates. Active nitrogen mineralization might cause larger nitrogen leaching, resulting in higher nitrate concentration in stream waters in some forest areas in Japan.

Introduction

Extensive survey (1278 points) on forest streams throughout Japan in 2003 revealed that nitrate concentration is high in the streams close to urban and industrial area (Konohira et al. 2006), and that there is a significant positive relationship between the nitrate concentration in streams and nitrogen deposition around the streams (Shindo et al. 2005). Long-term nitrogen deposition might lead to nitrogen saturation in some forest areas in Japan. Direct relationship between nitrogen deposition and nitrogen leaching, however, remained unclear in those Japanese forests. We studied the relationship between nitrogen leaching and nitrate concentration of streams in several forest areas in the central part of Japan (50-200 km west of Tokyo).

Materials and methods

Water, leaf litter, and soil samples were collected in forest areas with no human activities on the ground in 2008. Nitrate concentration was measured by an ion chromatography (DIONEX, DX-120), and CN contents by an element analyzer (Thermo Electron, Flash EA 1112). Potential N mineralization rate was determined by an incubation method under waterlogged condition at 40 C during 7 days (Keeney, 1982). Nitrogen leaching rate was measured by using an ion exchange resin (Organo, Amberlite MB-1). The resin bags were buried at 40 cm depth below the ground during 6 months from May to November (exchanged once in August) in 2008. Nitrate and ammonium ions absorbed by resin were extracted by using 1 M KCl, and measured by colorimetrically after neutralization by NaOH addition.

Results and discussion

Nitrate concentration in the streams ranged from 0.1 to 1.4 mg N/L with little seasonal change between May and November. Nitrogen leaching rate during 6 months ranged from 3.3 to 9.9 kg N/ha/6months with larger rates in the first half of the study period (spring-summer>autumn, Fig. 1). There is a significant positive relationship between the stream nitrate concentration and the nitrogen leaching rates close to the streams (r^2=0.71, p=0.009). The C/N ratio of leaf litter ranged from 24.6 to 34.7 in summer and from 37.0 to 75.1 in autumn. The ratio of surface soil was between 12.8 and 23.1 in summer and between 13.3 and 22.8 in autumn. The potential N mineralization rate ranged from 0.3 to 16.2 microgram N/g dry soil/day, and significantly negatively correlated with C/N ratio in surface soil (r^2=0.61, p=0.022). There is a positive relationship between the potential N mineralization rate and N leaching rate except for one forest area (r^2=0.90, p=0.001).

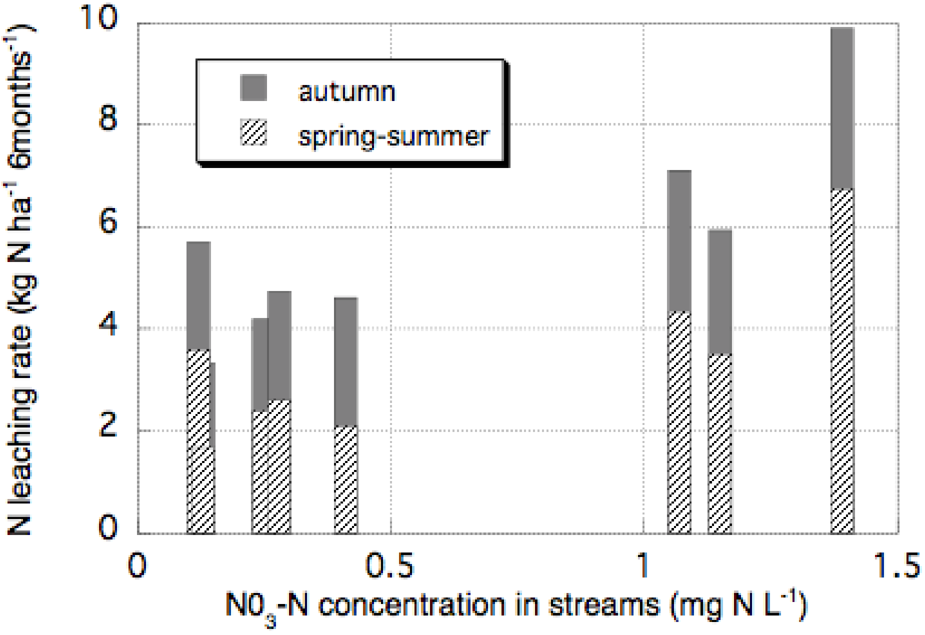

Fig. 1 Relationship between N leaching rate and stream nitrate concentration in several Japanese forests.

Conclusions

Long-term nitrogen deposition might stimulate nitrogen mineralization in surface soil and increase nitrogen leaching, resulting in increase in nitrate concentration of streams in some forest areas in Japan.

Acknowledgment

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Patterns of tree-ring δ^{15}N are species- and age-specific

Yuan-wen Kuang[a,*], **Jiong Li**[a], **Yun-ting Fang**[b], **Ying Tu**[b]
[a] South China Botanical Garden, Chinese Academy of Sciences, Guangzhou, 510650, China; [b] Institute of Applied Ecology, Chinese Academy of Sciences, Shenyang, 110016, China
[*] Phone: +86 20 37082092; Fax: +86 20 37252615; E-mail: kuangyw@scbg.ac.cn

Keywords: N isotopic composition, Tree age, Tree-ring, Tree species.

Abstract Tree-ring δ^{15}N has been frequently used to reveal the historical emissions of anthropogenic N, the changes in forest N cycle and in plant N availability. The homogeneities of tree-ring δ^{15}N, which were of the most importance in above research, among different aged tree species from the same and different sites were seldom concerned up to date. In this study, the patterns of tree-ring δ^{15}N over time in southern China were used to test whether they were species and age dependent. At the same sampling site, tree-ring δ^{15}N progressively increased against the time for *Cinnamomun camphora,* a broadleaf species, with positive values, while progressively decreased for *Pinus massoniana*, a coniferous species, with many negative values. Contrast patterns of tree-ring δ^{15}N between two species from the same site suggested they may use different soil N sources. Within the same species, tree-ring δ^{15}N in *Pinus kwangtungensis* (also coniferous) patterned heterogeneously in different aged trees. In the older tree, tree-ring δ^{15}N were negatively fluctuated against the time. In the younger one, however, tree-ring δ^{15}N increased progressively with positive values. At the different sites, the same tree species (*Pinus massoniana*) presented the similar tree-ring δ^{15}N patterns significantly decreasing over the time. Our results in the present study demonstrated that patterns of tree-ring δ^{15}N are species- and age-specific. Thus in the future, the species- and age-depended tree-ring δ^{15}N should be carefully taken into consideration in the stable dendro-isotopic chronology research.

Introduction

Tree-ring δ^{15}N has been frequently used in the fields of forest ecology, dendrochronology, and environmental sciences. Based on a fertilization treatment experiment of trees in 80-year-old beech (*Fagus sylvatica* L.) stands that N addition increased tree-ring δ^{15}N, while unfertilized trees displayed a decreasing δ^{15}N trend with time, researchers concluded that N addition to forest ecosystems could be traced back in tree-ring δ^{15}N and suggested that wood N isotope analysis was a promising tool for studying the long-term effects of N deposition on forests (Elhani et al. 2005). However, even in a same question elucidation, temporal trends of tree-ring δ^{15}N were reported non-coinciding. For example, in the research of forest N availability using tree-ring δ^{15}N, McLauchlan et al. (2007) demonstrated, based on the declining trends of tree-ring δ^{15}N from 22 trees in a northeastern forest at White Mountains, that N availability declined over the past 75 years. Recently, McLauchlan and Craine (2012) found tree-ring δ^{15}N increased steadily in a hardwood tree while declined in other hardwood trees in Indianan hardwood forests of USA over the same period. They concluded that have been little change in N availability for these forests despite high levels of N deposition in the region. In other environmental change research, researchers inferred that the coherent decreasing trends of tree-ring δ^{15}N among different tree species (red pine trees*,* see Choi et al. 2005*;* see Bukata and Kyser 2007; pine and beech trees, see Savard et al. 2009; red spruce trees*,* see Doucet et al. 2012) that temporal trends in tree-ring nitrogen isotopic compositions reflected the changes in ecosystem nitrogen sources or cycles and could be used to study past changes. Unlike most of the decreasing trends of tree-ring δ^{15}N, Hietz et al. (2010) reported the significant increase of tree-ring δ^{15}N in Spanish cedar (*Cedrela odorata*) and big-leaf mahogany (*Swietenia macrophylla*) during the past century from a remote and pristine tropical rainforest in Brazil. They concluded that the δ^{15}N increase in rain forest was unlikely to be a direct signal of changed N deposition. Therefore, the homogeneities of tree-ring $\delta^{15}N$ within or among tree species from different/same region(s) are of the most importance in stable dendroisotope research. Up to date, this kind of comparison has little been concerned. In this study, we detected the patterns of tree-ring $\delta^{15}N$ among different aged tree species from the same and different sites and tested their coherence to determine the impacts of species, age and growing site on tree-ring $\delta^{15}N$.

Materials and methods

Tree-rings for dendro-isotopic chronology analysis were sampled from three different sites of south China. Disc of one Camphor tree (*Cinnamomum camphora growing from 1940 to 2004*) and one Masson pine tree (*Pinus massoniana growing from 1980 to 2010*) were collected from Dinghushan, Zhaoqing of Guangdong. Two Kwangtung pine trees (*Pinus kwangtungesis growing from 1885 to 2005 and 1980 to 2010, respectively*) were collected from Nanling, Shaoguan of Guangdong. Another Masson pine tree growing from 1870 to 2005 was sampled from Yongfeng of Jiangxi.

After careful dating, xylem of those tree-rings was split out in sequence from the pith to the outer part along four radii with an electric micro-chisel. All the increments were dried at 65℃ and ground. The nitrogen isotopic composition of the woody tissues was analyzed by taking an approximate amount of 25-30 mg in tin capsules using an isotope ratio mass spectrometer (Isoprime 100) coupled to an elemental analyzer (Elementar vario MICRO cube).

Results and discussion

Among all the tree-rings, contents of N in the sapwood were commonly higher than those in the heartwood. The elevation of N content in sapwood was due to the N translocation when the heartwood dead.

Unlike the N patterns in the tree-rings, values of $\delta^{15}N$ were dis-coherent inter tree-rings and inter species. At the same sampling site (Dinghushan), tree-ring $\delta^{15}N$ progressively increased against the time for *Cinnamomun camphora* with positive values, while progressively decreased for *Pinus massoniana* with many negative values. At different sites, the same tree species (*P. massoniana*) presented the similar tree-ring $\delta^{15}N$ patterns significantly decreasing over the time. Within the same species from the same site (Nanling), tree-ring $\delta^{15}N$ in *P. kwangtungensis* patterned heterogeneously in different aged trees. In the older tree, tree-ring $\delta^{15}N$ were negatively fluctuated against the time. In the younger one, however, tree-ring $\delta^{15}N$ increased progressively with positive values.

Although the selected sites in this study exposed very high level of atmospheric N deposition during the past decades, the influence of N deposition was not coherently reflected in the tree-rings, especially those from the same site. Variations of tree-ring $\delta^{15}N$ trends could by influenced by many factors. Internally, the translocations of N from heartwood to sapwood, specific nitrogen-bearing compounds in tree tissues, the effect of tree age on physiology and the uptake of (NH_4^+-N or NO_x^--N) by roots might contribute to the non-coinciding trends of tree-ring $\delta^{15}N$. Externally, the climate, relative rates of soil N transformations (immobilization, ammonification, and nitrification), the amounts and $\delta^{15}N$ values of soil N, mycorrhizal activities could also lead to the different long-term trends of tree-ring $\delta^{15}N$. The changes might indicate a more open N cycle of trees (Hietz et al. 2010). The species-specific trends of tree-ring $\delta^{15}N$ suggested changes in the partitioning of ammonium and nitrate among species, in nitrification ^{15}N rates, and/or offsetting changes in the dependence of species on mycorrhizal fungi (McLauchlan and Craine 2012).

Conclusions

Results in the present study confirmed that patterns of tree-ring δ^{15}N are species- and age-specific, which will be of great importance for using tree-ring δ^{15}N signal as a reliable indicator. In the future, the species- and age-depended tree-ring δ^{15}N should be carefully taken into consideration in the stable dendro-isotopic chronology research.

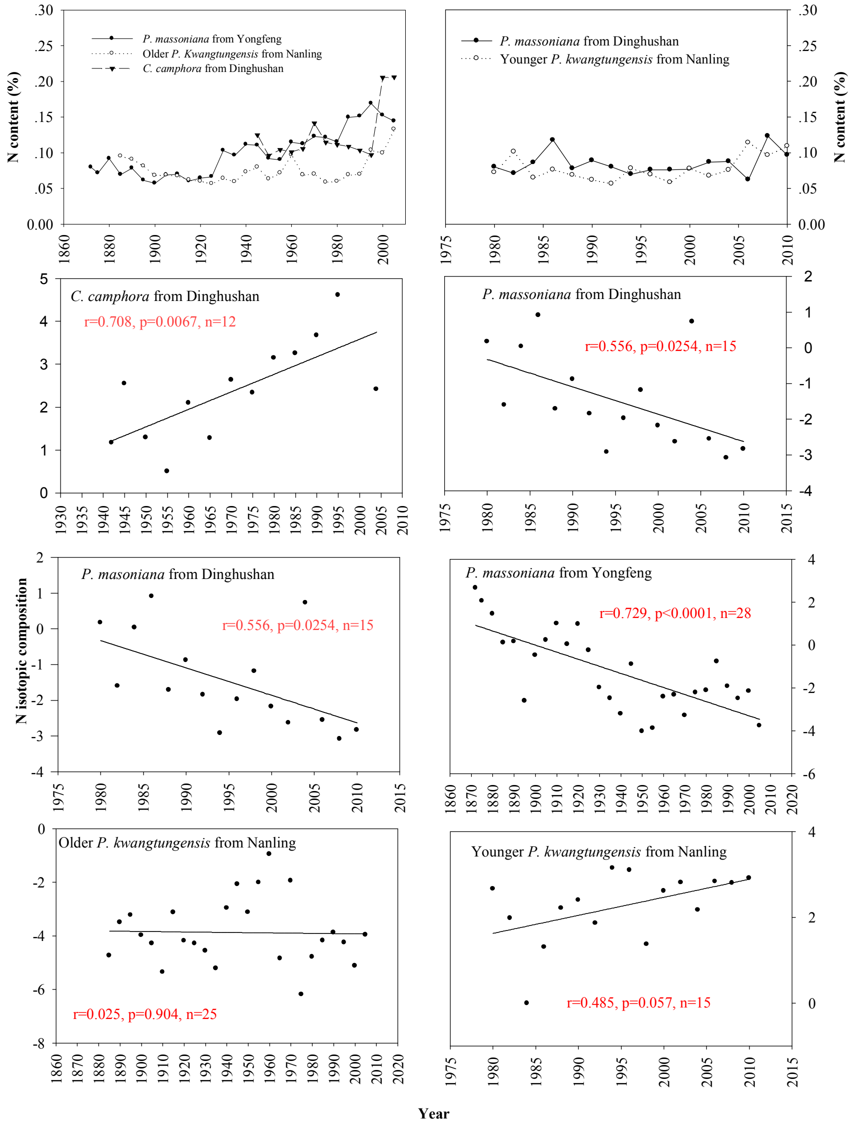

Figure Patterns of tree-ring N content and δ^{15}N in different aged species from Dinghushan and Nanling in Guangdong province and from Yongfeng in Jiangxi province.

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Fluxes of nitrous oxide and methane in temperate forests of different stages of nitrogen saturation in central Japan

Shaoyan Fan[a], Keisuke Koba[a], and Muneoki Yoh[a]
[a] Tokyo University of Agriculture and Technology,Tokyo, 183-0054, Japan;
[*] Phone: +81 80 35790050; Fax: +81 42 367 5900; E-mail: 50012536017@st.tuat.ac.jp

Keywords: Nitrous oxide, methane, nitrogen saturation, nitrification, temperate forest.

Abstract

Long-term nitrogen deposition has caused considerable perturbation called nitrogen saturation in forest system globally. Nitrogen saturation may affect significantly the fluxes of nitrous oxide and methane, but quantitative impact on these gas fluxes has not been fully understood yet. In this study, nitrous oxide and methane fluxes were investigated in three temperate forests of different stages of nitrogen saturation in central Japan. Our data indicate that the N_2O emission was significantly enhanced with the development of nitrogen saturation. The results suggest that nitrification is stimulated in the surface soil due to increased nitrogen availability in a nitrogen-saturated forest to be a main factor that controls N_2O emission.

Introduction

Nitrous oxide (N_2O) and methane (CH_4) are strong greenhouse gases. Forest soil has been recognized as a net sink of CH_4 and as a source of N_2O in general. According to the Fourth Assessment Report of the IPCC (2007), estimated N_2O emission from soil under natural vegetation is 6.0 (3.3–9.0) Tg N year^{-1}, and temperate forest soils emit 1.0 (0.2–2.0) Tg N year^{-1} of N_2O, but these estimations are highly uncertain (IPCC 2001). One of the reasons may be that the impact of nitrogen saturation on N_2O has not been reasonably taken into consideration, which may affect significantly the gas emissions. Aber et al. (1989) suggested that nitrogen saturation would activate soil nitrification in forest systems, which is the main process of N_2O production in aerobic condition. An increase in N_2O emission is therefore expected due to nitrogen saturation. In addition, increased inorganic N availability may reduce the soil uptake of atmospheric CH_4 by inhibiting the oxidation of CH_4 (Bédard and Knowles, 1989; Mochizuki et al., 2012). It is important to evaluate the impact of nitrogen saturation on the fluxes of these gases in forest ecosystems, which are receiving chronic N deposition due to human activities.

Materials and methods

Fluxes of N_2O and CH_4 were measured monthly by a chamber method at 12 spots set continuously along a slope in a nitrogen-saturated site (Tama Hill, located in the suburbs of Tokyo Japan, which is reported to be an N-saturated forest (Yoh et al., 2001)) from May-2012 to Apr-2013. Two control sites that are relatively N-limited (Fukushima and Izu in central Japan) were also studied in August 2012. The soil temperature, soil moisture and inorganic N in soil were simultaneously determined. Net nitrification rate of the surface soil (0–10 cm) at selected spots was measured in situ twice (July and October) by a cylinder method, in which intact soil core was incubated on site for one month.

Results and discussion

In Aug-2012, the overall N_2O emission rate was 4.39 g N ha^{-1} day^{-1} in Tama Hill, which was about 4.5 times higher than those of control sites (1.01 g N ha^{-1} day^{-1} in Fukushima and 0.96 g N ha^{-1} day^{-1} in Izu). The CH_4

oxidation rate was 14.1 g CH_4 ha^{-1} day^{-1} at Tama Hill, which was significantly lower than those of control sites (16.3 g CH_4 ha^{-1} day^{-1} in Fukushima and 23 g CH_4 ha^{-1} day^{-1} in Izu).

Seasonally, the N_2O flux varied from -0.06 to 4.7 g N ha^{-1} day^{-1} and the CH_4 flux varied from -11.1 to -14.1 g CH_4 ha^{-1} day^{-1} on the catchment basis in Tama Hill. The N_2O flux showed a typical seasonal variation, which was related to soil moisture and ambient temperature. In contrast, the flux of CH_4 uptake fell within a narrow range at Tama Hill in a whole year. We found high spatial variation of N_2O flux among 12 plots along the slope, which was generally higher at the bottom and lower around upslope.

A positive correlation was found between the rate of N_2O emission and the net nitrification rate in October, suggesting that nitrification was the major process of N_2O production. However, the relationship of the N_2O emission to the net nitrification rate was not clear in July, which may be because of the occurrence of denitrification in some humid spots (the bottom of the slope).

Conclusions

Our results revealed N-saturation in forest ecosystem obviously stimulates soil N_2O emission, and nitrification can be mostly the major process of N_2O production.

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Possible overgrowth of bamboo caused by nitrogen saturation

Yuki Aihara[a,*], Keisuke Koba[a], Muneoki Yoh[a]
[a]Tokyo University of Agriculture and Technology, Fuchu, Tokyo, 183-8509, Japan
[*] Phone: +86 42-367-5900; Fax: +86 42-367-5900; E-mail: aioueai@gmail.com

Keywords: nitrogen saturation, bamboo, morphological change, lodging, overgrowth.

Abstract Nitrogen saturation has been suggested to affect plant growth and the allometry of root-shoot biomass allocation. We studied morphological changes in bamboo showing lodging (falling down), which was observed in a forest site that has been reported to be nitrogen-saturated (Yoh et al, 2001). No significant morphological difference was found for 'straight-bamboo' between the N-saturated and two control sites. 'Lodging-bamboo' in the N-saturated site, however, had significantly larger mass of branches-and-leaves and abnormal growth in the middle of culm. Root density was also found to be lower in an N-saturated site. It appears that nitrogen saturation may be causing remarkable morphological changes in bamboo that come to lodging.

Introduction

In recent years, nitrogen saturation, a state where the amount of available nitrogen exceeds plant and microbial nutritional demand due to nitrogen deposition, has been reported (Aber et al. 1989). In a nitrogen-saturated forest, a phenomenon of lodging (falling down) is observed in moso bamboo (*Phyllostachys pubescens*). In the case of rice, it is known that foliar biomass is increased and internodal growth is promoted under high nitrogen nutrition, resulting in rice lodging. In addition, it has been suggested that forest fine root biomass is decreased at high nitrogen availability (Gundersen et al. 1998). Thus, we hypothesized that, similar to rice, nitrogen saturation would have caused morphological changes leading to a lodging phenomenon in bamboo, a family of rice. Based on this assumption, we studied the cause of bamboo lodging from the following morphological changes; 1) an increase in culm height, 2) an increase in branches-and-leaves biomass, 3) a decrease in root system.

Materials and methods

We studied the biometry of bamboo in a nitrogen-saturated site (Tama hill, Tokyo, Japan) and control sites (Fukushima and Izu, Japan). Diameter at breast height (DBH), each internode length, culm height, mass of branches-and-leaves, and root density in the soil surface (0-5 cm) were measured. Culm height and mass of branches-and-leave of the same DBH bamboos (around 11cm) were compared. The total carbon and total nitrogen content of leaves were measured with CN Corder (Yanaco Technical Science Inc.).

Results and discussion

For 'straight-bamboo' (standing straight), no significant difference was found in the leaf nitrogen concentration, culm height, and the mass of branches-and-leaves between an N-saturated and two control sites. 'Lodging-bamboo' in an N-saturated site, however, had significantly larger mass of branches-and-leaves and longer maximum internode. Very low root density in the soil surface was also measured, and a root mat in the soil surface appeared hardly to exist in this site while it was observed in a control site. These morphological changes suggest the higher load of canopy, the lower culm strength and lower uprooting resistance by root system. These may be responsible for bamboo lodging as observed in the N-saturated site; nitrogen saturation may affect these morphologies likely causing bamboo lodging.

Conclusions

We found that some lodging bamboo in N-saturated site had significantly larger mass of branches-and-leaves, abnormal growth in the middle of culm and smaller root density. These morphological changes may be caused by excess of nitrogen. Further research is necessary to study the strength of bamboo culm, mass of branches-and-leaves of lodging individual, and mass of whole root to demonstrate more conclusively how bamboo lodging occurs as a consequence of nitrogen saturation.

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Seasonal Changes of Soil Nitrogen Mineralization in *Platycladus orientalis* (L.) Franco Plantation on Limestone Mountains

Hui Wang[a,b]*, Shanshan Zhang[a,b], Baoshan Yang[a,b], Qinglin Chen[a,b]
[a] School of Resources and Environment, University of Jinan, Jinan, 250022, R. B. China; [b] Shandong Provincial Engineering Technology Research Center for Ecological Carbon Sink and Capture Utilization, Jinan, 250022, R. B. China
* Phone: +86 351 82767237; Fax: +86 531 82769233; E-mail: hwang_118@163.com

Keywords: limestone mountains, *Platycladus orientalis* (L.) Franco plantation, *in-situ* incubation, soil nitrogen mineralization.

Abstract The limestone mountain ecosystem is one of the important parts on the earth surface system (Liu et al., 2009). The limestone area is about 200×10^4 km^2 in China and it is about one fifth of Chinese land area (Wen et al., 1994). The limestone mountain habitats have comprehensive effects on the vegetation restoration and ecological remediation and as a result which threatens the regional ecological safety. The researches on the limestone mountain area are focused on the tree species for the vegetation restoration, soil respiration, the nutrition cycle, and the regeneration of the sapling (Feng et al., 2008; Zhao et al., 2009; Yang et al., 2009). The nitrogen mineralization in restored plantation on the limestone mountains was little concerned. In order to explore nitrogen mineralization of the *Platycladus orientalis* (L.) Franco plantation during non-growing season and growing season on limestone mountains. We employed an intact soil core in situ incubation technique with PVC tubes, and studied the soil nitrogen mineralization in *P. orientalis* (L.) Franco plantations with different restoration years (5-year old, 10-year old, 25-year old) from 1 November 2011 to 1 February 2012 and 31 May 2012 to 27 August 2012. The results demonstrated that: (1) in non-growing season, the net nitrogen nitrification rates and mineralization rates reached maximum in November and they were 0.073 ± 0.042, 0.113 ± 0.011, 0.149 ± 0.023 mg·kg^{-1}·d^{-1} and 0.108 ± 0.044, 0.234 ± 0.023, 0.247 ± 0.031 mg·kg^{-1}·d^{-1} in three restored forest soil respectively; (2) in growing season, the net nitrogen nitrification rates and mineralization rates reached maximum in June and they were 0.351 ± 0.051, 0.382 ± 0.028, 0.587 ± 0.095 mg·kg^{-1}·d^{-1} and 0.358 ± 0.060, 0.476 ± 0.027, 0.613 ± 0.109 mg·kg^{-1}·d^{-1} in three restored forest soil respectively. (3) in growing season and non-growing season, the typical soil physical and chemical characteristics had obvious correlations with soil nitrogen mineralization ability, and the relations were different in different restored phases. The soil humidity and net nitrogen mineralization rate showed a quadratic function relation ($r = 0.567$, $p = 0.034$; $r = 0.891$, $p = 0.011$); however in non-growing season, the soil pH value almost had no influence on the soil net nitrogen mineralization rates. In non-growing season, the soil net nitrogen mineralization rate was positively correlated with C/N ratio and soil organic carbon content ($r=0.221$, $p = 0.569$; $r = 0.326$, $p = 0.392$), however, in growing season, the soil net nitrogen mineralization rate was negatively correlated with C/N ratio and soil organic carbon content ($r = -0.176$, $p = 0.651$; $r = -0.326$, $p = 0.392$). This indicated that the different succession phases after the vegetation restoration of limestone mountains decided the difference of the soil net nitrogen mineralization rates between the non-growing season and growing season. The research concluded that nitrogen mineralization changed with succession phases of *Platycladus orientalis* (L.) Franco plantation on limestone mountains. The changing patterns of mineralization and the correlations between soil mineralization with the physicochemical properties implied that the changes of nitrogen transformation may be affected by integrated influence with the plantation succession after vegetation restoration in limestone mountains. The detailed mechanisms of the nitrogen cycle are in need to be investigated in the limestone mountain habitats.

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Effects of intercropping grasses on soil organic carbon and microbial community functional diversity under Chinese hickory (*Carya cathayensis* Sarg) stands

Jiasen Wu [a,b], Cifu Meng[b], Jianqin Huang[b] Jinchi Zhang [a]*, Penkun Jiang[b]*,

[a] College of Forest Resources and Environment，Nanjing Forestry University，Nanjing 210037,China
[b] Zhejiang Provincial Key Laboratory of Carbon Cycling in Forest Ecosystems and Carbon Sequestration, Zhejiang A & F University, Lin'an 311300, China
Tel.: +86-571-6108-1397; E-mail: jswu@zafu.edu.cn

Key words Chinese hickory (*Carya cathayensis* Sarg); interplanting grass; water soluble organic carbon (WSOC); microbial biomass carbon (MBC); microbial functional diversity

Abstract Chinese hickory (Carya cathayensis Sarg) is a unique woody oil tree species in China. Intensive management (IM) including heavy-application chemical fertilizer and long-term application of herbicides has resulted in serious soil loss and degradation. A field experiment consisting of four treatments (intercropping Chinese milk vetch (Astragalus sinicus L.), rape (Brassica campestris L.), ryegrass (Lolium perenne L.) and clean tillage) was conducted to study the effects of intercropping grasses on soil organic carbon (SOC) and microbial community functional diversity under Carya cathayensis stand.

The results showed that interplanting rape, ryegrass, and Chinese milk vetch under Carya cathayensis stands for 4 years increased total organic carben (TOC)(Fig.1), microbial biomass carbon (MBC), and water-soluble organic carbon (WSOC) by 23.1- 24.7, 138.6-159.7, and 56.2-69.5%, respectively, as compared with clean tillage(Table 1).

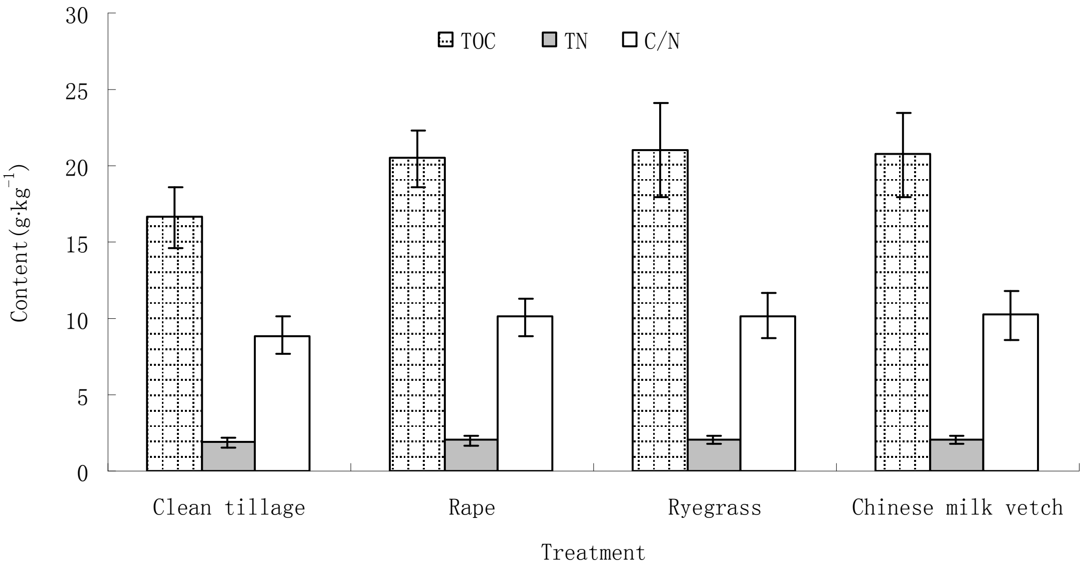

Fig.1 Comparison of the contents of organic C and N in the soils (0-20cm) under stand for different treatments after 4 years of experiment.

Table 1 Comparison of the concentrations of MBC and MBN as well as WSOC and WSON in the soils under Chinese hickory stand for different treatments after 4 years of experiment

Treatment*	MBC (mg kg^{-1})	MBN (mg kg^{-1})	WSOC (mg kg^{-1})	WSON (mg kg^{-1})	MBC/MBN	WSOC/WSON	MBC/TOC(%)	WSOC/TOC(%)
CT	104.9b#	9.3b	28.0b	1.78b	11.3b	15.7b	0.63b	0.17b
Rape	250.3a	15.1a	43.7a	1.97ab	16.6a	22.1a	1.22a	0.21a
Ryegrass	272.4a	14.9a	47.4a	2.09ab	18.3a	22.7a	1.30a	0.23a
CMV	256.2a	13.7a	46.4a	2.15a	18.7a	21.6a	1.24a	0.22a

*CT= Clean tillage; CMV=Chinese milk vetch.

Interplanting grasses markedly improved microbial community functional diversity which is characterizing by the increases in average well-color development (AWCD), and Shannon index (H) and evenness index (E). Interplanting grasses also changed carbon source utilization patterns of soil microbes.

The structure of SOC also was greatly changed by interplanting grasses. Interplanting grasses increased carbonyl C by 29.9-36.9% ($P<0.05$) and decreased alkyl C and alkoxy C and aromatic C by 10.0-16.4, 18.9-20.9 and 10.5-16.6% ($P < 0.05$), respectively(Fig.2).

Correlation analysis showed that there were significant positive correlations among TOC, WSOC, WSON, WBC, WBN, AWCD and E (P<0.05 or P<0.01) (Table2) .

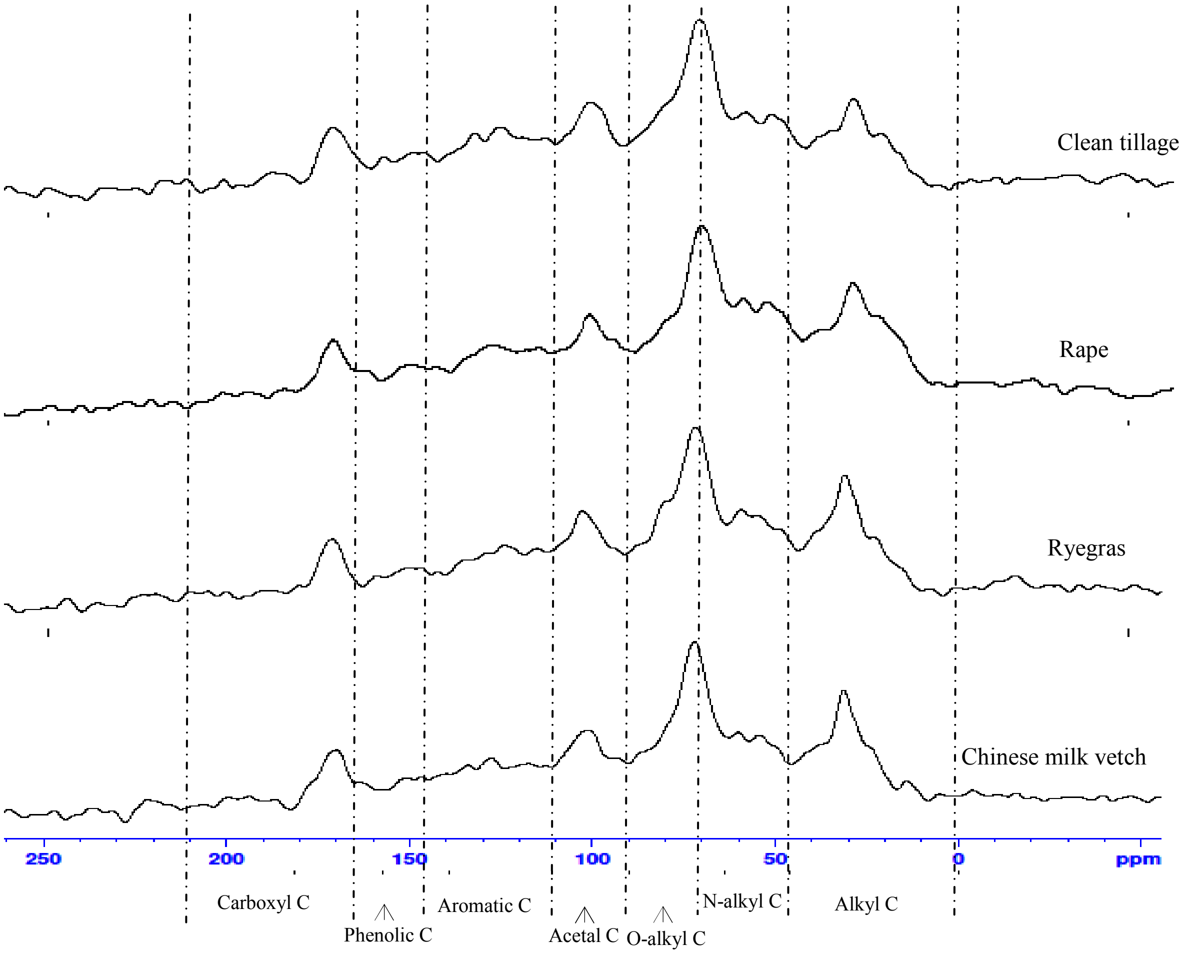

Fig. 2 NMR spectra of soil total organic carbon under Chinese hickory stand

Table 2 Relationships among chemical properties and microbial functional diversity in the soils under Chinese hickory stand

	MBC	MBN	WSOC	WSON	AWCD	E	H
TOC	0.679**	0.348*	0.645**	0.415*	0.532**	0.393*	0.499*
MBC		0.875**	0.736**	0.695**	0.498*	0.356*	0.336*
MBN			0.752**	0.498*	0.453*	0.393*	0.375*
WSOC				0.548**	0.367*	0.402*	0.578**
WSON					0.435*	0.378*	0.745**
AWCD						0.786**	0.941**
E							0.871**

Significance：$*P < 0.05$, $**P < 0.01$.

Theme 2: Advances in research technologies and methodologies

Identification of Phenanthrene-Metabolizing Bacteria in Forest Soils by DNA-Stable Isotope Probing

Chunling Luo*, Yishan Jiang, Longfei Jiang, Gan Zhang

State Key Lab Laboratory of Organic Geochemistry, Guangzhou Institute of Geochemistry, Chinese Academy of Sciences, Guangzhou 510640, China

* Author to whom correspondence should be addressed (email: clluo@gig.ac.cn)

Keywords: Phenanthrene; Biodegradation; Stable isotope probing; Forest soils

Abstract

Stable isotope probing (SIP) was used to identify the aerobic phenanthrene-degrading microorganism in soil microcosm constructed with a clean forest soil. Sequencing indicated that the organism involving the degradation of phenanthrene belongs to the genus *Caulobacter*. The future work will focus on the degrading mechanism such as functional genes analysis.

Introduction

Polycyclic aromatic hydrocarbons (PAHs) are among the most persistent pollutants that accumulate in natural environment mainly as a result of anthropogenic activities, furthermore PAHs are known to be highly toxic, mutagenic, genotoxic and carcinogenic to living organisms. Therefore, the improvement of the available bank of microbial resources and information is crucial to the proper management of PAHs polluted sites and effluents. Although many aerobic PAHs degraders have been identified through enrichment and isolation procedures, data on the microorganisms actually responsible for *in situ* biodegradation is still lacking. Recent advances in molecular methods, specifically stable isotope probing (SIP), were utilized to identify such bacteria. Here, we present results towards this goal using phenanthrene as initial model contaminant.

Materials and methods

Labeled (^{13}C) or unlabeled phenanthrene were transferred to the soil samples and then incubated. The phenanthrene removal efficiency were measured at different incubation time, meanwhile DNA was extracted and subject to isopycnic ultracentrifugation and fractionation, the selected fraction were amplified by PCR and digested to obtain the terminal restriction fragment length polymorphism (T-RFLP) patterns respectively. T-RFLP profiles in each fraction were then studied to determine which T-RFLP fragments were more dominant in the heavy fractions of the samples exposed to labeled contaminant in comparison with those exposed to the unlabeled contaminant.

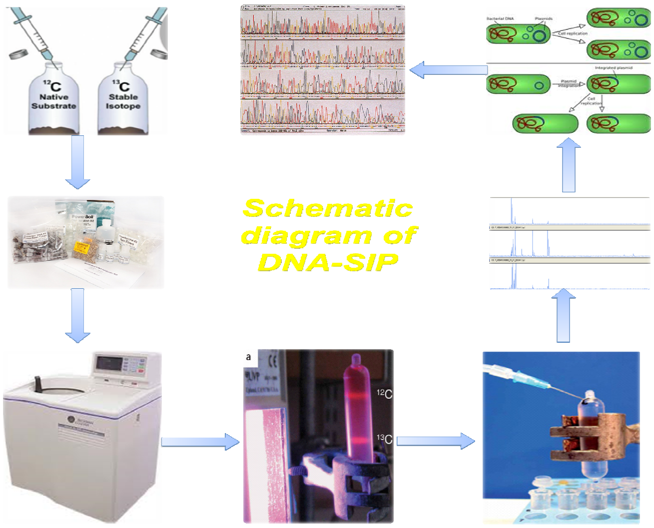

FIGURE 1. The schematic diagram of DNA-SIP

Results and discussion

It found fragment 290 bp was distributed throughout the gradient profile in the forest soil which showed the corresponding microorganism may be responsible for the uptake and degradation of phenanthrene. Sequencing indicated the microorganism was a member of the genus *Caulobacter* .

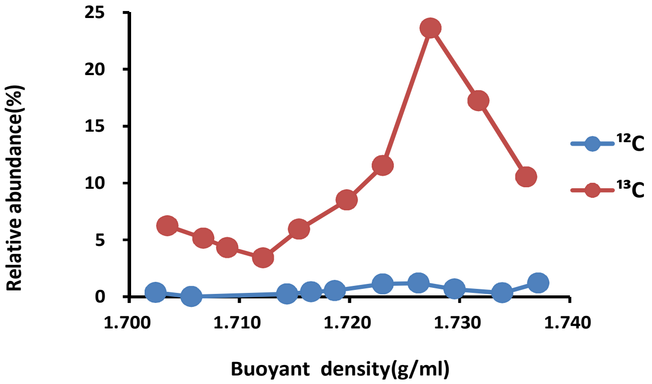

FIGURE 2. The relative abundance of the dominant fragment over a range of buoyant density (BD) from DNA extracted from the agricultural soil added with either labeled (^{13}C) or unlabeled (^{12}C) phenanthrene

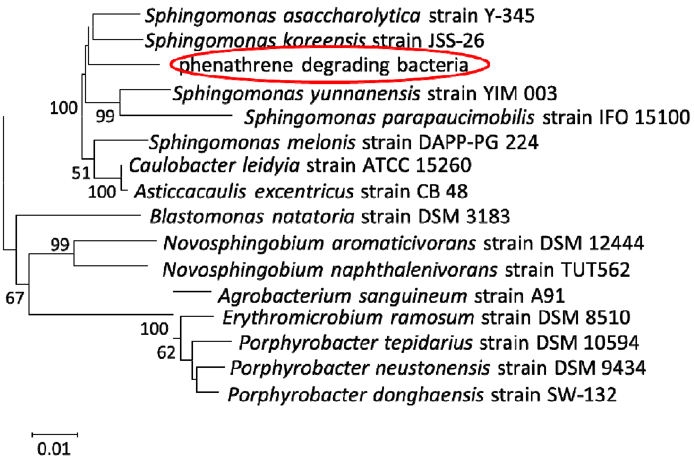

FIGURE 3. Phylogenetic neighbor-joining tree of phenathrene degrading bacteria

Conclusions

^{13}C labeled phenanthrene provides a good model compound for investigating biodegradation with stable isotope probing (SIP). Future work will focus on the functional genes of the bacteria.

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Theme 3: Linking ecosystem processes and management to forest biodiversity and functions

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Effect of Fire Disturbance on Short-term Soil Respiration of Typical Forest types in Daxing'an Mountain

Sun Long[1],Hu Tongxin[1] , Ji Hong Kim[2]* , Hu Haiqing[1]*
([1] *College of Forestry, Northeast Forestry University, Harbin 150040, China* ; [2]*College of Forest & Environmental Sciences, Kangwon National University, Korea*)
Phone:+86 15104538086; E-mail: htxhtxapple@sina.com

Keywords: Fire disturbance; short-term soil respiration; environmental factors; Q10

Abstract Daxing'an Mountain is the main distribution area of forests in north China. It is also the area where forest fires happen frequently. The study of the effect of fire disturbance on short-term soil respiration of the typical forests of this area (Betula platyphylla Suk. forest, Larix gmelinii Rupr. forest) is important for understanding the function of fire disturbance in carbon cycle and carbon balance of forest ecosystem. The results showed that the soil respiration rate of the post-fire plots of Betula platyphylla Suk. forest and Larix gmelinii Rupr. forest was reduced by 14% and 10% respectively, as compared with the control plots. There was no significant difference in the soil heterotrophic respiration rate for the two forest types between the post-fire plot and control plot. The RC values of the post-fire plots of the two forests were reduced significantly in comparison to the control plot. The proportion of variation of soil respiration rate that could be explained by the soil temperature (T) and soil water content (W) at a depth of 5cm in logarithmic model was 70.8%-83.1% for the control plot of Betula platyphylla Suk. forest, 62.6%-86.2% for post-fire plot of Betula platyphylla Suk. forest, 73.5%-83.7% for the control plot of Larix gmelinii Rupr.forest, and 87.2%-88.7% for the post-fire plot of Larix gmelinii Rupr. forest. The short-term Q10 values of the control plot of Betula platyphylla Suk. forest, the post-fire plot of Betula platyphylla Suk. forest, the control plot of Larix gmelinii Rupr. forest, and the post-fire plot of Larix gmelinii Rupr. forest were 5.33, 5, 9.12 and 5.26 respectively. The result of our study provided data basis for the research of the effect of fire disturbance on soil carbon balance and the estimation of soil carbon flux.

Introduction

Forest ecosystem is an important part of terrestrial ecosystem. The carbon storage of northern forest system is high, accounting for about 1/3 - 1/2 of the total global carbon. It contains about 200- 500 Gt carbon and occupies an important position in global carbon pool (Lehner, et al., 2004). Moreover, the northern forest systems in high-latitude area are very sensitive to the climate change (McGuire, et al., 2009; Piao, et al., 2008). Serious forest fire often occurs to the northern forest ecosystem, bringing uncertainties to the research on the change of global carbon balance (French, et al., 2004). These uncertainty factors mainly come from the differences in soil characteristics of high-latitude area and the uncertainty of environmental changes after fire. Meanwhile, the heterogeneity of fire behaviors due to wind direction, topography, supply of combustible substrate (Hinzman, et al.,2003;Kasischke, et al.,2005;Rocha, et al.,2011) causes significant changes to the main environmental factors of forest after fire, such as temperature, soil water content, activity of soil microorganisms and the distribution of plant root. All these lead to immeasurable effect on soil respiration rate. Such effect tends to persist for a long time after fire accident (Flannigan, et al., 2009; O'Neill, et al., 2002). Therefore, the construction of short-term model of soil respiration after fire disturbance is very important. Due to limited research conditions, previous studies are mainly concentrated on the soil respiration a long time after fire disturbance (Czimczik, et al., 2006; O'Neill, et al., 2002; Tan, et al., 2012). The extent of such effect depends on fire intensity and duration (O'Neill, et al., 2003; Tan, et al., 2012). Currently, there have been few thorough researches on the effect of fire disturbance on short-term soil respiration. Therefore, the research results that are available do not fully reflect the real situation. There is a lack of in-depth understanding on short-term soil carbon exporting process, or the influence factors and its mechanism. This brings great inconvenience to accurately estimating the soil carbon emission after fire disturbance and the establishment of the regional carbon cycle model.

Materials and methods

The soil respiration flux was measured using LI-8100-103 survey room connected to LI-8100 Automatic Measuring System for Soil Carbon Flux (LI-COR Inc., NE, USA). Five SH-200PVC rings with a diameter of 19 cm and a height of 8 cm were set up in each plot randomly at the end of July, 2012. The ring was processed and then stuck into soil with 3 cm above the soil. It was ensured that the location of the PVC ring did not change during the measurement process. Trench method was used to determine the soil heterotrophic respiration (Rh) (Bond-Lamberty, et al., 2004). The soil temperature (T) at 5cm and the voltage V4 were determined with the temperature probe (p/n8100-201) and the soil moisture probe of ECH20 EC-5 (p/n 8100-202) during the measurement of soil respiration. The V4 value was converted to volumetric water content (W) with the formula provided by the instrument.

Results and discussion

The fitting using exponential equation had a better effect than linear fitting for the interaction between short-term Rs and Rh, T and W, and T and W, for the two forest types after fire disturbance. The statistical analysis results showed certain differences in the relationship between these factors (Table 1).

There was a large difference in the interaction of T and W for different plots. Rs was significantly correlated with T and W for *Betula platyphylla Suk.* forest control plots and post-fire plots, with the determination coefficients of 0.805 and 0.861, respectively. However, Rh was not significantly correlated with T or W. There was significant correlation in the relationships between Rs & Rh and T & W, for *Larix gmelinii* forest control plots and post-fire plots. The determination coefficients of T and W with Rs were 0.837 and 0.887, respectively; the determination coefficients of T and W with Rh were 0.81 and 0.73, respectively.

The two forest types differed in the response to soil water content. The effect of short-term soil respiration on water content of *Betula platyphylla Suk.* forest after fire disturbance was more significant, and there was no significant response of short-term soil respiration to soil water content of *Larix gmelinii Rupr.* forest after fire disturbance. Similar results are reported in the previous researches (Cook, et al., 2008; Li Lisha et al, 2005; Rayment, et al., 2000). The effect of soil water content on soil respiration rate varied in previous research. Some believed that in northeastern China where rain is abundant, the soil water content could only be the main influencing factor of soil respiration rate under extreme conditions. Thus, there is the possibility that the effect of water on soil respiration in this area is masked by the effect of temperature (Liu Ying et al, 2009). There was also difference in the correlation between soil respiration and soil water content for various forest types and under various environmental conditions. This might be due to the autotrophic respiration of roots (Zhou, et al., 2007).

Conclusions

The soil respiration rates of *Betula platyphylla Suk.* forest and *Larix gmelinii* forest post-fire plots were reduced by 14% and 10% after fire disturbance, as compared to the control plots, respectively. RC values of post-fire plots were significantly were reduced as compared to the control plots for the two forest types. This showed that the autotrophic respiration rate reduced for the two forest types. The short-term damage to the roots may be one of the important components for the reduction of short-term soil respiration rate after fire disturbance. Combining with previous researches, it was found that there was certain difference in the response of soil respiration rate to temperature (T) at 5 cm and soil water content (W) for the two forest types. But on the whole, soil temperature and soil water content were still the main environmental factors controlling the change of soil respiration rate of this area. The short-term Q_{10} values of two types forest control plots were reduced to different degrees as compared to post-fire plots for the two forest types. The changing conditions of roots after fire disturbance need to be studied further to understand the effect of short-term Q_{10} after fire disturbance for this area.

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A research review on soil active organic carbon fractionation、analytical methods and affecting factors

Lu Xin[a],Hu Haiqing[b],Sun Long[*]
[a,b]College of forestry, Northeast Forestry University, No.26 Hexing Road Xiangfang District, Harbin, P.R.China 150040
[*] Phone: +86-451-82191976; Fax: +86-451-82191976; E-mail: sunlong365@126.com

Keywords:soil active organic carbon;characteristics;analytical methods;affecting factors.

Abstract: Forest soil organic carbon is an important part of global carbon cycle and soil active organic carbon as the active chemical component in it is organic carbon dynamics sensitivity index plays a very important role in the global carbon cycle.In the current research,it already caused attention of the Soil Science, Ecology and Environmental Science.The active part of the accounts for only of the total organic carbon a small portion of,but directly involved in soil biological、chemical conversion process,therefore,soil organic carbon active components has important significance on soil carbon library balance and soil chemical biochemistry fertility conservation. This paper introduces the representative active carbon fractions:the characterization of dissolved organic carbon,microbial biomass carbon,mineralizable carbon,light fraction organic carbon, particulate organic carbon and briefly describes the current domestic and foreign often used methods and reviews the main affecting factors of forest soil active organic carbon:soil water content, seasonal variation and temperature, land-use and management on soil active organic carbon.

Introduction

Soil is the second largest organic carbon pool on the earth only after the oceans and it is the main part of terrestrial planet carbon pool. As carbon source or sink,it affects the change of concentration of CO_2 in the atmosphere, plays a very important role in the global carbon cycle.At present, the soil quality is more attention. Soil organic carbon as the important indicators of soil quality, has became one of the important references for sustainable forest management.At the same time, soil organic carbon is also the core for the soil quality (An et al.2009), its quality and quantity affects the soil physical,chemical, and biological characteristics and process.It influences and controls the plant primary production, is an important index of soil quality evaluation,and plays an important role in maintaining the forest productivity and in the process of the global carbon balance (Geng et al.2009). Decomposition of soil organic carbon largely affects the concentration of CO2 in the atmosphere, has a relatively direct relationship to global temperature change. Soil organic carbon changed a few percent in number,though not significant influenced on soil quality, but for concentration of CO_2 in the atmosphere,5% of the world's soil organic carbon changed, its quantity has been over current global total anthropogenic CO_2 emissions.Soil active organic composation is an important part of organic carbon. Its characters are very active,so it susceptiblly to be interferenced by ecosystem change(Yang et al.2003;Ni et al.2003).Under the influence of climate change, land use, or tillage measures, change of its content and speed is more significant than total organic carbon and inert organic carbon.Although it accounts for only a smaller part of the soil total organic carbon, is directly involved in the soil biochemical conversion process,therefore,it has great significance for the balance of soil carbon pool and fertility of soil chemistry, biological chemistry(Zhong et al.2010). Soil active organic carbon as the active chemical components in soil organic carbon, is very important to soil carbon conversion and is closely related to soil productivity, so it can significantly affect soil chemical dissolution, adsorption, desorption, absorption even biological toxicity(Liu et al.2006).It is an useful sensitivity index for state of soil organic carbon, and at the same time reflects the the dynamic of soil carbon pool(Jiang et al.2002;Zhou et al.2005).Therefore,a more comprehensive research of soil organic carbon especially the analytical methods of the active component, process and the impact factor is very crucial. It can help the assessment of soil organic carbon change and global carbon cycle, and has a great significance for the prediction and strategy formulation of climate change.

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Research progress on effects of forest fire disturbance on soil respiration and measuring method

Hu Haiqing[a], Zhang Fushan[b], Wei Shujing[c], Sun Long[*]

[a,b,c]College of forestry, Northeast Forestry University, No.26 Hexing Road Xiangfang District, Harbin, P.R.China 150040

[*] Phone: +86-451-82191976; Fax: +86-451-82191976; E-mail: sunlong365@126.com

Key Words: fire disturbance, forest ecosystems, soil respiration, measuring method, influencing factor

Abstract: Forest fire is a major disturbance of forest ecosystems, leads to the changes of soil carbon storage. After fire, the balance of forest ecosystems would be broken and the climate would be changed because of the material cycle, energy flow and information transmission were destroyed as the release of the carbonic gases. Soil is a main biosphere for carbon pool. Soil carbon release into atmosphere mainly through soil respiration, and small changes in soil respiration can have a great effect on CO2 atmospheric concentrations as the tremendous storage of soil carbon. In this paper, we expounded and compared the various methods of measuring soil respiration, summarized the effects of forest fire disturbance on soil respiration and measuring methods, and reviewed the conditions of soil respiration after forest fire. And we also suggested and prospected emphases of further study in forest fire and soil respiration of forest ecosystems.

Introduction

Forest fire is an important disturbance factor for forestry ecosystems, which lead to changes in soil carbon storage. Carbon-containing gas emissions by fire disturbance has an critical influence on on the material cycle, energy flow and the deliverying of information, affecting the carbon balance of forest ecosystems and climate change. After fire disturbance, forest ecosystem composition, structure and function will change, thereby affecting the circulation of material and energy flow of the ecosystem. Our country lacks of forest, national forest covering area is nearly 20.36%, it is also a fire-prone area, with annual of average of 16000 fire accidents, and annual average post-fire area was 9×105hm2 (Xie Keyong et al., 2008). Soil as the main terrestial carbon repository, containing 1300~2000PgC, accounting for 67% of total cabon(Jenkison D S, et al, 1991) , and reserves 2 to 3 times of the land and more than 2 times of atmospheric carbon pools, accounting for 20%~40% of CO2 input value, Soil carbon fluxes up to 68±4×1015gC/a,even subtlely changes in soil carbon will cause the significant changes of the CO2 concentration. Soil carbon releases CO2 into atomsphere mainly through soil respiration. In recent years, there were many researches about terrestial ecosystem soil respiration, research area including farmland, forest, prairie, wetland, desert, tundra and other ecosystem (Aslam T et al., 2000, Qi Zhiyong et al., 2003, Zhang Yulan et al., 2010). Although there are many researchs about the interference factor effect on terrestrial ecosystems soil respiration , such as input fo nitrogen, freezing and thawing, CO2 concentation, drought (Sponseller R A et al., 2007, Peng Qin et al., 2008, Ma Honglianget al., 2003), research about fire disturbance on the forest ecosystem is less. Therefore, this article elaborated various measurment methods and contrast them; the fire disturbance on soil respiration rate of forest ecosystems and their measuring methods; fire distubance on soil environment. Finally propoed the issues which should be focused of fire disturbance on soil respiration in the furutre researches, which fire disturbance and soil respiration research directions were discussed.

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Nutrient availability alters soil CO_2 production in a subtropical forest

Qingkui Wang[a,*], Tongxin He[b], Silong Wang[a]

[a] Huitong Experimental Station of Forest Ecology, State Key Laboratory of Forest and Soil Ecology, Institute of Applied Ecology, Chinese Academy of Sciences, Shenyang 110164, People's Republic of China

[b] University of Chinese Academy of Sciences, Beijing 100039, People's Republic of China

* Phone: +86 24 83970344; Fax: +86 24 83970300; E-mail: qwang@iae.ac.cn

Keywords: nutrient availability, soil organic C mineralization, litter addition, priming effect.

Abstract Deposition of atmospheric N and P and enrichment of CO_2 concentration may increase soil nutrient availability and C input through litterfall and roots. We performed an experiment in which *Pinus massoniana* and *Michelia macclurei* litter labeled by ^{13}C and inorganic nutrients were added individually or together to soil collected from a forest in tropical China. The aim of the experiment was to investigate the effect of C addition and nutrient availability on the decomposition of native SOC. The production of CO_2 was measured continuously over the succeeding 120 days during laboratory incubation. *P. massoniana* and *M. macclurei* litter additions dramatically increased total CO_2 production and caused a significant positive priming effect of 7.4% and 22.4%, respectively. Inorganic N and P additions suppressed soil respiration by 6.6% and 7.1%, respectively, when added individually. After the 120-d incubation period, inorganic N addition resulted in a higher decrease in the priming effect induced by *P. massoniana* and *M. macclurei* litter compared with P addition. These results suggest that increases in soil nutrient availability from atmospheric N and P deposition can reduce the decomposition of SOC and increase soil C deposits in subtropical forests potentially the most vulnerable.

Introduction

SOC decomposition is directly linked to CO_2 emission, and consequently, to the feedback of global climate changes. In forest ecosystems, leaf litter, dead fine roots and root exudates, as the major sources of SOC input, influence SOC decomposition through the priming effect (Kuzyakov, 2010). Nutrient availability is important in explaining the tremendous differences in the extent of the priming effect observed in literature. However, no general conclusion on the response of soil CO_2 emission to N and P addition has yet been drawn (Hamer and Marschner, 2005; Hartley et al., 2010; Wang et al., 2013; Zhang and Wang, 2012). In the present study, the aim is to determine the interaction between C and nutrient addition on priming effects of native SOC decomposition in subtropical forest soil using ^{13}C partition techniques.

Materials and methods

The soil used in this experiment was collected at a layer of 0–10 from a *Cunninghamia lanceolata* forest located at the Huitong National Research Station of Forest Ecosystem. For incubation, 240 g soil (dry weight) for each replicate of each treatment was placed in a 500 mL Mason jar. Then, ^{13}C-labeled litter, ammonium chloride solution, and potassium dihydrogen phosphate solution were added to the soils with 60% of water holding capacity. All the Mason jars were incubated for 120 d at 28 °C. The released CO_2 was measured using alkali-trapping techniques at different intervals. The amount of CO_2-C derived from soil was calculated by the equations: $C_S = C_t (\delta_L - \delta_t)/(\delta_L - \delta_S)$. The priming effect during the 120-d incubation period was calculated using the equation: $PE = 100 \times (CO_2\text{-}C_{tratment} - CO_2\text{-}C_{control})/CO_2\text{-}C_{control}$.

Results and discussion

When different types of litter were added individually, CO_2 production from native SOC was increased by 7.4% and 22.4% due to the addition of *P. massoniana* and *M. macclurei* litter, respectively (Fig. 1). Increase in the production of CO_2 from native SOC after the addition of organic substrate is called the priming effect. *M. macclurei* litter caused a higher positive priming effect after the 120-d incubation period compared with *P. massoniana* litter (Fig. 2), being in agreement with the findings of other researchers (Nottingham et al., 2009;

Wang et al., 2013; Zhang and Wang, 2012). One possible mechanism for the positive priming effect is the activation of microorganisms by easily available substrates, thus resulting in enhanced SOC degradation by microbial growth and an accompanying increase in intracellular and extracellular enzyme productions (Hamer and Marschner, 2005).

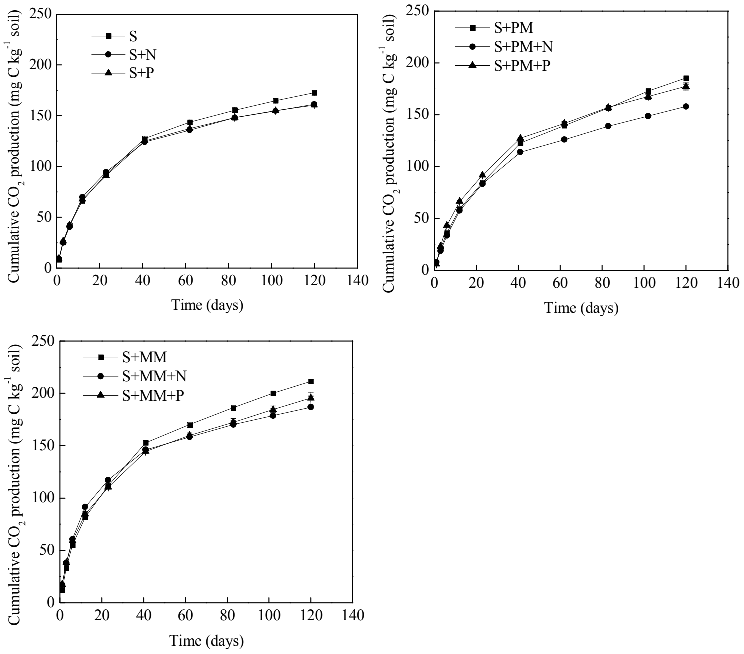

Fig. 1 The effect of *P. massoniana* (PM) litter, *M. macclurei* (MM) litter, and nutrient (N and P) addition on the cumulative amount of CO_2-C derived from native SOC.

Either inorganic N or P addition decreased CO_2 production from native SOC, whether litter was added to soil or not (Fig. 1), suggesting that adding N and P decreased the priming effect induced by litter addition. Numerous studies, similar to ours, have monitored the effect of nutrient addition on soil respiration (Mo et al., 2008; Hartley et al., 2010; Zhang and Wang, 2012). After N addition, the priming effect induced by *P. massoniana* and *M. macclurei* litter addition decreased from 7.4% and 22.4% to -8.6% and 8.2%, respectively. P addition caused the priming effect induced by *P. massoniana* and *M. macclurei* litter to decrease to 2.6% and 13.2%, respectively.

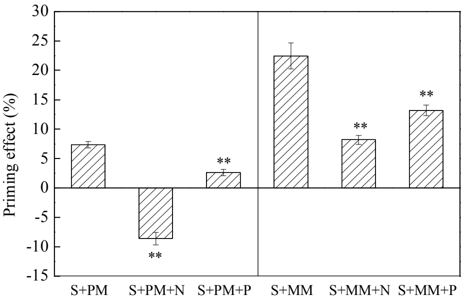

Fig. 2 The effects of *P. massoniana* (PM) litter, *M. macclurei* (MM) litter, and nutrient addition on the priming effect after the 120-d incubation period. The asterisks denote the significant effects of N and P addition on priming effects.

Conclusions

Our study is the first quantitative research on the effects of P addition on the priming effect in a subtropical forest. *M. macclurei* litter addition induced a higher priming effect than *P. massoniana* litter addition. Inorganic N and P addition decreased the priming effect induced by litter addition, suggesting that atmospheric N and P deposition might increase C deposit in soil by suppressing SOC mineralization and increasing input of litter and roots under atmospheric CO_2 concentration enrichment in subtropical forests.

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Differential responses of ammonia oxidizing archaea and bacteria to four main types of vegetation in subtropical area

Li Yongchun[*], Liu Burong, Guo Shuai, Qin Hua, Xu Qiufang [* *]

Zhejiang Provincial Key Laboratory of Carbon Cycling in Forest Ecosystems and Carbon Sequestration, School of Environmental and Resource Sciences, Zhejiang A & F University, Lin'an, 311300, Zhejiang, China

* First author: Phone: +86 571 61102657; E-mail addresses: yongchun101@hotmail.com

* *Corresponding author: Phone: +86 571 63740882; E-mail addresses: xuqiufang@zafu.edu.cn

Key words: vegetation type; soil; ammonia-oxidation microorganism; DGGE; real-time PCR

Introduction

Nitrogen is one of the most important elements that can limit plant growth in forest ecosystems (yang et al. 2003). Ammonia-oxidizing bacteria (AOB) and archaea (AOA) are considered as the key drivers of global nitrogen (N) biogeochemical cycling (He et al. 2009). However, population sizes of AOB and AOA may vary between soil types and plant communities (Jurgens, G. et al. 1997). Broad-leaved forest (BF), Chinese fir forest (CF), Pinus massoniana forest (PF) and moso bamboo forest (MB) are widely distributed in subtropical area of southern China. The objective of the present study was to quantify and characterize the AOB and AOA communities in acidic soils under four stands in subtropical area.

Materials and methods

The sampling area was located in Tianmu Mountain, Lin'an County (30°18′~30°21′N and 119°24′~119°27′E), Zhejiang Province, China. This area belongs to a typical central subtropical climate with an annual precipitation of 1390~1870 mm. The average annual temperature is 8.8~14.8°C. Red soil is the major soil type in this area with pH (H_2O) ranging from 4.7 to 6.0. Soil samples were collected from 0 to 20 cm surface soil in August 2010 by taking 5 soil cores from each plot and mixing them to form one composite sample. All samples were passed through a 2.0 mm sieve and were divided into two parts: one (fresh sample) was stored at -80°C for DNA extraction; the other was air-dried and used for physicochemical properties determination. The community structure and functional gene abundance of soil AOA and AOB were measured by using PCR-DGGE and real-time quantitative PCR.

Results and discussion

Cluster analysis showed that BF and MB samples were grouped together, respectively, but were distinct from PF and CF samples, demonstrating differences in the effect of different vegetation types on the AOA community. The structure of AOA communities changed with vegetation type, with distinct populations in different forest soils. However, the patterns were internally divergent for all of AOB communities, and the samples of four types of vegetation were not clearly separated. Significantly higher archaeal *amo*A abundance was detected in CF than that in BF and MB ($P < 0.05$); whereas for bacteria *amo*A abundance, no significant difference was found among the four different forest stands. The AOA : AOB ratios measured in soils of BF, PF and MB tended to be lower (0.35— 0.78) than those in CF soils (1.05), perhaps because the soils of CF are more acidic (4.45) and higher ratio of C/N than three other stands soils (Boyle-Yarwood, SA et al. 2008). The bacterial *amo*A gene copy numbers were near to those of archaeal amoA genes in three stand soils with the exception of BF. In the soils of BF, the bacterial amoA gene copy numbers (8.14×10^{6} g-1 of soil) were significantly higher than those of archaeal amoA genes (2.57×10^6 g-1 of soil) ($P < 0.05$) , which indicated a potential role of AOB in nitrification.

Conclusions

This study demonstrates vegetation type-specific effects on AOA and AOB community. The structure of AOA communities changed with vegetation type, while the structure of AOB communities was insensitive to different forest stand soils. The AOA : AOB ratios varied with four forest stand soils. Compare with AOB community, the AOA community is sensitive and responds differentially to different vegetation types in subtropical area.

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Changes in labile soil organic matter pools and microbial biomass after reforestation of Chinese fir site with a broadleaf species

Xiaohua Wan[a], Zhiqun Huang[a, *], Zongming He[b], Zhenhong Hu[a], Zaipeng Yu[a], Minhuang Wang[a], Yusheng Yang[a]
[a] College of Geographical Science, Fujian Normal University, Fuzhou, 350007, China; [b] College of Forestry, Fujian Agriculture and Forestry University, Fuzhou, 350002, China
[*]Telephone No. +86-0591-84334802; Fax No. +86-0591-83441543; and E-mail: zhiqunhuang@hotmail.com

Keywords: Chinese fir, dissolved organic matter, light fraction organic matter, microbial biomass carbon, PLFA, tree species

Abstract This study aimed to determine the influence of tree species on soil labile organic matter pools and microbial characteristics 19 years after reforestation of Chinese fir (*Cunninghamia lanceolata* (Lamb.) Hook) woodland with itself or a native broadleaf species, *Mytilaria laosensis*. The results showed that tree species transition had a significant impact on soil dissolved organic carbon (C) and nitrogen (N) pools. Water, hot water and KCl extractable organic C pools were greater in all three layers (0-5, 5-10, 10-20 cm) in *M. laosensis* soil than in *C. lanceolata* soil. In the 0-5 and 5-10 cm layers, the concentrations of dissolved organic N extracted by water and hot water in *M.laosensis* plantation were significantly higher than that in *C.lanceolata* plantation. The sizes of soil dissolved organic C and N pools in different solvents generally followed the same order: KCl >hot water> water. In the top 5-cm soil layer, *M.laosensis* plots also had greater concentrations of light fraction organic C and N than *C.lanceolata* plots. The fumigation extraction method and phospholipid fatty acids (PLFA) analysis indicated that there was significantly greater microbial biomass in *M.laosensis* soil than in *C.lanceolata* soil. The mass of fungal PLFAs, bacterial PLFAs and total PLFAs were positively correlated with soil dissolved organic C and N extracted by hot water. This demonstrated that hot water extracted organic matter may contains some microbial biomass. Soil labile organic matter and microbial biomass can be used as indicators of soil quality, our results therefore indicated that the transition of land use change from *C.lanceolata* to *M.laosensis* can improve soil fertility in the plantation.

Introduction

Chinese fir (*Cunninghamia lanceolata* (Lamb.) Hook) is a native conifer timber species and now covers 9.11 million hectares, accounting for more than 18% and 5% of all forest plantations in China and the world, respectively. Field observation suggested that growth of Chinese fir in the replant woodlands is significantly reduced and this problem occurs in many Chinese fir growing regions, which has drawn considerable attention from ecologists, microbiologists etc (Zhang, 1997; Huang et al. 2000). The decrease of *C. lanceolata* growth in the replant woodland was attributed to the depletion of soil nutrients (Luan et al. 2010), allelopathy (Huang et al. 2000) and pathogenic fungi (Zhang & Zak, 1994). As the result, plantings of native broadleaved tree species in *C. lanceolata* sites are currently encouraged in subtropical China for provision of multiple environmental outcomes including enhanced biodiversity and improved soil fertility. However, little information is available on the land use transition between native broadleaf and pure conifer plantations on the changes in the quantity of labile fraction soil organic matter. For this study, it was hypothesized that conversion from *C. lanceolata* sites to broadleaved tree species plantations can increase the size of labile soil organic matter pools and microbial characteristics. As the extractions of labile organic matter by cold and hot water and salt solution inevitably extract some soil microbial components (Curtin et al. 2006), we hypothesized that dissolved organic matter may contains microbial biomass and therefore are related with the mass of phospholipid fatty acid (PLFA).

Materials and methods

The experimental site is located at Xiayang forest farm (26°48′N, 117°58′E), northwest Fujian Province, South Eastern China. The experimental site has a humid subtropical climate. Mean annual rainfall and average temperature over the trail period were 1669 mm and 19.3 ℃, respectively. This long-term experiment site consisted of a completely randomized block design with two tree species: 19-yr-old *C.lanceolata* and *M.laosensis* plantations. The treatments were replicated 4 times for a total 8 plots, each measuring 20 m×30 m. Details on experiment site are described in Huang et al. (2013). Soil samples were collected at three depths (0-5, 5-10, 10-20 cm) from *M. laosensis* and *C. lanceolata* plots. Three extraction methods (water, hot water, and 2 M KCl) were used for measurements of dissolved organic carbon (DOC) and nitrogen (DON) pools. The soil light fraction organic matter was collected by the method of Huang et al. (2011). Soil microbial biomass carbon was determined by the chloroform fumigation-extraction method (Vance et al., 1987). In addition, phospholipid fatty acids (PLFA) analysis was used to characterize soil microbial community under the two tree species plantations.

Results and discussion

Tree species transition from *C.lanceolata* to *M.laosensis* increased the size of soil DOC and DON pools, which agrees with the results of others (Xing et al., 2010; Jiang et al., 2010) showing the influence of tree species on the concentration of soil labile organic matter. The larger DOC and DON pools in *M.laosensis* soil coincided with higher litter C and N contents and lower C/N ratios, suggesting that the difference in the size of DOC and DON pools between *M.laosensis* and *C.lanceolata* may be related to differences in the litter quality or quantity or both. Soil light fraction organic matter mainly consists of plant-like and labile soil organic matter and is reported to be sensitive to changes in forest management, including changes in tree species. Our results showed that the concentrations of light fraction organic C and N in 0-5 cm soil layer under *M.laosensis* were significantly higher than under *C.lanceolata*. The fumigation extraction method and PLFA analysis indicated that there was significantly greater microbial biomass in *M.laosensis* soil than in *C.lanceolata* soil. Some authors had found that land use change from *C.lanceolata* to broadleaved tree species plantation in subtropical region can decrease soil microbial biomass and the mass of PLFAs (Xia et al., 2010; Wang & Wang, 2007). A previous study on the same site showed that the increases in content of lipid biomarkers under *M.laosensis* were attributed to higher litter quality (Huang et al., 2013), which agreed with our study. In this study, hot water extracted organic matter were positively correlated with the microbial biomass carbon and the mass of fungal and bacterial PLFAs, which indicated that hot water extracted organic matter may contains some microbial components (Balaria et al., 2009). Hot water extractable organic matter was largely composed of carbohydrates and N-containing components and therefore can be use as a sensitive indicator of soil quality (Chantigny 2003; Chodak et al., 2003). So our results indicated that reforestation in *C.lanceolata* site with broadleaved tree species may improve soil fertility and microbial activities.

Conclusions

Results have clearly demonstrated that tree species transition from *C.lanceolata* to *M.laosensis* increased the size of soil labile organic matter pools and microbial biomass. Both of them can be used as indicators of soil quality, so our results indicated that the transition of land use change from *C.lanceolata* to *M.laosensis* can improve soil fertility in the plantation.

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Conversion of a natural evergreen broadleaved forest into pure plantation forests in a subtropical area: Effects on soil respiration and microbial biomass

Jianfen Guo, Zhijie Yang, Chengfang Lin, Xiaofei Liu, Guangshui Chen, Yusheng Yang*
College of Geographical Science, Fujian Normal University, Fuzhou 350007, China;
Key Laboratory for Subtropical Mountain Ecology, Fuzhou 350007, China

Corresponding author: Yusheng Yang (geoyys@fjnu.edu.cn), Tel: +86 591 83482530; Fax: +86 591 83465397

E-mail: jfguo@fjnu.edu.cn, Tel: +86 591 83483731; Fax: +86 591 83465397

Abstract: For the last several decades, native broadleaved forests in many areas of south China have been converted into plantations of more productive forest species for timber use. This paper presents a case study examining how this forest conversion affects soil respiration (Rs) and microbial biomass carbon (MBC) in surface soils (0-10cm) by comparing two 36 year-old plantation forests of Chinese fir (*Cunninghamia lanceolata,* CF) and *Pinus massoniana* (PM) with an adjacent relict natural forest of *Castanopsis carlesii* (NF, ~200 year old) in Sanming, Fujian, China. From October 2010 to September 2012, Rs rate and MBC averaged 161.7 mg C m^{-2} h^{-1} and 508 mg kg^{-1} respectively in the NF. The corresponding values were 95.1 mg C m^{-2} h^{-1} and 412 mg kg^{-1} for CF, and 103.2 mg C m^{-2} h^{-1} and 399 mg kg^{-1} for PM, respectively. Mean annual carbon flux was 1421, 837 and 907 g C m^{-2} yr^{-1} in NF, CF and PM, respectively. Significant differences ($P<0.05$) in Rs and MBC between NF and two plantations were found. The mean annual Rs was correlated significantly with mean annual soil temperature, soil organic matter (SOM) and MBC storages at 0-10 cm depth across different forests. Further, soil MBC was significantly correlated with SOM. These results indicated that forest conversion influenced soil properties such as soil temperature, microbial biomass and organic matter, which in turn affected the magnitude of soil respiration. How long these changes would persist needs the further study. Increased understanding of the effects of disturbance during forest conversion on the net exchange of C between soil and the atmosphere will enable more accurate modeling of ecosystem C cycling.

Key words: soil respiration, microbial biomass carbon, native forest, monoculture plantation

Introduction

The effects of land use change on soil carbon storage are of concern in the context of international policy agendas on greenhouse gas emissions mitigation, and the first of all are those associating with the conversion of native forest to agricultural system, especially in tropical zone. However, the effects of conversion of natural forest to tree plantation have less been assessed. Due to rapid human population growth, demand for timber, fuel material, and other forest products is increasing. In many areas of South China, native broadleaved forests have been cleared for the last several decades, and subsequent development has involved the plantation of more productive forest species. Following timber extraction, the forest land is slashed, burned, and planted with economical conifer species, especially Chinese fir (*Cunninghamia lanceolata*) (Yang et al., 2003). As an important native conifer, Chinese fir has been widely planted for more than 1000 years and used for a variety of wood products. Planting area has reached 6 million ha and accounted for 24% of all forested land in China (Yu, 1996). Although carbon storage in vegetation has been investigated before (e.g. Chen et al. (2005)), there is little known about the effects of forest conversion to tree plantations on soil C stores and dynamics in the subtropical China.

Soil carbon storage is largely dependent on environmental, biogeochemical and land-management factors. Conversion from natural forest to tree plantation can have marked effects on soil carbon content as a result of the interactions between changes in detrital inputs and subsequent process mediated by soil microorganisms (Wang et al., 2004). Such changes have important implications not only for soil sustainability, but also for the global carbon cycle.

Soil respiration (Rs) represents a major component of the soil carbon cycle (Dilustro et al., 2005) and is an indicator of soil carbon storage, soil biological activity and overall soil quality (Tufekcioglu et al., 2001). In general, Rs depends upon the respiration of plant roots and soil microorganisms. Environmental factors such as soil temperature and soil moisture are known to have pronounced influence on the seasonal dynamics of Rs (Raich and Tufekcioglu, 2000). Soil physical and chemical properties such as texture, organic matter content, root density, and microbial biomass may also affect the magnitude of Rs (Wang et al., 2003; Gough and Seiler, 2004).

Although there are a number of studies on soil respiration and microbial biomass comparisons among forest types, largely in temperate and tropical forests (Li et al., 2004; Michelsen et al., 2004), relatively few studies were carried out in forests of southern China, an area of important subtropical forests. Furthermore, the impact of land use conversions on soil carbon pools and fluxes is still unclear. Information about the spatial and temporal distribution of Rs under different forest ecosystems is useful for understanding soil carbon and nutrient dynamics in these systems, and assessing the carbon storage capacity for global CO_2 budgets.

During the 1970s, part of natural *Castanopsis carlesii* forest at the Chenda Experimental Station in Sanming, Fujian was clear-cut to establish a series of pure conifer and broadleaved tree plantations such as *Cunninghamia lanceolata*, *Pinus massoniana* and *Castanopsis carlesii*. These plantations and an adjacent natural forest of *Castanopsis carlesii* had a homogeneous substrate (similar mineralogy, depths, and horizonation). In this paper, we focus on two 36 year-old plantation forests of *Cunninghamia lanceolata* (Chinese fir, CF) and *Pinus massoniana* (PM) and an adjacent relict natural forest of *Castanopsis carlesii* (NF, ~200 year old) as a control to assess the effect of forest conversion on Rs and microbial biomass. We hypothesized that the Rs rate and microbial biomass carbon (MBC) changed greatly with forest types in subtropical China. The specific objectives were: 1) to determine differences in Rs and microbial biomass under two plantation forests of CF and PM, and an adjacent NF, 2) to examine the temporal pattern of Rs, 3) to examine the relationships among Rs, MBC, organic matter, fine root biomass, soil temperature, and soil moisture.

Materials and methods

Site description

The study was carried out in the Chenda Experimental Forestry farm, Sanming, Fujian, China (26º19'N, 117 º36'E). It borders the Daiyun Mountain on the southeast, and the Wuyi Mountain on the northwest. The region has a middle sub-tropical monsoonal climate, with a mean annual temperature of 19.1 ºC and a relative humidity of 81 %. The mean annual precipitation is 1749 mm, mainly occuring from March to August (Fig. 1). Mean annual potential evapotranspiration is 1585 mm. The growing season is relatively long with an annual frost-free period of around 330 days. The parent material of the soil is sandy shale and soils are classified as red soils (humic Planosols in FAO system). Thickness of the soil exceeds 1.0 m.

Selected forest characteristics and some properties of the surface soil (0-20 cm) of the three sites are described in Table 1. NF represents the evergreen, broadleaved *C. carlesii* forest in mid-subtropical China with old age (~200 year). In addition to *C. carlesii*, the overstory also contained other tree species, such as *Castanopsis kawakamii*, *Schima superba*, *Litsea subcoriacea*, and *Elaeocarpus decipiens*. In 1975, part of this NF was clear-cut, slashed and burned. In 1976, the soil was prepared by digging holes and then 1-year-old seedlings of *C. lanceolata* (Chinese fir) and *P. massoniana* were planted at 3000 trees per hectare. The plantation forests were managed with similar practices, such as weed-controlling and fertilizing during the first 3 years, and thinning twice between 10~15 year old. In January 2010, three 20 m × 20 m permanent plots were located at each forest.

Soil CO_2 efflux, soil temperature and soil moisture

We measured soil CO_2 efflux from October 2010 to September 2012 using three automated soil CO_2 flux systems (Li-8100, Li-Cor Inc, Lincoln, NE, USA) equipped with the 20 cm survey chamber (Model 8100-103). Before sampling, green plants grown inside the collar were cut carefully. At the time of sampling, headspace air was circulated by a pump from the chamber to the analyzer unit with an air flow rate at 1.7 L min^{-1}. The CO_2 concentration in the chamber was measured by an absolute, non-dispersive, infrared (NDIR) gas analyzer, and logged every second for 2-5 minutes depending on the respiration rates. The CO_2 flux was calculated by the exponential regression of the CO_2 concentration over time. The measurement data during the first 15 seconds were discarded from the regression to avoid any artifact by closing the chamber.

At the time of R_S sampling, soil temperature at 5 cm depth was measured using a hand-hold long-stem thermometer (Model SK-250WP, SK SATO, Japan) placed adjacently to each collar, and soil moisture at 0-12 cm depth was recorded using a time domain reflectometry (TDR) unit (Model TDR300, Spectrum, USA) with two 12 cm long rods vertically inserted into the underground near each collar.

Microbial biomass carbon

Mineral soil (0-10cm) sample was collected from five locations at each plot in April 2011, July 2011, October 2011, and January 2012. These five samples were combined to form one composite sample for each plot. After removing stones, pebbles and large pieces of plant materials, the sample was sieved and kept field moist for the analyses of MBC.

MBC was determined by the chloroform fumigation-extraction method (Vance et al., 1987). A 25 g (dry weight equivalent) moist soil sample was fumigated with chloroform for 24 h and extracted with 100 mL 0.5 M K_2SO_4, shaken for 30 min and also filtered through a membrane filter with 0.45-μm pores. These filtrates were analyzed for organic C using a TOC Analyzer (Elementar Analysensysteme GmbH, Germany). MBC was calculated by using a conversion factors (*k*c) of 0.45.

Soil organic matter and fine root biomass

SOM was determined by the ignition method using a 5 g dried subsamples from the same soil samples used for soil MBC.

Sequential coring was used to determine fine root biomass. Ten soil cores (1.2 m × 6.8 cm i.d.) were removed randomly in each forest plot from the soil surface down to 80 cm depth in April 2011, July 2011, October 2011, and January 2012. Cores were washed with tap water to remove adhering soil and accompanying organic debris. Roots were distinguished from the soil by softly washing them over a series of sieves with mesh sizes of 2.0 mm and 5.0 mm. Roots were separated diameter classes of <2 mm (fine root), 2–5 mm (small root), and >5 mm (coarse root). Fine roots (< 2 mm diameter) were also classified by physiological status (live or dead) based on color, texture and shape of the root (Fahey and Hughes, 1994). All fine root samples were oven-dried (80 °C) to constant weight and weighed.

Statistical analysis

Each plot was an experimental unit, so replicate data were averaged by plots for analysis. Before analysis, all variables were checked for normal distribution (Kolmogorov-Smirnov test) and homogeneity (Levene test). R_S was in the natural logarithmic way transformed to achieve homogeneity. One-way analysis of variance (ANOVA) with Tukey's HSD test was used to test the differences of R_S, soil temperature, soil moisture and MBC between forests over the whole year. All results were represented as mean value ± standard errors. Statistical significance was established at the 5% level, unless otherwise mentioned.

As for the relationship between seasonal R_S, soil temperature and soil moisture, linear and nonlinear regression model analyses were performed as follows:

$$R_S = \alpha \times e^{\beta \times T} \qquad (1)$$

$$R_S = m \times M + n \qquad (2)$$

Where R_S is mean Rs rate ($\mu mol \cdot m^{-2} \cdot s^{-1}$), T is soil temperature (°C), M is volumetric soil moisture (%), and α, β, m, n are constants fitted by the least-square technique.

The annual R_S in each plot was estimated by extrapolating measurements to monthly fluxes and summing them for a year (Davidson *et al.*, 2000). Pearson linear correlations between Rs rate, soil MBC, fine roots biomass, and SOM were also conducted. All statistical analyses were performed using SPSS software (SPSS 13.0 for windows, SPSS Inc. Chicago, IL, USA).

Results

Soil respiration

Temporal patterns of Rs follow patterns of soil temperature for three forests (Fig. 2a). The Rs generally peaked in later spring or early summer (May or June) and then it gradually fell into the lowest valley in winter (January). The annual mean R_S was the highest in the NF (161.7 mg C m^{-2} h^{-1}), whereas the lowest in the CF (95.1 mg C m^{-2} h^{-1}) throughout the whole observed period (Table 2). No significant difference of the annual mean R_S was found between the CF and PM (Table 2). The average annual soil surface CO_2 flux in the NF (1421 g C m^{-2} yr^{-1}) was significantly higher than those in the CF (837 g C m^{-2} yr^{-1}) and PM (907 g C m^{-2} yr^{-1}).

Soil temperature and moisture

The seasonal variation of soil temperature in three forests followed a bell-shaped curve (Fig. 2b). For all forests, soil temperature rose to a maximum in July and dropped to a minimum in January or February. There were no significant differences in monthly soil temperature among the studied forests (Fig. 2b).

The seasonality of soil moisture at the depth of 0-12 cm fluctuated frequently, with serration pattern during the whole seasons (Fig 2c). Over 2 years of measurement, soil moisture ranged from 4.9-18.9 % in the NF, 6.9-22.9 % in the CF, and 6.6-19.3 % in the PM.

MBC, SOM and fine root biomass

Soil MBC in the top 10 cm was highest in the NF (508 mg kg^{-1}) and lowest in the PM (399 mg kg^{-1}) among forest types. Compared with NF, soil MBC was significantly lower ($P < 0.05$) in two plantations of CF and PM. However the difference between CF and PM was not statistically significant (Table 2).

There was significant difference in SOM at 10 cm depth among forests ($P < 0.05$), except between the CF and the PM ($P > 0.05$). The NF (65.8 g kg^{-1}) had significantly higher SOM content than the CF (41.2 g kg^{-1}) and PM (36.2 g kg^{-1}) (Table 2).

Live fine root (< 2 mm) biomass in the NF and CF was significantly higher than that in the PM ($P < 0.05$). The PM forest had the highest live fine root biomass (428 g m^{-2}) while the PM forest had the lowest (131 g m^{-2}) among three forests (Table 2).

Correlation analysis

The seasonal R_S exhibited a positively exponential correlation with soil temperature for all forests (Fig. 3). Soil temperature at 5 cm depth could explain 71% to 91% of seasonal variation of R_S in these forests. Nevertheless, no significantly linear relationship of the seasonal R_S with soil moisture at 0-12 cm was found in three forests (Fig. 4).

The Rs rate was highly correlated with MBC (r=0.977) and SOM concentrations at 0-10 cm depth (r=0.964). Additionally, soil MBC was significantly correlated with SOM (r=0.999). However, live biomass of fine root (< 2 mm in diameter) was not significantly correlated with the Rs rate, MBC and SOM concentrations at 0-10 cm depth across different forests (Table 3).

Discussion

As hypothesized, the Rs rate (Table 2) differed greatly between NF and plantations of CF and PM. Average Rs rates in this study (95.1–161.7 mg CO_2 m^{-2} h^{-1}) are lower than the values reported in other tropical forest studies. For example, Schulze (1967) reported 1527 mg C m^{-2} h^{-1} in highly productive Costa Rican wet rain forest. Smith (1996), working in Amazonia, found a range of soil CO_2 efflux (mg C m^{-2} h^{-1}) of 427 to 489 in plantations and 351 in native forest. Also, mean Rs rates in the NF and two plantations of CF and PM were lower than those of other subtropical forests, e.g., monsoon broadleaved forest (478 mg CO_2 m^{-2} h^{-1}) and mixed conifer-broadleaved forest (435 mg CO_2 m^{-2} h^{-1}) in Dinghushan Mountain (Yi et al., 2003). Annual carbon flux of the NF forest was higher than those of other subtropical climatic forests, e.g., monsoon broadleaved forest (1150 g C m^{-2} yr^{-1}) and mixed conifer-broadleaved forest (1042 g C m^{-2} yr^{-1}) in Dinghushan Mountain (Yi et al., 2003), and *Quercus glauca* forest (657 g C m^{-2} yr^{-1}) in Hangzhou (Huang et al., 1999). Annual carbon flux of the CF and PM were much higher than that of 10-year-old Chinese fir stand in Huitong (593 g C m^{-2} yr^{-1}) (Fang et al., 1997), but slightly lower than that of 14-year-old Chinese fir stand in Qianyanzhou (932 g C m^{-2} yr^{-1}) (Zhou et al., 2002).

Soil temperature and moisture are important factors controlling the temporal variation of Rs at ecosystem level. Many studies (e.g. Fang and Moncrieff, 2001; Yang et al., 2005), including those carried out in subtropical China, have related variation in Rs to soil temperature. The temporal pattern of Rs in our study did followed soil temperature across the research period. However, the correlation of Rs with soil moisture was poor (Fig. 4). Wagai et al. (1998) suggested that the two environmental factors might have a confounding effect on Rs rates, because soil temperature tended to be high when the soil moisture was low and *visa versa*. This was apparent in our study as well (Fig. 2b and Fig. 2c). In subtropical China, soil temperature and soil water content often change asynchronically over the year and peaked differently in July and May or June, respectively. A dry period usually occurs during mid-summer when soil temperature reach its maximum while soil water content at a relative low level due to less rain event. Thus, Rs will be restricted by soil water content and the maximum Rs will not happen during this period.

Even through soil temperatures in the three forests were very similar during study periods, Rs rates were significantly higher in the NF than in the CF and PM. This indicates that the effect of soil temperature on Rs varies with site conditions such as SOM, soil biological activity and root activity.

SOM is an important factor in controlling Rs (Mallik and Hu, 1997). For example, Franzluebbers et al. (1995) reported that crop management practices such as no tillage might influence Rs rates through their effect on SOM. Greater SOM in the NF than in other two forests are likely the result of greater input of litter to the soil in the NF (Table 1). The significant relationship (r= 0.999) between SOM and MBC observed in our study is similar to results by Witter et al. (1993) (R^2 = 0.82) and Moore et al. (2000) (R^2= 0.36).

It is well known that the microorganisms convert soil organic C into CO_2 through their metabolic activities. As the decomposer, the importance of microorganisms in SOM transformations must be recognized. Especially when different treatments from the same site or soils under similar conditions are compared, soil MBC might be related to C mineralisation (Shen et al., 1997). For example, Shen et al. (1997) found that Rs rate was closely related to soil MBC. This was in agreement with the results in the present study.

The contribution of root respiration on total Rs is well documented in the literature (Raich and Tufekcioglu, 2000). Respiration by root systems, including its associated microbial components, represents a significant portion of Rs in most ecosystems (Kelting et al., 1998), and hence a major factor influencing Rs rates *in situ*. The proportion of the total Rs flux that is attributable to live root respiration appears to be very high in cold, northern biomes, ranging from 50–93% in arctic tundra (Chapin et al., 1980) and from 62–89% in boreal forests (Ryan et al., 1997). In temperate zones, estimated proportions of the total Rs flux that is derived from live root respiration range from 33–50% in broadleaved forests (Bowden et al., 1993) and from 35–62% in pine forests (Striegl and Wickland, 1998). However, we observed no significant relationship ($r = 0.197$) between Rs rate and fine root biomass.

It is clear that Rs is significantly related to soil MBC and SOM in our study. However, it was impossible to separate the degree of each contributing factor on total Rs. Correlations between Rs and MBC and SOM may help to model Rs rates and clarify some of the uncertainty and heterogeneity involved.

Conclusions

In summary, the Rs rate in this study was highly correlated with biotic variables (i.e., soil MBC) and SOM. Additionally, Rs, MBC and SOM were greater in the NF forest than in plantation forests of CF and PM. The effect of forest conversion on soil properties was significant. This was associated with changes in the microenvironment, amount of litter input and microbial activity, and site disturbance during the establishment of plantations. Hence, understanding variation in soil CO_2 efflux and their relation to environmental factors can help guide forest management. Also, increased understanding of the effects of disturbance, including prescribed fire and harvests, on the net exchange of C between soil and the atmosphere via forest conversion or land use change will enable more accurate modeling of ecosystem C cycling.

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Comparison of soil properties under introduced *Eucalyptus urophylla* plantations in reference to native *Pinus massoniana* plantations and natural broadleaved forests in South China

Shucai Zeng[a]*, Douglass F. Jacobs[b], Joshua L. Sloan[b], Li Xue[a], Shuangshuang Chu[a], Xiangyang Pei[a]

[a] *College of Forestry, South China Agricultural University, Guangzhou 510642, China*
[b] *Department of Forestry and Natural Resources, Hardwood Tree Improvement and Regeneration Center, Purdue University, West Lafayette, IN 47907-2061, USA*
*Telephone No. 8613427633688; Fax No. +86-20-85280256; and E-mail: sczeng@scau.edu.cn

Key words: Soil physical properties; soil pH; CEC; nutrient contents; soil degradation

Abstract: Effects of fast growing exotic eucalyptus plantations (EPs) on soil attributes have been widely studied in the world; however, findings have been inconsistent. Such eucalyptus plantations comprise one of the most commercially important forest types in China. Due to fast growth rates, short rotations, and a continuously expanding area being brought under plantation management, EPs receive much more attention from the public and researchers than other plantations in the region with respect to the effects on soil quality and the environment. Eucalyptus plantation establishment is often not socially acceptable and is consequently forbidden by forestry authorities in some cities and counties of South China due to its reported adverse impacts on environment. To better understand the influences of EPs on soil quality and the differences among forest types, we compared soil physicochemical properties, soil organic matter (SOM), and nutrient contents under EPs with those under Masson pine (*Pinus massoniana* Lamb.) plantations (MPPs) and natural broadleaved forest (NBF) in over 30 sites in South China. Results revealed that EPs had significantly lower porosity, water holding capacity, and available Zn in the A horizon, significantly lower SOM, total N, available N, and available K contents in both the A and B horizons, and significantly lower available Cu in the B horizon than NBF. Eucalyptus plantations had significantly higher SOM in the A horizon and total N in the B horizon compared to those in MPPs, and EPs had significantly lower available K in the A and B horizons, and available Zn in the B horizon relative to those in MPPs. No significant differences were observed in pH, cation exchange capacity, or base saturation among EPs, MPPs, and NBF, or in soil physical properties between EPs and MPPs. We conclude that EPs showed soil degradation in terms of physical properties, SOM, and nutrient contents in comparison to NBF, but did not exhibit any apparent soil deterioration compared to MPPs.

Introduction

Much debate has occurred regarding the effects of Eucalyptus plantations (EPs) on soils, the environment, and plant communities (El-Amin et al., 2001). Research results with respect to the effects of EPs on soil properties and fertility have been inconsistent. Some studies have shown considerable improvement in soil properties following EP establishment (Garten, 2002; Mishra et al., 2003), while others have reported very limited soil improvement or even serious degradation of soil attributes due to EP establishment (Richter et al., 1999; Freier et al., 2010). Thus, uncertainty remains regarding the effects of EPs on soil quality. The differences in soil properties between EPs and other plantation and forest types have not been thoroughly described (Singh et al., 1989). The objective of the present study is to investigate the differences in soil properties, SOM, and nutrient contents between EPs (*Eucalyptus urophylla* plantations), Masson pine (*Pinus massoniana* Lamb.) plantations (MPPs), and natural broadleaved forest (NBF) in a relatively large landscape in South China. The results will provide new insights into how forest types affect soil attributes in South China.

Material and methods

The study was conducted in Guangdong Province, China. The forest types examined in this study included EPs (*Eucalyptus urophylla*), MPPs, and NBFs, all among the major forest types found distributed throughout the province. The sampling plots were determined based on the design of the sixth national forest resources survey in Guangdong. In the forest survey, there are 1000 permanent plots. Among them, 36 are EPs, 28 are MPPs, and 35 are NBFs. Every plantation or forest was located on a different site.

Results and discussion

Eucalyptus plantations and MPPs had significantly higher soil bulk density, and significantly lower total porosity, non-capillary porosity, total volume water, and hygroscopic moisture contents than NBF in the A horizon. In the B horizon, however, only hygroscopic moisture content was significantly different between EPs and NBF, with EPs exhibiting a lower hygroscopic moisture content relative to NBF. No significant differences in soil pH were found between EPs, MPPs, and NBF in either the A or B horizons. No significant differences in CEC or base saturation (BS) were found between EPs, MPPs, and NBF.

In the present study, both EPs and MPPs had significantly lower SOM contents than NBF in both A and B horizons, with SOM under the A and B horizons of EPs being 74.7% and 65.8% that of NBF, respectively. Contents of total N, available N, available K, and available Zn in both A and B horizons, and available Cu content in the B horizon under EPs were significantly lower than under NBF. Contents of total P, total K, available P, and available boron in both A and B horizons, and available Cu in the A horizon, did not differ significantly between EPs and NBF.

Conclusions

Compared to NBF, EPs showed soil degradation in terms of physical properties, SOM content, and nutrient contents, which was particularly evident in the A horizon. However, EPs did not cause any obvious degradation in chemical properties (including pH, CEC, and BS) as compared to NBF. No significant differences were observed in soil physical and chemical properties between EPs and MPPs. SOM in the A horizon and total N in the B horizon under EPs were significantly higher than under MPPs, but available K in the A and B horizons under EPs was significantly lower than under MPPs. So, when compared to MPPs, EPs did not exhibit notable adverse effects on soil properties and nutrient contents.

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Effect of saline irrigation on aeolian sandy soil and the “Green Great Wall” in Taklimakan Desert

Congjuan Li*, Jiaqiang Lei, Xinwen Xu
Xinjiang Institute of Ecology and Geography, Chinese Academy of Sciences, 818 South Beijing Road, 830011,
Urumqi, Xinjiang, People’s Republic of China

Keywords: Saline irrigation; Soil evolution; Artificial shelterbelt; Ecological restoration

Abstract: Saline irrigation on aeolian sandy soil and “Green Great Wall” was conducted along Taklimakan Desert Highway artificial shelterbelt eco-engineering. Results showed that significant soil salts and nutrients accumulated at surface of shelterbelt, and no soil salinization (no more than 0.5 mS cm^{-1}) at the root zone (40-60 cm). The main root extended to an average depth of 100-150 cm. More than 86.6 % of the lateral roots (in terms of biomass, the same below) occur in the depth interval 20-80 cm, and no active absorbing roots were found at the salt accumulation layers (0-10 cm). In all, artificial shelterbelt with saline irrigation exerts significant action on sandy soil evolution, and saline irrigation is the sole water resource for plant growth in this area.

Introduction

Water is a primary resource limitation to plant growth, especially in water-restricted area (Leffler et al., 2004; Ghrab et al., 2013). However, any use of saline irrigation water as well as freshwater irrigation in combination with high rates of evaporation can affect soil characteristics; especially for soil salinization and salinity hazards to vegetation due to salt accumulation in the root zone (Wang et al., 2011), which is a major threat for plant growth and species self-renewal in irrigated areas (Rhoades et al., 1997; Tedeschi et al., 2005). Taklimakan desert is the largest mobile desert in the world, also been called “Dead Sea” since fewer organisms lived there. While, the longest desert highway (566 km) and artificial shelterbelt (436 km) ecological engineering (Green Great Wall) has been conducted here, to ensure the smooth of highway and the normal growth for artificial shelterbelt, the salt groundwater became the sole water resource since no other water can be used. So, clarify the effects of salt irrigation on soil and plants are essential for the sustainable of “Green Great Wall” in the Taklimakan desert.

Materials and methods

The study was conducted in the Taklimakan Desert , 7 sampling sites with different salinity (3.6 g L^{-1}- 26.2 g L^{-1}) groundwater irrigation were selected for soil water and chemical properties analysis, , besides, the shifting sandy soil was selected as the CK. The intact root systems of the studied plants were excavated to investigate the effects of salt irrigation on the plants root distribution. at last, took the roots to laboratory and washed them clear for oven-drying and gained feeder roots biomass.

Fig. 1 The protecting effect of Taklimakan Desert highway artificial shelterbelt

Results and discussion

Effects on soil evolution Surface soil salinity was greatly correlated with the mineralization of irrigation water in Taklimakan Desert Highway artificial shelterbelt. and no soil salinization at the root zone, This may be the significant evaporation lead soil salt moving up (Pereira et al., 2002), or polysalt or salt excretion for halophytes (Wang et al., 2004; Wang et al., 2006). Soil nutrients accumulated significantly at surface soil, this can be interpreted as vegetation litter decomposition, roots turnover and other biogeochemical cycle (Schlesinger et al., 1996). Besides, the nutrients accumulation rate at surface soil decreased with the increasing of mineralization of irrigated groundwater (15.5-26.6 g L^{-1}), which may be interpreted as great higher salinity restricts the litter decomposition rate (Walpola and Arunakumara, 2010).

Effects on plants Saline irrigation do not exert salinity hazards on plants so far, after 7 years irrigation with saline groundwater, soil salts at the root zone were no more than 0.5 mS cm^{-1}, especially, no feeder roots can be found at the salt accumulation layers (0-10 cm). Which also can be interpreted as the salt surface accumulation by higher evaporation (Pereira et al., 2002), and polysalt or salt excretion for halophytes (Flowers et al., 1986; Jithesh et al., 2006), besides we can consider this phenomenon as the plants adaptability to the salt stress through root morphology adjustment (Xu et al., 2008).

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Changes in glomalin-related soil protein, SOC, N and other soil physic-chemical properties during vegetation succession of original Korean pine forests in Changbaishan Mts.

Wenjie Wang[a], Ji Changping[a], Zhang Wentian[a], Han Shijie[b], Zu Yuangang[a]
[a] Key laboratory of Forest Plant Ecology, Northeast Forestry University,Harbin 150040, China
[*] Phone: +86 451 82190092; Fax: +86 451 82190092; E-mail: wjwang225@hotmail.com

Korean pine forest is the climatix vegetion in northeast China and Changbai Mts national reserve is one typical site for studying the succession changes from early stage (poplus-betula forest) to late stage (korean pine-broadleaf forest). In this paper, soils from 0-10cm, 10-20cm and 20-30cm soils of 7 successional stages were sampled and glomalin-related soil protein, GRSP(easily extracted,E-GRSP and total,T-GRSP), SOC, N, P,K and soil pH, EC were measured for finding their successional changes. The result showed that, 1) GRSP(E-GRSP and T-GRSP), SOC, N, P showed similar decreasing tendency with soil depth, while soil K increased with soil depth. 2) During the successional process, both E-GRSP and T-GRSP showed significant increases in deeper soil of (10)20-30cm ($p<0.05$), while no significant changes were found in surface soils of 0-10cm ($p>0.05$). For 20-30cm soils, linear relation between the E-GRSP (y) and successional time (x) was $y=0.74+0.001x$, $r^2=0.442$,$p=0.001$, while the linear relation for T-GRSP was $y=8.79+0.0069x$, $r^2=0.203$,$p=0.041$. 3) the successional process also significant affect SOC, P, N and K, but differed between surface and deep soils. For SOC and P, temporal changes in surface soil were not significant, while they were significant increased in deep soil (20-30cm). For N and P, significant increases in surface soil (0-10cm) were found, but no marked changes in deep soils. 3). General marked linear relations between GRSP and soil fertility parameters were observed ($p<0.05$). Except K, all others were positive relations. However, different soil layers, these relations slightly differ among different parameters. When all soil layer together, the GRSP-soil properties relations were more pronounced. 4). IR spectrum showed logarithmically increasing tendency in functional groups at 1750-1480cm^{-1}($y=82.2\ln(x)+1408$, $r^2=0.5326$,$p=0.06$)) and 1480-1320cm^{-1}($y=29.7\ln(age)+295.2$, $r^2=0.7254$,$p<0.05$),but logarithmically decreasing tendency in functional group at 1290-930 cm^{-1} ($y=-63.6\ln(x)+1545$,$r^2=0.5311$,$p=0.06$). 5) XDR results showed that 2 typical diffraction peaks were at 19.8°(4.47Å) and 26.3°(3.35 Å), but differences were not obvious at different successional stages. 6) 3-D fluorescence spectrum and ultraviolet spectrophotometry scan of GRSP from different successional stage were also discussed. 7) In conclusion, our results manifested that forest succession can affect the quantity (total amount) and quality (composition) of GRSP, and these changes are important for soil carbon sequestration and nutrient sustainability owing to their general close inter-correlations.

Effects of *Ageratina adenophora* invasion on soil phosphorus and soil potassium in *Eucalyptus* plantation

Xinhui Huang[a], Fuke Yu[b,*], Xuehua Wang[a], Xiaoying Li[a], Yanxia Wang[a], Jiangang Ma[a], Danhui Qi[a]
[a]College of Environmental Science and Engineering, Southwest Forestry University, Kunming 650224, P. R. China; and [b]Institute of Environmental Sciences and Ecological Restoration, School of Life Sciences, Yunnan University, Kunming 650091, P. R. China.
*Telephone: +86-871-65090855; Fax: +86-871-65090855; and E-mail: frank-yu@163.com; ylhxh2001@163.com
Keywords: *Ageratina adenophora*, biological invasion, *Eucalyptus* plantation, soil phosphorus, soil potassium, ecological effects.

Abstract *Eucalyptus* tree-*Ageratina adenophora* compound system is considered as a new invasion in Yunnan, southwest China in recent years. In this paper, the effects of *A. adenophora* invasion on soil phosphorus, soil potassium in *E.* plantation were investigated, based on the exploration of its causes, the assessment of its risk and the prediction of its succession. The results showed that the invasion had a different effect on four different chemical indexes (TP, AP, TK, AK) of soil in *E.* plantation, characterized with a certain complexity. Its effect on soil phosphorus (TP, AP) and soil potassium (TK, AK) was related to seasons, exposure and invasive degrees of *A. adenophora*, but there was no unified rule for them, which should be studied further. It's expected to provide a theoretical basis for the sustainable operation and scientific management of *E.* plantation under the condition of *A. adenophora* invasion.

Introduction

A. adenophora, an herbal plant, belongs to *Eupatorium* Genus of Compositae Family, originated from Mexico and Costa Rica in Central America, now it is a typical vicious invasive weed worldwide, which is widely distributed in more than 30 countries and regions in tropical and subtropical areas (Xie et al, 2001). In the 1940s, it was introduced into Lincang, the boundary county in Yunnan China, from Myanmar, now, it has been widely spread to Yunnan, Guizhou, Sichuan, Chongqing, Guangxi, even further to Taiwan (Xie et al, 2001), and it continues to spread further eastward and northward at an annual speed of 20km (Wang & Wang, 2006). Its invasion could produce many ecological effects, such as changes in soil quality (Kourtev et al, 2002; Niu et al, 2007), the exclusion of local species (Stinson et al, 2006; Mangla et al, 2008), damages to regional biodiversity (Wang et al, 2010; Pritekel et al, 2006), which has brought about enormous economic losses (Xu et al, 2006; Zhu et al, 2005). Meanwhile, due to the covertness of its invasive effects on soil quality, along with lack of in-depth researches and deficiency in the understanding of its occurrence mechanism and influential factors, there is a major technological challenge on the cause exploration and risk assessment of its invasion.

Recently, in parts of Yunnan such as Kunming, Chuxiong, Pu'er, etc., it was found that in *E.* plantation with rare local species, *A. adenophora* could not only survive but widely spread, thus *E.* tree-*A. adenophora* compound system appeared (Huang et at, 2013). Behind such phenomenon lied some major scientific issues, e.g., what's the essential reason for such a compound system? What ecological effects would it produce, and how would it go in succession? Based on its great significance, a series of studies had been done. In this paper, the effect of *A. adenophora* invasion on soil water, soil organic matter, soil nitrogen in *E.* plantation would be mainly explored.

Materials and methods

A brief introduction to the research area

Humashan Hill in Kunming, Yunnan was selected as the research site, with its geographical coordination of 25°06′76″N and 102°76′51″E and an altitude of about 1,920m above sea level. It goes from eastward to westward, characterized with obvious dry and wet seasons. From mid May to mid October, it's the rainy season, while from the late October to early May, the dry season, with an annual average temperature around 16℃ and 850-950mm of annual rainfall. The soil in the research site is characterized with red earth, with *E. globules* plantation as its main vegetation with the invasion of *A. adenophora*.

Sample sites selecting

Different water and thermal condition of the sunny side and shadowy side of Humashan Hill and different invasive degrees of *A. adenophora* into *E.* plantation were taken into consideration, thus 4 sample sites with an area of 10m×10m with a similar altitude were selected in *E.* plantation on the sunny and shadowy side of the Hill respectively, marked with SIS (severely invasive sample, an invasive coverage of 51%~70%, treatment 1), MIS (moderately invasive sample, an invasive coverage of 31%~50%, treatment 2), LIS (lightly invasive sample, an invasive coverage of 11%~30%, treatment 3) and WIS (weakly invasive sample, an invasive coverage below 10%, CK) respectively. These sample sites are used for soil samples collecting.

Soil sample collecting and the test of its chemical indexes

In September, 2011 (the rainy season) and April, 2012 (the dry season), soils were collected twice as samples for the test of chemical indexes. The specific test indexes and methods were shown as below: The concentration of total phosphorous (TP) was measured with Sulfuric Acid-perchloric Acid Extraction and Molydenum-Antimony-D-iso-ascorbie-Acid-colorimetry (MADAC); the concentration of available phosphorus (AP) was measured by Ammonium Fluoride Extraction and MADAC; the concentration of total potassium (TK) was measured with Molten Sodium Hydroxide-Colorimetry; the concentration of available potassium (AK) was measured with Ammonium Acetate Extraction-Flame Photometry.

3 Results and discussions

The effect of *A. adenophora* invasion on soil phosphorus in *E.* plantation

The effect of the invasion of *A. adenophora* on soil phosphorus in *E.* plantation was related to seasons, exposure, and invasive degrees.

As for soil TP, during the dry season, on the sunny side, in all samples, soil TP was characterized with no significant increase (compared to CK); by contrast, on the shadowy side, in SIS and LIS, soil TP increased significantly, while in MIS, soil TP was characterized with no significant change (compared to CK). During the rainy season, in all samples, soil TP increased significantly (compared to CK), in additon, in LIS and MIS, soil TP is significantly higher than in SIS; by contrast, on the shadowy side, in all samples, soil TP was characterized with significant increase (compared to CK), in addition, in LIS, soil TP is significantly higher than in MIS and SIS.

As for soil AP, during the dry season, on the sunny side, in samples with different degrees of invasive *A. adenophora*, there was no significant change in soil AP compared to CK; while on the shadowy side, in SIS, soil AP increased significantly, by contrast, in MIS and SIS, there was no significant change in soil AP compared to CK. During the rainy season, on the sunny side, in samples with different degrees of invasive *A. adenophora*, there was no significant change in soil AP compared to CK; while on the shadowy side, in SIS, soil AP decreased significantly, by contrast, in MIS and SIS, soil AP increased significantly compared to CK.

The effect of *A. adenophora* invasion on soil potassium (K) in *E.* plantation

The effect of the invasion of *A. adenophora* on soil soil potassium (K) in *E.* plantation was also related to seasons, exposure, and invasive degrees.

Take soil TK for instance, during the dry season, on the sunny side, in all samples, soil TK was characterized with significant decrease, with an order as follow: MIS > LIS> SIS (compared to CK); by contrast, on the shadowy side, in SIS and LIS, soil TK was characterized with significant increase, while in MIS, soil TK decreased significantly (compared to CK). During the rainy season, in SIS and LIS, soil TK was characterized with significant increase and no significant increase respectively, while in LIS, soil TK decreased significantly (compared to CK); by contrast, on the shadowy side, in all samples, soil TK was characterized with significant increase with the invasion (compared to CK).

Take soil AK for another instance, during the dry season, on the sunny side, in SIS and MIS, soil AK increased significantly, while in LIS, there was no significant change in soil AK (compared to CK); on the shadowy side, in SIS and LIS, soil AK decreased significantly, while there was no significant change in soil AK in MIS (compared to CK). During the rainy season, on the sunny side, soil AK increased significantly in all the samples (compared to CK), with the order as below: LIS<SIS<MIS; by contrast, on the shadowy side, soil AK also increased significantly in all the samples (compared to CK), with the order as below: LIS >SIS>MIS.

Conclusions

The effects of the invasion of *A. adenophora* on four different chemical indexes (TP, AP, TK, AK) of soil in *E.* plantation were characterized with great differences and a certain complexity as well. Its effect on soil phosphorus (TP, AP) and soil potassium (TK, AK) was related to seasons, exposure and invasive degrees of *A. adenophora*, whereas, there was no unified rule suitable for all of them, thus its influential mechanism required for further study.

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Rapid soil fungal community response to intensive management in a bamboo forest ecosystem developed from reclaimed rice paddies

Authors: Hua Qin[a], Hailong Wang[a, *], P. James Strong[b], Yongchun Li[a], Qiufang Xu[a], Qifeng Wu[c]

[a] School of Environmental and Resource Sciences, Zhejiang A & F University, Lin'an, Hangzhou 311300, China

[b] Callaghan Innovation Research Ltd, University of Canterbury, Private Bag 4800, Christchurch, 8140, New Zealand

[c] Agricultural Technology Extension Centre, Lin'an Municipal Bureau of Agriculture, Lin'an, Hangzhou 311300, China

[*] Corresponding author. Tel.: + 86 571 63705212; Fax: + 86 571 63740889.

E-mail address: nzhailongwang@gmail.com (H. Wang)

Introduction

Phyllostachys praecox has an intensive management regime that includes applying winter mulch and large amounts of mineral fertilizer to stimulate earlier bamboo shoot emergence. According to our previous studies, long-term intensive management has led to significant soil acidification as well as the accumulation of soil nutrients such as nitrogen, phosphorus and potassium. Soil fungi play an important role in soil ecosystems where they break down plant residues, promote nutrient cycling and stimulate plant growth. They differ in their response to NPK fertilizers, and N fertilizers alter not only the fungal biomass, but also the abundance of fungal species. We expected long-term intensive management to alter the composition of fungal communities in the soils under bamboo stands. The objective was to explore PLFA and 18S rDNA-based molecular approaches to assess the impact of high rate mineral fertilizer application and winter mulch on soil fungal abundance and community composition in long-term intensive managed bamboo stands.

Materials and methods

The bamboo stands investigated in this study were located in Taihuyuan township, Lin'an County, Zhejiang Province, China (30°16′ 072″-263″N, 119°34′ 117″-977″E). Paddy fields in this area were converted to bamboo stands progressively from 1980. Bamboo stands received no fertilizer during the first four years after conversion, but were intensively managed from the fifth year. A space-for-time substitution procedure was used to reconstruct chronological sequence for a bamboo stand. Twenty-one bamboo stands were selected to represent 7 different stand age-classes: 1 year (1YR), 4 years (4YR), 6 years (6YR), 8 years (8YR), 10 years (10YR), 12 years (12YR) and 20 years (20YR), each with triplicate. Fungal biomass (concentration of fungal phospholipid fatty acid marker), fungal DNA (18S rDNA real-time qPCR) and fungal community composition (culture-independent methods: DGGE, cloning and sequencing) were measured for bamboo stands.

Results and discussion

Although fungal DNA abundance and PLFA biomass were unaffected during the first two years of intensive management, both increased significantly after three years of intensive management. The fungal/bacterial ratio generally remained constant (except the stands with 8 and 12 years intensive management). Sequencing of typical bands revealed that the majority of the soil fungi were species of either *Sordariomycetes* or *Chytridiomycetes*. Cluster analysis by Ward's method revealed notable short-term change in fungal communities, but this was followed by minimal long term change. Fungal PLFA biomass correlated linearly with soil pH while 18S gene abundance correlated significantly with soil total N content. Redundancy analysis revealed a significant correlation between fungal community composition variation and stand age, soil pH and concentration of soil total N and organic C.

Conclusions

The soil fungal community composition responded to the intensive management rapidly, but did not vary greatly over the longer term. Intensive management of bamboo soils generally had little effect on fungal DNA abundance, fungal biomass, bacterial biomass or the fungal/bacterial (F/B) ratios during the first two years, likely due to the minor changes of soil pH and nutrient content. A significant increase in fungal DNA abundance was observed from the fourth year of intensive management, and a significant increase in the F/B ratio was observed after winter mulch. In contrast to previous studies where a high N input negatively affected soil fungal community, the high input of the organic material high in C-content generally offset the negative impact of N fertilizer application on the fungal community. The organic material and high rate of N fertilizer had synergistic effect on fungal biomass.

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Beneficial effect of biosolids on soil fertility, tree growth and carbon sequestration of radiata pine plantation on a poor site

Jianming Xue[a,*], Mark Kimberley[b], Hailong Wang[c], Peter Wilks[d]

[a] Scion, Private Bag 29237, Christchurch; [b] Scion, Private Bag 3020, Rotorua, New Zealand; [c] College of Environmental and Resource Sciences, Zhejiang A & F University, Lin'an 311300, Zhejiang, China; [d] PF Olsen Ltd., Richmond, Nelson, New Zealand. [*] Phone: +64 3 3642949; Fax: +64 3 3642812; E-mail: jianming.xue@scionresearch.com

Keywords: growth, carbon sequestration, radiata pine plantation, biosolids.

Abstract Repeated application of biosolids to a plantation forest on a poor site significantly improved soil fertility, tree nutrition and growth, and increased carbon storage in the radiata pine stand and the soil. This study suggests that optimum use of biosolids on marginal land was an effective means of increasing carbon sequestration in the forests and soils.

Introduction

Forests are at the center of New Zealand's climate change response efforts, and forestry is New Zealand's largest potential carbon sink. In order for New Zealand to realise the considerable opportunities offered by planting forests on marginal land, improved technologies and integrated management practices are needed to enable forest growers to earn money from environmental services, such as carbon sequestration. The marginal land has several biophysical constraints with poor soil as one of main constraints. There is an opportunity to improve forest growth through the application of organic waste high in nutrients such as biosolids, and enhance soil organic matter content along the way (Turvey and Burns, 2009). The objective of this study was to investigate the long-term effects of repeated applications of biosolids on soil chemical properties, tree nutrition and growth, and total C storage of radiata pine stand over 13 years.

Materials and methods

The trial was established in a 6-year-old radiata pine stand in the Rabbit Island plantation in Nelson, New Zealand in 1997. The soil at the trial site is a sandy soil, with low nitrogen (N) supply. The trial is a split-plot design with four replicates. Three biosolids treatments, applied in main-plots, were (1) Control (no biosolids), (2) Standard treatment (300 kg N ha^{-1}), and (3) High treatment (600 kg N ha^{-1}). Each main-plot contains three tree stocking rates (subplots) at 300, 450 and 600 stems ha^{-1}. There are 36 subplots (25 m×25 m) in total. Biosolids were applied in 1997, 2000, 2003, 2006 and 2009 at the same rates. The biosolids contain 8-10% N. Details of biosolids properties and method of application were given by Wang et al. (2004).

Tree height and diameter at breast height of all trees were measured annually from 1997 (age 6) to 2010 (age 19). At age 12 years, pith to bark increment cores at breast height were taken from four randomly chosen trees in each plot for measuring wood density. The Forest Carbon Predictor was used to provide annual estimates from age 6 to 19 years for each plot of carbon stocks in above and below ground live biomass along with associated dead wood and litter pools (Beets et al., 2012).

To monitor tree nutrition status changes, current-year foliage samples were collected annually from selected trees in each plot in March since 1998. The long-term impact of biosolids applications on soil chemical properties was assessed from samples taken from the forest floor litter layer, topsoil (0–0.25 m) and subsoil (0.25–0.5 m) in May 2010. Soil samples were analysed for soil pH, total C, N and S, Olsen P, and exchangeable cations, while foliage and litter samples for mineral nutrients. Statistical analyses were performed using the SAS Version 9.2.

Results and discussion

Effect of biosolids application on forest floor litter and soil chemical properties

Both the Standard and High biosolids application significantly ($P < 0.05$) increased N, P and S concentrations but reduced Mn concentration and C/N ratios in forest floor litter (data not shown). The Standard treatment also significantly ($P < 0.05$) increased B concentration in the litter when compared to the control. The results indicate biosolids application improved the litter quality as a result of improved tree nutrition status (data not shown).

In the top soil layer (0−0.25 m), significantly ($P < 0.05$) higher total C, N and P, Olsen P and CEC but lower pH were found for both the Standard and High treatments (Table 1). In the subsoil layer (0.25−0.5 m), the High treatment significantly increased total C, N and P, Olsen P and reduced soil pH while the Standard treatment significantly increased total C and Olsen P and reduced soil pH when compared to the Control (Table 1). The results indicate that the biosolids application, especially the High treatment, not only resulted in accumulation of C, N and P in the topsoil but also caused some movement of these nutrients down the soil profile. This agrees with findings of Lu and O'Connor (2001) who reported that biosolids-derived P may be susceptible to leaching through sandy soils, due to the low soil P-sorbing capacity. Biosolids application significantly ($P < 0.05$) reduced soil C/N ratios at 0−0.25 m but increased the ratios at 0.25-0.5 m. This could be explained by the relatively greater downward movement of biosolids-derived C than N. The lower pH in both the Standard and High treatments could be a result of the nitrification of biosolids-derived N.

Biosolids application increased the soil organic C content up to the depth of 50 cm examined in this study. It has been reported that biosolids application increases soil C storage through direct supply of organic matter to soil and also indirectly by increasing root biomass. Soil organic matter increases have often been shown to relate strongly to improvements in plant productivity on marginal lands (Bolan *et al.*, 2012)

Table 1**.** Effect of biosolids application on soil chemical properties (sampled in May 2010). For each depth, values within a column followed by different letters differ significantly at $P = 0.05$ (LSD test)

Depth	Treatment	pH	Total C	Total N	Total P	C/N	Olsen P	K	Ca	Mg	Na	CEC
			%				mg kg^{-1}	cmol$_c$ kg^{-1}				
0-0.25m	Control	5.4 a	0.63 b	0.03 b	0.024 c	22 a	21 c	0.15 a	1.05 a	1.08 a	0.08 a	4.80 b
	Standard	5.0 b	0.93 a	0.05 a	0.029 b	18 b	39 b	0.13 a	1.23 a	1.09 a	0.11 a	5.46 a
	High	4.8 b	1.03 a	0.06 a	0.032 a	17 b	54 a	0.15 a	1.26 a	1.08 a	0.09 a	5.41 a
0.25-0.5m	Control	5.7 a	0.25 c	0.02 b	0.026 b	14 b	15 c	0.12 a	0.77 a	1.02 a	0.07 a	4.14 a
	Standard	5.3 b	0.43 b	0.03 b	0.026 b	16 ab	24 b	0.11 a	0.96 a	1.15 a	0.08 a	4.97 a
	High	5.0 c	0.65 a	0.04 a	0.030 a	18 a	33 a	0.12 a	1.11 a	1.16 a	0.09 a	5.00 a

Effect of biosolids application on tree nutrition

Annual foliage analyses indicate N was the main factor limiting tree growth. Foliar N concentration of the Control treatment averaged 1.2% since monitoring began in 1998 (data not shown), indicating N deficiency (Will 1985).

Biosolids application significantly ($P < 0.05$) increased foliar N concentration with the Standard treatment averaging 1.4% N and the High treatment 1.5% N (data not shown).

Effect of biosolids application on tree growth and total forest carbon stocks

Stem volume was consistently higher in plots with biosolids than those without biosolids (Fig. 1 left). At age 19 years, stem volume (mean ± standard error) of the High treatment was 479 ± 9 m^3 ha^{-1}, 34% greater than the Control, while stem volume of the Standard treatment was 450 ± 9 m^3 ha^{-1}, 25% greater than the Control.

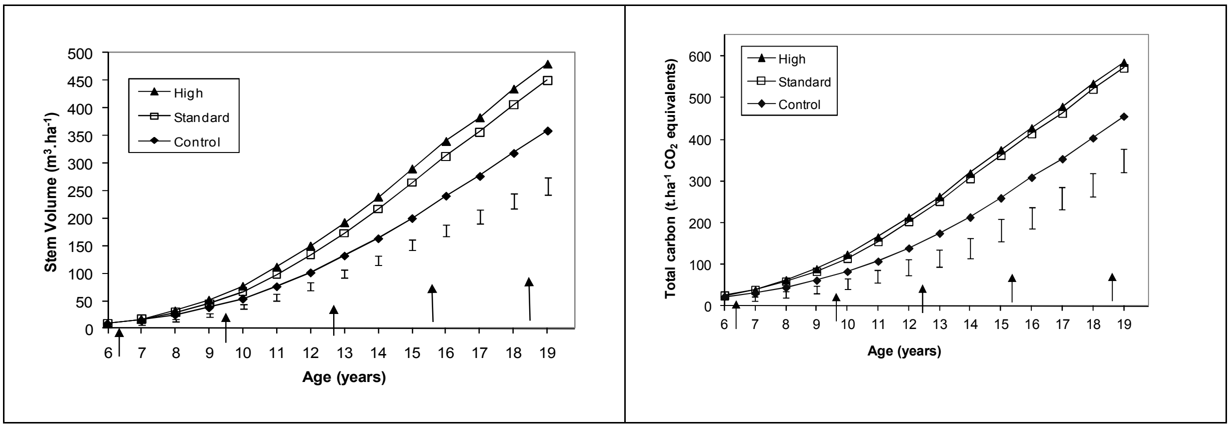

Fig. 1. Effect of biosolids application on annual stem volume (left) and total C stocks of radiata pine. Arrows indicate time of biosolids application. Error bars show least significant differences ($P = 0.05$) for comparisons among the treatments.

Total forest C stock estimates from age 8 years onwards were significantly greater in plots with biosolids applied than Control plots (Fig. 2 right). At age 19 years, total forest C stocks (mean ± standard error), summed above and below ground, were 456 ± 16 , 571 ± 16 and 585 ± 16 (t/ha, CO_2 equivalents) for Control, Standard and High treatments, respectively. Significant differences were found between the Control and both biosolids treatments, but not between the Standard and High treatments. Compared to the Control, the Standard and High biosolids treatments increased total forest C stocks at age 19 years by 25% and 28% respectively

Conclusions

Repeated application of biosolids to a plantation forest on a poor site significantly improved soil fertility, tree nutrition and forest productivity, with increased carbon storage in the radiata pine stand and the soil. This study suggests that optimum use of biosolids on marginal land was an effective means of increasing carbon sequestration in the forests and soils.

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Carbon stock of dead wood, litter and mineral soil in Japanese forests

Shinji Kaneko[a,*], Satoru Miura[a], ShinUgawa[b], Kazuki Nanko[a] and Masamichi Takahashi[a]
[a] Forestry Forest Products Resaerch Institute,Tsukuba, 350-8687, Japan, [b] Kagoshima University, Kagoshima, 890-0065, Japan
[*] Phone: +81 29 829 8226 Fax: +81 29 884 3720; E-mail: kanekos@ffpri.affrc.go.jp

Keywords: Kyoto Protocol, forest, dead wood, litter, mineral soil, carbon stock, monitoring, national inventory

Abstract The national forest soil carbon inventory (NFSCI) project had started since 2006 in order to verify the reports of carbon stock accounting to the United Nations Framework Convention on Climate Change (UNFCCC). In this presentation, we show the results of the first phase of the project which was carried out from 2006 to 2010 in fiscal year (FY). Survey plots were systematically selected over the forest sector in Japan. At each plot, the carbon stock of dead wood, litter and surface mineral soil (0-30cm) were surveyed. The NFSCI project showed that the average carbon stock was 0.41, 0.52 and 6.85 kg m^{-2} for dead wood, litter, and mineral soil (0-30cm), respectively. The nationwide carbon stock of these three pools in Japanese forest, which was 1.97 Tg in ground total, was 1.3 time as much as that of forest living biomass.

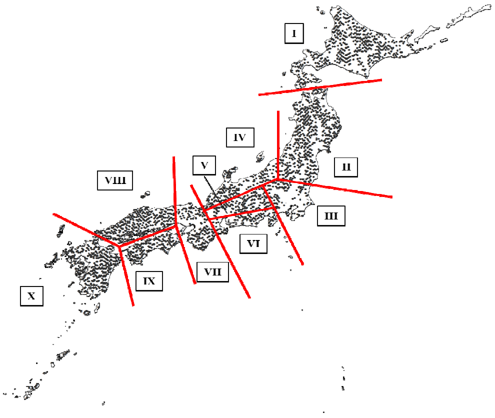

Figure 1. Eight regions and location of survey plots in forest sector of Japan.

Introduction

Japan consists of four main islands with thousands small islands, extending along the Pacific coast of Asian continent. The total land area is about 378,000 km^2, and roughly 70% of the country is covered by forests in hills and mountains. Forty one percent of forest land is covered with coniferous-planted forests and the rest is natural deciduous or evergreen broad-leaved forests. According to the Japanese forest soil classification system (Forest Soil Division 1976), Brown forest soil group (corresponding to Cambisols or Andosols in WRB) dominantly distributes (70 %), and the other major soil groups are Black soil group (Andosols; 12 %), Immature soil group (Regosol, Arenosol, Fluvisol, and Leptosols 4 %) and Podzolic soil group (Podozol 4 %).

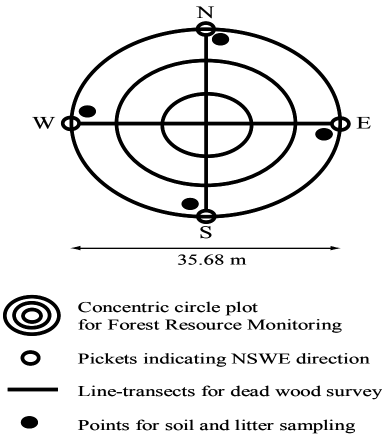

Figure 2. Sampling points in a survey plot.

The Japanese government is required to account carbon stock change for five carbon pools: aboveground biomass, belowground biomass, dead wood, litter, and soil organic carbon in forest sector in order to accomplish the Kyoto Protocol and the United Nations Framework Convention on Climate Change requirements. In the reports, carbon stock changes in dead wood, litter and soil organic carbon per unit area are estimated by using a modified CENTURY model (CENTURY-jfos) and are multiplied by land area of each forest management type. Meanwhile, NFSC project had started since 2006 in order to verify the estimates in the reports to the UNFCCC. In this presentation we will show the results of the first phase survey during the term from FY2006 to FY 2010.

Materials and methods

Survey plots were systematically selected from the plots of the Forest Resources Monitoring Survey (FRMS) conducted by the Japanese forestry agency. FRMS covered over the forest sector with 4km × 4km grid (http://www.rinya.maff.go.jp/j/keikaku/ monitar/). The total number of the plots for NFSC project is 2889, which is one fifth of the total number of the FRMS (Figure 1). The soil surveys were done at the area with 0.1 ha of nested plots (Figure 2). For dead wood, the volume was estimated by line-intersected method (Brown 1974) and the wood density was estimated by decay class classification by visual judgment. The carbon stock of dead wood is calculated by density, carbon concentration (500mg/g) and the volume estimated. For litter, fine woody debris (< 5cm in diameter), L, F and H layers, is taken from a frame with 50 cm square at four points in each survey plot. Soil samples for chemical analysis and volumetric analysis were taken from the layers with 0-5, 5-15 and 15-30cm in depth. The gravel percentage was visually estimated in each layer. The carbon concentrations of litter samples and soil samples were measured by dry-combustion method. The carbon stock of litter was calculated by the weight and its carbon concentration. For carbon stock in the soil, carbon concentration was multiplied by bulk density of the mineral soil at every three layer, accounting gravel volume deduction.

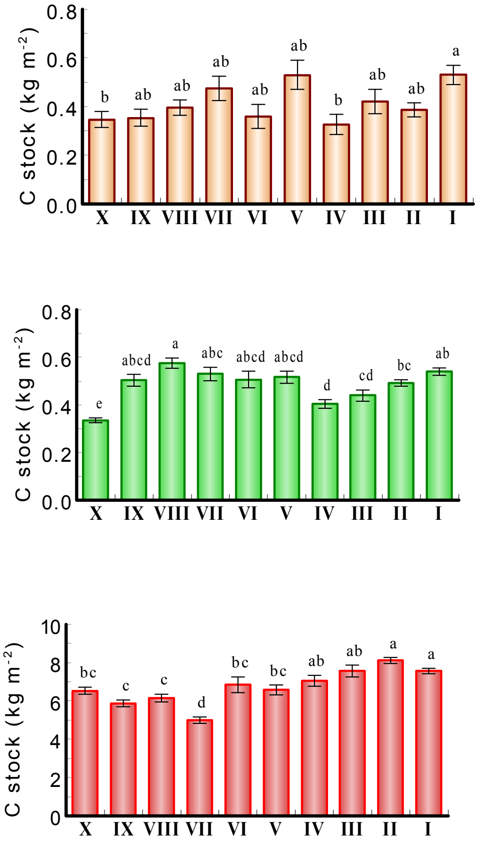

Figure 3. Carbon stocks of dead wood (a), litter (b), and soil (c)

The letters of I – X on horizontal axis denote the region in figure 1.

Results and discussion

The average carbon stock was 0.41, 0.52 and 6.85 kg m^{-2} for dead wood, litter, and surface mineral soil (0-30cm), respectively. The average carbon stock of litter was lower than those reported in cool temperate forests in European countries. The average carbon stock of the surface mineral soil (0-30cm) was slightly lower than that of the previous report in Japan (Morisada et. al. 2004). In this NFSCI project systematic sampling method was adopted to the survey, whereas sampling points were selected from the target area by 'expert surveyors judgment' in the former studies, which may be a reason of the discrepancy in the soil carbon stock estimates in Japan.

The nationwide carbon stock was 0.11, 0.12 and 1.74 Tg for dead wood, litter, and mineral soil (0-30cm), respectively. The carbon stock of these three pools was 1.3 times as much as that of nationwide forest living biomass reported in the Global Forest Resources Assessment 2010 (Food and Agriculture Organization of the United States 2010).

As for spatial variation, the carbon stocks of dead wood were significantly different among regions in Japan ($p<0.001$) (Figure 3). The difference among regions was also significantly detected in litter and soil carbon stocks ($p<0.001$ and $p<0.001$, respectively). Although the soil carbon stock was generally high in the northern regions, some areas have high soil carbon stocks especially in the south-western regions. Such areas were located at the eastern part of active volcanoes. Because the soils derived from volcanic ashes assumed to have a high ability of carbon sequestration, high carbon stock may be caused by the deposition of the volcanic ashes even in warm areas.

The lowest soil carbon stock was found in Kinki region (VII), including Kyoto and Nara prefectures, where the capital has historically been overloaded. In this area, excessive forest utilization continued for more than 1000 years. As a consequence, severe soil erosion had widely occurred in mountains exploited. Now, the regions are covered with trees by rehabilitation efforts but the soils are still immature conditions with low carbon accumulation. This suggests that human influences on soil carbon stock could not recover within a short period even after afforestation practices.

Table 1. Statistics of dead wood, litter and soil carbon stocks (kg m^{-2}).

Pool	Number of plots	Mean	Sample SD	Sample SE
Dead wood	1951	0.41	0.63	0.01
Litter	1933	0.52	0.33	0.01
Soil	1921	6.85	3.26	0.07

Conclusions

The National Forest Soil Carbon Inventory project found that the latest values of the average carbon stock in dead wood, litter, and surface mineral soil (0-30cm) were 0.41, 0.52 and 6.85 kg m^{-2}, respectively. The accuracy of these data would be high because systematic sampling was employed to obtain the average values in the nationwide forest sector. In this project, it is also revealed that carbon stock of mineral soil differs with regions probably due to the influences by volcanic ash deposition and human disturbances.

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Effects of forest conversion on carbon mineralization and microbial community composition in top- and subsoil horizons in subtropical China

Maokui Lyu[a,b], Jinsheng Xie[a,b*], Yanxiang Zhou[a,b], Zhijie Yang[a,b], Janfen Guo[a,b], Yusheng Yang[a,b].
[a] State Key Laboratory of Humid Subtropical Mountain Ecology, Fuzhou, 350007, China; and [b] College of Geographical Sciences, Fujian Normal University, Fuzhou, 350007, China
[*] Phone: +86 0591-83465013; Fax: +86 0591-83465397; E-mail: jshxie@163.com

Keywords: Chinese fir, carbon dynamics, deep soil, PLFA, priming effect.

Abstract Although a large amount of soil carbon (C) is stored in subsoil horizons, most studies on soil C dynamics focus on the upper layers. Little is known, however, about the response of the soil carbon dynamics in subsoil horizons to land use change. The aim of this study is to assess the effects of forest conversion of secondary broadleaf forests (SF) into Chinese fir (CF) plantation on C mineralization and microbial community composition in topsoil (0-10 cm) and subsoil (60-80 cm). Our results showed that the cumulative of C mineralization content in topsoil were similar between SF and CF by addition of glucose, however, in subsoil, it was significantly lower in CF than in SF ($P<0.01$). The priming effect (PE) in subsoil were more significantly affected by fresh C addition compared with the topsoil. PE in subsoil was related positively with supply of fresh C, which can reach the same level to the topsoil which absence of fresh C, suggesting that microbial activity in deep soil was mainly regulated by the availability of C. During the incubation period, the microbial diversity of the two horizons in both SF and CF were different significantly. The fungi content increased by fresh C input more significant in subsoil than that in topsoil horizon, indicated that fungi would be the predominant actors of glucose decomposition and induced PE in subsoil layer. We conclude that forest conversion may lead to the increase in C availability that may have effects on distribution of microbial groups and C mineralization that cause the loss of C in deep soil.

Introduction

Soils play a key role in the global C cycle as not only are they the most important terrestrial C sink but they also release CO_2 into the atmosphere. Soil organic carbon (SOC) stock is the result of the net balance between primary production and C mineralization (Garcia-Pausas et al., 2008). Forest plantations have been advocated as a measure to sequestrate C from the atmosphere and mitigate future climate change (Winjum and Schroeder, 1997). The large scale of afforestation activities during the last three decades has made China the greatest acreage with plantations (SFA, 2008). Previous studies have indicated that ecosystem C stock of this plantation was reduced by 45% at age of 33 years compared with the natural broadleaved forest which was cut for planting Chinese fir (Chen et al., 2005), a large number of SOC were lost in the process of plantations, and the contribution of subsoil (below 20 cm depth) to total profile SOC loss ranged from 53.2% in the recently regenerated stand to 81.1% in the 16-year-old stand, emphasizing the importance of subsoil for the SOC balance (Chen et al., 2013). This led to a doubt that forest conversion may lead to acceleration of native SOC decomposition, as result of any change in land use and agricultural practice that increases the distribution of fresh C along the soil profile (Jobbágy et al., 2000; Hurd et al., 1974; Lal et al., 2004). The objective of this study was to assess the PE response to the forest conversion in top- and subsoil layer, and to determine that the effects of fresh C addition on the main microbial groups level (fungi, bacteria, etc.). We hypothesized that: (1) conversing natural forest to plantations may result in decreased the potential of C mineralization because of increased the input of fresh C in the process of plantation; and (2) there would be lower PE because of the soil microbes controls the intensity of their degradation of SOM (PE).

Materials and methods

The study field is located on a small watershed in Chenda Town (26°19′N, 117°36′), Sanming City, Fujian Province, China. For this purpose soil samples of surface (0-10 cm) and subsurface (60-80 cm) horizons were collected from a secondary forest of *Castanopsis kawakamii* Hayata (SF) and an adjacent 36-year-old *Cunninghamia lanceolata* Lamb. (Chinese fir) (CF) under three independent soil profile. Experimental units consisted of 50 g (oven-dried basis) samples of fresh sieved soil placed in 500 ml flasks and incubated at 25 °C for 90 days. After 15 days of pre-incubation, 1 g C-glucose per kg soil of labeled glucose was added to half of the incubated soil samples and mixed with the soil (soil with glucose). The other half without glucose (control soils) was also mixed to apply the same physical disturbance. The CO_2 evolved was trapped in NaOH and was measured by continuous flow colorimetry. $\delta^{13}C\text{-}CO_2$ was analyzed by an elemental analyser coupled to a mass spectrometer after precipitating the carbonates with excess $BaCl_2$ and filtration. For each flask, the NaOH solutions sampled over the different dates were then pooled together to produce a single sample which received $BaCl_2$. Microbial C were determined by the fumigation-extraction technique. Destructive sampling of flasks was performed at days 10, 30, 60, and 91 to assess microbial biomass. At the end of incubation, the soil microbial community structure was determined by the phospholipid fatty acids (PLFA) from 10 g subsamples stored at 20 °C. The method we used was adapted from White et al. (1979) and slightly modified (after a pilot run) to maximize extraction of fatty acids from the soil.

Results and discussion

The supply of glucose to soil significantly increased ($P<0.001$, one-way ANOVA) the amount of unlabelled C released as CO_2 and stimulated microbial growth, demonstrating that microbes were limited by energy. The stimulation of decomposers induced a significant increase in production of unlabelled C-CO_2, an effect known as priming(Kuzyakov et al., 2000; Fontaine et al., 2004). It has been previously proposed that the PE may result from decomposition of recalcitrant old SOC by stimulated microbes. The cumulative respiration of unlabelled C (control soil) of the SF was significant higher than that of the CF in topsoil. But the PE of the CF was significant higher than the SF both in top- and subsoil, the PE was about 116.7 and 156.9 mg-C kg^{-1} in topsoil, respectively. However, in subsoil, it was 170.5 mg-C kg^{-1} (in SF) and 196.4 mg-C kg^{-1}(in CF), indicated that the impact of fresh C addition to deep soil layers more significantly increased the rates of C mineralization in subsoil horizons than that in topsoil. Our results support the previously suggested idea (Fontaine et al., 2005, 2007) that in the absence of fresh organic carbon, an essential source of energy for soil microbes, the stability of organic carbon in deep soil layers is maintained. We propose that a lack of supply of fresh C may prevent the decomposition of the organic carbon pool in deep soil layers in response to future changes in temperature. In addition, the supply of glucose significantly increased total microbial biomass, however, was not sustainable. The microbial biomass was decreased from day 10 until the end of incubation, however, was decreased from day 30 for the CF in subsoil. It was mainly because of the formation of labelled biomass (Fontaine et al., 2004). The microbial community structure, characterized by the fatty acid methyl esters (FAMEs) analysis, was significantly affected by the supply of glucose. The content of bacteria and fungi were increased because of fresh C input. The fungi: bacteria and Gram-positive: Gram-negative ratio was also significantly increased. Moreover, in topsoil, the amount of the fungi increased by addition of glucose was 3.68 and 1.93 nmol g^{-1}soil in SF and CF, respectively, i.e. 83% and 46% of the fungi increased by glucose. However, in subsoil. it was about 1.33 and 0.55 nmol g^{-1}soil in SF and CF, respectively, i.e. 107% and 86% of the fungi increased by glucose. So, fungi would be the predominant actors of glucose decomposition and induced PE in subsoil layer mainly due to PE is low when nutrient availability is high; in contrast, microbes release nutrients from SOM when nutrient availability is low (Fontaine et al., 2011). Tree plantations established on the natural/secondary forest lands would lead to the soil quality decline, and that the nutrient level is lower than the pre-harvest level. Overall, forest conversion would result in large number of C loss by C mineralization, we proposed that the potential of the C mineralization have decreased because of Chinese fir have a high rate of C (e.g. root litter/ exudates) input to the soil in the process of regeneration, although the fresh C input to the subsoil layer , microbial community composition were significantly changed.

Conclusions

The Cumulative of C mineralization in topsoil were similar between SF and CF by addition of glucose, in subsoil, it was significantly lower in CF than that in SF. Forest conversion have reduced the potential of C mineralization in deep soil though their PE. The increase in microbial biomass and the acceleration of SOC decomposition was concomitant

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Effects of Forest Management on Carbon Sequestration and Soil Stability

Shirong Liu [a],*, **Hui Wang**[a]
[a] Research Institute of Forest Ecology, Environment and Protection, Chinese Academy of Forestry, Chinese Academy of Forestry, Beijing, 100091 PR. China

Keywords forest, soil, carbon stock, soil respiration, soil carbon chemical stability, forest management.

Abstract

Forests, as a principal component of terrestrial ecosystems, have the huge carbon stock and carbon sink capacity. There are so many studies indicating that forest soil is the largest carbon pool, and plays an important role in regulating ecosystem carbon cycling because a slight variation of soil respiration caused by biotic or abiotic factors can produce a large CO2 emission into the atmosphere exacerbating climate change. However, there are great uncertainties in estimations of forest soil carbon, soil carbon components and its temporal/spatial variability. The mechanisms underlying soil carbon processes and soil carbon stability have been little known, due to the diversity of forest ecosystems, the complexity of soil biotic and abiotic interactive processes under a changing environment. This paper to synthesize the findings from literature reviews in recent ten years on forest soil C stock and soil C process in China, including soil C stocks in different forests, soil C chemical stability, soil respiration and its portioning components in association with underlying mechanisms, and impacts of climate changes and land use change on soil C processes, etc. The research progress of some key soil carbon processes is presented, and the principal unresolved scientific issues are addressed. We also discuss the future research development of forest soil carbon processes in China for the global perspective. The review is to provide the ultimate scientific results for better understanding the mechanisms of forest soil carbon processes focusing on biotic and abiotic interaction and aboveground and belowground interaction, by which help to develop an adaptive forest management regime to enhance soil carbon sequestration potential and soil C stability under a changing environment.

Effects of precipitation variation on distribution pattern of soil bacterial diversity in broad-leaved Korean pine mixed forest

Nannan Wang[a*], Shilan LI [a], XueYang[a] , Shijie Han[b], Fujuan Feng[a]
[a]Northeast Forestry University, Harbin 150040, China; [b]Institute of Applied Ecology, Chinese Academy of Sciences, Shenyang 110016, China.
*Phone: 18646554038; E-mail: wnn20112898@sina.cn

Key words: soil bacteria; 454 Pyrosequencing; precipitation; broad-leaved Korean pine mixed forest.

Abstract: Broad-leaved Korean pine mixed forest, which has important ecological value, is the climax vegetation in Northeast of China, and Changbai Mountains is an ideal area to study the positive and negative feedback of temperate forest on precipitation variation. In this study, we analyzed the spatial heterogeneity of soil bacteria at the depth of 0~5 cm and 5~10 cm, and rhizosphere soil at 30% increase in precipitation, 30% decrease in precipitation and the control plots in broad-leaved Korean pine mixed forest of Changbai Mountains. There are 299181 valid sequences we sequenced in total, and 271496 sequences through optimized, average sequence are 33242 for each soil sample. The results showed that the diversity and the richness of soil bacteria decreased with soil depth. The diversity and evenness of soil bacteria responded differently for precipitation variation in two layers of topsoil, and the diversity and evenness of rhizosphere decreased as precipitation increased. The dominant microorganism population in different precipitation plots were same, *Proteobacteria, Acidobacteria, Planctomycetes, Actinobacteria* and *Chloroflexi.* Precipitation variation did not change the type of advantage bacterium group but change its abundance. The response mechanism of dominant microorganism population for precipitation variations was different with each other. From the sample similarity, we found that precipitation variations influenced the soil bacterial community composition, and the response magnitude of topsoil differed from rhizosphere.

Introduction

Under the background of global warming, the global or regional precipitation pattern will change. The variation of precipitation pattern will cause the soil moisture change, affect the water use efficiency of the plants and soil microorganism and the function and process of terrestrial ecosystems directly. As an important part of ecosystem, soil microbial community play an important role in the growth of plants, ecological energy flow, and material cycle in the ecologic system and even the degradation of environmental pollutants and detoxification, etc. It also has a significant impact on maintain soil quality and ecosystem stability.

There are a lot of methods applied in research of soil microbial communities.Because 454 pyrosequencing sequencing technique can provide complete and useful information and revealed tremendous diversity in the variable in a short time, it has been used widely in a lot of researches of environmental microbial community diversity.

Materials and methods

Study sites were selected in baihe County of Jilin Province on the Changbai Mountains, northeastern China, located at 42°24′10″N～40°24′12″N,128°05′41″E～128°05′46″E.

Soil samples were collected in the depth of 0~5 cm and 5~10 cm, and rhizosphere soil at 30% increase in precipitation, 30% decrease in precipitation and the control plots in broad-leaved Korean pine mixed forest of Changbai Mountain on October 2011.

We use the conventional method to analyze soil chemical properties and microbial biomass. Samples total DNA extraction and purification use OMEGA E.Z.N.A soil DNA extraction kit. Then analyzed soil bacterial community composition based on 454 Pyrosequencing.

Results and discussion

There are 299181 valid sequences we sequenced in total, and 271496 sequences through optimized, average sequence are 33242 for each soil sample.

The results showed that the diversity and the richness of soil bacteria decreased with soil depth. The diversity and evenness of soil bacteria responded differently for precipitation variation in two layers of topsoil, and the diversity and evenness of rhizosphere decreased as precipitation increased. The bacterial diversity index is related with soil physical and chemical properties and microbial biomass, especially significantly correlated with soil organic carbon. The significant correlation between bacterial diversity index and soil organic carbon indicates that soil organic matter plays a decisive role on soil bacteria community in acidic soil.

The dominant microorganism population in different precipitation plots was same, *Proteobacteria, Acidobacteria, Planctomycetes, Actinobacteria* and *Chloroflexi.* From the sample similarity, we found that precipitation variations influenced the soil bacterial community composition, and the response magnitude of topsoil differed from rhizosphere.

Conclusions

Precipitation variation changed abundance of dominant microorganism population, but did not change the type of advantage bacterium group. The response mechanism of dominant microorganism population for precipitation variations is different with each other.

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Soil organic carbon dynamics and sources following afforestation of croplands with poplar in a semi-arid region in northeast China

Ya-Lin Hu [a, *], **De-Hui Zeng** [a]

[a] *State Key Laboratory of Forest and Soil Ecology, Institute of Applied Ecology, Chinese Academy of Sciences, Shenyang 110164, People's Republic of China*

** E-mail: huyl@iae.ac.cn*

Keywords: cropland afforestation, sandy soil, semi-arid region, SOC stock, soil density fractionation, δ^{13}C

Abstract Afforestation of former croplands has been proposed as a promising mitigation of the rising atmospheric CO_2 emissions in view of the commitment to the Kyoto Protocol. In this study, we collected samples of forest floor, fine root and mineral soil in 23 paired plots of poplar plantations (*Populus × xiaozhuanica* W. Y. Hsu & Liang) with different stand basal areas (SBA, ranging from 0.2 to 32.6 $m^2 ha^{-1}$) and reference maize croplands using a paired-site design. Our results found that: (1) afforestation resulted in linear increases of Δ_C (refers to the difference in SOC content between a poplar plantation and the paired cropland) in the forest floor and 0–10 cm mineral soil with SBA ($R^2=0.67$, $p<0.001$ and $R^2=0.34$, $p=0.003$, respectively), but there were no clear relationships between SOC stocks in the soil deeper (>10 cm) and SBA; (2) fine root C stock increased by afforestation across all the soil layers ($p<0.05$), and root Δ_C had a quadratic curve (the first two mineral soil layers) or linear (the other mineral soil layers) relationship with SBA; (3) soil Δ_C stocks in the light fraction linearly increased with SBA ($R^2=0.40$, $p=0.02$), but not for heavy fraction; (4) SOC derived from crop decreased significantly in the light and heavy fractions in the surface mineral layer, but tree-derived C in bulk soil and two fractions increased gradually with the increases of SBA. Our study implied that cropland afforestation could sequester new C in surface mineral soil accompanying the increases inputs of litterfall and root, but SOC stability didn't enhance in the semi-arid regions.

Introduction

Afforestation of degraded croplands has occurred globally and has been promoted as a means to sequester CO_2 from the atmosphere to abate its rising concentration caused by large anthropogenic emissions (Laganière et al. 2010). For example, in China alone, 72 million ha of croplands were planted with trees between 1999 and 2003 under a large-scale afforestation program, the Grain for Green Project, in the Three-North region (Cao 2008). Most empirical studies have suggested that the direction and magnitude of SOC stock changes had large variations after afforestation of croplands, and were affected by many factors such as previous land-use type, climate, soil texture, tree species composition, stand age, and management practices (Paul et al. 2002). However, there is little information on the change of C stocks in deeper soil layers because the majority of previous studies only reported changes of SOC stocks in the top 30 cm (Laganière et al. 2010). Moreover, the changes of SOC stocks are often not detected by conventional methodologies within a short-time frame for most experiments due to the small changes in soil C when compared to the size of SOC reservoir (Galdo et al., 2003).

Density fractionation physically separates SOC into light fraction (LF) and heavy fraction (HF), and there has been a substantial increase in the density fractionation assessing SOC dynamics induced by land use and management practices (Janzen et al., 1992; Degryze et al., 2004; John et al., 2005; Tan et al., 2007; Huang et al., 2011). However, soil fractionation and C analysis only provided information on net changes of SOC, but not for soil C balance between the loss of old C and input of new C. The ^{13}C natural abundance technique offers an elegant approach to quantify the relative contribution of new vs. old SOC (Galdo et al., 2003).

The SOC stocks are determined by the balance between the input of C derived from litterfall and rhizodeposition and the loss of C mainly through soil organic matter decomposition (Laganière et al., 2010), which are not only affected by stand age, but also by tree density that influences soil microclimatic conditions and the amount of litterfall. Therefore, stand basal area (SBA), integrating information in both stand age and tree density, is more feasible and correct to evaluate the dynamics and sources of SOC along stand development.

Obtaining SOC dynamics and sources after afforestation is important principally in semi-arid regions because of the vast area with ~17.7% of total land surface area (Lal, 2004). Poplar is one of the most widely afforested trees on croplands in the Keerqin Sandy Lands, a semi-arid region in northeastern China. In this present study, we mainly evaluated the dynamics of C stocks in the forest floor, mineral soil and fine roots along stand development after afforestation of croplands with poplar in this semi-arid region. We hypothesized that: (1) SOC stocks would increase rapidly following cropland afforestation due to the enhanced inputs of litterfall and roots, and (2) the sources of SOC would gradually convert from crop-derived to tree-derived.

Materials and methods

This study site is located in the southeastern region of the Keerqin Sandy Lands (42°30′–42°55′N, 122°19′–122°30′E), China. Forty-six 20×20 m plots, 23 poplar (*Populus × xiaozhuanica* W. Y. Hsu & Liang, a hybrid of *P. nigra var. italica* and *P. simonii*) plantations and 23 adjacent maize croplands, were selected following a paired-plot experimental design.

Soil and fine roots samples were collected from six soil layers (i.e., 0–10, 10–20, 20–40, 40–60, 60–80 and 80–100 cm) in each plot. In addition, the forest floor samples were collected in the poplar stands. Soil samples in 0–10 cm were physically separated into two pools (i.e., LF and HF) by a modified density fractionation method.

SOC concentration was determined using the $K_2Cr_2O_7$–H_2SO_4 oxidation method. The isotope ratio $^{13}C/^{12}C$ in a sample was determined using isotope ratio mass spectrometer (Finnigan DELTAplusXP, Thermo Fisher Scientific, USA).

Soil C content was calculated from determinations of SOC concentration and soil bulk density as

$$SOC_{total} = SOC_{con} \times BD \times SLD$$

where SOC_{total} was soil organic C content and the SOC_{con}, BD and SLD were SOC concentrations, soil bulk density and soil layer depth

We estimated the sources of SOC in poplar plantation based on an isotope mass balance and $\delta^{13}C$ values, and the fractional tree-derived SOC ($F_{\text{tree-C}}$) was calculated using a two-component mixing equation:

$$F_{Tree-C}(\%) = \frac{\delta^{13}C_{poplar} - \delta^{13}C_{crop}}{\delta^{13}C_{tree} - \delta^{13}C_{crop}} \times 100\%$$

where $\delta^{13}C_{\text{poplar}}$ and $\delta^{13}C_{\text{crop}}$ values are actual measured values in bulk soil, light and heavy fractions in poplar plantation and its paired cropland, respectively. The $\delta^{13}C_{\text{tree}}$ value is $\delta^{13}C$ of poplar leaf litter (-29.63‰).

Results and discussion

Soil Δ_C had an increased trend with increasing SBA in the 0–10 cm layer, but not in the other soil layers. Our results implied that afforestation with hybrid poplar on croplands could sequester atmospheric CO_2 into surface soils. The changes of SOC in LF are more sensitive to change of land use. In our study, there were significantly positive correlations between the SBA and soil Δ_C stocks in the light fraction but not in heavy fraction. It suggested that the increased SOC stocks following afforestation of cropland with poplar were mainly due to the significant increases of SOC contents in LF.

SOC stocks in the forest floor layer ranged from 0 to 0.74 kg C m^{-2} across all the studied poplar stands, and increased along SBA. Greater root C contents were also found in poplar plantations than that in croplands, indicating the importance of tree root C in soil C sequestration. Moreover, root Δ_C had quadratic relationships with SBA in the 0–10 and 10–20 cm layers, but increased linearly with SBA in the other deeper layers. It has been proposed that the increased soil C input rates and the lack of tillage disturbance would cause the increase in soil C stocks after cropland afforestation (Dondini et al., 2009).

The values of $\delta^{13}C$ in bulk soil and LF were negatively correlated to the SBA. SOC derived from crop in LF and HF significantly decreased by 51% and 27%, respectively. However, SOC derived from poplar in bulk soil, LF and HF increased with the increases of SBA. On average, the percentages of SOC derived from poplar in poplar plantations were 40% in bulk soil, 77% in LF, and 33% in HF. Such quantitative information confirmed that the C inputs from tree (litter and roots) were the major causes enhancing soil C sequestration after cropland afforestation in Keerqin Sandy lands. However, the increases of SOC stocks in HF were not enough to offset the loss of the old SOC, which resulted in no significant changes in SOC stocks in HF. It implied that SOC stability might be not enhanced by afforestation with poplar on croplands in the semi-arid region. Soil mineralogy and climate conditions could affect the replacement of old SOC by new SOC among after afforestation (Dondini et al., 2009). The less physical protection in the sandy soil can result in a fast turnover of SOC in HF in our study (Lützow et al., 2007).

Conclusions

Afforestation with poplar trees on croplands was effective to sequester atmospheric C into forest floor, root and surface mineral soil in the semiarid region in northeast China. The accumulated forest floor C along stand development was one of the most important aspects to increase SOC stocks in topsoil. However, stability of soil organic C was not enhanced due to a fast turnover of SOC in the sandy soils in semi-arid regions.

Acknowledgement

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Nutritional characteristics in needles of different sources of radiata pine clones and their relationships with tree growth on a serpentine soil

Jianming Xue[a,*], Colleen Carlson[b], Peter Clinton[c]

[a] Scion, Private Bag 29237, Christchurch, New Zealand; [b] Scion, PO Box 29237, Christchurch, New Zealand, now Virginia Tech (cacarlson@vt.edu); [c] Scion, Private Bag 29237, Christchurch, New Zealand. [*] Phone: +64 3 3642949; Fax: +64 3 3642812; E-mail: jianming.xue@scionresearch.com

Keywords: Nutritinal attributes, radiata pine clones, growth, serpentine soil.

Abstract The variation in foliar nutrient concentrations existed between and within clone sources of radiata pine. The relative contribution of each nutrient varies in the different sources of clones. There is little similarity among 3 sources of clones. One consistent pattern across all 3 sources is the negative correlation between the log K and log Mg concentrations. The volume increment was positively correlated to foliar K and Fe concentrations for both GTI and Puruki clones, but negatively correlated to foliar Mg concnetration for Serpentine clones

Introduction

Serpentine soils are widely distributed throughout the globe across all climatic zones. These soils are generally unsuitable for agriculture and forestry because they contain low levels of several essential plant nutrients (P, N and K), high concentrations of Mg, Ni, Cr and Co and low soil moisture holding capacity (Kazakou et al., 2008). Plant species growing on serpentine soils exhibit acclimation and adaptation to the low nutrient availability and high heavy metal concentrations and are often drought tolerant (Brady et al., 2005). This study aim to investigate the nutritional profiles of 3 clonal sources of radiata pine in relation to tree growth in a serpentine soil in New Zealand.

Materials and methods

Trial location and and clonal material

The study site is located at Aniseed Valley in Nelson, New Zealand. This serpentine soil is high in extractable Ca and Mg but low in extractable K and P. The trial has four plots. Three ramets of each of 40 radiata pine clones were randomly planted in each of four plots. Of the 40 clones, 20 were created through fascicle cuttings from the control-pollinated families selected for high volume growth rate and improved stem form (GF24-31) but of unknown nutritional characteristics (referred to as GTI clones). The remaining 20 clones were created through fascicle cuttings from the open-pollinated families (GF7), which were originally selected from trees growing on pumice soil (referred to as Puruki clones) at Puruki in central North Island with different nutrition-related upper and middle crown yellowing symptom scores and on serpentine soil (referred to as Serpentine clones) near Nelson in the northern South Island with different diameter growth.

Growth measurement, plant test and statistical analysis

Height and diameter at breast height (DBH) were measured for individual trees in all four plots in July 2005 and 2006 (year 4). Tree stem volume (VOL) was calculated as $(3.14 \times (DBH/2)^2 \times height)/3$. Current-year needles were sampled and analysed for C, N and S using LECO CNS-2000 Analyzer and P, K, Ca, Mg, B, Cu, Zn, Fe and

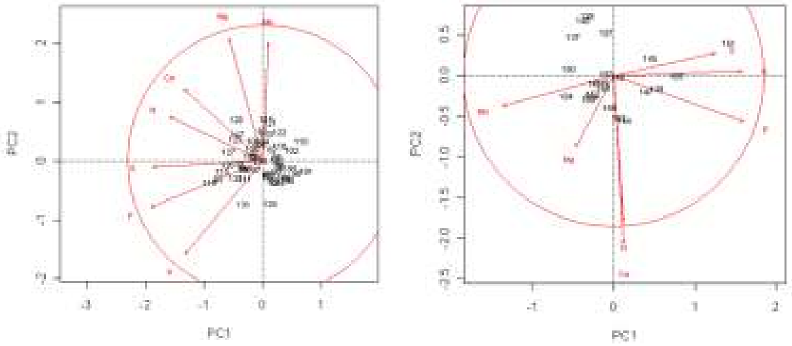
Mn using ICP-OES after a HNO_3/H_2O_2 digestion. Needle $\delta^{13}C$ (IC), a surrogate of water use efficiency, and ^{15}N (IN), an indicator of potential N availability, were determined on sub-samples using continuous-flow isotope ratio mass spectrometry. Between- and within-groups principal components analyses (PCA) were conducted to test foliar nutritional characteristics of clonal sources, and stepwise regression analyses to test the relationships between tree growth and foliar nutrient concentrtions within each clonal source.

Results and discussion

Nutritional characteristics of different source of clones

For GTI material, 2 PCA axes appear significant, accounting for 40 and 26 % of the variation respectively. Distance biplot with circle of equivalent contribution (Fig. 1a) indicates that, for PCA1 and PCA2, K and Mg have higher than average contribution. PCA1 appears to be closely correlated with log of N concentration, while PCA2 more closely correlated with the log of Mg and K concentrations. Mg and K appear inversely correlated.

For Puruki material, 2 PCA axes account for 39 and 30 % of the variation respectively. Distance biplot (Fig. 1b) indicates that almost all the nutrients contribute approximately equivalently to PCA1 and 2. The log S concentration appears to have the highest loading on PCA1, while the log of the Mn concentration the greatest loading on PCA2. Mg and Mn appear closely positively correlated and similarly the log concentrations of S and P.



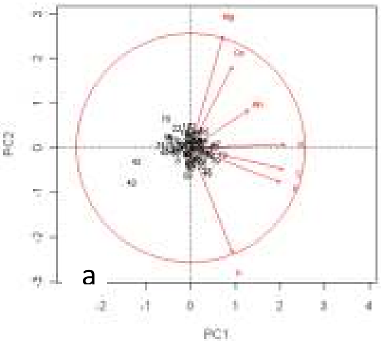


Fig. 1. PCA distance biplot with circle of equivalent contribution for GTI material (a), Puruki material (b), and Serpentine material (c).

For Serpentine material, 2 PCA axes accounted for 39 and 23 % of the variation respectively. Distance biplot (Fig. 1c) indicates that Ca has an important role to play. PCA1 is dominated by the log of K concentration, which is positively correlated with S and negatively correlated with Mn. PCA2 is dominated by the log concentrations of Ca and N, which are positively correlated.

Relationships between tree growth and foliar nutrient concentrations

The increments of DBH (not shown) and volume (Table 1) were better predicted (than DBH and volume) by the foliar nutrient data. The converse was true for height (not shown). For both GTI and Puruki clones, foliar K and Fe concnetrations positively contributed to the volume increment, while for Serpentine clones, foliar Mg cocnentration negatively contributed to the volume increment.

Table 1. Results of stepwise regression models to predict $\ln(Vol_{in})$.

Data used	**Dependent variable**	**Model**	**R^2**
GTI clones (n=77)	$\ln(Vol_{in})$	$4.9 + 0.5\ln(FW) - 1.2\ln(Cu) + 1.1\ln(Fe) + 0.7\ln(K) - 0.6\ln(Mn) + 1.1\ln(Zn)$	0.425
Puruki clones (n=51)	$\ln(Vol_{in})$	$1.9 + 0.4\ln(FW) + 1.2\ln(Fe) + \ln(K) - 0.9\ln(P)$	0.451
Serpentine clones (n=22)	$\ln(Vol_{in})$	$3.8 + 0.7\ln(FW) - 2.4\ln(Mg)$	0.604

Vol_{in} is the volume increment between 2006 and 2005. FW – Dry weight of 100 fascicles.

Conclusions

The relative contribution of each nutrient varies in the different sources of material. There is little similarity among 3 sources of clones. One consistent pattern across all 3 sources is the negative correlation between the log K and log Mg concentrations. The volume increment was positively correlated to foliar K and Fe concentrations for both GTI and Puruki clones, but negatively correlated to foliar Mg concnetration for Serpentine clones.

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Aggregates stability and land variation in the humid forest region of southern Cameroon.

Fokom R*[1]., Adamou S[2]., Tchameni N S[1]., Teugwa M[1]., Nana W. L[1]. Nwaga D[2]., Etoa F. X[1]., Tsala Dzomo G[2]. Amvam Zollo P. H[1].

1Department of Biochemistry, Faculty of Sciences, University of Yaoundé I, Cameroon.

2 Department of Plant Biology, Faculty of Sciences, University of Yaoundé I, Cameroon.

Aggregation is an important temporal property of soil structure that is always affected by land used and management. Aggregate stability has a strong influence on many processes in soil and could greatly vary according to land used systems. In this study, we focus on the variation of wet stable aggregate of 1 2 mm diameter across three land use systems of the humid forest zone of the south region of Cameroon. Soil samples were collected from forest, fallow and continuous disturbed soil of this region. Samples were from 0-10 cm depths and collected in three plots of forest, fallow and continuous disturbed soils respectively. After drying the samples at lab temperature (24°C), the different sizes of aggregates were separated and results express as mean wet diameter. The wet aggregate stability (WAS) on 1-2 mm aggregates was also determined and link to glomalin related soil protein and organic matter content. The mean wet diameter obtained greatly varies within the three land use system; with the highest value obtain in the forest and the lowest in the continuous cropped field. The variance analysis of data showed significant differences among the percentage of WAS in all the three lands use systems, with the highest in forest, following by the fallow and then the continuous growing field. Regression analysis of data of the three land use systems showed that the variability of aggregate stability was mainly explained by glomalin related soil protein and soil organic matter content ($r=0.80$ in $P<0.001$); ($r=0.75$ in $P<0.001$). WAS of 1 to 2 mm diameter could be a good indicators to follow soil degradation in the humid forest zone in general precisely the south region of Cameroon.

Key words: land use systems, water stable aggregates, soil,

*corresponding authors, rfokom@gmail.com

Compare the amount of carbon sequestration in natural populations conifers and broad-leaved

(Case Study: MarzanAbad)

N. Hosieini, A. Sheykholeslami, T. Ahmadi
Group of Forestry, Islamic Azad University, Chalous Branch

Abstract

Climate change and global warming due to increased concentrations of greenhouse gases, is today one of the most important challenges of sustainable development. One of the most important greenhouse gases is carbon dioxide, which has harmful effects on human life on earth. . In this study lumps of pure conifers and broad-leaved mixed Rzbyn Hassan Abad Branch was in the area of carbon sequestration in soil values (15-0 and 30-15 cm in depth) was estimated Also, the relationship between some soil physical and chemical factors of soil organic carbon were also studied. The results showed that the total carbon sequestration conifers and broad leaf mass per unit area, respectively, 9/56 and 35/29 ha Stepwise regression results showed that the saturated soil moisture, nitrogen and soil organic carbon content were the most important factors. Economic value of deposition of soil by mass, respectively, 11,380 and 5,870 rials per hectare was calculated Given these results, it is essential that appropriate protection and management of protected forests and protected forests in other parts of the same Positive step towards reducing atmospheric carbon concentrations and thus reduce climate change and global warming will be removed.

Key words: climate change, forest carbon sequestration, soil, forests, Hasan Abad Branch, greenhouse gas

^{15}N natural abundance of leaf and soil in response to 4- and 8-yr nitrogen additions in a temperate steppe of northern China

Haiyan Ren[a], Jianhui Huang[b], Zhuwen Xu[a], Shasha Zhang[a], Yunting Fang[a,*]
[a] State Key Laboratory of Forest and Soil ecology, Institute of Applied Ecology, the Chinese Academy of Sciences, Shenyang, 110164, China
[b] State Key Laboratory of Vegetation and Environmental Change, Institute of Botany, the Chinese Academy of Sciences, Beijing, 100093, China
[*] Phone: +86 24 83970541; Fax: +86 24 83970300; E-mail: fangyt@iae.ac.cn

Keywords: grassland, nitrogen addition, nitrogen stable isotope.

Abstract

Nitrogen (N) deposition is pojected to rapidly increase particularly in East Asia. Leaf δ^{15}N has been suggested to a strong indicator of ecosystem N status (δ^{15}N increases as ecosystem N saturation progresses), thus can provide insights into how N deposition changes ecosystem N cycling. However, how δ^{15}N of leaf and soil in grassland ecosystems changes under elevated N inputs is less well understood. We used N addition experiments to achieve N-enriched conditions in three dominant (*Agropyron cristatum*, *Artemisia frigida* and *Stipa krylovii*) and other four common species (*Cleistogenes squarrosa*, *Potentilla bifurca*, *Potentilla tanacetifolia* and *Melilotoides ruthenica*) in a temperate steppe of northern China. Our objectives were to (i) assess changes in leaf δ^{15}N during 4- and 8-yr N addtions (in 2008 and 2012) in a temperate steppe and (ii) relate these changes to plant N uptake preferences and soil-N-cycling processes like denitrification and NH_3 volatilization.

Eight years of N addition significantly increased δ^{15}N in leaf and soil but not soil total N. Both leaf N concentration and soil inorganic N enhanced with N addition. Leaf δ^{15}N in control plots showed small variation between sampling years, ranging from -0.30‰ in 2008 to -1.04 ‰ in 2012. However, the effects of N addition on leaf δ^{15}N varied with treatment duration and with species. Four years of N addition significantly increased leaf δ^{15}N of *A. frigida*, one dominant species. After 8 years of N added, the effect of N addition became more pronounced. Increases in leaf δ^{15}N were apparent for five of the seven species, compared to the control. Leaf δ^{15}N of *M. ruthenica*, a legume, decreased with 4- and 8-yr N addtions. Variable leaf δ^{15}N responses among species suggest that different species may utilize different N sources, which will be further examined after measurement of δ^{15}N for soil available N. The increases in δ^{15}N for most species and soil N indicate that grassland ecosystem N will progress toward to N saturation with elevated N deposition in northern China.

Introduction

Nitrogen isotopes composition in leaves can provide integrated information about nitrogen cycling in terrestrial ecosystems (Robinson 2001; Craine et al. 2009; Fang et al. 2012). At the global scale, leaf δ^{15}N increases with increasing leaf N concentrations (Craine et al. 2009). In the case study, recent researches based on forests indicate that N addition increases (Corre et al. 2010; Fang et al. 2011) or unaffects (Guerrieri et al. 2011) leaf δ^{15}N. However, it remains unclear how elevated N input affects δ^{15}N of leaves and soil in temperate grasslands, and how different species respond to resource variation. Our objectives were to (i) assess changes in leaf δ^{15}N with increasing N supply in a temperate steppe and (ii) relate these changes to plant N uptake preferences and soil-N-cycling processes such as denitrification and NH_3 volatilization.

Materials and methods

This study was conducted in a temperate steppe at Duolun county (116°17′ E, 42°02′ N, elevation 1324 m a.s.l.), Inner Mongolia, China. Mean annual temperature amounts to 2.1 °C and mean annual precipitation is about 380 mm. Dominant vegetation at the study site consists of two C_3 grasses (*S. krylovii* and *A. cristatum*), and a C_3 forb (*A. frigida*). Our field experiment relied on the long-term N addition platform, and samples of leaves and surface soil at 10 cm depth were collected in the control and adding 10 g N m^{-2} yr^{-1} plots. $\delta^{15}N$ and total N concentration of leaf and soil samples were determined using a continuous flow isotope mass spectrometer (IsoPrime100). Soil inorganic N concentration was also measured by continuous slow-analyzer.

Results and discussion

Overall, $\delta^{15}N$ in leaves and soil increased with increasing N supply (Fig. 1, 2). 8-yr N addition resulted in significant increases in leaf $\delta^{15}N$ for the five of the seven studied species but decreases in only one legume *M. ruthenica*, and unaffected leaf $\delta^{15}N$ in one dominant species *S. krylovii* (Fig. 1c). Leaf $\delta^{15}N$ also decreased in the legume and did not respond in *S. krylovii* or *P. tanacetifolia* during 4-yr N addition (Fig. 1a). The other four species showed an increasing trend of leaf $\delta^{15}N$ in response to 4-yr N addition, although the effects of N addition on leaf $\delta^{15}N$ were not significant (Fig. 1a). Leaf N concentration significantly increased with both 4- and 8-yr N addition (Fig. 1b, d). Soil inorganic N concentration increased with N addition, though soil total N did not respond to N addition (Fig. 2).

There were three lines of evidence suggesting enhanced leaf $\delta^{15}N$ under N addition: (i) increased NH_3 volatilization led to increased soil $\delta^{15}N$ (Cheng et al. 2009), and accordingly increased leaf $\delta^{15}N$; (ii) increased N-oxide emissions was caused by soil-N-cycling processes such as accelerated denitrification (Corre et al. 2010), causing enriched ecosystem $\delta^{15}N$; (iii) increases in leaf $\delta^{15}N$ with N addition depended on species. We found leaf $\delta^{15}N$ pattern of the legume was different from that of other non-legume species, probably resulting from N uptake preferences of plants. Thus the measurements of $\delta^{15}N$ in soil ammonium, nitrate and dissolved organic N are needed to evaluate plant N sources.

Conclusions

Our results suggest that $\delta^{15}N$ for most species and soil N increases with N addition, implying that grassland ecosystem N may progress toward to N saturation with elevated N deposition in northern China.

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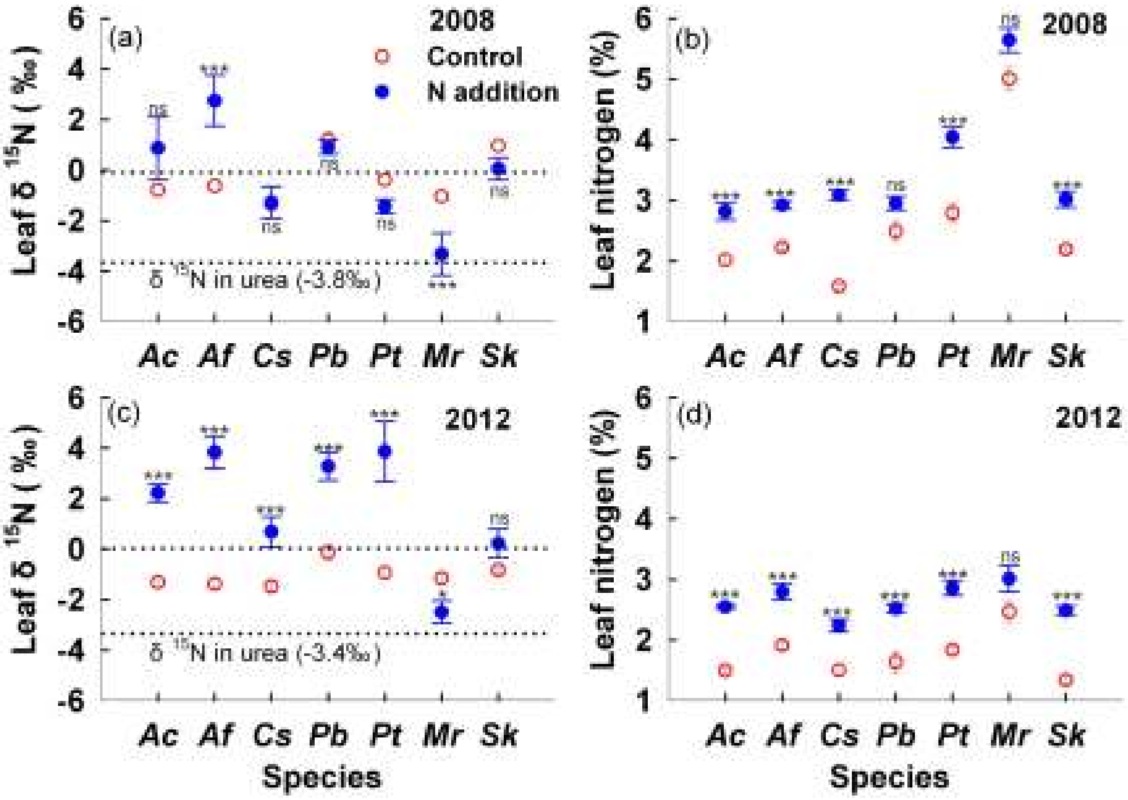

Fig. 1 Effects of 4- and 8-yr nitrogen additions (in 2008 and 2012) on ^{15}N natural abundance ($\delta^{15}N$) and nitrogen concentration in leaves of the seven steppe species. Data are means ± SE, where sample size is 5 in all treatments. Abbreviations: *Ac*, *Agropyron cristatum*; *Af, Artemisia frigida*; *Cs*, *Cleistogenes squarrosa*; *Pb*, *Potentilla bifurca*; *Pt*, *Potentilla tanacetifolia*; *Mr*, *Melilotoides ruthenica*; *Sk*, *Stipa krylovii*. *** $P < 0.001$; * $P < 0.05$; ns, not significant.

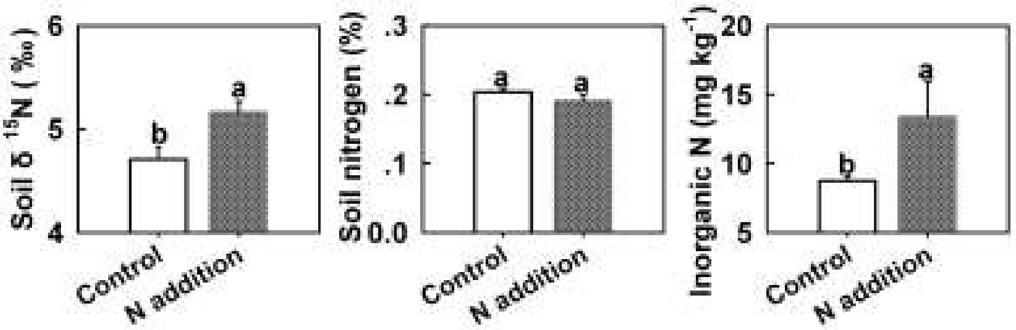

Fig. 2 Impacts of 8-yr nitrogen addition on ^{15}N natural abundance ($\delta^{15}N$), total nitrogen and inorganic nitrogen concentrations in soil in a temperate steppe. Data are means ± SE, where sample size is 5 in all treatments. Different letters above bars indicate significant differences ($P < 0.05$).

POSTER SESSION: TUESDAY, September 19, 2013 8:00PM-9:00PM

No.	Presenter	Title
01	Jianling Fan	Effect of nitrogen and sulfur addition on soil CO_2 emission in a subtropical red soil forestland
02	Jiali He	A transcriptomic network underlies microstructural and physiological responses to cadmium in Populus × canescens
03	Jie Luo	Net fluxes of ammonium and nitrate in association with H+ fluxes in fine roots of Populus popularis
04	Zhang Jing	Accumulated glomalin soil-related protein under elevated CO_2 and nitrogen deposition enhance soil carbon stock
05	Hideshige Toda	Direct relationship between stream nitrate concentration and nitrogen leaching in forest areas in the central part of Japan
06	Yuan-wen Kuang	Patterns of tree-ring δ15N are species- and age-specific
07	Shaoyan Fan	Fluxes of nitrous oxide and methane in temperate forests of different stages of nitrogen saturation in central Japan
08	Yuki Aihara	Possible overgrowth of bamboo caused by nitrogen saturation
09	Chunling Luo	Identification of Phenanthrene-Metabolizing Bacteria in Forest Soils by DNA-Stable Isotope Probing
10	Nannan Wang	Effects of precipitation variation on distribution pattern of soil bacterial diversity in broad-leaved Korean pine mixed forest
11	Sun Long	Effect of Fire Disturbance on Short-term Soil Respiration of Typical Forest types in Daxing’an Mountain
12	Lu Xin	A research review on soil active organic carbon fractionation、analytical methods and affecting factors
13	Hu Haiqing	Research progress on effects of forest fire disturbance on soil respiration and measuring method
14	Xinhui Huang	Effects of Ageratina adenophora invasion on soil phosphorus and soil potassium in Eucalyptus plantation
15	Hua Qin	Rapid soil fungal community response to intensive management in a bamboo forest ecosystem developed from reclaimed rice paddies
16	Jianming Xue	Effect of vermicomposted biosolids on seedling growth and nutrient uptake by exotic and native tree species on a pumice soil
17	Yalin Hu	Soil organic carbon dynamics and sources following afforestation of croplands with poplar in a semi-arid region in northeast China
18	Hui Wang	Seasonal Changes of Soil Nitrogen Mineralization in Platycladus orientalis (L.) Franco Plantation on Limestone Mountains

List of Participants

(Alphabetical order)

No.	Participants	Institution/University	Country	Title	Email
1	Ali Sheykholeslami	Islamic Azad University, Chalous Branch	Iran	Doctor	islamiali@gmail.com
2	Ang Wang	Research Institute of Tropical，Chinese Academy of Forestry Forestry	China	Mr.	studentwangang@126.com
3	Charles Driscoll	Syracuse University	United States	Professor	ctdrisco@syr.edu
4	Chris Johnson	Syracuse University	United States	Doctor	cejohns@syr.edu
5	Chunling Luo	Guangzhou Institute of Geochemisty, Chinese Academy of Sciences	China	Doctor	clluo@gig.ac.cn
6	Chunwu Zhu	Institute of Soil Science,CAS	China		cwzhu@isss.ac.cn
7	Congjuan Li	Xinjiang Institute of Ecology and Geography, Chinese Academy of Sciences	China	Doctor	li_congjuan@163.com
8	Dongwei liu	Institute of Applied Ecology, Chinese Academy of Sciences	China	Ms.	liudongwei1987@sina.com
9	Edith Bai	Institute of Applied Ecology, Chinese Academy of Sciences	China	Professor	baie@iae.ac.cn
10	Enrong Yan	East China Normal University	China		eryan@des.ecnu.edu.cn
11	Faming Wang	South China Botanical Garden, Chinese Academy of Sciences	China	Doctor	wangfm@scbg.ac.cn
12	Fokom Raymond	University of Douala	Cameroon	Mr.	rfokom@gmail.com
13	Fuke Yu	Yunnan University	China	-	frank-yu@163.com
14	Fusheng Chen	Jiangxi Agricultural University	China	Dr.	chenfush@yahoo.com
15	Hailong Wang	Zhejiang A & F University	China	Professor	nzhailongwang@gmail.com
16	Haiqing Hu	Northeast Forestry University	China	Professor	huhq@nefu.edu.cn
17	Haiyan Ren	Institute of Applied Ecology	China	Doctor	renhy@iae.ac.cn

18	Haohao Wu	Institute of Atmospheric Physics, Chinese Academy of Sciences; Chang'an University	China	Mr.	whh_xkp@aliyun.com
19	Hideshige Toda	Shinshu University	Japan	Professor	h-toda@shinshu-u.ac.jp
20	Hongyan Yu	Institute of Soil Science, Chinese Academy of Sciences	China		hyyu@issas.ac.cn
21	Hua Qin	Zhejiang A & F University	China	Doctor	sagi.qinhua@gmail.com
22	Hui Wang	Institute of Forest Ecology, Environment and Protection, Chinese Academy of Forestry	China	Doctor	wanghui@caf.ac.cn
23	Hui Wang	University of Jinan	China	Professor	hwang_118@163.com
24	Hui Xu	Institute of Applied Ecology, Chinese Academy of Sciences	China	Professor	hui_xu67@hotmail.com
25	Jean-Michel Carnus	INRA	France	Doctor	Michel.Carnus@pierroton.inra.fr
26	Jia Lu	Shenyang Agricultural University	China	Ms.	lujia1989188@126.com
27	Jiacun Gu	Northeast Forestry University	China	Doctor	gjchun001@163.com
28	Jiali He	Northwest A&F University	China	Ms.	pangjia8866@163.com
29	Jianfen Guo	College of Geographical Science	China	Doctor	jfguo@fjnu.edu.cn
30	Jianfeng Hua	Institute of Botany, Jiangsu Province and Chinese Academy of Sciences	China		jfhua2009@gmail.com
31	Jianling Fan	Institute of Soil Science, Chinese Academy of Sciences	China	Doctor	fanjianling@163.com
32	Jianming Xue	Scion	New Zealand	Doctor	jianming.xue@scionresearch.com
33	Jianxin Sun	Beijing Forestry University	China	Professor	sunjianx@bjfu.edu.cn
34	Jiaqi Chen	Shenyang Agricultural University	China	Mr.	opichen@163.com
35	Jiasen Wu	Zhejiang Provincial Key Laboratory of Carbon Cycling in Forest Ecosystems and Carbon Sequestration, Zhejiang A &	China	Professor	jswu@zafu.edu.cn

		F University			
36	Jie Luo	Northwest A&F University	China	Mr.	luojie654@163.com
37	Jing Zhang	SouthChina Botanical Garden, Chinese Academy of Sciences	China	Ms.	zhangj@scib.ac.cn
38	Junqiang Zheng	Institute of Applied Ecology, Chinese Academy of Sciences	China	Doctor	zhjq79@yahoo.com
39	Kazumichi Fujii	Forestry and Forest Products Research Institute	Japan	Doctor	fkazumichi@affrc.go.jp
40	Lanzhu Ji	Institute of Applied Ecology, Chinese Academy of Sciences	China	Professor	ji.lanzhu@iae.ac.cn
41	Lin Tong	South China Botanical Garden, Chinese Academy of Sciences	China	Student	tonglin@scbg.ac.cn
42	Liqing Sha	Xishuangbanna Tropical Botanical Garden	China	Doctor	shalq@xtbg.ac.cn
43	Long Sun	Northeast Forestry University	China	Mr.	sunlong365@126.com
44	Lujia Zheng	Fujian Normal University	China	Student	448426350@qq.com
45	Maihe Li	Swiss Federal Research Institute	China	Professor	maihe.li@wsl.ch
46	Maokui Lyu	College of Geographical Sciences, Fujian Normal University	China	Ms.	228lmk@163.com
47	Minhuang Wang	Fujian Normal University	China	Student	eco_wmh@163.com
48	Muneoki Yoh	Tokyo University of Agriculture and Technology	Japan	Professor	yoh@cc.tuat.ac.jp
49	Nannan Wang	Northeast Forestry University	China	Ms.	wnn201289@sina.cn
50	Ning Wang	Northeast Forestry University	China	Student	164229812@qq.com
51	Peter Clinton	New Zealand Forestry Research Institute	New Zealand	Professor	Peter.Clinton@scionresearch.com
52	Qiang Yu	Institute of Applied Ecology, Chinese Academy of Sciences	China	Doctor	yuqiang@iae.ac.cn
53	Qingkui Wang	Institute of Applied Ecology, Chinese Academy of Sciences	China	Mr.	qwang@iae.ac.cn
54	Qiufang Xu	Zhejiang A & F University	China	Professor	xuqiufang@zafu.edu.cn

55	Scott Chang	University of Alberta	Canada	Professor	scott.chang@ales.ualberta.ca
56	Shaoyan Fan	Tokyo University of Agriculture and Technology	Japan	Ms.	fanshaoyan@gmail.com
57	Shijie Han	Institute of Applied Ecology, Chinese Academy of Sciences	China	Professor	hansj@iae.ac.cn
58	Shirong Liu	Chinese Academy of Forestry	China	Professor	Liusr@caf.ac.cn
59	Shinji Kaneko	Forestry and Forest Products Research Institute	Japan	Doctor	kanekos@ffpri.affrc.go.jp
60	Shuangshuang Chu	Agricultural University Of South China	China	Student	hbchushuangshuang@163.com
61	Shucai Zeng	College of Forestry, South China Agricultural University	China	Professor	sczeng@scau.edu.cn
62	Thomas Robert Fox	Virginia Tech	United States	Professor	trfox@vt.edu
63	Tongxin Hu	Northeast Forestry University	China	Mr.	htxhtxapple@sina.com
64	Weiwei Dai	Institute of Applied Ecology,Chinese Academy of Sciences	China	Ms.	daiweiwei@hotmail.com
65	Weixin Cheng	Institute of Applied Ecology, Chinese Academy of Sciences	China	Professor	chengwx@iae.ac.cn
66	Wenjie Wang	Northeast Forestry University	China	Professor	wjwang225@hotmail.com
67	Wenyuan Kuang	South China Botanical Garden, Chinese Academy of Sciences	China	Doctor	kuangyw@scbg.ac.cn
68	Xiangyang Pei	Agricultural University Of South China	China	Student	532810816@qq.com
69	Xiaohua Wan	Fujian Normal University	China	Mrs.	xiaohuawan2012@foxmail.com
70	Xin Lu	Northeast Forestry University	China	Mr.	luxinnefu@163.com
71	Xingguo Han	Institute of Applied Ecology, Chinese Academy of Sciences	China	Professor	hanxg@iae.ac.cn
72	XingKai Xu	Institute of Atmospheric Physics, Chinese Academy of Sciences	China	Professor	xingkai_xu@mail.iap.ac.cn

73	Xinhui Huang	Southwest Foresty University	China	Ms.	ylhxh2001@163.com
74	Xiyun Chen	Beijing Normal University	China	Doctor	chen.xiyun@bnu.edu.cn
75	Xudong Zhang	Institute of Applied Ecology, Chinese Academy of Sciences	China	Professor	xdzhang@iae.ac.cn
76	Xuefeng Li	Institute of Applied Ecology, Chinese Academy of Sciences	China	Doctor	lisnowmount@163.com
77	Yalin Hu	Institute of Applied Ecology,Chinese Academy of Sciences	China	Doctor	huyl@iae.ac.cn
78	Yang Kai	Institute of Applied Ecology, Chinese Academy of Sciences	China	Ms.	yk@dlnu.edu.cn
79	Yishan Jiang	Guangzhou Institute of Geochemistry	China	Ms.	jiangyishan_12345@yahoo.com
80	Yong Jiang	Institute of Applied Ecology, Chinese Academy of Sciences	China	Professor	jiangyong@iae.ac.cn
81	Yongchun Li	Zhejiang A & F University	China	Doctor	yongchun101@hotmail.com
82	Yoshiyuki Inagaki	Forestry and Forest Products Research Institute	Japan	Doctor	yinagaki@affrc.go.jp
83	Yuanwen Kuang	South China Botanical Garden, Chinese Academy of Sciences	China	Doctor	kuangyw@scbg.ac.cn
84	Yuepeng Pan	Institute of Atmospheric Physics, Chinese Academy of Sciences	China	Doctor	pyp@dq.cern.ac.cn
85	Yuki Aihara	Tokyo University of Agriculture and Technology	Japan	Ms.	aioueai@gmail.com
86	Yunting Fang	Institute of Applied Ecology, Chinese Academy of Sciences	China	Professor	fangyt@iae.ac.cn
87	Zhanqing Hao	Institute of Applied Ecology, Chinese Academy of Sciences	China	Professor	hzq@iae.ac.cn
88	Zhe Liu	Institute of Applied Ecology, Chinese Academy of Sciences	China	Doctor	liuzhe@iae.ac.cn
89	Zhengwen Wang	Institute of Applied Ecology, Chinese Academy of	China	Professor	wangzw@iae.ac.cn

		Sciences			
90	Zhibin Luo	College of Forestry and State Key Laboratory of Crop Stress Biology in Arid Areas, Northwest A&F University	China	Professor	luozbbill@163.com
91	Zhihong Xu	Griffith University	Australia	Professor	zhihong.xu@griffith.edu.au
92	Zhiqun Huang	Fujian Normal University	China	Professor	wanxiaohua7@163.com
93	Zhou Zhang	Research Institute of Tropical Forestry, CAF	China	Doctor	zhouzhang@pku.edu.cn