Livestock slurry is a major source of atmospheric methane (CH₄), but surface crusts harboring methane-oxidizing bacteria (MOB) could mediate against CH₄ emissions. This study examined conditions for CH₄ oxidation by in situ measurements of oxygen (O₂) and nitrous oxide (N₂O), as a proxy for inorganic N transformations, in intact crusts using microsensors. This was combined with laboratory incubations of crust material to investigate the effects of O₂, CH₄, and inorganic N on CH₄ oxidation, using ¹³C-CH₄ to trace C incorporation into lipids of MOB. Oxygen penetration into the crust was 2 to 14 mm, confining the potential for aerobic CH₄ oxidation to a shallow layer. Nitrous oxide accumulated within or below the zone of O₂ depletion. With 102 ppmv CH₄ there was no O₂ limitation on CH₄ oxidation at O₂ concentrations as low as 2%, whereas CH₄ oxidation at 104 ppmv CH₄ was reduced at ≈5% O₂. As hypothesized, CH₄ oxidation was in general inhibited by inorganic N, especially NO₂⁻, and there was an interaction between N inhibition and O₂ limitation at 102 ppmv CH₄, as indicated by consistently stronger inhibition of CH₄ oxidation by NH₄⁺ and NO₃⁻ at 3% compared with 20% O₂. Recovery of ¹³C in phospholipid fatty acids suggested that both Type I and Type II MOB were active, with Type I dominating high-concentration CH₄ oxidation. Given the structural heterogeneity of crusts, CH₄ oxidation activity likely varies spatially as constrained by the combined effects of CH₄, O₂, and inorganic N availability in microsites.
Enhanced priming of old, not new soil carbon at elevated atmospheric CO$_2$

Rising atmospheric CO$_2$ concentrations accompanied by global warming and altered precipitation patterns calls for assessment of long-term effects of these global changes on carbon (C) dynamics in terrestrial ecosystems, as changes in net C exchange between soil and atmosphere will impact the atmospheric CO$_2$ concentration profoundly. In many ecosystems, including the heath/grassland system studied here, increased plant production at elevated CO$_2$ increase fresh C input from litter and root exudates to the soil and concurrently decrease soil N availability. Supply of labile C to the soil may accelerate the decomposition of soil organic C (SOC), a phenomenon termed ‘the priming effect’, and the priming effect is most pronounced at low soil N availability. Hence, we hypothesized that priming of SOC decomposition in response to labile C addition would increase in soil exposed to long-term elevated CO$_2$ exposure. Further, we hypothesized that long-term warming would enhance SOC priming rates, whereas drought would decrease the priming response. We incubated soil from a long-term, full-factorial climate change field experiment, with the factors elevated atmospheric CO$_2$ concentration, warming and prolonged summer drought with either labile C (sucrose) or water to assess the impact of labile C on SOC dynamics. We used sucrose with a $^{13}$C/$^{12}$C signature that is distinct from that of the native SOC, which allowed us to assess the contribution of these two C sources to the CO$_2$ evolved. Sucrose induced priming of SOC, and the priming response was higher in soil exposed to long-term elevated CO$_2$ treatment. Drought tended to decrease the priming response, whereas long-term warming did not affect the level of priming significantly. We were also able to assess whether SOC-derived primed C in elevated CO$_2$ soil was assimilated before or after the initiation of the CO$_2$ treatment 8 years prior to sampling, because CO$_2$ concentrations were raised by fumigating the experimental plots with pure CO$_2$ that was $^{13}$C-depleted compared to ambient CO$_2$. Surprisingly, we conclude that sucrose addition primed decomposition of relatively old SOC fractions, i.e. SOC assimilated more than 8 years before sampling.
Productivity and carbon footprint of perennial grass-forage legume intercropping strategies with high or low nitrogen fertilizer input

A three-season field experiment was established and repeated twice with spring barley used as cover crop for different perennial grass-legume intercrops followed by a full year pasture cropping and winter wheat after sward incorporation. Two fertilization regimes were applied with plots fertilized with either a high or a low rate of mineral nitrogen (N) fertilizer. Life cycle assessment (LCA) was used to evaluate the carbon footprint (global warming potential) of the grassland management including measured nitrous oxide (N2O) emissions after sward incorporation. Without applying any mineral N fertilizer, the forage legume pure stand, especially red clover, was able to produce about 15 t aboveground dry matter ha−1 year−1 saving around 325 kg mineral N fertilizer ha−1 compared to the cocksfoot and tall fescue grass treatments. The pure stand ryegrass yielded around 3 t DM more than red clover in the high fertilizer treatment. Nitrous oxide emissions were highest in the treatments containing legumes. The LCA showed that the low input N systems had markedly lower carbon footprint values than crops from the high N input system with the pure stand legumes without N fertilization having the lowest carbon footprint. Thus, a reduction in N fertilizer application rates in the low input systems offsets increased N2O emissions after forage legume treatments compared to grass plots due to the N fertilizer production-related emissions. When including the subsequent wheat yield in the total aboveground production across the three-season rotation, the pure stand red clover without N application and pure stand ryegrass treatments with the highest N input equalled. The present study illustrate how leguminous biological nitrogen fixation (BNF) represents an important low impact renewable N source without reducing crop yields and thereby farmers earnings.

Fire increases the risk of higher soil N2O emissions from Mediterranean Macchia ecosystems

Intensification of droughts under climate change is projected to increase fire frequency in the Mediterranean region. Fires cause direct emission of greenhouse gases (GHG) such as carbon dioxide (CO2) and nitrous oxide (N2O), due to the combustion of organic matter, creating a positive feedback on climate change. However, the potential importance of indirect GHG emissions due to changes in soil biological and chemical properties after fire is less well known. Increased soil mineral nitrogen (N) concentrations after fire pose a risk for increased emissions of gaseous N, but studies on the post-fire N2O production and soil N turnover rates (mineralization, nitrification, microbial immobilization, denitrification) are still rare. We determined N2O production, rates of N turnover and pathways for N2O production from the soil of burned and unburned plots of a Macchia shrubland in central Spain using a 15N labelling approach. Measurements were initiated before the controlled burning and continued for up to half a year after fire. Fire markedly increased the risk of N2O emissions from soil through denitrification (N2O production rate was 3 to ≈30 times higher in burned soils compared to control, with N2O being produced solely from soil nitrate). In contrast, soil gross N cycling rates were not accelerated after fire. Thus, the increased N2O production was not closely linked with N mineralization, but may be explained by increased mineral N availability from ash, increased pH in burned plots, and less competition for available N and C sources due to...
Impacts of Climate Change on Terrestrial Ecosystem Functioning – An Overview

CLIMA!TE - background

The concentration of CO₂ in the atmosphere is increasing, global temperatures are increasing, and local precipitation patterns are changing with increases in the intensity of rain events and drought periods. This is expected to affect the structure and functioning of terrestrial ecosystems (IPCC, 2013) with major impacts on natural environments as well as ecosystems used for agriculture or forestry. Over the past three decades, major efforts have been devoted to understanding and predicting such impacts of climate change on ecosystem processes and functioning in order to understand the urgency of the changes as well as the possibilities for ecosystem adaptation or climate change mitigation. These efforts have included observations of past changes, monitoring of ongoing changes, observations across environmental gradients (space for time substitution), ecosystem manipulation experiments mimicking future climate changes, and dynamic ecosystem modelling (Beier, 2004; Rustad, 2008). Each of these approaches has its forces and drawbacks, but across all a general limitation is that observations and experiments have focused on a single climate factor. For example, observations across gradients can hardly combine simultaneous and ideal differences in two or even three climate factors at the same time to provide a multi-factor response picture. Ecosystem experiments, which could do it, often limits themselves to one factor for practical reasons or because of lack of resources, since inclusion of one extra factor doubles the number of experimental units and the demand for resources in a classic experimental design. Therefore, very few multi-factor climate change experiments exist. Instead, the underlying assumption has been that the individual responses are known based on single factor experiments, then dynamic ecosystem or global models can predict the responses of the combined factors. This approach may seem reasonable but is constrained by at least two problems, which CLIMA!TE specifically aimed to overcome: 1. When several factors act together, they may interact, and these interactions among the different climate change factors may not be linear and/or predictable. Computer models may predict some of these interactions relatively well (e.g., resource limitations due to increased growth), while other interactions may be unpredictable. Beier, C., et al. The assumption that the impact of the "climate change cocktail" may be predicted from an understanding of the individual factors may therefore be erroneous. 2. Even when models do predict the interactions, we still need multi-factor experiments to train and test the models in order to know if the predictions are correct. Another inherent problem related to climate change and experimentation is the time scale. Climate change acts over decades, meaning that climate change experiments running for 2-4 years only highlight short-term and transient effects on the ecosystems, while lacking the ability to inform about long-term and more stable effects. The "long term" perspective of climate change was therefore another important rationale for the CLIMA!TE experiment. The "long term" perspective of climate change calls for long term experiments, which for decades has been argued from the scientific community, was therefore another important rationale for the CLIMA!TE experiment. The VILLUM FOUNDATION provided a very rare opportunity to pursue this in reality. In summary, the CLIMA!TE experiment was driven by two major rationales: 1) a need for realistic experiments involving combinations of the main climate change drivers and 2) the long term perspective of climate change.
A decade of free-air CO2 enrichment increased the carbon throughput in a grass-clover ecosystem but did not drastically change carbon allocation patterns

The response of the soil carbon cycle to increasing atmospheric CO2 concentration has far reaching consequences for the ecosystem carbon balance under future climatic conditions. We report on work carried out in the Swiss free-air CO2 enrichment (FACE) experiment, where we used in situ 13CO2 labelling to determine whether elevated CO2 (+230 μL L−1) concentration changes the fate of recently assimilated carbon in the soil microbial community. Elevated CO2 (eCO2) concentration had an overall positive effect on microbial abundance (P <0·001) with the gram-negative bacteria showing significantly increased quantities. Gram-negative bacteria and saprotrophic fungi tended to utilize a higher amount of recently assimilated carbon under eCO2. Arbuscular mycorrhizal fungi (AMF) utilized plant-assimilated carbon within 1 day after the 13CO2 pulse and 13C uptake patterns in AMF suggest that carbon transfer is faster under eCO2 concentration than under ambient CO2 (aCO2). Additionally, the respiration of recently assimilated carbon was significantly higher under eCO2 than aCO2 concentration. Our data suggest that elevated atmospheric CO2 concentration accelerated and increased the utilization of recently assimilated carbon by the microbial community without changing the microbial community composition drastically. We conclude that a higher standing soil microbial biomass under eCO2 concentration was the key cause for the higher carbon flow through the plant-soil system. Carbon utilization by microbial functional groups was only little affected by a decade of CO2 enrichment.
Bacteria and fungi respond differently to multifactorial climate change in a temperate heathland, traced with $^{13}$C-Glycine and FACE CO$_2$.

To understand the responses of soil microorganisms to predicted climate changes, as these directly control soil carbon (C) dynamics. The rate of turnover of soil organic carbon is mediated by soil microorganisms whose activity may be affected by climate change. After one year of multifactorial climate change treatments, at an undisturbed temperate heathland, soil microbial community dynamics were investigated by injection of a very small concentration (5.12 m gC g$^{-1}$ soil) of 13C-labeled glycine (13 C 2, 99 atom %) to soils in situ. Plots were treated with elevated temperature (+ 1°C, T), summer drought (D) and elevated atmospheric carbon dioxide (510 ppm [CO2]), as well as combined treatments (TD, TCO2, DC02 and TDC02). The 13C enrichment of respired CO$_2$ and of phospholipid fatty acids (PLFAs) was determined after 24 h. 13C-glycine incorporation into the biomarker PLFAs for specific microbial groups (Gram positive bacteria, Gram negative bacteria, actinobacteria and fungi) was quantified using gas chromatography-combustion-stable isotope ratio mass spectrometry (GC-C-IRMS). Gram positive bacteria opportunistically utilized the freshly added glycine substrate, i.e. incorporated 13C in all treatments, whereas fungi had minor or no glycine derived 13C-enrichment, hence slowly reacting to a new substrate. The effects of elevated CO$_2$ did suggest increased direct incorporation of glycine in microbial biomass, in particular in G + bacteria, in an ecosystem subjected to elevated CO$_2$. Warming decreased the concentration of PLFAs in general. The FACE CO$_2$ was 13C-depleted ($\delta^{13}$C=12.2 %) compared to ambient ($\delta^{13}$C=2.8 %), and this enabled observation of the integrated longer term responses of soil microorganisms to the FACE over one year. All together, the bacterial (and not fungal) utilization of glycine indicates substrate preference and resource partitioning in the microbial community, and therefore suggests a diversified response pattern to future changes in substrate availability and climatic factors.

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Biological $^{12}$C-$^{13}$C fractionation increases with increasing community-complexity in soil microcosms
Isotope fractionation is a ubiquitous phenomenon in natural ecosystems. When chemical elements move through food chains, natural isotope ratios change because biological processes tend to discriminate against heavier isotopes. This effect can be used to trace flows of matter, estimate process-rates and determine the trophic level of organisms in biological systems. While it is widely accepted that 15N-accumulates in natural food-chains, it is disputed to which extent this is the case for C-13. We constructed sand-microcosms inoculated with a dilution series of soil organisms and amended with glucose as the source of organic carbon. We demonstrated that the proportion of C-13 in respiratory CO$_2$ correlated inversely with community complexity. Our results therefore suggest that increasing community complexity, with increasing synergy, competition and predation, facilitates increasing C-12-C-13 isotopic fractionation. (C) 2013 Elsevier Ltd. All rights reserved.

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Can current moisture responses predict soil CO2 efflux under altered precipitation regimes? A synthesis of manipulation experiments

As a key component of the carbon cycle, soil CO2 efflux (SCE) is being increasingly studied to improve our mechanistic understanding of this important carbon flux. Predicting ecosystem responses to climate change often depends on extrapolation of current relationships between ecosystem processes and their climatic drivers to conditions not yet experienced by the ecosystem. This raises the question of to what extent these relationships remain unaltered beyond the current climatic window for which observations are available to constrain the relationships. Here, we evaluate whether current responses of SCE to fluctuations in soil temperature and soil water content can be used to predict SCE under altered rainfall patterns. Of the 58 experiments for which we gathered SCE data, 20 were discarded because either too few data were available or inconsistencies precluded their incorporation in the analyses. The 38 remaining experiments were used to test the hypothesis that a model parameterized with data from the control plots (using soil temperature and water content as predictor variables) could adequately predict SCE measured in the manipulated treatment. Only for 7 of these 38 experiments was this hypothesis rejected. Importantly, these were the experiments with the most reliable data sets, i.e., those providing high-frequency measurements of SCE. Regression tree analysis demonstrated that our hypothesis could be rejected only for experiments with measurement intervals of less than 11 days, and was not rejected for any of the 24 experiments with larger measurement intervals. This highlights the importance of high-frequency measurements when studying effects of altered precipitation on SCE, probably because infrequent measurement schemes have insufficient capacity to detect shifts in the climate dependencies of SCE. Hence, the most justified answer to the question of whether current moisture responses of SCE can be extrapolated to predict SCE under altered precipitation regimes is 'no' - as based on the most reliable data sets available. We strongly recommend that future experiments focus more strongly on establishing response functions across a broader range of precipitation regimes and soil moisture conditions. Such experiments should make accurate measurements of water availability, should conduct high-frequency SCE measurements, and should consider both instantaneous responses and the potential legacy effects of climate extremes. This is important, because with the novel approach presented here, we demonstrated that, at least for some ecosystems, current moisture responses could not be extrapolated to predict SCE under altered rainfall conditions.

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Collembola feeding habits and niche specialization in agricultural grasslands of different composition

The introduction of white clover in grassland is a common practice to improve the quality of the pasture and to limit the use of industrial sources of inorganic fertilizer N inputs. However, little is known about the extent to which the introduction of different crop compositions affects soil quality in general, and soil biota in particular. Recent studies have shown that epedaphic and euvedaphic Collembola can have distinct differences in feeding strategy that suggests trophic niche differentiation according to soil habitat. Combining fatty acid (FA) biomarkers with the carbon isotopic ratios technique, we investigated belowground trophic interactions. We compared the FA composition of the three most predominant groups of Collembola (Isotoma spp., Lepidocyrtus cyaneus and Poduromorpha) and bulk soil in white clover-only, a grass-clover mixture, and grass-only plots. Differences between FA-δ13C of Collembola groups and the FA-δ13C signatures of potential food sources (plant material and soil microorganisms) were calculated to explore trophic links in the three cropping combinations. Collembola showed difference in FA compositions between groups. We observed a lower amount of neutral lipid fatty acids (NLFAs) in Isotoma spp. compared to L. cyaneus. Poduromorpha showed a higher relative percentage of the NLFAs 16:1 u 7 and 20:4 compared to L. cyaneus, and of 18:3 compared to Isotoma spp. The NLFA oleic/linoleic ratio (18:1 u 9/18:2 u 6,9) ratio was higher in Poduromorpha compared to L. cyaneus in all the treatments. Soil FA analysis highlighted a larger fungal/bacterial ratio in grass compared to clover plots, while in Collembola no differences in the FA pattern were detected in relation to the treatments. Nevertheless, results of d 13 C fractionation in Collembola disclosed differences in the food sources used depending on the crop composition. Apparently, Isotoma spp. and L. cyaneus fed on clover-related diet in clover plots and more on grass-related diet in mixture treatments while Poduromorpha fed more on a plant-related diet, such as leaf litter, in the mixture treatment. Our results suggest differentiation in Collembola feeding strategy and in the diet in relation to food availability and palatability.
Combined climate factors alleviate changes in gross soil nitrogen dynamics in heathlands

The ongoing climate change affects biogeochemical cycling in terrestrial ecosystems, but the magnitude and direction of this impact is yet unclear. To shed further light on the climate change impact, we investigated alterations in the soil nitrogen (N) cycling in a Danish heathland after 5 years of exposure to three climate change factors, i.e. warming, elevated CO2 (eCO(2)) and summer drought, applied both in isolation and in combination. By conducting laboratory N-15 tracing experiments we show that warming increased both gross N mineralization and nitrification rates. In contrast, gross nitrification was decreased by eCO(2), an effect that was more pronounced when eCO(2) was combined with warming and drought. Moreover, there was an interactive effect between the warming and CO2 treatment, especially for N mineralization: rates increased at warming alone but decreased at warming combined with eCO(2). In the full treatment combination, simulating the predicted climate for the year 2075, gross N transformations were only moderately affected compared to control, suggesting a minor alteration of the N cycle due to climate change. Overall, our study confirms the importance of multifactorial field experiments for a better understanding of N cycling in a changing climate, which is a prerequisite for more reliable model predictions of ecosystems responses to climate change.

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Effects of green manure storage and incorporation methods on nitrogen release and N2O emissions after soil application
More efficient use of green manure-derived nitrogen (N) may improve crop yields and reduce environmental impacts in stockless organic arable farming. In this 3-month incubation study, we tested a new strategy where green manure leys are harvested and preserved until the following spring either as compost mixed with straw or as silage of harvested ley biomass. Grass-clover compost or silage was soil-incorporated by either simulated ploughing (green manure placed at 15 cm depth) or harrowing (green manure mixed into the upper 5-cm soil horizon) in order to assess treatment effects on net release of plant-available N, nitrous oxide (N2O) fluxes, and soil respiration. Grass-clover silage provided the highest net N release with similar results for the two incorporation methods. Up to one third of the total N content in silage became plant-available during the three months. In contrast, no net N release was observed for the composted grass-clover and straw mixture. In fact, soil incorporation of compost by harrowing caused temporal immobilization of soil mineral N. Silage incorporated by ploughing gave rise to largest N2O effluxes with silage-induced emissions corresponding to 0.3 % of applied total N. Possibly N2O production via denitrification was stimulated by oxygen-limited conditions near the decomposing silage. In contrast, compost incorporated by harrowing caused net N2O uptake, presumably an effect of reduced mineral N availability in this treatment. Overall, our study revealed that ensiled grass-clover was the best fertilizer product, and that the method chosen for incorporation of green manure is likely to influence N2O emissions.

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Effects of Lime and Concrete Waste on Vadose Zone Carbon Cycling
In this work we investigate how lime and crushed concrete waste (CCW) affect carbon cycling in the vadose zone and explore whether these amendments could be employed to mitigate climate change by increasing the transport of CO2 from the atmosphere to the groundwater. We use a combination of experimental and modeling tools to determine ongoing biogeochemical processes. Our results demonstrate that lime and CCW amendments to acid soil contribute to the climate forcing by largely increasing the soil CO2 efflux to the atmosphere. In a series of mesocosm experiments, with barley (Hordeum vulgare L.) grown on podzolic soil material, we have investigated inorganic carbon cycling through the gaseous and liquid phases and how it is affected by different soil amendments. The mesocosm amendments comprised the addition of 0, 9.6, or 21.2 kg m−2 of crushed concrete waste (CCW) or 1 kg lime m−2. The CCW and lime treatments increased the dissolved inorganic carbon (DIC) percolation flux by about 150 and 100%, respectively, compared to the controls. However, concurrent increases in the CO2 efflux to the atmosphere (ER) were more than one order of magnitude higher than increases in the DIC percolation flux. Analysis of soil solutions, coupled reactive-transport modeling studies, and a decrease in soil carbonate contents over the experiment altogether suggested that the increased ER from amended mesocosms was derived from the carbonate contained in the amendments, which, hence, mostly escaped to the atmosphere. Our results are important in the context of climate change due to the widespread application of lime to acidic soils. The CCW amendment had no adverse effects on plant growth and groundwater quality.

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Gas cleaning with hot char beds studied by stable isotopes
The chemistry taking place in a high temperature char bed used for binding aromatic tar compounds has been studied in detail. 13C labelled tar compounds were used to trace the incorporation into the char bed using isotope ratio mass spectrometry (IRMS) and GC-MS. Furthermore, compounds labelled with 2H (deuterium) were used to support proposed reaction mechanisms. It was found that at 700-800 °C the aromatic tar compounds bind irreversibly to the char by a radical reaction and, hence, become an integrated part of the char. Thermally induced reactions may occur prior to the binding reaction. The findings explain the tar reducing properties of the char bed in two-stage gasifiers. A living char bed for hot gas cleaning is discussed. © 2014 Elsevier B.V.

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Leaf surface wax is a source of plant methane formation under UV radiation and in the presence of oxygen
The terrestrial vegetation is a source of UV radiation-induced aerobic methane (CH4) release to the atmosphere. Hitherto pectin, a plant structural component, has been considered as the most likely precursor for this CH4 release. However, most of the leaf pectin is situated below the surface wax layer, and UV transmittance of the cuticle differs among plant species. In some species, the cuticle effectively absorbs and/or reflects UV radiation. Thus, pectin may not necessarily contribute substantially to the UV radiation-induced CH4 emission measured at surface level in all species. Here, we investigated the potential of the leaf surface wax itself as a source of UV radiation-induced leaf aerobic CH4 formation. Isolated leaf surface wax emitted CH4 at substantial rates in response to UV radiation. This discovery has implications for how the phenomenon should be scaled to global levels. In relation to this, we demonstrated that the UV radiation-induced CH4 emission is independent of leaf area index above unity. Further, we observed that the presence of O2 in the atmosphere was necessary for achieving the highest rates of CH4 emission. Methane formation from leaf surface wax is supposedly a two-step process initiated by a photolytic rearrangement reaction of the major component followed by an α-
cleavage of the generated ketone.

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**Short-term utilization of carbon by the soil microbial community under future climatic conditions in a temperate heathland**

An in-situ13C pulse-labeling experiment was carried out in a temperate heath/grassland to study the impacts of elevated CO2 concentration (510ppm), prolonged summer droughts (annual exclusion of 7.6±0.8%) and increased temperature (~1°C) on belowground carbon (C) utilization. Recently assimilated C (13C from the pulse-label) was traced into roots, soil and microbial biomass 1, 2 and 8 days after pulse-labeling. The importance of the microbial community in C utilization was investigated using 13C enrichment patterns in different microbial functional groups on the basis of phospholipid fatty acid (PLFA) biomarker profiles. Climate treatments did not affect microbial abundance in soil or rhizosphere fractions in terms of total PLFA-C concentration. Elevated CO2 significantly reduced the abundance of gram-negative bacteria (17:0cy), but did not affect the abundance of decomposers (fungi and actinomycetes) in rhizosphere fractions. Drought favored the bacterial community in rhizosphere fractions whereas increased temperature reduced the abundance of gram-negative bacteria (19:0cy) and changed the actinomycetes community (10Me16:0, 10Me18:0). Fastest and highest utilization of recently assimilated C was observed in rhizosphere associated gram-negative bacteria followed by gram-positive bacteria. Utilization of recently assimilated C by rhizosphere associated actinomycetes and fungi was relatively low, but much more pronounced in the soil. The utilization of recently assimilated C by the microbial community was faster under elevated CO2 conditions compared to ambient. We conclude that changing climatic conditions will affect C utilization by the soil microbial community but might not drastically change the terrestrial C balance. © 2013 Elsevier Ltd.

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Technical Note: Mesocosm approach to quantify dissolved inorganic carbon percolation fluxes

Dissolved inorganic carbon (DIC) fluxes across the vadose zone are influenced by a complex interplay of biological, chemical and physical factors. A novel soil mesocosm system was evaluated as a tool for providing information on the mechanisms behind DIC percolation to the groundwater from unplanted soil. Carbon dioxide partial pressure ($pCO_2$), alkalinity, soil moisture and temperature were measured with depth and time, and DIC in the percolate was quantified using a sodium hydroxide trap. Results showed good reproducibility between two replicate mesocosms. The $pCO_2$ varied between 0.2 and 1.1 %, and the alkalinity was 0.1-0.6 meq L$^{-1}$. The measured cumulative effluent DIC flux over the 78-day experimental period was 185-196 mg L$^{-1}$ m$^{-2}$ and in the same range as estimates derived from $pCO_2$ and alkalinity in samples extracted from the side of the mesocosm column and the drainage flux. Our results indicate that the mesocosm system is a promising tool for studying DIC percolation fluxes and other biogeochemical transport processes in unsaturated environments.

UV-induced N2O emission from plants

Nitrous oxide (N 2 O) is an important long-lived greenhouse gas and precursor of stratospheric ozone-depleting mononitrogen oxides. The atmospheric concentration of N 2 O is persistently increasing; however, large uncertainties are associated with the distinct source strengths. Here we investigate for the first time N 2 O emission from terrestrial vegetation in response to natural solar ultra violet radiation. We conducted field site measurements to investigate N 2 O
atmosphere exchange from grass vegetation exposed to solar irradiance with and without UV-screening. Further laboratory tests were conducted with a range of species to study the controls and possible loci of UV-induced N\textsubscript{2}O emission from plants. Plants released N\textsubscript{2}O in response to natural sunlight at rates of c. 20 e 50 nmol m\textsuperscript{-2} h\textsuperscript{-1}, mostly due to the UV component. The emission response to UV-A is of the same magnitude as that to UV-B. Therefore, UV-A is more important than UV-B given the natural UV-spectrum at Earth's surface. Plants also emitted N\textsubscript{2}O in darkness, although at reduced rates. The emission rate is temperature dependent with a rather high activation energy indicative for an abiotic process. The prevailing zone for the N\textsubscript{2}O formation appears to be at the very surface of leaves. However, only c. 26\% of the UV-induced N\textsubscript{2}O appears to originate from plant-N. Further, the process is dependent on atmospheric oxygen concentration. Our work demonstrates that ecosystem emission of the important greenhouse gas, N\textsubscript{2}O, may be up to c. 30\% higher than hitherto assumed.

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**Annual maize and perennial grass-clover strip cropping for increased resource use efficiency and productivity using organic farming practice as a model**
A cropping system was designed to fulfill the increasing demand for biomass for food and energy without decreasing long term soil fertility. A field experiment was carried out including alternating strips of annual maize (Zea mays L.) and perennial ryegrass (Lolium perenne L.) – clover (Trifolium repens+Trifolium pretense L.) mixture grown in the same field. In autumn an annual strip was established with green-rye (Secale cereale L.) after soil incorporation of a 1st year grass-clover a 6-m wide strip followed by maize sowing in May. The perennial strips were established without incorporating the same 1st year grass-clover in an equivalent 6-m wide strip, resulting in an early competitive advantage for the perennial strip toward the annual strip. Throughout the growing season maize was never able to recovery from this and yields were reduced with around 50\% when grown adjacent to grass-clover (0–50cm) compared to with >50cm distance. There was significantly greater clover content in the sward when grown with >150cm distance to maize (30\%) compared to the 0–25cm distance (10\%) indicating more available soil mineral N in the interface between the strips related to a strong ability of the grass to compete for soil mineral N. Maize yields were clearly associated with N fertilizer application. When fertilizer N was applied through slurry or anaerobic digested slurry maize yields was increasing with up to 100\% equivalent to 1200g carbon (C) m\textsuperscript{-2} or 35MJm\textsuperscript{-2}. However, the same relative growth reduction was found when grown in close proximity to the grass-clover strip. If slurry is available maize secures an efficient N uptake, however, long-term effects of maize cropping and biomass removal on soil quality is of concern. The present strip cropping system did not possess the right balance of co-existence and complementarity with relative yield advantages for the whole crop cycle between 0.96 and 1.01. Thus, the total land area required under traditional cropping attaining the yields achieved when dividing the field in strips is the same. Greater complementarity between strips is needed to gain the potential strip cropping advantages.

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Common arbuscular mycorrhizal networks amplify competition for phosphorus between seedlings and established plants

Common mycorrhizal networks (CMNs) influence competition between plants, but reports regarding their precise effect are conflicting. We studied CMN effects on phosphorus (P) uptake and growth of seedlings as influenced by various disruptions of network components. Tomato (Solanum lycopersicon) seedlings grew into established networks of Rhizophagus irregularis and cucumber (Cucumis sativus) in two experiments. One experiment studied seedling uptake of 32P in the network in response to cutting of cucumber shoots; the other analysed seedling uptake of P and nitrogen (N) in the presence of intact or severed arbuscular mycorrhizal fungus networks and at two soil P concentrations. Pre-established and intact networks suppressed growth of tomato seedlings. Cutting of cucumber shoots mitigated P deficiency symptoms of seedlings, which obtained access to P in the extraradical mycelium and thereby showed improved growth. Solitary seedlings growing in a network patch that had been severed from the CMN also grew much better than seedlings of the corresponding CMN. Interspecific and size-asymmetric competition between plants may be amplified rather than relaxed by CMNs that transfer P to large plants providing most carbon and render small plants P deficient. It is likely that grazing or senescence of the large plants will alleviate the network-induced suppression of seedling growth.

General information

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Effects of digestate from anaerobically digested cattle slurry and plant materials on soil microbial community and emission of CO₂ and N₂O
Anaerobic digestion of animal manure and crop residues may be employed to produce biogas as a climate-neutral source of energy and to recycle plant nutrients as fertilizers. However, especially organic farmers are concerned that fertilizing with the digestates may impact the soil microbiota and fertility because they contain more mineral nitrogen (N) and less organic carbon (C) than the non-digested input materials (e.g. raw animal slurry or fresh plant residues). Hence, an incubation study was performed where (1) water, (2) raw cattle slurry, (3) anaerobically digested cattle slurry/maize, (4) anaerobically digested cattle slurry/grass-clover, or (5) fresh grass-clover was applied to soil at arable realistic rates. Experimental units were sequentially sampled destructively after 1, 3 and 9 days of incubation and the soil assayed for content of mineral N, available organic C, emission of CO2 and N2O, microbial phospholipid fatty acids (biomass and community composition) and catabolic response profiling (functional diversity). Fertilizing with the anaerobically digested materials increased the soil concentration of NO3− ca. 30–40% compared to when raw cattle slurry was applied. Grass-clover contributed with four times more readily degradable organic C than the other materials, causing an increased microbial biomass which depleted the soil for mineral N and probably also O2. Consequently, grass-clover also caused a ∼10 times increase in emissions of CO2 and N2O greenhouse gasses compared to any of the other treatments during the 9 days. Regarding microbial community composition, grass-clover induced the largest changes in microbial diversity measures compared to the controls, where raw cattle slurry and the two anaerobically digested materials (cattle slurry/maize, cattle slurry/grass-clover) only induced minor and transient changes.

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**Impact of future climatic conditions on the potential for soil organic matter priming**
Terrestrial carbon (C) storage and turnover are of major interest under changing climatic conditions. We present a laboratory microcosm study investigating the effects of anticipated climatic conditions on the soil microbial community and related changes in soil organic matter (SOM) decomposition. Soil samples were taken from a heath-land after six years of exposure to elevated carbon dioxide (eCO2) in combination with summer drought (D) and increased temperature (T). Soil C-dynamics were investigated in soils from: (i) ambient, (ii) eCO2, and (iii) plots exposed to the combination of factors simulating future climatic conditions (TDeCO2) that simulate conditions predicted for Denmark in 2075. 13C enriched glucose (3 atom% excess) was added to soil microcosms, soil CO2 efflux was measured over a period of two weeks and separated into glucose- and SOM-derived C. Microbial biomass was measured using chloroform fumigation extraction, and compound-specific phospholipid fatty acid analysis was used to determine microbial community composition and substrate use. We observed that glucose additions induced SOM priming in ambient and eCO2 treated soils, but not in soil exposed to future climatic conditions. Climate treatments and glucose additions did not affect relative abundances of microbial functional groups but the fate of glucose through the microbial community was changed by climate treatments as revealed by the incorporation of 13C in PLFAs. Soil treated with eCO2 showed a high flow of glucose through gram-positive bacteria whereas in ambient and future soils utilization of glucose by actinomycetes and fungi (putative SOM-decomposers) was greater. Our results suggest that individual climate change factors may influence pathways of C-flux through microbial communities and therefore affect soil processes; these factors may counterbalance each other and maintain ecosystem stability. This highlights the importance of studying climate change factors in combination to fully assess consequences of environmental change on plant-soil systems. © 2013 Elsevier Ltd.
In situ 13CO2 pulse-labeling in a temperate heathland – development of a mobile multi-plot field setup

Pulse-labeling with 13CO2 and the subsequent analysis of 13C-carbon via isotope ratio mass spectrometry (IRMS) have been shown to be an excellent method to investigate the terrestrial carbon cycle. Improving 13CO2 manipulation experiments will facilitate our understanding of carbon cycling processes. A mobile field setup for in situ 13CO2 pulse-labeling was developed for low vegetation field experiments. Two pulse-labeling experiments were conducted in a Danish heathland in September 2010 (Exp1) and May 2011 (Exp2). A flow-through system was developed where labeling chambers were supplied with 13CO2-enriched air from a gas reservoir. Reservoir and chamber air was sampled over the course of the experiments and analyzed for CO2 concentration and isotopic composition on a GasBench II interfaced with an isotope ratio mass spectrometer. The soil CO2 efflux and the atom% excess in soil respiration were assessed after the 13CO2-pulse to verify the setup performance. The carbon dioxide concentrations and 13CO2 enrichments were stable during the experiments. The CO2 concentrations conformed to the aimed values, whereas the 13CO2 enrichments were lower than expected. The sources of error for the deviation in observed atom% 13CO2 values are discussed, and a measurement procedure is suggested for samples highly enriched in 13C by using adjusted resistor settings of the mass spectrometer. However, more work has to be done. Enrichment patterns in soil respiration agree with published observations indicating satisfactory performance of the developed system. A mobile flow-through system suitable for continuous in situ 13CO2 pulse-labeling was successfully developed that is easily applicable in remote natural ecosystems. Copyright © 2013 John Wiley & Sons, Ltd.
Long-term effects of cropping system on N2O emission potential
The potential for N2O emissions outside the main growing season may be influenced by long-term effects of cropping system. This was investigated by collecting intact soil cores (100 cm3, 0-4 cm depth) under winter wheat in three organic cropping systems and a conventional reference within a long-term crop rotation experiment. Average annual inputs of C in crop residues and manure ranged from 1.7 to 3.3 Mg ha⁻¹. A simulated freeze-thaw cycle resulted in a flush of CO₂ during the first 48 h, which could be mainly from microbial sources. Other samples were adjusted to approximately −10, −30 or −100 hPa and amended with excess ¹⁵NO₃⁻ prior to freezing and thawing. Denitrification was the main source of N₂O during a 72-h incubation at 22 °C, as judged from N₂O and total ¹⁵N evolution. Although the input of C in the conventionally managed cropping system was significantly less than in the organic cropping systems, it showed higher N₂O evolution at all three matric potentials. Estimates of relative gas diffusivity (Dp/D0) in soil from the four cropping systems indicated that C input affected soil aeration. Soil from the two cropping systems with highest C input showed N₂O evolution at Dp/D0 in excess of 0.02, which is normally considered a threshold for development of anaerobic sites in the soil, presumably because the oxygen demand was also high. The study shows that cropping system affects both soil gas diffusivity and C availability, and that both characteristics significantly influence the N₂O emission potential.

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Nitrous oxide emission from Ulva lactuca incubated in batch cultures is stimulated by nitrite, nitrate and light
Biomass yields from some species of macroalgae exceed the yields in traditional terrestrial production systems. This renewable carbon source possesses a potential for energy purposes and thus reduction in fossil fuel carbon dioxide (CO2) emissions. Previous experiments have indicated that nitrous oxide (N2O) may be produced by green algae. We investigated the N2O emissions in the green alga Ulva lactuca. Significant N2O emissions, along with CO2 uptake, were demonstrated from vital U. lactuca material from different natural populations incubated in the laboratory with nitrite (NO2⁻) and nitrate (NO3⁻) and at a light intensity of 225μmolphotonsm⁻²s⁻¹. No emission of N2O was observed in darkness. The N2O emission increased in a Michaelis–Menten characteristic manner with increasing concentrations of both NO3⁻ and NO2⁻. The light dependency indicated that the N2O emission was related to algal photosynthesis, and not bacterial activity. As algal NO3⁻ reductase (NR) converts NO3⁻ to NO2⁻ in light, and N2O emission was observed from both NO3⁻ and NO2⁻, it is proposed that NO2⁻ reductase (NiR) activity may have generated the observed N2O, however the mechanism needs further investigation. This apparent N2O production by algae emphasizes the need for experiments under natural conditions in order to evaluate potential greenhouse gas balances associated with large-scale productions
for energy purposes.

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**Priming of soil carbon decomposition in two inner Mongolia grassland soils following sheep dung addition: A study using13C natural abundance approach**

To investigate the effect of sheep dung on soil carbon (C) sequestration, a 152 days incubation experiment was conducted with soils from two different Inner Mongolian grasslands, i.e. a Leymus chinensis dominated grassland representing the climax community (2.1% organic matter content) and a heavily degraded Artemisia frigida dominated community (1.3% organic matter content). Dung was collected from sheep either fed on L. chinensis (C3 plant with δ13C = -26.8‰; dung δ13C = -26.2‰) or Cleistogenes squarrosa (C4 plant with δ13C = -14.6‰; dung δ13C = -15.7‰). Fresh C3 and C4 sheep dung was mixed with the two grassland soils and incubated under controlled conditions for analysis of 13C-CO2 emissions. Soil samples were taken at days 17, 43, 86, 127 and 152 after sheep dung addition to detect the δ13C signal in soil and dung components. Analysis revealed that 16.9% and 16.6% of the sheep dung C had decomposed, of which 3.5% and 2.8% was sequestered in the soils of L. chinensis and A. frigida grasslands, respectively, while the remaining decomposed sheep dung was emitted as CO2. The cumulative amounts of C respired from dung treated soils during 152 days were 7-8 times higher than in the un-amended controls. In both grassland soils, ca. 60% of the evolved CO2 originated from the decomposing sheep dung and 40% from the native soil C. Priming effects of soil C decomposition were observed in both soils, i.e. 1.4 g and 1.6 g additional soil C kg-1 dry soil had been emitted as CO2 for the L. chinensis and A. frigida soils, respectively. Hence, the net C losses from L. chinensis and A. frigida soils were 0.6 g and 0.9 g C kg-1 soil, which was 2.6% and 7.0% of the total C in L. chinensis and A. frigida grasslands soils, respectively. Our results suggest that grazing of degraded Inner Mongolian pastures may cause a net soil C loss due to the positive priming effect, thereby accelerating soil deterioration. © 2013 Ma et al.
The natural abundance of 15N in litter and soil profiles under six temperate tree species: N cycling depends on tree species traits and site fertility

We investigated the influence of tree species on the natural 15N abundance in forest stands under elevated ambient N deposition. We analysed δ15N in litter, the forest floor and three mineral soil horizons along with ecosystem N status variables at six sites planted three decades ago with five European broadleaved tree species and Norway spruce. Litter δ15N and 15N enrichment factor (δ15Nlitter–δ15Nsoil) were positively correlated with N status based on soil and litter N pools, nitrification, subsoil nitrate concentration and forest growth. Tree species differences were also significant for these N variables and for the litter δ15N and enrichment factor. Litter from ash and sycamore maple with high N status and low fungal mycelia activity was enriched in 15N (+0.9 delta units) relative to other tree species (European beech, pedunculate oak, lime and Norway spruce) even though the latter species leached more nitrate. The δ15N pattern reflected tree species related traits affecting the N cycling as well as site fertility and former land use, and possibly differences in N leaching. The tree species δ15N patterns reflected fractionation caused by uptake of N through mycorrhiza rather than due to nitrate leaching or other N transformation processes.

UV-induced carbon monoxide emission from living vegetation

The global burden of carbon monoxide (CO) is rather uncertain. In this paper we address the potential for UV-induced CO emission by living terrestrial vegetation surfaces. Real-time measurements of CO concentrations were made with a cavity enhanced laser spectrometer connected in closed loop to either an ecosystem chamber or a plant-leaf scale chamber. Leaves of all examined plant species exhibited emission of CO in response to artificial UV-radiation as well as the UV-component of natural solar radiation. The UV-induced rate of CO emission exhibited a rather low dependence on temperature, indicating an abiotic process. The emission of CO in response to the UV-component of natural solar radiation...
Consequences of field N\textsubscript{2}O emissions for the environmental sustainability of plant-based biofuels produced within an organic farming system

One way of reducing the emissions of fossil fuel-derived carbon dioxide (CO\textsubscript{2}) is to replace fossil fuels with biofuels produced from agricultural biomasses or residuals. However, cultivation of soils results in emission of other greenhouse gases (GHGs), especially nitrous oxide (N\textsubscript{2}O). Previous studies on biofuel production systems showed that emissions of N\textsubscript{2}O may counterbalance a substantial part of the global warming reduction, which is achieved by fossil fuel displacement. In this study, we related measured field emissions of N\textsubscript{2}O to the reduction in fossil fuel-derived CO\textsubscript{2}, which was obtained when agricultural biomasses were used for biofuel production. The analysis included five organically managed feedstocks (viz. dried straw of sole cropped rye, sole cropped vetch and intercropped rye–vetch, as well as fresh grass–clover and whole crop maize) and three scenarios for conversion of biomass into biofuel. The scenarios were (i) bioethanol, (ii) biogas and (iii) coproduction of bioethanol and biogas. In the last scenario, the biomass was first used for bioethanol fermentation and subsequently the effluent from this process was utilized for biogas production. The net GHG reduction was calculated as the avoided fossil fuel-derived CO\textsubscript{2}, where the N\textsubscript{2}O emission was subtracted. This value did not account for fossil fuel-derived CO\textsubscript{2} emissions from farm machinery and during conversion processes that turn biomass into biofuel. The greatest net GHG reduction, corresponding to 700–800 g CO\textsubscript{2} m\textsuperscript{-2}, was obtained by biogas production or coproduction of bioethanol and biogas on either fresh grass–clover or whole crop maize. In contrast, biofuel production based on lignocellulosic crop residues (i.e. rye and vetch straw) provided considerably lower net GHG reductions (≤215 g CO\textsubscript{2} m\textsuperscript{-2}), and even negative numbers sometimes. No GHG benefit was achieved by fertilizing the maize crop because the extra crop yield, and thereby increased biofuel production, was offset by enhanced N\textsubscript{2}O emissions.
Effects of slow and fast pyrolysis biochar on soil C and N turnover dynamics
This study compared the effect of two principal pyrolysis methods on the chemical characteristics of biochar and the impact on C and N dynamics after soil incorporation. Biochar was produced from wheat straw that was thermally decomposed at 525 °C by slow pyrolysis (SP) in a nitrogen flushed oven and by fast pyrolysis (FP) using a Pyrolysis Centrifuge Reactor (PCR). After 65 days of soil incubation, 2.9% and 5.5% of the SP- and FP-biochar C, respectively, was lost as CO2, significantly less than the 53% C-loss observed when un-pyrolyzed feedstock straw was incubated. Whereas the SP-biochar appeared completely pyrolyzed, an un-pyrolyzed carbohydrate fraction (8.8% as determined by acid released C6 and C5 sugars) remained in the FP-biochar. This labile fraction possibly supported the higher CO2 emission and larger microbial biomass (SMB-C) in the FP-biochar soil. Application of fresh FP-biochar to soil immobilized mineral N (43%) during the 65 days of incubation, while application of SP-biochar led to net N mineralization (7%). In addition to the carbohydrate contents, the two pyrolysis methods resulted in different pH (10.1 and 6.8), particle sizes (113 and 23 μm), and BET surface areas (0.6 and 1.6 m2 g−1) of the SP- and FP-biochars, respectively. The study showed that independently of pyrolysis method, soil application of the biochar materials had the potential to sequester C, while the pyrolysis method did have a large influence on the mineralization-immobilization of soil N.

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Microbial biomass, microbial diversity, soil carbon storage, and stability after incubation of soil from grass-clover pastures of different age

A laboratory incubation study with clover grass pasture soils of seven different ages (0, 1, 2, 3, 4, 5, and 16 production years) was carried out to determine initial soil carbon (C) and nitrogen (N) stocks and potentials for greenhouse gas emissions (N₂O and CO₂). Compared with the soil from the recently established pasture, an increase of total soil C and N was observed along with pasture age. Greenhouse gas emissions were low and not significantly different among the soils from younger pastures (0-5 years), but especially N₂O emissions increased markedly in the soil from 16-year-old grass-clover. Low emissions might mainly be due to an early C limitation occurring in the soils from younger pastures, which was also corroborated by decreasing levels of cold water-extractable C and early shifts within the microbial community. However, higher emissions from the old pasture soil were offset by its increase in total soil C. A longer ley phase without soil disturbance may therefore be beneficial in terms of overall C sequestration in systems with temporary grass-clover swards.

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Web of Science (2012): Impact factor 2.505
ISI indexed (2012): ISI indexed yes
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Keywords: Soil, Nitrous oxide emission, Fumigation-extraction, Organic-matter, N₂O emission, Manure type, Nitrate, Cultivation, Management, Crop, CO₂
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Soil respiration is stimulated by elevated CO₂ and reduced by summer drought: three years of measurements in a multifactor ecosystem manipulation experiment in a temperate heathland (CLIMAITE)

This study investigated the impact of predicted future climatic and atmospheric conditions on soil respiration (RS) in a Danish Calluna-Deschampsia-heathland. A fully factorial in situ experiment with treatments of elevated atmospheric CO₂ (+130 ppm), raised soil temperature (+0.4 °C) and extended summer drought (5–8% precipitation exclusion) was established in 2005. The average RS, observed in the control over 3 years of measurements (1.7 μmol CO₂ m⁻² sec⁻¹), increased 38% under elevated CO₂, irrespective of combination with the drought or temperature treatments. In contrast, extended summer drought decreased RS by 14%, while elevated soil temperature did not affect RS overall. A significant interaction between elevated temperature and drought resulted in further reduction of RS when these treatments were combined. A detailed analysis of short-term RS dynamics associated with drought periods showed that RS was reduced by ~50% and was strongly correlated with soil moisture during these events. Recovery of RS to pre-drought levels occurred within 2 weeks of rewetting; however, unexpected drought effects were observed several months after summer drought treatment in 2 of the 3 years, possibly due to reduced plant growth or changes in soil water holding capacity. An empirical model that predicts RS from soil temperature, soil moisture and plant biomass was developed and accounted for 55% of the observed variability in RS. The model predicted annual sums of RS in 2006 and 2007, in the control, were 672 and 719 g C m⁻² y⁻¹, respectively. For the full treatment combination, i.e. the future climate scenario, the model predicted that soil respiratory C losses would increase by ~21% (140–150 g C m⁻² y⁻¹). Therefore, in the future climate, stimulation of C storage in plant biomass and litter must be in excess of 21% for this ecosystem to not suffer a reduction in net ecosystem exchange.

General information
Publication status: Published
Organisations: Risø National Laboratory for Sustainable Energy, Biosystems Division, Department of Chemical and Biochemical Engineering, Ecosystems Programme, University of Copenhagen
Strip cropping of alternating perennial grass–clover and annual rye–vetch intercrops when grown within an organic farming system

A field experiment was carried out including alternating perennial ryegrass (Lolium perenne L.)–clover (Trifolium repens+Trifolium pratense L.) pasture mix with annual winter rye (Secale cereale L.)–vetch (Vicia villosa L.) intercrops. The annuals were established after soil incorporation of a 1st-year grass–clover in a 6-m wide strip as both inter- (IC) and sole crops (SC): (1) rye SC, (2) vetch SC and (3) rye–vetch IC. The perennial strips were established without incorporating the 1st-year grass–clover in an equivalent 6-m wide strip. This resulted in an early interspecific competitive advantage for the perennial strip and especially limiting growth of the rye component. Relative clover proportion in the sward increased with increasing distance to the annual strip indicating more available soil mineral N in the interface between the perennial and the annual strip. Compensative growth of the grass–clover when grown in close proximity to the annual strip was only partly counterbalancing the decreased total crop productivity in the rye–vetch intercrop. Across the whole growing season (September–August) approximately the same amount of biomass was produced when dividing the field into strips (6m×6m) as compared to growing the same area with the traditional single-field cropping strategy. There was a greater total aboveground plant N uptake in sole cropped vetch and the rye–vetch intercrop compared to the rye sole crop due to vetch N2-fixation, but with severe vetch-growth depression when intercropped. The amount of vetch-N2 fixed was reduced with about 9gNm−2 when intercropped as compared to the sole cropping situation. Light interception by the annual crop when grown in close proximity to the grass–clover strip was reduced due to the lower aboveground biomass yield and assumed belowground competitive interactions. Less soil water content below the perennial strip indicated greater water uptake, than below the annual strips. Unfortunately, the present strip cropping system did not possess the right balance of co-existence and complementarity. However, from a practical point of view the system was manageable indicating potentials to diversify agricultural fields and develop future cropping systems which are more complex and thereby resilient to externalities.

General information
Publication status: Published
Organisations: Department of Chemical and Biochemical Engineering, Ecosystems Programme, Aarhus University, Lund University
Contributors: Hauggaard-Nielsen, H., Johansen, A., Carter, M. S., Ambus, P., Jensen, E.
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Publication information
Journal: Field Crops Research
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Ratings:
BFI (2012): BFI-level 1
Scopus rating (2012): CiteScore 2.93 SJR 1.315 SNIP 1.96
Terrestrial plant methane production

We evaluate all experimental work published on the phenomenon of aerobic methane (CH4) generation in terrestrial plants. We conclude that the phenomenon is true. Four stimulating factors have been observed to induce aerobic plant CH4 production, i.e. cutting injuries, increasing temperature, ultraviolet radiation and reactive oxygen species. Further, we analyze rates of measured emission of aerobically produced CH4 in pectin and in plant tissues from different studies and argue that pectin is very far from the sole contributing precursor. Hence, scaling up of aerobic CH4 emission needs to take into consideration other potential sources than pectin. Due to the large uncertainties related to effects of stimulating factors, genotypic responses and type of precursors, we conclude that current attempts for upscaling aerobic CH4 into a global budget is insufficient. Thus it is too early to draw the line under the aerobic methane emission in plants. Future work is needed for establishing the relative contribution of several proven potential CH4 precursors in plant material.

General information
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Contributors: Mikkelsen, T. N., Bruhn, D., Møller, I. M., Ambus, P.
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Source: dtu
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Research output: Contribution to conference » Conference abstract for conference – Annual report year: 2012 » Research

Terrestrial plant methane production and emission

In this minireview, we evaluate all experimental work published on the phenomenon of aerobic methane (CH4) generation in terrestrial plants and plant. Clearly, despite much uncertainty and skepticism, we conclude that the phenomenon is true. Four stimulating factors have been observed to induce aerobic plant CH4 production, i.e. cutting injuries, increasing temperature, ultraviolet radiation and reactive oxygen species. Further, we analyze rates of measured emission of aerobically produced CH4 in pectin and in plant tissues from different studies and argue that pectin is very far from the sole contributing precursor. In consequence, scaling up of aerobic CH4 emission needs to take into consideration other potential sources than pectin. Due to the large uncertainties related to effects of stimulating factors, genotypic responses and type of precursors, we conclude that current attempts for upscaling aerobic CH4 into a global budget is inadequate. Thus it is too early to draw the line under the aerobic methane emission in plants. Future work is needed for establishing the relative contribution of several proven potential CH4 precursors in plant material.

General information
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Contributors: Bruhn, D., Møller, I. M., Mikkelsen, T. N., Ambus, P.
Pages: 201-209
Publication date: 2012
Peer-reviewed: Yes

Publication information
Journal: Physiologia Plantarum
Volume: 144
Issue number: 3
ISSN (Print): 0031-9317
Ratings:
BFI (2012): BFI-level 1
Scopus rating (2012): CiteScore 3.61 SJR 1.61 SNIP 1.346
UV-induced carbon monoxide emission from sand and living vegetation

The global burden of carbon monoxide, CO, is rather uncertain. In this paper we address the potential of UV-induced CO emission by terrestrial surfaces. Real-time measurements of [CO] were made with a cavity enhanced laser connected in closed loop to either an ecosystem chamber or a leaf scale chamber. Sand and leaves of all examined plant species exhibited emission of CO in response to artificial UV-radiation and the UV-component of natural solar radiation. The UV-induced rate of CO emission exhibited a rather low dependence on temperature, indicating an abiotic process. The emission of CO in response to the UV-component of natural solar radiation was also evident at the ecosystem scale. When scaled to the global level, the UV-induced emission of CO by the major types of terrestrial surfaces, living leaves and soil (here represented by sand), amounts up to 28 Tg yr\(^{-1}\). This source has till now not been accounted for by IPCC, but is equivalent to 14–56% of the 50–200 Tg yr\(^{-1}\) from sources currently accounted for (IPCC 2001). In addition to this are other known sources that ought to be considered. The hitherto unaccounted for terrestrial sources of CO amounts up to 207 Tg yr\(^{-1}\), almost two-thirds of the latest estimated global CO burden of 360 Tg yr\(^{-1}\) (IPCC, 2001).

General information

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Organisations: Department of Chemical and Biochemical Engineering, Ecosystems Programme
Contributors: Bruhn, D., Albert, K. R., Mikkelsen, T. N., Ambus, P.
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Application of biochar to soil and N\(_2\)O emissions: potential effects of blending fast-pyrolysis biochar with anaerobically digested slurry

Soil applications of recalcitrant biochar offer the possibility of mitigating climate change effects through long-term carbon sequestration and potentially also by reducing emissions of the potent greenhouse gas nitrous oxide (N\(_2\)O). This laboratory study examined the effect of combining a fast-pyrolysis biochar at small (1% by mass) and large (3%) concentrations with anaerobically digested slurry on soil N\(_2\)O and carbon dioxide (CO\(_2\)) emissions over a period of 55 days. The results showed that fast-pyrolysis biochar applied on its own increased N\(_2\)O emissions from soil. However, when biochar was applied together with slurry, the larger biochar concentration decreased N\(_2\)O emissions by 47%,
relative to those from the slurry treatment with the smaller biochar concentration. Reduced N2O emissions coincided with enhanced soil microbial activity and immobilization of nitrogen. A combined application of biochar and anaerobic digested slurry could therefore be beneficial for cropping systems in terms of soil nitrogen retention while concurrently mitigating N2O fluxes and sequestering carbon in soil.

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Contributors: Bruun, E., Müller-Stöver, D. S., Ambus, P., Hauggaard-Nielsen, H.
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Web of Science (2011): Impact factor 2.34
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
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Cowpea N rhizodeposition and its below-ground transfer to a co-existing and to a subsequent millet crop on a sandy soil of the Sudano-Sahelian eco-zone
Nitrogen (N) rhizodeposition by cowpea (Vigna unguiculata (L.) Walp) is potentially a large N source in cropping systems of Sub-Saharan Africa. A field experiment was conducted to measure cowpea N rhizodeposition under the conditions of the Sudano-Sahelian zone using direct 15N labelling techniques to trace the amount of deposition and its transfer to associated and subsequent crops. Half of the total cowpea crop N was located below-ground at plant maturity, which exceeded 20 kg N ha−1 when intercropped with millet. Only 15% of the below-ground cowpea N was recovered in roots, while 85% was found in the rhizodeposited pools. The experiment demonstrated that direct below-ground N transfer occurred from cowpea to millet in intercrop at a rate of 2 kg N ha−1 over the growing season. Forty percent of the 25 kg below-ground N that the cowpea crop left at harvest were identifiable in the top 0.30 m soil in the beginning of the next planting season 7 months later; a pool still present at the end of that second season. Thus, the subsequent crop of millet (Pennisetum glaucum (L.) R. Br.) only recovered 2.5 kg N ha−1 from the below-ground cowpea pre-crop N during this growth season. The role and potential of cowpea as N provider has been underestimated in the past by ignoring the large proportion of N contained in its rhizodeposits. However, information is needed to determine how losses of the rhizodeposited N can be minimized to fully harness the potential of cowpea as N provider in agro-ecosystems of the region.

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Organisations: Ecosystems, Biosystems Division, Risø National Laboratory for Sustainable Energy, Limagrain Iberic, International Crop Research Institute for the Semi-Arid Tropics
Contributors: Laberge, G., Haussmann, B. I., Ambus, P., Jensen, H. H.
Pages: 369-382
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ISSN (Print): 0032-079X
Ratings:
Effects of clover density on N2O emissions and plant-soil N transfers in a fertilised upland pasture

Legumes have the potential to alter nitrous oxide (N2O) emissions in grass-legume mixtures via changes in soil N availability, but the influence of legume abundance on N2O fluxes in grazed multi-species grasslands has faced little attention to date. In this paper, a combination of 15N-labelled fertilizer application and automatic chamber measurements was used to investigate N2O fluxes and soil-plant N transfers for high- and low-density clover patches in an intensively-managed, upland pasture (Auvergne, France) over the course of one growing season. During the six-month study period, N2O fluxes were highly variable. Maximum daily N2O emission was 52 g N2O-N ha⁻¹, and was associated with fertilizer application early in the growing season. Smaller peaks of N2O emission occurred in response to cutting events and fertilizer application later in the growing season. Nitrous oxide fluxes derived from 15N-labelled fertilizer peaked at 40% shortly after fertilizer application, but the dominant source of N2O fluxes was the soil N pool. Contrary to expectations, clover density had no significant effects on N content or patterns of 15N recovery in plant or soil mineral N pools. Nevertheless, we found a tendency for increased N2O-N losses from the low clover treatment. Furthermore, 15N recovery in N2O was higher in the low- compared to the high-density clover treatment during favorable growing conditions, suggesting transient shifts in plant/soil competition for N depending on legume abundance. Multiple regression analysis revealed that water-filled pore space (WFPS) and clover dry mass were the main factors driving cumulative N2O emissions in the high clover treatment, whereas variation in cumulated N2O emissions in the low clover treatment was best explained by WFPS and grass mass. We hypothesize that clover density had indirect effects on the sensitivity of N2O emissions to abiotic and biotic factors possibly via changes in soil pH. Overall, our results suggest that spatial heterogeneity in clover abundance may have relatively little impact on field-scale N2O emissions in fertilized grasslands.
Effects of elevated atmospheric CO2, prolonged summer drought and temperature increase on N2O and CH4 fluxes in a temperate heathland

In temperate regions, climate change is predicted to increase annual mean temperature and intensify the duration and frequency of summer droughts, which together with elevated atmospheric carbon dioxide (CO2) concentrations, may affect the exchange of nitrous oxide (N2O) and methane (CH4) between terrestrial ecosystems and the atmosphere. We report results from the CLIMAITE experiment, where the effects of these three climate change parameters were investigated solely and in all combinations in a temperate heathland. Field measurements of N2O and CH4 fluxes took place 1–2 years after the climate change manipulations were initiated. The soil was generally a net sink for atmospheric CH4. Elevated temperature (T) increased the CH4 uptake by on average 10 μg C m−2 h−1, corresponding to a rise in the uptake rate of about 20%. However, during winter elevated CO2 (CO2) reduced the CH4 uptake, which outweighed the positive effect of warming when analyzed across the study period. Emissions of N2O were generally low.

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Web of Science (2011): Impact factor 3.504
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Web of Science (2011): Indexed yes
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Source: orbit
Source ID: 277019
Research output: Contribution to journal › Journal article – Annual report year: 2011 › Research › peer-review

Energy Production from Marine Biomass (Ulva lactuca)
The background for this research activity is that the 2020 goals for reduction of the CO2 emissions to the atmosphere are so challenging that exorbitant amounts of biomass and other renewable sources of energy must be mobilised in order to – maybe – fulfil the ambitious 2020 goals. The macroalgae is an unexploited, not researched, not developed source of biomass and is at the same time an enormous resource by mass. It is therefore obvious to look into this vast biomass resource and by this report give some of the first suggestions of how this new and promising biomass resource can be exploited.

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Organisations: Department of Systems Biology, Department of Chemical and Biochemical Engineering, Ecosystems Programme, Center for BioProcess Engineering, Danish Technological Institute, Aarhus University, Ørsted A/S
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The application was approved by Energinet.dk with a total budget of 10.5 million DKK and with a funding from Energinet.dk of 8.5 million DKK. The project was running from April 2008 to October 2011. The partners in the project are:

1. Aarhus University Department of Bioscience (former National Environmental Research Institute, Aarhus University)
2. Risø DTU (DTU is Technical University of Denmark)
3. DONG Energy A/S, the largest utility company in Denmark
4. Danish Technological Institute.

The contract holder is Danish Technological Institute.

Field emissions of N2O during biomass production may affect the sustainability of agro-biofuels

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Organisations: Ecosystems, Biosystems Division, Rise National Laboratory for Sustainable Energy, Bioenergy and Biomass, Aarhus University
Contributors: Carter, M. S., Hauggaard-Nielsen, H., Heiske, S., Thomsen, S. T., Jensen, M., Schmidt, J. E., Johansen, A., Ambus, P.
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Electronic versions:
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Greenhouse gas emissions from cultivation of energy crops may affect the sustainability of biofuels

Agro-biofuels are expected to reduce the emissions of greenhouse gases because CO2 emitted during the combustion of the biofuels has recently been taken from the atmosphere by the energy crop. Thus, when replacing fossil fuels with biofuels we reduce the emission of fossil fuel-derived CO2 into the atmosphere. However, cultivation of the soil results in emission of other greenhouse gasses, especially nitrous oxide (N2O). Agricultural activity is the dominant source of N2O, which is produced by microbes in the soil when the nitrogen availability is high, for instance following fertilization or incorporation of crop residues. In this study we relate measured field emissions of N2O to the reduction in fossil fuel-derived CO2, which is obtained when energy crops are used for biofuel production. The analysis includes five organically managed crops (viz. maize, rye, rye-vetch, vetch and grass-clover) and three scenarios for conversion of biomass to biofuel. The scenarios are 1) bioethanol production, 2) biogas production and 3) co-production of bioethanol and biogas, where the energy crops are first used for bioethanol fermentation and subsequently the residues from this process are utilized for biogas production. The net reduction in greenhouse gas emissions is calculated as the avoided fossil fuel-derived CO2, where the N2O emission has been subtracted. This value does not include farm machinery CO2 emissions and fuel consumption during biofuel production. Thus, the actual net greenhouse gas reduction will be lower than indicated by our data. We obtained the greatest net reduction in greenhouse gas emissions by co-production of bioethanol and biogas or by biogas alone produced from either fresh grass-clover or whole crop maize. Here the net reduction corresponded to about 8 tons CO2 per hectare per year. The worst result was obtained for bioethanol produced from vetch straw where high N2O emissions outweighed the avoided fossil fuel-derived CO2.

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Contributors: Carter, M. S., Hauggaard-Nielsen, H., Heiske, S., Thomsen, S. T., Jensen, M., Schmidt, J. E., Johansen, A., Ambus, P.
Number of pages: 454
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Publication date: 2011
Influence of fast pyrolysis temperature on biochar labile fraction and short-term carbon loss in a loamy soil

Production of bio-oil, gas and biochar from pyrolysis of biomass is considered a promising technology for combined production of bioenergy and recalcitrant carbon (C) suitable for sequestration in soil. Using a fast pyrolysis centrifuge reactor (PCR) the present study investigated the relation between fast pyrolysis of wheat straw at different reactor temperatures and the short-term degradability of biochar in soil. After 115 days incubation 3–12% of the added biochar-C had been emitted as CO2. On average, 90% of the total biochar-C loss occurred within the first 20 days of the experiment, emphasizing the importance of knowing the biochar labile fraction when evaluating a specific biochars C sequestration potential. The pyrolysis temperature influenced the outputs of biochar, bio-oil and syngas significantly, as well as the stability of the biochar produced. Contrary to slow pyrolysis a fast pyrolysis process may result in incomplete conversion of biomass due to limitations to heat transfer and kinetics. In our case chemical analysis of the biochars revealed unconverted cellulosic and hemicellulosic fractions, which in turn were found to be proportional with the short-term biochar degradation in soil. As these labile carbohydrates are rapidly mineralized, their presence lowers the biochar-C sequestration potential. By raising the pyrolysis temperature, biochar with none or low contents of these fractions can be produced, but this will be on the expense of the biochar quantity. The yield of CO2 neutral bio-oil is the other factor to optimize when adjusting the pyrolysis temperature settings to give the overall greatest climate change mitigation effect.

Is methane released from the forest canopy?

Laboratory experiments show that rates of CH4 emission from plant material depend exponentially on temperature and linearly on UV irradiance. The UV irradiance shall be spectrally weighted and shorter wavelengths results in higher CH4 emissions. Global upscaling models for estimating aerobic CH4, based on lab results, have been conducted with varying results, but until now field measurements based on profile and eddy covariance measurements have failed to show CH4 emissions from forest canopies. To detect CH4 production or consumption in the canopy of a beech stand we connected a
CH4 analyzer to a canopy air profile system that samples air below and above the canopy from seven different heights. A profile system with many vertical sample points can detect gas concentration gradients with a high sensitivity only under conditions with no or little air movements. Under these conditions we found indications of periodic CH4 emissions in the canopy, but more data need to be analyzed before the magnitude of the canopy source of CH4 can be established.

Measurement of carbon dioxide fluxes in a free-air carbon dioxide enrichment experiment using the closed flux chamber technique
Carbon dioxide (CO2) fluxes, composing net ecosystem exchange (NEE), ecosystem respiration (ER), and soil respiration (SR) were measured in a temperate heathland exposed to elevated CO2 by the FACE (free-air carbon enrichment) technique, raising the atmospheric CO2 concentration from c. 380 μmol mol−1 to 510 μmol mol−1. All CO2 fluxes were measured by the static chamber methodology. Although the FACE technique enriches the atmosphere with CO2 to a fixed level, the above ground CO2 concentrations may nevertheless locally vary strongly (from about ambient to 1000 μmol mol−1). Deployment of static chambers to FACE experiments should therefore be performed with great care in order to ensure reproducible conditions with respect to chamber headspace CO2 concentration. We demonstrate that the fluxes measured by closed chambers relate linearly to the initial headspace CO2 concentration. When changing the initial headspace CO2 concentration from 380 to 510 μmol mol−1 the net CO2 assimilation expressed by NEE increased instantaneously 1.51 times in control plots and 1.71 times in FACE plots. By contrast, ER in control plots decreased, being 0.87 times that measured at the low CO2 concentration, and the flux also decreased in FACE plots, to 0.79 times that at low concentration. Similar SR in control plots was decreased 0.94 times in control plots and 0.88 times in FACE plots. We found that a useful method to achieve stable and reproducible chamber headspace and soil CO2 concentration prior to commencement of flux measurements was to turn off the FACE system at least 10 min in advance. Within 10 min a new equilibrium was established between the soil and atmosphere, apparently due to CO2 degassing from the top soil. The observed increase in SR in response to increased CO2 persisted for up to 18 h during which measurements should be performed. Soil CO2 concentrations were increased by up to 500 μmol mol−1 by the FACE treatment, substantially more than the 130 μmol mol−1 enrichment achieved in the atmosphere suggesting that the increased SR flux was caused by increased belowground respiration.
Organic matter flow in the food web at a temperate heath under multifactorial climate change

The rising atmospheric CO2 concentration, increasing temperature and changed patterns of precipitation currently expose terrestrial ecosystems to altered environmental conditions. This may affect belowground nutrient cycling through its intimate relationship with the belowground decomposers. Three climate change factors (elevated CO2, increased temperature and drought) were investigated in a full factorial field experiment at a temperate heathland location. The combined effect of biotic and abiotic factors on nitrogen and carbon flows was traced in plant root → litter → microbe → detritivore/omnivore → predator food-web for one year after amendment with 15N13C2-glycine. Isotope ratio mass spectrometry (IRMS) measurement of 15N/14N and 13C/12C in soil extracts and functional ecosystem compartments revealed that the recovery of 15N sometimes decreased through the chain of consumption, with the largest amount of bioactive 15N label pool accumulated in the microbial biomass. The elevated CO2 concentration at the site for 2 years increased the biomass, the 15N enrichment and the 15N recovery in detritivores. This suggests that detritivore consumption was controlled by both the availability of the microbial biomass, a likely major food source, and the climatic factors. Furthermore, the natural abundance δ13C of enchytraeids was significantly altered in CO2-fumigated plots, showing that even small changes in δ13C-CO2 can be used to detect transfer of carbon from primary producers to detritivores. We conclude that, in the short term, the climate change treatments affected soil organism activity, possibly with labile carbohydrate production controlling the microbial and detritivore biomass, with potential consequences for the decomposition of detritus and nutrient cycling. Hence, there appears to be a strong coupling of responses in carbon and nitrogen cycling at this temperate heath. Copyright © 2011 John Wiley & Sons, Ltd.
Reactive nitrogen and greenhouse gas flux interactions in terrestrial ecosystems

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Contributors: Ambus, P., Skiba, U., Butterbach-Bahl, K., Sutton, M.
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Reduced N cycling in response to elevated CO2, warming, and drought in a Danish heathland

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Research output: Contribution to conference › Conference abstract for conference – Annual report year: 2011 › Research

Reduced N cycling in response to elevated CO2, warming, and drought in a Danish heathland: Synthesizing results of the CLIMAITE project after two years of treatments

Field-scale experiments simulating realistic future climate scenarios are important tools for investigating the effects of current and future climate changes on ecosystem functioning and biogeochemical cycling. We exposed a seminatural Danish heathland ecosystem to elevated atmospheric carbon dioxide (CO2), warming, and extended summer drought in all combinations. Here, we report on the short-term responses of the nitrogen (N) cycle after 2 years of treatments. Elevated CO2 significantly affected aboveground stoichiometry by increasing the carbon to nitrogen (C/N) ratios in the leaves of both co-dominant species (Calluna vulgaris and Deschampsia flexuosa), as well as the C/N ratios of Calluna flowers and by reducing the N concentration of Deschampsia litter. Belowground, elevated CO2 had only minor effects, whereas warming increased N turnover, as indicated by increased rates of microbial NH4+ consumption, gross mineralization, potential nitrification, denitrification and N2O emissions. Drought reduced belowground gross N mineralization and decreased fauna N mass and fauna N mineralization. Leaching was unaffected by treatments but was significantly higher across all treatments in the second year than in the much drier first year indicating that ecosystem N loss is highly sensitive to changes and variability in amount and timing of precipitation. Interactions between treatments were common and although some synergistic effects were observed, antagonism dominated the interactive responses in
treatment combinations, i.e. responses were smaller in combinations than in single treatments. Nonetheless, increased C/N ratios of photosynthetic tissue in response to elevated CO2, as well as drought-induced decreases in litter N production and fauna N mineralization prevailed in the full treatment combination. Overall, the simulated future climate scenario therefore lead to reduced N turnover, which could act to reduce the potential growth response of plants to elevated atmospheric CO2 concentration.

The competitive ability of pea–barley intercrops against weeds and the interactions with crop productivity and soil N availability

Grain legumes, such as peas (Pisum sativum L.), are known to be weak competitors against weeds when grown as the sole crop. In this study, the weed-suppression effect of pea–barley (Hordeum vulgare L.) intercropping compared to the respective sole crops was examined in organic field experiments across Western Europe (i.e., Denmark, the United Kingdom, France, Germany and Italy). Spring pea (P) and barley (B) were sown either as the sole crop, at the recommended plant density (P100 and B100, respectively), or in replacement (P50B50) or additive (P100B50) intercropping designs for three seasons (2003–2005). The weed biomass was three times higher under the pea sole crops than under both the intercrops and barley sole crops at maturity. The inclusion of joint experiments in several countries and various growing conditions showed that intercrops maintain a highly asymmetric competition over weeds, regardless of the particular weed infestation (species and productivity), the crop biomass or the soil nitrogen availability. The intercropping weed suppression was highly resilient, whereas the weed suppression in pea sole crops was lower and more variable. The pea–barley intercrops exhibited high levels of weed suppression, even with a low percentage of barley in the total biomass. Despite a reduced leaf area in the case of a low soil N availability, the barley sole crops and intercrops displayed high weed suppression, probably because of their strong competitive capability to absorb soil N. Higher soil N availabilities entailed increased leaf areas and competitive ability for light, which contributed to the overall competitive ability against weeds for all of the treatments. The contribution of the weeds in the total dry matter and soil N acquisition was higher in the pea sole crop than in the other treatments, in spite of the higher leaf areas in the pea crops.
Ecosystem-atmosphere exchange of carbon in a heathland under future climatic conditions

Global change is a reality. Atmospheric CO2 levels are rising as well as mean global temperature and precipitation patterns are changing. These three environmental factors have separately and in combination effect on ecosystem processes. Terrestrial ecosystems hold large amounts of carbon, why understanding plant and soil responses to such changes are necessary, as ecosystems potentially can ameliorate or accelerate global change. To predict the feedback of ecosystems to the atmospheric CO2 concentrations experiments imitating global change effects are therefore an important tool. This work on ecosystem-atmosphere exchange of carbon in a heathland under future climatic conditions, shows that extended summer drought in combination with elevated temperature will ensure permanent dryer soil conditions, which decreases carbon turnover, while elevated atmospheric CO2 concentrations will increase carbon turnover. In the full future climate scenario, carbon turnover is over all expected to increase and the heathland to become a source of atmospheric CO2. The methodology of static chamber CO2 flux measurements and applying the technology in a FACE (free air CO2 enrichment) facility is a challenge. Fluxes of CO2 from soil to atmosphere depend on a physical equilibrium between those two medias, why it is important to keep the CO2 gradient between soil and atmosphere unchanged during measurement. Uptake to plants via photosynthesis depends on a physiological process, which depends strongly on the atmospheric CO2 concentration. Photosynthesis and respiration run in parallel during measurements of net ecosystem exchange, and these measurements should therefore be performed with care to both the atmospheric CO2 concentration and the CO2 soil-atmosphere gradient.
ecosystem services and functioning in the future. In a field scale experiment on temperate heathland, manipulation of precipitation and temperature was performed with retractable curtains, and atmospheric CO2 concentration was increased by FACE. The combination of elevated CO2 and warming was expected to affect belowground processes additively, through increased belowground sequestration of labile carbohydrates due to elevated CO2 in combination with temperature increased process rates. Together, these changes might increase microbial activity and availability of plant nutrients. Two years after the start of the experiment, belowground processes responded significantly to the treatments. In the combined temperature and CO2 treatment the dissolved organic nitrogen concentration decreased and the ammonium concentration increased, but this release of nutrients was not mirrored by plant parameters. Microbial biomass carbon and microbial enrichment with 13C and 15N (1 year after 13C215N-glycine was injected into the soil) increased in warmed plots and in elevated CO2 plots, but not when these treatments were combined. Furthermore, drought led to an increase in Calluna biomass and total plant nitrogen pool. The full combination of warming, elevated CO2 and periodic drought did not unambiguously express the ecosystem responses of single factors additively, which complicates predictions of ecosystem responses to multifactor climate change.

General information
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Organisations: Ecosystems, Biosystems Division, Rise National Laboratory for Sustainable Energy, University of Copenhagen
Contributors: Andresen, L. C., Michelsen, A., Ambus, P., Beier, C.
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Scopus rating (2010): SJR 1.746 SNIP 1.301
Web of Science (2010): Impact factor 2.674
Web of Science (2010): Indexed yes
Original language: English
Keywords: Bio systems, Environment and climate
DOIs:
10.1007/s10533-010-9489-3
Source: orbit
Source ID: 263987
Research output: Contribution to journal › Journal article – Annual report year: 2010 › Research › peer-review

Development of an accumulation-based system for cost-effective chamber measurements of inert trace gas fluxes
As soil–atmosphere fluxes of greenhouse gases are characterized by high temporal fluctuations, frequent measurements in the range of hours to days need to be deployed, resulting in high analytical costs. We have therefore developed a new low-cost system that combines high-frequency automated sampling with low-frequency chemical analysis. The System for Inert Gas Monitoring by Accumulation (SIGMA) is suited particularly for stand-alone observations in remote locations. The SIGMA is connected to an automated chamber with headspace sampling several times per day. Air samples are aggregated in sampling bags, which reduces the number of subsequent laboratory analyses and allows calculation of average flux rates over extended sampling periods. The SIGMA was tested under field conditions and compared with a conventional autochamber system, where flux rates were measured several times per day. Sample air fillings of the SIGMA sampling bags varied less than 5% between bags and diverged

General information
Publication status: Published
Organisations: Ecosystems, Biosystems Division, Rise National Laboratory for Sustainable Energy, Centre for Ecology and Hydrology
Pages: 785-792
Publication date: 2010
Peer-reviewed: Yes

Publication information
Journal: European Journal of Soil Science
Volume: 61
Issue number: 5
Effects of elevated atmospheric CO2 prolonged summer drought and temperature increase on N2O and CH4 fluxes in a temperate heathland

General information
Publication status: Published
Organisations: Ecosystems, Biosystems Division, Risø National Laboratory for Sustainable Energy
Publication date: 2010
Peer-reviewed: No
Event: Abstract from Nordflux Workshop on Ecosystem disturbance and GHG exchange in the Nordic Region, Gunnarsholt (IS), 7-10 Sep.
Keywords: Bio systems, Environment and climate
Source: orbit
Source ID: 270448
Research output: Contribution to conference > Conference abstract for conference – Annual report year: 2010 > Research

Emissions of nitrous oxide from arable organic and conventional cropping systems on two soil types

General information
Publication status: Published
Organisations: Ecosystems, Biosystems Division, Risø National Laboratory for Sustainable Energy
Contributors: Chirinda, N., Carter, M. S., Albert, K. R., Ambus, P., Olesen, J., Porter, P., Petersen, S.
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Journal: Agriculture, Ecosystems & Environment
Volume: 136
Issue number: 3-4
ISSN (Print): 0167-8809
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Web of Science (2010): Impact factor 2.399
Web of Science (2010): Indexed yes
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Keywords: Bio systems, Environment and climate
DOIs:
10.1016/j.agee.2009.11.012
Source: orbit
Source ID: 253721
Research output: Contribution to journal > Journal article – Annual report year: 2010 > Research

Emissions of nitrous oxide from Irish arable soils: effects of tillage and reduced N input
Nitrous oxide (N2O) flux measurements from an Irish spring barley field managed under conventional and reduced tillage and different N fertilizer applications at the Teagasc Oak Park Research Centre were made for two consecutive seasons. The aim was to investigate the efficacy of reduced tillage and reduced N fertilizer on seasonal fluxes and emission factors of N2O and to study the relationship between crop yield and N-induced fluxes of N2O. The soil is classified as a sandy
loam with a pH of 7.4 and a mean organic carbon and nitrogen content at 15 cm of 19 and 1.9 g kg\(^{-1}\) dry soil, respectively. Reduced tillage had no significant effect on N\(_2\)O fluxes from soils or crop grain yield. Multiple regression analysis revealed that soil moisture and an interaction between soil moisture and soil nitrate are the main significant factors affecting N\(_2\)O flux. The derived emission factor was 0.6% of the applied N fertilizer, approximately 50% of the IPCC default EF of 1.25% used by the Irish EPA to estimate GHG or the IPCC revised EF of 0.9%. This resulted in huge overestimations of 2,275 and 1,050 tonnes of N\(_2\)O-N for using the old and revised IPCC default factors respectively. By reducing the applied nitrogen fertilizer by 50% compared to the normal field rate, N\(_2\)O emissions could be reduced by 57% with no significant decrease on grain yield or quality. This was consistent over the 2 years of measurements.

**Phosphorus resources in the mycorrhiza mycelium of adult plants is poorly available to a seedling connecting into the mycelium**

**General information**
Publication status: Published
Organisations: Ecosystems, Biosystems Division, Rise National Laboratory for Sustainable Energy
Contributors: Abdalla, M., Jones, M., Ambus, P., Williams, M.
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Journal: Nutrient Cycling in Agroecosystems
Volume: 86
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ISSN (Print): 1385-1314
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Scopus rating (2010): SJR 1.008 SNIP 1.279
Web of Science (2010): Impact factor 1.957
Web of Science (2010): Indexed yes
Original language: English
Keywords: Bio systems, Environment and climate
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URLs:
http://www.springerlink.com/content/0l4373w644r70827/
Source: orbit
Source ID: 244614
Research output: Contribution to journal › Journal article – Annual report year: 2010 › Research › peer-review

Temperate terrestrial ecosystems are currently exposed to increased atmospheric CO\(_2\) and progressive climatic changes with increased temperature and periodical drought. We here present results from a field experiment, where the effects of these three main climate change related factors are investigated solely and in all combinations at a temperate heathland. Significant responses were found in the top soils below the two dominant species (Calluna vulgaris and Deschampsia flexuosa). During winter incubation, microbial immobilization of N and ammonification rate decreased in response to warming in Deschampsia soil, and microbial immobilization of N and P decreased in warmed Calluna soil. Warming tended to increase microbial N and P in Calluna but not in Deschampsia soil in fall, and more microbial C was accumulated under drought in Calluna soil. The effects of warming were often counteracted or erased when combined with CO\(_2\) and drought. Below Deschampsia, the net nitrification rate decreased in response to drought and, while phosphorus availability and microbial P immobilization decreased, but nitrification increased in response to elevated CO\(_2\).
Furthermore, leaf litter decomposition of both species decreased in response to drought. These complex changes in availability and release of nutrients from soil organic matter turnover and mineralization in response to elevated CO2 and climate change may influence the future plant carbon sequestration and species composition at temperate heathlands.

**General information**
Publication status: Published
Organisations: Ecosystems, Biosystems Division, Risø National Laboratory for Sustainable Energy, University of Copenhagen
Pages: 381-396
Publication date: 2010
Peer-reviewed: Yes

**Relating N2O emissions from energy crops to the avoided fossil fuel-derived CO2 - a study on bioethanol and biogas produced from organically managed maize, rye, vetch and grass-clover**

**General information**
Publication status: Published
Organisations: Ecosystems, Biosystems Division, Risø National Laboratory for Sustainable Energy, Bioenergy and Biomass
Contributors: Carter, M. S., Haugaard-Nielsen, H., Thomsen, S. T., Heiske, S., Jensen, M., Schmidt, J. E., Johansen, A., Ambus, P.
Publication date: 2010
Peer-reviewed: No
Keywords: Bio refinery, Bio systems
Source: orbit
Source ID: 270439
Research output: Contribution to conference › Conference abstract for conference – Annual report year: 2010 › Research

**Abiotic Aerobic Methane Release from Plant Material**

**General information**
Publication status: Published
Organisations: Ecosystems, Biosystems Division, Risø National Laboratory for Sustainable Energy
Contributors: Bruhn, D., Ambus, P., Mikkelsen, T. N.
Publication date: 2009
Peer-reviewed: No
Event: Poster session presented at ILEAPS/ICOS/NEU Workshop on eddy covariance flux measurements of CH4 and N2O exchanges, Hyytälä (FI), 8-11 April, .
Keywords: Bio energy, Ecosystems, climate effects, greenhouse gasses
Source: orbit
Source ID: 252009
Research output: Contribution to conference › Poster – Annual report year: 2009 › Research
Application of the DNDC model to predict emissions of N2O from Irish agriculture

Models are increasingly used to examine the potential impacts of management and climate change in agriculture. Our aim in this paper was to assess the applicability of the field-DeNitrification DeComposition (DNDC) model in Irish agriculture. This study provides the results of that evaluation, which is a prerequisite for using the model for assessing management impacts in the future. The DNDC model was tested against seasonal and annual data sets of nitrous oxide flux from a spring barley field and a cut and grazed pasture at the Teagasc Oak Park Research Centre, Co. Carlow, Ireland. In the case of the arable field, predicted fluxes of N2O agreed well with measured fluxes for medium to high fertilizer input (70–160 kg N ha−1) but poorly described those fluxes from zero fertilizer treatments. In terms of cumulative flux values, the relative deviation of the predicted fluxes from the measured values was a maximum of 6% for the highest N fertilizer inputs but increased to 30% for the medium N and more than 100% for the zero N fertilizer treatments. There is a linear correlation of predicted against measured flux values for all fertilizer treatments (r² = 0.85) but the model underestimated the seasonal flux by 24%. Incorporation of literature values from a range of different studies on arable and pasture land did not significantly improve the regression. The description by DNDC for measured fluxes of N2O from reduced tillage plots was poor with underestimation of up to 55%. For the cut and grazed pasture the relative deviations of predicted to measured fluxes were 150 and 360% for fertilized and unfertilized plots. A sensitivity analysis suggests that the poor model fit is due to DNDC overestimating WFPS and the effect of initial soil organic carbon (SOC) on N2O flux. As the arable and grassland soils differed only in SOC content, reducing SOC of the grassland field to that of the arable field value significantly improved the fit of the model to measured data such that the relative deviations decreased to 9 and 5% respectively. Sensitivity analysis highlighted air temperature as the main determinant of N2O flux, an increase in mean daily air temperature of 1.5 °C resulting in almost a 65% increase in the annual cumulative flux. This is interesting as with future global warming, N2O flux from the soil will have a strong positive feedback. It can be concluded that DNDC is unsuitable for predicting N2O from Irish grassland due to its overestimation of WFPS and effect of SOC on the flux.

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Publication status: Published
Organisations: Ecosystems, Biosystems Division, Risø National Laboratory for Sustainable Energy, Trinity College Dublin, University of Aberdeen
Contributors: Abdalla, M., Wattenbach, M., Smith, P., Ambus, P., Jones, M., Williams, M.
Pages: 327-337
Publication date: 2009
Peer-reviewed: Yes

Aquatic Biomass for Biofuel

General information
Publication status: Published
Organisations: Bioenergy and Biomass, Biosystems Division, Risø National Laboratory for Sustainable Energy, Ecosystems
Publication date: 2009
Peer-reviewed: No
Event: Poster session presented at Beyond Kyoto, Århus (DK), 5-7 March.
Keywords: Bio energy, Microbial energy technology
Source: orbit
Source ID: 256374
Atmospheric composition change: Ecosystems–Atmosphere interactions

Ecosystems and the atmosphere: This review describes the state of understanding the processes involved in the exchange of trace gases and aerosols between the earth’s surface and the atmosphere. The gases covered include NO, NO2, HONO, HNO3, NH3, SO2, DMS, Biogenic VOC, O3, CH4, N2O and particles in the size range 1 nm–10 μm including organic and inorganic chemical species. The main focus of the review is on the exchange between terrestrial ecosystems, both managed and natural and the atmosphere, although some new developments in ocean–atmosphere exchange are included. The material presented is biased towards the last decade, but includes earlier work, where more recent developments are limited or absent. New methodologies and instrumentation have enabled, if not driven technical advances in measurement. These developments have advanced the process understanding and upscaling of fluxes, especially for particles, VOC and NH3. Examples of these applications include mass spectrometric methods, such as Aerosol Mass Spectrometry (AMS) adapted for field measurement of atmosphere–surface fluxes using micrometeorological methods for chemically resolved aerosols. Also briefly described are some advances in theory and techniques in micrometeorology. For some of the compounds there have been paradigm shifts in approach and application of both techniques and assessment. These include flux measurements over marine surfaces and urban areas using micrometeorological methods and the up-scaling of flux measurements using aircraft and satellite remote sensing.

The application of a flux-based approach in assessment of O3 effects on vegetation at regional scales is an important policy linked development secured through improved quantification of fluxes. The coupling of monitoring, modelling and intensive flux measurement at a continental scale within the NitroEurope network represents a quantum development in the application of research teams to address the underpinning science of reactive nitrogen in the cycling between ecosystems and the atmosphere in Europe. Some important developments of the science have been applied to assist in addressing policy questions, which have been the main driver of the research agenda, while other developments in understanding have not been applied to their wider field especially in chemistry-transport models through deficiencies in obtaining appropriate data to enable application or inertia within the modelling community. The paper identifies applications, gaps and research questions that have remained intractable at least since 2000 within the specialized sections of the paper, and where possible these have been focussed on research questions for the coming decade.

General information
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Organisations: Risø National Laboratory for Sustainable Energy, Biosystems Division, Biosystems Division. Management, Ecosystems, Centre for Ecology and Hydrology, University of Oslo, Université Blaise Pascal, Clermont-Ferrand II, Università degli Studi di Urbino Carlo Bo, Research Institute for Nature and Forest, Institut National de la Recherche Agronomique, Wageningen IMARES, National Institute for Agronomic Research, Finnish Meteorological Institute, Catholic University of the Sacred Heart, Justus Liebig University Giessen, Agroscope, European Commission Joint Research Centre Institute, Consiglio Nazionale delle Ricerche, Energy Research Centre of the Netherlands, Netherlands Organisation for Applied Scientific Research, Chalmers University of Technology, Norwegian Meteorological Institute, Istituto di Scienze dell'Atmosfera e del Clima, University of Copenhagen, Pierre and Marie Curie University - University of Paris VI, University of Leicester, University of Bonn, Bundesforschungsanstalt für Landwirtschaft, Forschungs Zentrum Karlsruhe GmbH, Hungarian Meteorological Service, Estonian University of Life Sciences, University of Edinburgh, Stockholm University, Indiana University - Purdue University Indianapolis, University of Manchester, Austrian Federal Office and Research Centre for Forests, Max Planck Institute, National University of Ireland, University of Helsinki
Pages: 5193-5267
Publication date: 2009
Peer-reviewed: Yes

Publication information
Journal: Atmospheric Environment
Volume: 43
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Scopus rating (2009): SJR 1.977 SNIP 1.467
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DOI:
Biochar in fertile clay soil: Impact on carbon mineralization, microbial biomass and GHG emissions

**General information**
Publication status: Published
Organisations: Bioenergy and Biomass, Biosystems Division, Risø National Laboratory for Sustainable Energy, Ecosystems
Contributors: Bruun, E., Hauggaard-Nielsen, H., Ambus, P.
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Peer-reviewed: No
Keywords: Bio energy, Bioenergy and biomass

Bio-char investigated by analytical flash pyrolysis and GCMS

**General information**
Publication status: Published
Organisations: Biomass Gasification, Biosystems Division, Risø National Laboratory for Sustainable Energy, Ecosystems, Department of Chemical and Biochemical Engineering, CHEC Research Centre
Number of pages: 1
Publication date: 2009

Biochar soil application to mitigate climate change

Production of energy carriers (oil, gas) and biochar from pyrolysis of biomass is by many considered a promising technology for combined production of bioenergy and recalcitrant C suitable for sequestration in soil. The mechanism behind biochar-C sequestration is straightforward: Due to its recalcitrant characteristics the microbial decomposition of biochar is much slower in comparison to the mineralization of the original feedstock. Conversion of organic residues like household waste or cereal straw to biochar is hence proposed a way to withdraw CO2 from the atmosphere and sequester it on a long term basis in the soil. The experiments presented here illustrate the C sequestration potentials of biochar originating from fast pyrolysis of wheat straw. It is documented that after 47 days in soil 95 % of the added biochar-C is still present in the soil as compared to only 56 % if straw is applied untreated to the soil. The type and settings of pyrolysis influence the chemical quality of the biochar produced significantly. Biochar chemical analysis revealed that the degradation of biochar in soil appears to be proportional with the biochar cellulosic and hemicellulosic fraction. Furthermore, the pyrolyzer temperature settings strongly influence the proportion of cellulose and hemicellulose remaining in the biochar. As these biochar fractions relative rapidly are mineralized to CO2 by microbial respiration they are – in climate mitigation perspective - unwanted. At the upcoming Climate Conference in Copenhagen (COP15) December 2009, the use of biochar as a mitigation tool will be on the agenda and for the time being (July 2009) 20 countries and Parties to the United Nations Framework Convention on Climate Change (UNFCCC) have made submissions to the UNFCCC seeking the inclusion of biochar as a climate mitigation and adaptation tool.
Climate change alters nutrient cycling: Nitrogen uptake in temperate heath vegetation and soil microbes is influenced by elevated temperature CO2 and drought

General information
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Organisations: Ecosystems, Biosystems Division, Risø National Laboratory for Sustainable Energy
Contributors: Andresen, L., Michelsen, A., Jonasson, S., Beier, C., Ambus, P.
Publication date: 2009
Peer-reviewed: No
Event: Poster session presented at International Scientific Congress on Climate Change, Copenhagen, Denmark.
Keywords: Bio energy, Ecosystems, climate effects, greenhouse gasses
Source: orbit
Source ID: 244646
Research output: Contribution to conference > Poster – Annual report year: 2009 > Research

Climate controls on gas- and water mediated losses of N from a terrestrial ecosystem

General information
Publication status: Published
Organisations: Risø National Laboratory for Sustainable Energy, Biosystems Division, Ecosystems
Contributors: Ambus, P.
Publication date: 2009
Peer-reviewed: No
Event: Paper presented at NeU Workshop on landscape flows and transformations of nitrogen, Foulum (DK), 28 April.
Keywords: Bio energy, Ecosystems, climate effects, greenhouse gasses
Source: orbit
Source ID: 252008
Research output: Contribution to conference > Paper – Annual report year: 2009 > Research

Consequences of agro-biofuel production for greenhouse gas emissions

General information
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Organisations: Ecosystems, Biosystems Division, Rise National Laboratory for Sustainable Energy, Danish Centre for Environment and Energy
Contributors: Carter, M. S., Hauggaard-Nielsen, H., Johansen, A., Ambus, P.
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Consequences of agro-biofuel production for greenhouse gas emissions

General information
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Organisations: Ecosystems, Biosystems Division, Rise National Laboratory for Sustainable Energy, Bioenergy and Biomass
Contributors: Carter, M. S., Johansen, A., Hauggaard-Nielsen, H., Ambus, P.
Publication date: 2009
Peer-reviewed: No
Event: Poster session presented at EnergyDTU Internal Conference, Lyngby (DK),
Keywords: Bio energy, Ecosystems, climate effects, greenhouse gasses
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Research output: Chapter in Book/Report/Conference proceeding » Article in proceedings – Annual report year: 2009 » Research

Denitrification and N2O losses in a heathland under changing climate conditions

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Publication date: 2009
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Event: Paper presented at Seminar at University of Hohenheim, Stuttgart (DE), 2 June,
Keywords: Bio energy, Ecosystems, climate effects, greenhouse gasses
Source: orbit
Source ID: 244635
Research output: Contribution to conference » Poster – Annual report year: 2009 » Research

Denitrification and N2O losses in a heathland under changing climate conditions

General information
Publication status: Published
Organisations: Ecosystems, Biosystems Division, Rise National Laboratory for Sustainable Energy
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Source: orbit
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Research output: Contribution to conference » Paper – Annual report year: 2009 » Research

Ecosystem carbon balance under future climate conditions: the CLIMAITE project carbon synthesis

General information
Publication status: Published
Organisations: Ecosystems, Biosystems Division, Rise National Laboratory for Sustainable Energy, Biosystems Division.
Management, Danish Centre for Environment and Energy, University of Copenhagen
Pages: 042021
Publication date: 2009

Host publication information
Ecosystem recovery after drought events in our future climate

General information
Publication status: Published
Organisations: Ecosystems, Biosystems Division, Risø National Laboratory for Sustainable Energy, University of Copenhagen
Pages: 042029
Publication date: 2009

Effects of temperature, ultraviolet radiation and pectin methyl esterase on aerobic methane release from plant material

This study examines the effects of different irradiance types on aerobic methane (CH4) efflux rates from terrestrial plant material. Furthermore, the role of the enzyme pectin methyl esterase (PME) on CH4 efflux potential was also examined. Different types of plant tissue and purified pectin were incubated in glass vials with different combinations of irradiation and/or temperature. Purified dry pectin was incubated in solution, and with or without PME. Before and after incubation, the concentration of CH4 was measured with a gas chromatograph. Rates of CH4 emission were found to depend exponentially on temperature and linearly on UV-B irradiance. UV-B had a greater stimulating effect than UV-A, while visible light had no effect on emission rates. PME was found to substantially reduce the potential for aerobic CH4 emissions upon demethylation of pectin.

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Organisations: Ecosystems, Biosystems Division, Risø National Laboratory for Sustainable Energy, University of Copenhagen
Contributors: Bruhn, D., Mikkelsen, T. N., Øbro, J., Willats, W., Ambus, P.
Pages: 43-48
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Peer-reviewed: Yes

Publication information
Journal: Plant Biology
Volume: 11
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ISSN (Print): 1435-8603
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Scopus rating (2009): SJR 1.098 SNIP 0.966
Web of Science (2009): Indexed yes
Original language: English
Keywords: Bio energy, Ecosystems, climate effects, greenhouse gasses
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Glycine uptake in heath plants and soil microbes responds to elevated temperature, CO2 and drought
Temperate terrestrial ecosystems are currently exposed to climatic and air quality changes with increased atmospheric CO2, increased temperature and prolonged droughts. The responses of natural ecosystems to these changes are focus for research, due to the potential feedbacks to the climate. We here present results from a field experiment in which the effects of these three climate change factors are investigated solely and in all combinations at a temperate heath dominated by heather (Calluna vulgaris) and wavy hair-grass (Deschampsia flexuosa). Climate induced increases in plant production may increase plant root exudation of dissolved organic compounds such as amino acids, and the release of amino acids during decomposition of organic matter. Such free amino acids in soil serve as substrates for soil microorganisms and are also acquired as nutrients directly by plants. We investigated the magnitude of the response to the potential climate change treatments on uptake of organic nitrogen in an in situ pulse labelling experiment with 15N13C2-labelled glycine (amino acid) injected into the soil. In situ root nitrogen acquisition by grasses responded significantly to the climate change treatments, with larger 15N uptake in response to warming and elevated CO2 but not additively when the treatments were combined. Also, a larger grass leaf biomass in the combined T and CO2 treatment than in individual treatments suggest that responses to combined climate change factors cannot be predicted from the responses to single factors treatments. The soil microbes were superior to plants in the short-term competition for the added glycine, as indicated by an 18 times larger 15N recovery in the microbial biomass compared to the plant biomass. The soil microbes acquired glycine largely as an intact compound (87%), with no effects of the multi factorial climate change treatment through one year.

Greenhouse gas emissions from cultivation of energy crops - is it important?

Greenhouse gas emissions from cultivation of energy crops - is it important?
Greenhouse gas fluxes in a temperate shrub-land under future climatic and environmental conditions

General information
Publication status: Published
Organisations: Ecosystems, Biosystems Division, Risø National Laboratory for Sustainable Energy
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Keywords: Bio energy, Ecosystems, climate effects, greenhouse gasses
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Is organic farming a mitigation option? A study of N2O emission from winter wheat

General information
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Organisations: Ecosystems, Biosystems Division, Risø National Laboratory for Sustainable Energy
Contributors: Carter, M. S., Albert, K. R., Ambus, P.
Publication date: 2009
Peer-reviewed: No
Event: Poster session presented at International Scientific Congress on Climate Change, Copenhagen, Denmark.
Keywords: Climate and energy systems, Ecosystems, climate effects, greenhouse gasses
Electroonic versions: 2009_56.pdf
Source: orbit
Source ID: 241961
Research output: Contribution to conference › Poster – Annual report year: 2009 › Research

Klimavenlig majs ved minimas tilførsel af kvælstof

General information
Publication status: Published
Organisations: Ecosystems, Biosystems Division, Risø National Laboratory for Sustainable Energy
Contributors: Ambus, P.
Publication date: 2009
Peer-reviewed: Unknown

Publication information
Journal: LandbrugsAvisen
Issue number: 3 april
ISSN (Print): 1603-4236
Original language: Danish
Keywords: Bio energy, Ecosystems, climate effects, greenhouse gasses
Source: orbit
Source ID: 244675
Research output: Contribution to journal › Journal article – Annual report year: 2009 › Communication

Mindre økologisk drivhusgas

General information
N2O and CH4 fluxes in a temperate heathland under future climatic conditions

General information
Publication status: Published
Organisations: Ecosystems, Biosystems Division, Risø National Laboratory for Sustainable Energy
Publication date: 2009

Host publication information
Title of host publication: Abstracts
Keywords: Bio energy, Ecosystems, climate effects, greenhouse gasses
Source: orbit
Source ID: 252258
Research output: Chapter in Book/Report/Conference proceeding – Conference abstract in proceedings – Annual report year: 2009

Nitrogen rhizodeposition from soybean (Glycine max) and its impact on nutrient budgets in two contrasting environments of the Guinean savannah zone of Nigeria

Nitrogen (N) rhizodeposition by grain legumes such as soybean is potentially a large but neglected source of N in cropping systems of Sub-Saharan Africa. Field studies were conducted to measure soybean N rhizodeposition in two environments of the Guinean savannah of Nigeria using 15N leaf labelling techniques. The first site was located in Ibadan in the humid derived savannah. The second site was in Zaria in the drier Northern Guinean savannah. Soybean N rhizodeposition in the top 0.30 m of soil varied from 7.5 kg ha−1 on a diseased crop in Ibadan to 33 kg ha−1 in Zaria. More than two-thirds of soybean belowground N was contained in the rhizodeposits at crop physiological maturity, while the rest was found in the recoverable roots. Belowground plant-derived N was found to constitute 16–23% of the total soybean N. Taking rhizodeposited pools into account led to N budgets close to zero when all residues were removed. If residues were left in the field or recycled as manure after being fed to steers, soybean cultivation led to positive N budgets of up to +95 kg N ha−1. The role and potential of grain legumes as N purveyors have been underestimated in the past by neglecting the N contained in their rhizodeposits.

General information
Publication status: Published
Organisations: Ecosystems, Biosystems Division, Risø National Laboratory for Sustainable Energy, International Institute of Tropical Agriculture, Ibadan, University of Copenhagen
Contributors: Laberge, G., Franke, A. C., Ambus, P., Jensen, H. H.
Pages: 49-58
Publication date: 2009
Peer-reviewed: Yes

Publication information
Journal: Nutrient Cycling in Agroecosystems
Volume: 84
Issue number: 1
ISSN (Print): 1385-1314
Ratings:
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 1.006 SNIP 1.011
Web of Science (2009): Indexed yes
Nitrogen uptake in temperate heath vegetation and soil microbes is influenced by elevated temperature, CO2 and drought

General information
Publication status: Published
Organisations: Ecosystems, Biosystems Division, Risø National Laboratory for Sustainable Energy, University of Copenhagen
Contributors: Andresen, L., Michelsen, A., Johansson, S., Beier, C., Ambus, P.
Publication date: 2009
Peer-reviewed: No
Event: Poster session presented at BIOGEMON 2009, University of Helsinki (FI), 29 Jun - 3 Jul.
Keywords: Bio energy, Ecosystems, climate effects, greenhouse gasses
Electronic versions:
Biogeomon_presentation_2.pdf
Source: orbit
Source ID: 244663
Research output: Contribution to conference » Poster – Annual report year: 2009 » Research

Nitrous oxide emissions from forest ecosystems measured by eddy covariance technique

General information
Publication status: Published
Organisations: Ecosystems, Biosystems Division, Risø National Laboratory for Sustainable Energy, Biosystems Division.
Management
Publication date: 2009
Peer-reviewed: No
Event: Paper presented at ILEAPS/ICOS/NEU Workshop on eddy covariance flux measurements of CH4 and N2O exchanges, Hyytiälä (FI), 8-11 April.
Keywords: Bio energy, Ecosystems, climate effects, greenhouse gasses
Source: orbit
Source ID: 252010
Research output: Contribution to conference » Paper – Annual report year: 2009 » Research

Nødvendig viden om mark-emissioner for valg af biobrændsel

General information
Publication status: Published
Organisations: Ecosystems, Biosystems Division, Risø National Laboratory for Sustainable Energy
Contributors: Carter, M. S., Ambus, P.
Pages: 5-6
Publication date: 2009
Peer-reviewed: Unknown

Publication information
Journal: ICROFSnyt
Issue number: 3
Original language: Danish
Keywords: Bio energy, Ecosystems, climate effects, greenhouse gasses
URLs:
http://www.icrofs.org/
Source: orbit
Source ID: 253360
Research output: Contribution to journal » Journal article – Annual report year: 2009 » Communication
Pea-barley intercropping and short-term subsequent crop effects across European organic cropping conditions

Grain legumes are known to increase the soil mineral nitrogen (N) content, reduce the infection pressure of soil borne pathogens, and hence enhance subsequent cereals yields. Replicated field experiments were performed throughout W. Europe (Denmark, United Kingdom, France, Germany and Italy) to asses the effect of intercropping pea and barley on the N supply to subsequent wheat in organic cropping systems. Pea and barley were grown either as sole crops at the recommended plant density (P100 and B100, respectively) or in replacement (P50B50) or additive (P100B50) intercropping designs. In the replacement design the total relative plant density is kept constant, while the additive design uses the optimal sole crop density for pea supplementing with ‘extra’ barley plants. The pea and barley crops were followed by winter wheat with and without N application. Additional experiments in Denmark and the United Kingdom included subsequent spring wheat with grass-clover as catch crops. The experiment was repeated over the three cropping seasons of 2003, 2004 and 2005. Irrespective of sites and intercrop design pea-barley intercropping improved the plant resource utilization (water, light, nutrients) to grain N yield with 25–30% using the Land Equivalent ratio. In terms of absolute quantities, sole cropped pea accumulated more N in the grains as compared to the additive design followed by the replacement design and then sole cropped barley. The post harvest soil mineral N content was unaffected by the preceding crops. Under the following winter wheat, the lowest mineral N content was generally found in early spring. Variation in soil mineral N content under the winter wheat between sites and seasons indicated a greater influence of regional climatic conditions and long-term cropping history than annual preceding crop and residue quality. Just as with the soil mineral N, the subsequent crop response to preceding crop was negligible. Soil N balances showed general negative values in the 2-year period, indicating depletion of N independent of preceding crop and cropping strategy. It is recommended to develop more rotational approaches to determine subsequent crop effects in organic cropping systems, since preceding crop effects, especially when including legumes, can occur over several years of cropping.

General information
Publication status: Published
Organisations: Bioenergy and Biomass, Biosystems Division, Rise National Laboratory for Sustainable Energy, Ecosystems, University of Kassel, University of Reading, Ecole Superieure d’Agriculture, Mediterranea University of Reggio Calabria
Pages: 141-155
Publication date: 2009
Peer-reviewed: Yes

Publication information
Journal: Nutrient Cycling in Agroecosystems
Volume: 85
Issue number: 2
ISSN (Print): 1385-1314
Ratings:
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 1.006 SNIP 1.011
Web of Science (2009): Indexed yes
Original language: English
Keywords: Climate and energy systems, Ecosystems, climate effects, greenhouse gasses
DOIs:
10.1007/s10705-009-9254-y
Source: orbit
Source ID: 244604
Research output: Contribution to journal › Journal article – Annual report year: 2009 › Research › peer-review

Pea-barley intercropping for efficient symbiotic N-2-fixation, soil N acquisition and use of other nutrients in European organic cropping systems

Complementarity in acquisition of nitrogen (N) from soil and N-2-fixation within pea and barley intercrops was studied in organic field experiments across Western Europe (Denmark, United Kingdom, France, Germany and Italy). Spring pea and barley were sown either as sole crops, at the recommended plant density (P100 and B100, respectively) or in replacement (P50B50) or additive (P100B50) intercropping designs, in each of three cropping seasons (2003-2005). Irrespective of site and intercrop design, Land Equivalent Ratios (LER) between 1.4 at flowering and 1.3 at maturity showed that total N recovery was greater in the pea-barley intercrops than in the sole Crops Suggesting a high degree of complementarity over a wide range of growing conditions. Complementarity was partly attributed to greater soil mineral N acquisition by barley, forcing pea to rely more on N-2-fixation. At all sites the proportion of total aboveground pea N that was derived from N-2-fixation was greater when intercropped with barley than when grown as a sole crop. No consistent differences were found between the two intercropping designs. Simultaneously, the accumulation Of Phosphorous (P), potassium (K) and sulphur (S) in Danish and German experiments was 20% higher in the intercrop (P50B50) than in the respective sole crops, possibly influencing general crop yields and thereby competitive ability for other resources.
Comparing all sites and seasons, the benefits of organic pea-barley intercropping for N acquisition were highly resilient. It is concluded that pea-barley intercropping is a relevant cropping strategy to adopt when trying to optimize N-2-fixation inputs to the cropping system.

**General information**
Publication status: Published
Organisations: Bioenergy and Biomass, Biosystems Division, Risø National Laboratory for Sustainable Energy, Ecosystems
Pages: 64-71
Publication date: 2009
Peer-reviewed: Yes

**Publication information**
Journal: Field Crops Research
Volume: 113
Issue number: 1
ISSN (Print): 0378-4290
Ratings:
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 1.385 SNIP 1.7
Web of Science (2009): Indexed yes
Original language: English
Keywords: Bio energy, Nitrogen fixation, Interspecific competition, Land Equivalent Ratio (LER), Bioenergy and biomass, N-15-isotope techniques, Intercropping
DOIs:
10.1016/j.fcr.2009.04.009
Source: orbit
Source ID: 249393
Research output: Contribution to journal › Journal article – Annual report year: 2009 › Research › peer-review

**Production of biomass and bioenergy in organic agriculture and its consequences for soil quality, environment, biodiversity and socio-economy**

**General information**
Publication status: Published
Organisations: Bioenergy and Biomass, Biosystems Division, Risø National Laboratory for Sustainable Energy, Ecosystems
Publication date: 2009
Peer-reviewed: No
Keywords: Bio energy, Bioenergy and biomass
Source: orbit
Source ID: 244672
Research output: Contribution to conference › Poster – Annual report year: 2009 › Research

**Responses of carbon and water fluxes following drought events in combinations with warming and elevated CO2**

**General information**
Publication status: Published
Organisations: Ecosystems, Biosystems Division, Risø National Laboratory for Sustainable Energy
Publication date: 2009

**Host publication information**
Title of host publication: Oral and Poster Presentations of the BIOGEOMON 2009 Conference (online)
Publisher: Finnish Environment Institute
Keywords: Bio energy, Ecosystems, climate effects, greenhouse gasses
Electronic versions:
Biogeomon_presentation.pdf
Soil-atmosphere exchange of carbon in a heath land under future climatic conditions

General information
Publication status: Published
Organisations: Ecosystems, Biosystems Division, Rise National Laboratory for Sustainable Energy
Contributors: Selsted, M. B., Ambus, P.
Publication date: 2009
Peer-reviewed: No
Keywords: Bio energy, Ecosystems, climate effects, greenhouse gasses
On orbit
Source ID: 252151
Research output: Chapter in Book/Report/Conference proceeding › Conference abstract in proceedings – Annual report year: 2009 › Research

Soil carbon stocks: Changes in relationship to global change factors and soil management strategies

General information
Publication status: Published
Organisations: Ecosystems, Biosystems Division, Rise National Laboratory for Sustainable Energy
Contributors: Ambus, P.
Number of pages: 21
Pages: 21-21
Publication date: 2009

Host publication information
Title of host publication: Abstracts
Place of publication: Lyngby (DK)
Publisher: Technical University of Denmark (DTU)
Keywords: Bio energy, Ecosystems, climate effects, greenhouse gasses
Electronic versions:
abstracts_workshop_12_13_may.pdf
Source: orbit
Source ID: 252006
Research output: Chapter in Book/Report/Conference proceeding › Conference abstract in proceedings – Annual report year: 2009 › Research

Strip intercropping strategy for biomass to energy production while on the same time maintaining soil fertility

General information
Publication status: Published
Organisations: Ecosystems, Biosystems Division, Rise National Laboratory for Sustainable Energy, Lund University,
Danish Centre for Environment and Energy
Contributors: Hauggaard-Nielsen, H., Jensen, E. S., Carter, M. S., Johansen, A., Ambus, P.
Pages: 22-23
Publication date: 2009

Host publication information
Title of host publication: Energy conversion from biomass production
Publisher: NJF
(NJF Report, v. 5 no. 3).
Keywords: Bio energy, Ecosystems, climate effects, greenhouse gasses
URLs:
http://www.njf.nu/filebank/files/20091127$152629$fil$3x7rJRS6U5X3kzxW6Zic.PDF
Source: orbit
Source ID: 253366
Research output: Chapter in Book/Report/Conference proceeding › Article in proceedings – Annual report year: 2009 › Research
The influence of water stress on biomass and N accumulation, N partitioning between above and below ground parts and on N rhizodeposition during reproductive growth of pea (Pisum sativum L.)

In the next few years, grain legumes should be used as a mean of N acquisition in cropping systems due to the depletion of non-renewable sources of energy. However, this requires improvements in the accuracy with which biological N2 fixation, N balances and the N benefit for following crops are estimated. Moreover, grain legume crops are largely influenced by water stress while the world area exposed to drought periods may increase in the coming years due to global warming. This work aims to quantify biomass and N accumulation, N partitioning between above and below ground parts and N rhizodeposition by a pea (Pisum sativum L.) when influenced by water stress. In a controlled environment, pea plants were exposed to a severe drought or not stressed, either at flowering or during pod filling. N rhizodeposition was measured using the split root method and plants were harvested at the end of flowering (59 days after sowing, DAS 59), at the end of the drought period applied during pod filling (DAS 74) and at maturity (DAS 101). Water stress strongly affected pea dry weight and N accumulation. In both stressed treatments, nodule biomass and N content were reduced by about 65% in the absence of stress. Regardless of the treatment, total below ground plant N (root N + N rhizodeposition; BGN) and N rhizodeposition were correlated with total plant N content and the proportion of BGN to total plant N was similar among treatments at each sampling date. At DAS 59 and 74, the N contained in rhizodeposits represented around 30% of the total BGN and increased to around 60% at maturity though BGN decreased from around 20 to 13% of the total plant N between DAS 74 and maturity. The results suggest that water stress has no specific effect on N partitioning between above and below ground parts.

General information
- Publication status: Published
- Organisations: Risø National Laboratory for Sustainable Energy, Bioenergy and Biomass, Biosystems Division, Ecosystems, Laboratory of Plant Ecophysiology and Agroecology
- Contributors: Mahieu, S., Germont, F., Aveline, A., Hauggaard-Nielsen, H., Ambus, P., Jensen, E. S.
- Pages: 380-387
- Publication date: 2009
- Peer-reviewed: Yes

Publication information
- Journal: Soil Biology & Biochemistry
- Volume: 41
- Issue number: 2
- ISSN (Print): 0038-0717
- Ratings:
  - BFI (2009): BFI-level 2
  - Scopus rating (2009): SJR 2.059 SNIP 1.575
  - Web of Science (2009): Indexed yes
- Original language: English
- Keywords: Bio Energy, Bioenergy and biomass
- DOIs:
  - 10.1016/j.soilbio.2008.11.021
- Source: orbit
- Source ID: 238859

The newly discovered aerobic methane release from terrestrial vegetation: Causes and consequences

General information
- Publication status: Published
- Organisations: Ecosystems, Biosystems Division, Risø National Laboratory for Sustainable Energy
- Contributors: Bruhn, D., Ambus, P., Mikkelsen, T. N.
- Publication date: 2009
- Peer-reviewed: No
- Event: Poster session presented at International Scientific Congress on Climate Change, Copenhagen, Denmark.
- Keywords: Bio energy, Ecosystems, climate effects, greenhouse gasses
- Source: orbit
- Source ID: 244644
- Research output: Contribution to conference – Poster – Annual report year: 2009 – Research

The newly discovered aerobic methane release from terrestrial vegetation: Causes and consequences

General information
UV-irradiation induces aerobic methane release from plant material

BioConcens: Biomass and bioenergy production agriculture - eonsequences for soil fertility, environment, spread of animal parasites and socio-economy

CLIMAITE - a three factor climate change ecosystem manipulation experiment
Experimental design of multifactor climate change experiments with elevated CO2, warming and drought: the CLIMAITE project

Recent findings indicate that the interactions among CO2, temperature and water can be substantial, and that the combined effects on the biological systems of several factors may not be predicted from experiments with one or a few factors. Therefore realistic multifactorial experiments involving a larger set of main factors are needed. We describe a new Danish climate change-related field scale experiment, CLIMAITE, in a heath/grassland ecosystem. CLIMAITE is a full factorial combination of elevated CO2, elevated temperature and prolonged summer drought. The manipulations are intended to mimic anticipated major environmental changes at the site by year 2075 as closely as possible. The impacts on ecosystem processes and functioning (at ecophysiological levels, through responses by individuals and communities to ecosystem-level responses) are investigated simultaneously. The increase of [CO2] closely corresponds with the scenarios for year 2075, while the warming treatment is at the lower end of the predictions and seems to be the most difficult treatment to increase without unwanted side effects on the other variables. The drought treatment follows predictions of increased frequency of drought periods in summer. The combination of the treatments does not create new unwanted side effects on the treatments relative to the treatments alone.

Abiotic aerobic methane release from plant material
Canopy emissions of nitrous oxide in upland forests - an overlooked emission pathway?

General information
Publication status: Published
Organisations: Ecosystems, Biosystems Division, Risø National Laboratory for Sustainable Energy, Biosystems Division.
Contributors: Pihlatie, M., Ambus, P., Rinne, J., Pilegaard, K., Vesala, T.
Publication date: 2007
Peer-reviewed: No
Source: orbit
Source ID: 215583
Research output: Contribution to conference › Paper – Annual report year: 2007 › Research

Combined effects of drought, temperature and CO2 on GHG emissions from temperate shrub-land

General information
Publication status: Published
Organisations: Ecosystems, Biosystems Division, Risø National Laboratory for Sustainable Energy, Biosystems Division.
Publication date: 2007
Peer-reviewed: No
Event: Paper presented at COST 639 plenary meeting, Vienna, Austria.
Source: orbit
Source ID: 215582
Research output: Contribution to conference › Paper – Annual report year: 2007 › Research

Denitrification and N2O losses in a heath-land under changing climate conditions

General information
Publication status: Published
Organisations: Ecosystems, Biosystems Division, Risø National Laboratory for Sustainable Energy, Biosystems Division.
Publication date: 2007
Peer-reviewed: No
Source: orbit
Source ID: 215580
Research output: Contribution to conference › Paper – Annual report year: 2007 › Research

Ecosystem-atmosphere exchange of carbon in a heath land under future climatic conditions

General information
Publication status: Published
Organisations: Ecosystems, Biosystems Division, Risø National Laboratory for Sustainable Energy
Contributors: Selsted, M. B., Ibrom, A., Ambus, P.
Publication date: 2007
Peer-reviewed: No
Event: Poster session presented at Symposium on Soil Processes under Extreme Meteorological Conditions, Bayreuth (DE), 25-28 Feb.,
Source: orbit
Source ID: 252038
Research output: Contribution to conference › Poster – Annual report year: 2007 › Research
Effect of burning on soil nitrogen cycling and GHG emissions in a macchia ecosystem

General information
Publication status: Published
Organisations: Ecosystems, Biosystems Division, Risø National Laboratory for Sustainable Energy
Contributors: Ambus, P., Zechmeister-Boltenstern, S., Kitzler, B., Butterbach-Bahl, K., Dannenmann, M., Brüggemann, N., Cotrufo, F., Castaldi, S., Vaccari, F.
Publication date: 2007
Peer-reviewed: No
Event: Poster session presented at COST 639 second plenary meeting, Barcelona (ES),
URLs:
Source: orbit
Source ID: 215581
Research output: Contribution to conference › Poster – Annual report year: 2007 › Research

Effects of climate and management intensity on nitrous oxide emissions in grassland systems across Europe

General information
Publication status: Published
Organisations: Ecosystems, Biosystems Division, Risø National Laboratory for Sustainable Energy, Biosystems Division.
Pages: 135-152
Publication date: 2007
Peer-reviewed: Yes
Publication information
Journal: Agriculture, Ecosystems & Environment
Volume: 121
ISSN (Print): 0167-8809
Ratings:
Web of Science (2007): Indexed yes
Original language: English
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10.1016/j.agee.2006.12.024
Source: orbit
Source ID: 216439
Research output: Contribution to journal › Journal article – Annual report year: 2007 › Research › peer-review

Enzymatic evidence for the key role of arginine in nitrogen translocation by arbuscular mycorrhiza fungi

Enzymes of the urea cycle and N-15-labeling patterns of arginine (Arg) were measured to elucidate the involvement of Arg in nitrogen translocation by arbuscular mycorrhizal (AM) fungi. Mycorrhiza was established between transformed carrot (Daucus carota) roots and Glomus intraradices in two-compartment petri dishes and three ammonium levels were supplied to the compartment containing the extraradical mycelium (ERM), but no roots. Time courses of specific enzyme activity were obtained for glutamine synthetase, argininosuccinate synthetase, arginase, and urease in the ERM and AM roots. 15 NH 4 1 was used to follow the dynamics of nitrogen incorporation into and turnover of Arg. Both the absence of external nitrogen and the presence of L-norvaline, an inhibitor of Arg synthesis, prevented the synthesis of Arg in the ERM and resulted in decreased activity of arginase and urease in the AM root. The catabolic activity of the urea cycle in the roots therefore depends on Arg translocation from the ERM. N-15 labeling of Arg in the ERM was very fast and analysis of its time course and isotopomer pattern allowed estimation of the translocation rate of Arg along the mycelium as 0.13 µg Arg mg(-1) fresh weight h(-1). The results highlight the synchronization of the spatially separated reactions involved in the anabolic and catabolic arms of the urea cycle. This synchronization is a prerequisite for Arg to be a key component in nitrogen translocation in the AM mycelium.

General information
Publication status: Published
Organisations: Cell Biology, Biosystems Division, Risø National Laboratory for Sustainable Energy, Ecosystems
Pages: 782-792
Full accounting of the greenhouse gas (CO2, N2O, CH4) budget of nine European grassland sites

The full greenhouse gas balance of nine contrasted grassland sites covering a major climatic gradient over Europe was measured during two complete years. The sites include a wide range of management regimes (rotational grazing, continuous grazing and mowing), the three main types of managed grasslands across Europe (sown, intensive permanent and semi-natural grassland) and contrasted nitrogen fertilizer supplies. At all sites, the net ecosystem exchange (NEE) of CO2 was assessed using the eddy covariance technique. N2O emissions were monitored using various techniques (GC-cuvette systems, automated chambers and tunable diode laser) and CH4 emissions resulting from enteric fermentation of the grazing cattle were measured in situ at four sites using the SF6 tracer method. Averaged over the two measurement years, net ecosystem exchange (NEE) results show that the nine grassland plots displayed a net sink for atmospheric CO2 of -240 +/- 70 g C m(-2) year(-1) (mean confidence interval at p > 0.95). Because of organic C exports (from cut and removed herbage) being usually greater than C imports (from manure spreading), the average C storage (net biome productivity, NBP) in the grassland plots was estimated at -104 +/- 73 g cm(-2) year(-1) that is 43% of the atmospheric CO2 sink. On average of the 2 years, the grassland plots displayed annual N2O and CH4 (from enteric fermentation by grazing cattle) emissions, in CO2-C equivalents, of 14 +/- 4.7 and 32 +/- 6.8 g CO2-C equiv. m(-2) year(-1), respectively. Hence, when expressed in CO2-C equivalents, emissions of N2O and CH4 resulted in a 19% offset of the NEE sink activity. An attributed GHG balance has been calculated by subtracting from the NBP: (i) N2O and CH4 emissions occurring within the grassland plot and (ii) off-site emissions of CO2 and CH4 as a result of the digestion and enteric fermentation by cattle of the cut herbage. On average of the nine sites, the attributed GHG balance was not significantly different from zero (-85 +/- 77 g CO2-C equiv. m(-2) year(-1)).
Influence of $^{15}$N enrichment on the net isotopic fractionation factor during the reduction of nitrate to nitrous oxide in soil

Nitrous oxide, a greenhouse gas, is mainly emitted from soils during the denitrification process. Nitrogen stable-isotope investigations can help to characterise the N(2)O source and N(2)O production mechanisms. The stable-isotope approach is increasingly used with (15)N natural abundance or relatively low (15)N enrichment levels and requires a good knowledge of the isotopic fractionation effect inherent to this biological mechanism. This paper reports the measurement of the net and instantaneous isotopic fractionation factor ($\alpha_{i}(s/p)$) during the denitrification of NO(3)(-) to N(2)O over a range of (15)N substrate enrichments (0.37 to 1.00 atom% (15)N). At natural abundance level, the isotopic fractionation effect reported falls well within the range of data previously observed. For (15)N-enriched substrate, the value of $\alpha_{i}(s/p)$ was not constant and decreased from 1.024 to 1.013, as a direct function of the isotopic enrichment of the labelled nitrate added. However, for enrichment greater than 0.6 atom% (15)N, the value of $\alpha_{i}(s/p)$ seems to be independent of substrate isotopic enrichment. These results suggest that for isotopic experiments applied to N(2)O emissions, the use of low (15)N-enriched tracers around 1.00 atom% (15)N is valid. At this enrichment level, the isotopic effect appears negligible in comparison with the enrichment of the substrate. Copyright (C) 2007 John Wiley & Sons, Ltd.
Natural 15N abundance of soil N pools and N2O reflect the nitrogen dynamics of forest soils

Natural 15N abundance measurements of ecosystem nitrogen (N) pools and N-15 pool dilution assays of gross N transformation rates were applied to investigate the potential of delta N-15 signatures of soil N pools to reflect the dynamics in the forest soil N cycle. Intact soil cores were collected from pure spruce (Picea abies (L.) Karst.) and mixed spruce-beech (Fagus sylvatica L.) stands on stagnic gleysol in Austria. Soil delta N-15 values of both forest sites increased with depth to 50 cm, but then decreased below this zone. delta N-15 values of microbial biomass (mixed stand: 4.7 +/- 0.8 parts per thousand, spruce stand: 5.9 +/- 0.9 parts per thousand) and of dissolved organic N (DON; mixed stand: 5.3 +/- 1.7 parts per thousand, spruce stand: 2.6 +/- 3.3 parts per thousand) were not significantly different; these pools were most enriched in N-15 of all soil N pools. Denitrification represented the main N2O-producing process in the mixed forest stand as we detected a significant N-15 enrichment of its substrate NO3- (3.6 +/- 4.5 parts per thousand) compared to NH4+ (-4.6 +/- 2.6 parts per thousand) and its product N2O (-11.8 +/- 3.2 parts per thousand). In a N-15-labelling experiment in the spruce stand, nitrification contributed more to N2O production than denitrification. Moreover, in natural abundance measurements the NH4- pool was slightly N-15-enriched (-0.4 +/- 2.0 parts per thousand) compared to NO3- (-3.0 +/- 0.6 parts per thousand) and N2O (-2.1 +/- 1.1 parts per thousand) in the spruce stand, indicating nitrification and denitrification operated in parallel to produce N2O. The more positive delta N-15 values of N2O in the spruce stand than in the mixed stand point to extensive microbial N2O reduction in the spruce stand. Combining natural N-15 abundance and N-15 tracer experiments provided a more complete picture of soil N dynamics than possible with either measurement done separately.
Pea-barley intercropping for the control of weeds in European organic cropping systems

General information
Publication status: Published
Organisations: Bioenergy and Biomass, Biosystems Division, Risø National Laboratory for Sustainable Energy, Ecosystems
Pages: 258-259
Publication date: 2007

Host publication information
Title of host publication: Proceedings
Place of publication: Tjele
Publisher: Danish Research Centre for Organic Food and Farming, DARCOF
Editors: Andreasen, C., Elsgaard, L., Sørensen, L., Hansen, G.
ISBN (Print): 87-991343-3-0
Source: orbit
Source ID: 216649
Research output: Chapter in Book/Report/Conference proceeding – Article in proceedings – Annual report year: 2007 – Research

Pea-barley intercrops use nitrogen sources 20-30% more efficiently than the sole crops
Short-term carbon and nitrogen cycling in urine patches assessed by combined carbon-13 and nitrogen-15 labelling

Urine deposition by grazing animals is known to induce large NO emissions as a result of increased nitrification and denitrification in the soil. This is brought about by the increased N availability from the urine, in combination very likely also with increased organic C availability. Possible sources for C include the urine itself, increased solubility of soil C, lysis of microbial cells and leakage of C from scorched roots. The objective of this experiment was to test the hypothesis that: (i) urine deposition causes an increase in root-derived degradable C compounds in the soil, which (ii) fuel denitrification activity and N2O production. The study took advantage of carbon-13 pulse labelling the plant tissue combined with application of nitrogen-15 labelled synthetic urine as an attempt to identify the sources of N2O. Over a 6 weeks course, the CO2 evolved in response to urine application was equal to the quantity of organic C added. Immediately after the application, 87% of the respired CO2 appeared to be from the urine, and respiration of plant-derived C was temporarily decreased. The cumulated amount of respired C-13 plant carbon, however, was unaltered by the urine treatment indicating that root death was not a significant source to available C. Nitrous oxide emissions accumulated to 7, 59, 142 and 77 mg N2O-N m(-2), respectively, for control (0N), low urine N (LUN), high urine N (HUN) and high mineral N (HMN) treatments. Pair-wise comparisons indicated that HUN > LUN (P < 0.03), whereas HUN = HMN (P < 0.18). The N2O emission factors were 0.3% for the urine treatment, independent of urinary urea concentration and 0.15% for mineral N (NH4+). The N-15 isotopic data indicated that denitrification of soil NO3- was the sole source for N2O production in the urine-affected soil after 12 days of incubation. The initial source of N2O could not be identified because of lack of ability to detect the soil (NO3-) N-15. The source of N2O from added NH4+ was ambiguous since the isotopic signals of N2O, NH4+ and NO3- could not be discerned. Approximately, 50% of the urinary-N, independent of urea concentration, and 72% of the NH4+-was recovered after 6 weeks of incubation. This finding, in combination with the difference in the NO losses, emphasizes the potential to control N-emissions from urine patches through dietary control of the urine N-content.

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Biologically fixed N₂ as a source for N₂O production in a grass–clover mixture, measured by ¹⁵N₂ (erratum i vol. 74 p. 203)

The contribution of biologically fixed dinitrogen (N-2) to the nitrous oxide (N₂O) production in grasslands is unknown. To assess the contribution of recently fixed N-2 as a source of N₂O and the transfer of fixed N from clover to companion grass, mixtures of white clover and perennial ryegrass were incubated for 14 days in a growth cabinet with a N-15(2)-enriched atmosphere (0.4 atom% excess). Immediately after labelling, half of the grass-clover pots were sampled for N-2 fixation determination, whereas the remaining half were examined for emission of N-15 labelled N₂O for another 8 days using a static chamber method. Biological N-2 fixation measured in grass-clover shoots and roots as well as in soil constituted 342, 38 and 67 mg N m(-2) d(-1) at 16, 26 and 36 weeks after emergence, respectively. The drop in N-2 fixation was most likely due to a severe aphid attack on the clover component. Transfer of recently fixed N from clover to companion grass was detected at 26 and 36 weeks after emergence and amounted to 0.7 +/- 0.1 mg N m(-2) d(-1), which represented 1.7 +/- 0.3% of the N accumulated in grass shoots during the labelling period. Total N₂O emission was 91, 416 and 259 μg N m(-2) d(-1) at 16, 26 and 36 weeks after emergence, respectively. Only 3.2 +/- 0.5 ppm of the recently fixed N-2 was emitted as N₂O on a daily basis, which accounted for 2.1 +/- 0.5% of the total N₂O-N emission. Thus, recently fixed N released via easily degradable clover residues appears to be a minor source of N₂O.
Enzymatic evidence for the key role of arginine in nitrogen translocation by arbuscular mycorrhizal fungi

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Event: Abstract from 5th International Conference on Mycorrhiza, Granada, Spain.
Source: orbit
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Research output: Contribution to conference › Conference abstract for conference – Annual report year: 2006 › Research

Factors controlling regional differences in forest soil emission of nitrogen oxides (NO and N\textsubscript{2}O)

Soil emissions of NO and N\textsubscript{2}O were measured continuously at high frequency for more than one year at 15 European forest sites as part of the EU-funded project NOFRETETE. The locations represent different forest types (coniferous/deciduous) and different nitrogen loads. Geographically they range from Finland in the north to Italy in the south and from Hungary in the east to Scotland in the west.

The highest NO emissions were observed from coniferous forests, whereas the lowest NO emissions were observed from deciduous forests. The NO emissions from coniferous forests were highly correlated with N-deposition. The site with the highest average annual emission (82 µg NO-N m\textsuperscript{-2} h\textsuperscript{-1}) was a spruce forest in South-Germany (Hoglwald) receiving an annual N-deposition of 2.9 g m\textsuperscript{-2}. NO emissions close to the detection limit were observed from a pine forest in Finland where the N-deposition was 0.2 N m\textsuperscript{-2} a\textsuperscript{-1}. No significant correlation between N\textsubscript{2}O emission and N-deposition was found. The highest average annual N\textsubscript{2}O emission (20 µg N2O-N m\textsuperscript{-2} h\textsuperscript{-1}) was found in an oak forest in the Matra mountains (Hungary) receiving an annual N-deposition of 1.6 g m\textsuperscript{-2}. N\textsubscript{2}O emission was significantly negatively correlated with the C/N ratio.

The difference in N-oxide emissions from soils of coniferous and deciduous forests may partly be explained by differences in N-deposition rates and partly by differences in characteristics of the litter layer and soil. NO was mainly derived from nitrification whereas N\textsubscript{2}O was mainly derived from denitrification. In general, soil moisture is lower at coniferous sites (at least during spring time) and the litter layer of coniferous forests is thick and well aerated favouring nitrification and thus release of NO. Conversely, the higher rates of denitrification in deciduous forests due to a compact and moist litter layer lead to N\textsubscript{2}O production and NO consumption in the soil.

The two factors soil moisture and soil temperature are often explaining most of the temporal variation within a site. When comparing annual emissions on a regional scale, however, factors such as nitrogen deposition and forest and soil type become much more important.

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Publication information
Journal: Biogeosciences
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ISSN (Print): 1726-4170
Ratings:
Scopus rating (2006): SJR 1.032 SNIP 0.679
Methane oxidation in pig and cattle slurry storages, and effects of surface crust moisture and methane availability

Storages with liquid manure (slurry) may develop a surface crust of particulate organic matter, or an artificial crust can be established. Slurry storages are net sources of atmospheric methane (CH4), but a potential for bacterial oxidation of CH4 in surface crusts was recently suggested in a study of experimental storages. The present study was conducted to investigate methanotrophic activity under practical storage conditions. Surface crusts from slurry storages at two pig farms and four dairy farms were sampled in late autumn. Mixed samples (0-4 cm depth) were used to determine changes in CH4, O2 and CO2 during incubation, while intact subsamples were used to characterize CH4 oxidation as a function of CH4 availability and moisture content. Methane oxidation was observed in all materials except for an expanded clay product (Leca) sampled from a pig slurry storage. Despite significant variation between replicate subsamples, there was a significant increase in methanotrophic activity when CH4 concentrations increased from 500 to 50,000 ppmv. Maximum fluxes ranged from -1 to -4.5 g CH4 m(-2) d(-1). Surface crust samples were partly dried and then re-wetted in four steps to the original moisture content, each time followed by determination of CH4 fluxes. Only one surface crust material showed a relationship between CH4 fluxes and moisture content that would implicate gas diffusivity in the regulation of CH4 oxidation. The occurrence of inducible CH4 oxidation activity in slurry storage surface crusts indicates that there is a potential for stimulating the process by manipulation of gas phase composition above the stored slurry.

Sources of nitrous oxide emitted from European forest soils

Forest ecosystems may provide strong sources of nitrous oxide (N2O), which is important for atmospheric chemical and radiative properties. Nonetheless, our understanding of controls on forest N2O emissions is insufficient to narrow current flux estimates, which still are associated with great uncertainties. In this study, we have investigated the quantitative and qualitative relationships between N-cycling and N2O production in European forests in order to evaluate the importance of nitrification and denitrification for N2O production. Soil samples were collected in 11 different sites characterized by variable climatic regimes and forest types. Soil N-cycling and associated production of N2O was assessed following application of 15N-labeled nitrogen. The N2O emission varied significantly among the different forest soils, and was inversely correlated to the soil C: N ratio. The N2O emissions were significantly higher from the deciduous soils (13 ng N2O-N cm(-3) d(-1)) than from the coniferous soils (4 ng N2O- N cm(-3) d(-1)). Nitrate (NO3-) was the dominant substrate for N2O with an average contribution of 62% and exceeding 50% at least once for all sites. The average contribution of ammonium (NH4+) to N2O averaged 34%. The N2O emissions were correlated with gross nitrification activities, and as for N2O, gross nitrification was also higher in deciduous soils (3.4 mu gNcm(-3) d(-1)) than in coniferous soils (1.1 mu gNcm(-3) d(-1)). The ratio between N2O production and gross nitrification averaged 0.67% (deciduous) and 0.44% (coniferous). Our study suggests that changes in forest composition in response to land use activities and global change may have implications for regional budgets of greenhouse gases. From the study it also became clear that N2O emissions were driven by the nitrification activity, although the N2O was produced per se mainly from denitrification. Increased nitrification in response to accelerated N inputs predicted for forest ecosystems in Europe may thus lead to increased greenhouse gas emissions. 
emissions from forest ecosystems.

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Contributors: Ambus, P., Zechmeister-Boltenstern, S., Butterbach-Bahl, K.
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Stabilization and plant uptake of N from $^{15}$N-labelled pea residue 16.5 years after incorporation in soil
The decline of N from N-15-labelled mature pea residues was followed in unplanted soil over 16.5 yr. Eight years after residue incorporation, 24% of the residue N-15 input was still present in the soil and, after 16.5 yr, 16% of the residue N-15 input remained. A double exponential model successfully described the decay of N from N-15-labelled pea residues. The total residual N-15 declined with average decay constants of 1.45 yr(-1) for the 30 d to 1 yr period and of 0.07 yr(-1) for the 1-16 yr period. Sixteen years following incorporation of the residues, indicator plants growing in residues-amended soils were obtaining 1.7% of their N from residue N. This is, to our knowledge, the longest study on decay of N in soils from N-15-labelled crop residues. The current study thus provides a unique data set for our empirical understanding of N-dynamics in agricultural systems, which is a prerequisite to parameterize and validate N-simulation models. (c) 2006 Elsevier Ltd. All rights reserved.

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Source: orbit
Source ID: 309450
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The Biological Time Machine - Biological responses to multiple environmental and climatic changes, environment and stress

**General information**
Publication status: Published
Organisations: Risø National Laboratory for Sustainable Energy
The effect of increased N deposition on nitrous oxide, methane and carbon dioxide fluxes from unmanaged forest and grassland communities in Michigan

Atmospheric nitrogen deposition is anticipated to increase over the next decades with possible implications for future forest-atmosphere interactions. Increased soil N(2)O emissions, depressed CH(4) uptake and depressed soil respiration CO(2) loss is considered a likely response to increased N deposition. This study examined fluxes of N(2)O, CH(4) and CO(2) over two growing seasons from soils in unmanaged forest and grassland communities on abandoned agricultural areas in Michigan. All sites were subject to simulated increased N-deposition in the range of 1-3 g N m(-2) annually. Nitrous oxide fluxes and soil N concentrations in coniferous and grassland sites were on the whole unaffected by the increased N-inputs. It is noteworthy though that N(2)O emissions increased three-fold in the coniferous sites in the first growing season in response to the low N treatment, although the response was barely significant (p < 0.06). In deciduous forests, we observed increased levels of soil mineral N during the second year of N fertilization, however N(2)O fluxes did not increase. Rates of methane oxidation were similar in all sites with no affect of field N application. Likewise, we did not observe any changes in soil CO(2) efflux in response to N additions. The combination of tillage history and vegetation type was important for the trace gas fluxes, i.e. soil CO(2) efflux was greater in successional grassland sites compared with the forested sites and CH(4) uptake was reduced in post-tillage coniferous- and successional sites compared with the old-growth deciduous site. Our results indicate that short-term increased N availability influenced individual processes linked to trace gas turnover in the soil independently from the ecosystem N status. However, changes in whole system fluxes were not evident and were very likely mediated by competitive N uptake processes.

The thermal history of char as disclosed by carbon isotope ratios

The thermal history of char as disclosed by carbon isotope ratios

The thermal history of char as disclosed by carbon isotope ratios

The thermal history of char as disclosed by carbon isotope ratios
A comparative study of nitrous oxide emissions from a grazed pasture and an arable field in Ireland

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Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Ambus, P.
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Event: Abstract from CarboEurope meeting, Dublin, Ireland.
Source: orbit
Source ID: 308064
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Biomass production, symbiotic nitrogen fixation and inorganic N use in dual tri-component annual intercrops

The interspecific complementary and competitive interactions between pea (Pisum sativum L.), barley (Hordeum vulgare L.) and oilseed rape (Brassica napus L.), grown as dual and tri-component intercrops were assessed in a field study in Denmark. Total biomass production and N use at two levels of N fertilisation (0.5 and 4.0 g N/m²), were measured at five harvests throughout a growing season. All intercrops displayed land equivalent ratio values close to or exceeding unity, indicating complementary use of growth resources. Whereas both rape and barley responded positively to increased N fertilisation, irrespective of whether they were grown as sole- or intercrops, pea was strongly suppressed when grown in intercrop. Of the three crops barley was the strongest competitor for both soil and fertiliser N, rape intermediate and pea the weakest. Faster initial growth of barley than pea and rape gave barley an initial competitive advantage, an advantage that in the two dual intercrops was strengthened by the addition of N. Apparently the competitive superiority of barley was less strong in the tri-component intercrop, indicating that the impact of the dominant may, through improved growth of both rape and pea, have been diminished through indirect facilitation. Interspecific competition had a promoting effect on the percent of nitrogen derived from N2 fixation of pea, and most so at the low N fertilisation level. Results indicate that the benefits achieved from the association of a legume and nonlegume, in terms of N2 fixed were greatest when pea was grown in association with rape as opposed to barley which could indicate that the benefits achieved from the association of a legume and nonlegume are partly lost if the nonlegume is too strong a competitor.

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Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Andersen, M., Hauggaard-Nielsen, H., Ambus, P., Jensen, E.
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Web of Science (2005): Indexed yes
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From N2 fixation to N2O emission in a grass-clover pasture (poster)

General information
Publication status: Published
Inventories of N$_2$O and NO emissions from European forest soils

Forest soils are a significant source for the primary and secondary greenhouse gases N$_2$O and NO. However, current estimates are still uncertain due to the still limited number of field measurements and the herein observed pronounced variability of N trace gas fluxes in space and time, which are due to the variation of environmental factors such as soil and vegetation properties or meteorological conditions. To overcome these problems we further developed a process-oriented model, the PnET-N-DNDC model, which simulates the N trace gas exchange on the basis of the processes involved in production, consumption and emission of N trace gases. This model was validated against field observations of N trace gas fluxes from 19 sites obtained within the EU project NOFRETETE, and shown to perform well for N$_2$O ($r^2 = 0.68$, slope = 0.76) and NO ($r^2 = 0.78$, slope = 0.73). For the calculation of a European-wide emission inventory we linked the model to a detailed, regionally and temporally resolved database, comprising climatic properties (daily resolution), and soil parameters, and information on forest areas and types for the years 1990, 1995 and 2000. Our calculations show that N trace gas fluxes from forest soils may vary substantial from year to year and that distinct regional patterns can be observed. Our central estimate of NO emissions from forest soils in the EU amounts to 98.4, 84.9 and 99.2 kt N yr$^{-1}$ for the years 1990, 1995 and year 2000, respectively. This is < 1.0% of pyrogenic NOx emissions. For N$_2$O emissions the central estimates were 86.8, 77.6 and 81.6 kt N yr$^{-1}$, respectively, which is approx. 14.5% of the source strength coming from agricultural soils. An extensive sensitivity analysis was conducted which showed a range in emissions from 44.4 to 254.0 kt N yr$^{-1}$ for NO and 50.7 to 96.9 kt N yr$^{-1}$ for N$_2$O, for year 2000 meteorology.

The results show that process-oriented models coupled to a GIS are useful tools for the calculation of regional, national, or global inventories of biogenic N trace gas emissions from soils. This work represents the most comprehensive effort to date to simulate NO and N$_2$O emissions from European forest soils.

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Web of Science (2005): Indexed yes
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http://www.biogeosciences.net/bg/2/353/
Source: orbit
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Research output: Contribution to journal › Journal article – Annual report year: 2005 › Research › peer-review
Nitrous oxide emissions from a beech forest floor measured by eddy covariance and soil enclosure techniques

Spring time nitrous oxide (N2O) emissions from an old beech (Fagus sylvatica L.) forest were measured with eddy covariance (EC) and chamber techniques. The aim was to obtain information on the spatial and temporal variability in N2O emissions and link the emissions to soil environmental parameters. Mean N2O fluxes over the five week measurement period were 5.6 +/- 1.1, 10 +/- 1 and 16 +/- 11 μg N m(-2) h(-1) from EC, automatic chamber and manual chambers, respectively. High temporal variability characterized the EC fluxes in the trunk-space. To reduce this variability, resulting mostly from random uncertainty due to measuring fluxes close to the detection limit, we averaged the fluxes over one day periods. The variability in the chamber measurements was much smaller and dominated by high small scale spatial variability. The highest emissions measured by the EC method occurred during the first week of May when the trees were leafing and the soil moisture content was at its highest. If chamber techniques are used to estimate ecosystem level N2O emissions from forest soils, placement of the chambers should be considered carefully to cover the spatial variability in the soil N2O emissions. The EC technique, applied in this study, is a promising alternative tool to measure ecosystem level N2O fluxes in forest ecosystems. To our knowledge, this is the first study to demonstrate that the EC technique can be used to measure N2O fluxes in the trunk-space of a forest.
Oxidation of $^{13}$C-labeled methane in surface crusts of pig- and cattle slurry

Pan-European $\delta^{13}$C values of air and organic matter from forest ecosystems
Plant-mediated nitrous oxide emissions from beech (Fagus sylvatica) leaves

General information
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Organisations: Risø National Laboratory for Sustainable Energy
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Source ID: 308368
Research output: Contribution to journal › Journal article – Annual report year: 2005 › Research › peer-review

Relationship between gross nitrogen cycling and nitrous oxide emission in grass-clover pasture
Replacement of high-input N fertilized pastures with low-input grass-legume pastures may provide a mitigation option to reduce agricultural N(2)O emissions. This study examined the relationship between N-cycling rates and N(2)O production and evolution from the root zone of grass-clover pastures of various ages (production year 1, 2 and 8). The experimental approach included cross-labelling pasture monoliths with (15)N-enriched substrates to identify sources of N(2)O, in combination with assessment of gross N mineralization and nitrification. Nitrous oxide emissions were generally low, fluctuating between 82 and 136 μg N(2)O-N m(-2) d(-1), independent of pasture age. The (15)N labelling indicated that at least 50% of the N(2)O was derived from the soil NH(4)(+) pool, approaching 100% in June. In the two year old pasture the NH(4)(+) pool contributions to N(2)O emissions varied significantly with sampling time. Emission rates of N(2)O correlated positively with soil NH(4)(+) concentrations and the NH(4)(+) supply as expressed by gross mineralization. The N(2)O emissions showed a significant inverse relationship with soil NO(3)(-) and was not correlated with the supply of NO(3)(-) as expressed by gross nitrification. The ratio N(2)O vs. nitrification averaged 0.05% (range 0.004 to 0.29%) and varied with sampling time showing the lowest value in wet soil conditions.

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Sources of nitrous oxide production among European coniferous and deciduous forest types

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Contributors: Ambus, P., Zechmeister-Boltenstern, S.
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The thermal history of char as disclosed by carbon isotope ratios (poster)

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The urea cycle at work in *Glomus intraradices*

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Annual greenhouse gas balance of European grasslands. First results from GreenGrass

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Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Soussana, J., Pilegaard, K., Ambus, P.
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Event: Abstract from Greenhouse gas emissions from agriculture - mitigation options and strategies, Freiburg (FR), 4-12 Sep, .
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Source ID: 307507
Research output: Contribution to conference › Conference abstract for conference – Annual report year: 2004 › Research

Assessing the use of delta C-13 natural abundance in separation of root and microbial respiration in a Danish beech (*Fagus Sylvatica* L.) forest
Our understanding of forest biosphere-atmosphere interactions is fundamental for predicting forest ecosystem responses to climatic changes. Currently, however, our knowledge is incomplete partly due to inability to separate the major components of soil CO2 effluxes, viz. root respiration, microbial decomposition of soil organic matter and microbial decomposition of litter material. In this study we examined whether the delta(13)C characteristics of solid organic matter and respired CO2 from different soil-C components and root respiration in a Danish beech forest were useful to provide information on the root respiration contribution to total CO2 effluxes. The delta(13)C isotopic analyses of CO2 were performed using a FinniganMAT Delta(PLUS) isotope-ratio mass spectrometer coupled in continuous flow mode to a trace gas preparation-concentration unit (PreCon). Gas samples in 2-mL crimp seal vials were analysed in a fully automatic mode with an experimental standard error +/- 0.11 parts per thousand. We observed that the CO2 derived from root-free mineral soil horizons (A, B-W) was more enriched in C-13 (delta(13)C range -21.6 to -21.2 parts per thousand) compared with CO2 derived from root-free humus layers (delta(13)C range -23.6 to -23.4 parts per thousand). The CO2 evolved from root respiration in isolated young beech plants revealed a value intermediate between those for the soil humus and mineral horizons, delta(13)C(root) = -22.2 parts per thousand, but was associated with great variability (SE +/- 1.0 parts per thousand) due to plant-specific differences. delta(13)C of CO2 from in situ below-ground respiration averaged -22.8 parts per thousand, intermediate between the values for the humus layer and root respiration, but variability was great (SE +/- 0.4 parts per thousand) due to pronounced spatial patterns. Overall, we were unable to statistically separate the CO2 of root respiration vs. soil organic matter decomposition based solely on delta(13)C signatures, yet the trend in the data suggests that root respiration contributed similar to 43% to total respiration. The vertical gradient in delta(13)C, however, might be a useful tool in partitioning respiration in different soil layers. The experiment also showed an unexpected C-13-enrichment of CO2 (> 3.5 parts per thousand) compared with the total-C signatures in the individual soil-C components. This may suggest that analyses of bulk samples are not representative for the C-pools actively undergoing decomposition.

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Freeze-thaw regime effects on carbon and nitrogen dynamics in sub-arctic heath tundra mesocosms

Freeze-thaw fluctuations in soil temperature may be critical events in the annual pattern of nutrient mobilisation that supplies plant growth requirements in some temperate, and most high latitude and high altitude ecosystems. We investigated the effects of two differing freeze-thaw regimes, each of which is realistic of in situ spatial and temporal variation in field conditions, on C and N dynamics in sub-arctic heath tundra mesocosms. In addition, N-15 isotopic label was used to follow the partitioning of a labile N pool between major ecosystem components, both during the freeze-thaw treatments phase, and in a subsequent equilibration phase. A single deep freeze treatment phase enhanced dissolved total and labelled N pools in the soil solution at initial thaw, and resulted in reduced pool sizes at the end of the equilibration phase. By contrast, a multiple freeze-thaw cycling treatment directly enhanced the dissolved labelled N pool, but did not significantly affect dissolved total N. Furthermore, both dissolved labelled N and dissolved total N pools were significantly enhanced in the equilibration period following multiple freeze-thaw, the latter due to a marked increase in soil solution NH4+. Microbial biomass C was not significantly affected by either of the freezing treatments upon final thaw, but was significantly reduced over the combined treatment and equilibration phases of the multiple freeze-thaw regimes. Furthermore, the treatments had no significant effects on total or labelled N within the microbial biomass over either phase. Total mesocosm CO2 efflux rates remained closely correlated with soil temperature throughout the experiment in both regimes, suggesting that respiratory fluxes associated with treatment-induced microbial cell lysis were negligible. Together, these results indicate that moderate freeze-thaw fluctuations may have minimal influences on microbial biomass pools, but nevertheless can have strong contrasting effects on the amounts, forms, and timing of N and organic C supply into the soil solution. Ecosystem losses via N2O effluxes were of greatest magnitude immediately upon thawing in both treatments, and were of similar total magnitude to inorganic N leachates in throughflow. Herb leaves, total fine roots, and vascular stems accumulated some N-15 label in one or both of the freezing treatments by the end of the experiment. Together, these results indicating very small N losses relative to the magnitudes of internal transfers, suggest tight ecosystem N cycling both during and after freeze-thaw events. Furthermore, our small and subtle effects on microbial and soluble C and N pools relative to previous studies using more severe regimes, suggests that periods of moderate freeze-thaw fluctuations may have only a minor influence on the annual pattern of C and nutrient dynamics in seasonally cold ecosystems. (C) 2004 Elsevier Ltd. All rights reserved.

General information
Publication status: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Grogan, P., Michelsen, A., Ambus, P., Jonasson, S.
Pages: 641-654
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Microbial processes and nitrogen oxides emissions from forest soils

General information
Publication status: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Zechmeister-Boltenstern, S., Schindlbacher, A., Ambus, P., Butterbach-Bahl, K.
Publication date: 2004
Peer-reviewed: No
Event: Abstract from Eurosoil 2004, Freiburg, France.
Source: orbit
Source ID: 307506
Research output: Contribution to conference » Conference abstract for conference – Annual report year: 2004 » Research

Nitrogen oxides emissions in relation to microbial parameters at 13 European forest sites

General information
Publication status: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Zechmeister-Boltenstern, S., Schindlbacher, A., Ambus, P., Butterbach-Bahl, K.
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Source ID: 307505
Research output: Contribution to conference » Conference abstract for conference – Annual report year: 2004 » Research

Nitrous oxide emissions from North European forest ecosystems measured by Eddy covariance and enclosure techniques

General information
Publication status: Published
Organisations: Risø National Laboratory for Sustainable Energy
Publication date: 2004
Peer-reviewed: No

Publication information
Journal: Geophysical Research Abstracts
Volume: 6
ISSN (Print): 1607-7962
Original language: English
Source: orbit
Source ID: 306780
Research output: Contribution to journal » Journal article – Annual report year: 2004 » Research

N₂O emission from grass-clover swards is largely unaffected by recently fixed N₂

General information
Publication status: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Thyme, M., Ambus, P.
Publication date: 2004
Peer-reviewed: Unknown

Publication information
Journal: DARCOFenews
Issue number: 1
ISSN (Print): 1397-9884
Original language: English
URLs:
http://www.darcof.dk/enews/april04/emision.html
Source: orbit
Source ID: 306938
Research output: Contribution to journal › Journal article – Annual report year: 2004 › Communication

Photorespiration contributes to stomatal regulation and carbon isotope fractionation: A study with barley, potato and Arabidopsis plants deficient in glycine decarboxylase

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Publication status: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Igamberdiev, A., Mikkelsen, T. N., Ambus, P., Bauwe, H., Lea, P., Gardeström, P.
Pages: 139-152
Publication date: 2004
Peer-reviewed: Yes

Publication information
Journal: Photosynthesis Research
Volume: 81
ISSN (Print): 0166-8595
Ratings:
Scopus rating (2004): SJR 0.895 SNIP 0.744
Web of Science (2004): Indexed yes
Original language: English
DOIs:
10.1023/B:PRES.0000035026.05237.ec
Source: orbit
Source ID: 307056
Research output: Contribution to journal › Journal article – Annual report year: 2004 › Research › peer-review

Short term losses in urine patches: A 15N labelling study

General information
Publication status: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Ambus, P.
Publication date: 2004
Peer-reviewed: No
Source: orbit
Source ID: 306566
Research output: Contribution to conference › Conference abstract for conference – Annual report year: 2004 › Research

Assessing the use of d13C natural abundance in separation of root and microbial respiration in a Danish beech (Fagus sylvatica L.) forest

General information
Publication status: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Formanek, P., Ambus, P.
Publication date: 2003
Peer-reviewed: No
Biodegradation of chlorinated solvents in a water unsaturated topsoil

In order to investigate topsoils as potential sinks for chlorinated solvents from the atmosphere, the degradation of trichloromethane (CHCl3), 1,1,1-trichloroethane (CH3CCl3), tetrachloromethane (CCl4), trichloroethene (C2HCl3) and tetrachloroethene (C2Cl4) was studied in anoxic laboratory experiments designed to simulate denitrifying conditions in water unsaturated by measuring the release of N-15 in N-2 to the headspace from added N-15 labeled nitrate. The degradation of chlorinated aliphatic compounds was followed by measuring their concentrations in the headspace above the soil.

The headspace concentrations of all the chlorinated solvents except CH3CCl3 were significantly (P less than or equal to 0.05) lower after 41 days in biologically active batches as compared to sterile batches. For the compounds with significantly decreasing headspace concentrations, the decline was the least for CHCl3 within the 41 days of incubation. The headspace concentrations of trichloro- and tetrachloroethene decreased more than 50% during the first 20 days with no considerable indication of abiotic transformation. While slow abiotic removal was observed, tetrachloromethane was completely biotransformed after 16 days. Based on the results in this study, we conclude that anaerobic topsoils are potential sinks for these contaminants, and that a natural attenuation potential exists, even in water unsaturated topsoils.

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From N₂ fixation to N₂O emission in a grass-clover pasture (poster)

General information
Publication status: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Thyme, M., Ambus, P.
Publication date: 2003
Peer-reviewed: No
Event: Poster session presented at 12th N workshop 'Controlling N flows and losses', Exeter, United Kingdom.
Source: orbit
Source ID: 306175
Research output: Contribution to conference › Poster – Annual report year: 2003 › Research

Nitrous oxide fluxes from a beech forest floor measured by eddy covariance and soil enclosure techniques

General information
Publication status: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Pihlatie, M., Rinne, J., Ambus, P., Pilegaard, K., Dorsey, J., Rannik, Ü., Vesala, T.
Publication date: 2003
Peer-reviewed: No
Source: orbit
Source ID: 305938
Research output: Contribution to conference › Conference abstract for conference – Annual report year: 2003 › Research

Redistribution of slurry components as influenced by injection method, soil, and slurry properties

General information
Publication status: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Petersen, S., Nissen, H., Lund, I., Ambus, P.
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Publication date: 2003
Peer-reviewed: Yes

Publication information
Journal: Journal of Environmental Quality
Volume: 32
ISSN (Print): 0047-2425
Ratings:
Scopus rating (2003): SJR 1.729 SNIP 1.805
Web of Science (2003): Indexed yes
Original language: English
Source: orbit
Source ID: 306187
Research output: Contribution to journal › Journal article – Annual report year: 2003 › Research › peer-review

The arginine translocation hypothesis: Advanced mass spectrometry for studying the uptake and assimilation of NH4+ in Glomus intraradices

General information
Publication status: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Jakobsen, I., Trujillo, C., Ambus, P., Requena, N., Egsgaard, H.
Publication date: 2003
Peer-reviewed: No
Event: Abstract from 4th International Conference on Mycorrhizas, Montreal, Canada.
Source: orbit
The comparison of nitrogen use and leaching in sole cropped versus intercropped pea and barley

The effect of sole and intercropping of field pea (Pisum sativum L.) and spring barley (Hordeum vulgare L.) and of crop residue management on crop yield, NO3- leaching and N balance in the cropping system was tested in a 2-year lysimeter experiment on a temperate sandy loam soil. The crop rotation was pea and barley sole and intercrops followed by winter-rye and a fallow period. The Land Equivalent Ratio (LER), which is defined as the relative land area under sole crops that is required to produce the yields achieved in intercropping, was used to compare intercropping performance relative to sole cropping. Crops received no fertilizer in the experimental period. Natural N-15 abundance techniques were used to determine pea N-2 fixation. The pea-barley intercrop yielded 4.0 Mg grain ha(-1), which was about 0.5 Mg lower than the yields of sole cropped pea but about 1.5 Mg greater than harvested in sole cropped barley. Calculation of the LER showed that plant growth resources were used from 17 to 31% more efficiently by the intercrop than by the sole crops. Pea increased the N derived from N-2 fixation by 50% when sole cropped to 99% of the total aboveground N accumulation when intercropped. However, based upon aboveground N accumulation the pea-barley intercrop yielded about 85 kg N ha(-1), which was about 65 kg lower than sole cropped pea but about three times greater than harvested in sole cropped barley. Despite different preceding crops and removal or incorporation of straw, there was no significant difference between the subsequent non-fertilized winter-rye grain yields averaging 2.8 Mg ha(-1), indicating an equalization of the quality of incorporated residue by the NO3- leaching pattern. NO3- leaching throughout the experimental period was 61 to 76 kg N ha(-1). Leaching dynamics indicated differences in the temporal N mineralization comparing lysimeters previously cropped with pea or with barley. The major part of this N was leached during autumn and winter. Leaching tended to be smaller in the lysimeters originally cropped with the pea-barley intercrops, although not significantly different from the sole cropped pea and barley lysimeters. Soil N balances indicated depletion of N in the soil-plant system during the experimental period, independent of cropping system and residue management. N complementarity in the cropping system and the synchrony between residual N availability and crop N uptake is discussed.

Evaluating effects of sewage sludge and household compost on soil physical, chemical and microbiological properties

Recycling of organic wastes within agriculture may help maintain soil fertility via effects on physical, chemical and biological properties. Efficient use, however, requires an individual assessment of waste products, and effects should be compared with natural variations due to climate and soil type. An 11-month incubation experiment was conducted between April 1998 and March 1999, in which a sandy loam without or with anerobically digested sewage sludge (4.2 t dry matter (DM) ha(-1)) or household compost (17 t DM ha(-1)) was incubated under constant laboratory conditions at 10 degreesC, as well as in the field. The following properties were monitored: wet-stability of soil aggregates, clay dispersibility, hot-water extractable carbohydrates, resin-extractable P-i, inorganic N, biomass C and N, PLFA profiles, FDA hydrolysis activity, beta-glucosidase activity and CO2 evolution. In general, effects of waste amendment were positive, but moderate compared to the dynamics observed in unamended soil, and mainly occurred in the first several weeks after amendment. The temporal dynamics of inorganic N, FDA hydrolysis activity, biomass C and PLFA composition appeared to be faster under the fluctuating climatic conditions in the field. To evaluate accumulated effects of repeated waste applications, soil was also sampled from a field trial, in which the sewage sludge and household compost had been applied at the same rates as in the incubation study for three consecutive years. Sampling took place after the final harvest, i.e. 5 months after the final waste application. Compost amendment had increased potentially mineralizable N by a factor of 1.8, and sludge amendment had increased the amount of resin-extractable P-i by a factor of 1.6. However, there were no accumulated...
effects of waste amendment on the fraction of soil in wet-stable aggregates, or on the microbiological properties tested, which supported the observation from the incubation study that effects of organic wastes were transient. (C) 2002 Elsevier Science B.V. All rights reserved.

**General information**
Publication status: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Deboz, K., Petersen, S., Kure, L., Ambus, P.
Pages: 237-248
Publication date: 2002
Peer-reviewed: Yes

**Publication information**
Journal: Applied Soil Ecology
Volume: 19
Issue number: 3
ISSN (Print): 0929-1393
Ratings:
Web of Science (2002): Indexed yes
Original language: English
DOIs: 10.1016/S0929-1393(01)00191-3
Source: orbit
Source ID: 303775
Research output: Contribution to journal › Journal article – Annual report year: 2002 › Research › peer-review

**Greenhouse gas emission from agricultural and forest soils**

**General information**
Publication status: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Ambus, P.
Publication date: 2002
Peer-reviewed: No
Event: Abstract from PLE-Symposium on Climate Change and Plant-Ecosystem Interactions, Risø, Denmark.
Source: orbit
Source ID: 303834
Research output: Contribution to conference › Conference abstract for conference – Annual report year: 2002 › Research

**Gross N transformation rates after application of household compost or domestic sewage sludge to agricultural soil**
Gross N mineralization and immobilization was examined in soil amended with compost and sewage sludge on seven occasions during a year using N-15 pool dilution and enrichment techniques. Gross N mineralization was initially stimulated with both wastes and accelerated through the first 112 days of incubation, peaking at 5 mg N.kg(-1).d(-1) with compost compared with 4 mg N.kg(-1).d(-1) in control and sludge-treated soil. The magnitudes of mineralization rates exceeded those of immobilization by on average 6.3 (compost) and 11.4 (sludge) times, leading to a persistent net N mineralization cumulating up to 160 mg N.kg(-1) soil(compost) and 54 mg N.kg(-1) soil (sludge) over the season from May to November. The numerical model FLUAZ comprehensively predicted rates of gross mineralization and immobilization. Sludge exhibited an early season N-release, whereas compost released only 10% of the N during the first two months of incubation. This indicates that compost should be applied well in advance of sowing in order to match crop N demands.

**General information**
Publication status: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Ambus, P., Kure, L., Jensen, E.
Pages: 723-730
Publication date: 2002
Peer-reviewed: Yes

**Publication information**
Journal: Agronomie
Volume: 22
Issue number: 7-8
Original language: English
DOIs:
Natural carbon isotopes used to study methane consumption and production in soil
Changes in the isotopic composition of carbon can be used to reveal simultaneous occurrence of methane production and oxidation in soil. The method is conducted in laboratory jar experiments as well as in the field by using flux chambers. Simultaneous occurrence of production and oxidation of methane was suggested.

Photorespiration contributes to stomatal regulation and carbon isotope fractionation. A study with barley, potato and Arabidopsis plants deficient in the glycine decarboxylase

Production of N₂O in grass-clover pastures
Sources of N$_2$O in organic grass clover-pastures

**General information**
Publication status: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Ambus, P.
Publication date: 2002
Peer-reviewed: No
Source: orbit
Source ID: 304262
Research output: Contribution to conference › Conference abstract for conference – Annual report year: 2002 › Research

Undersøgelse af kvælstofbinding og lattergas fra kløvergræsmarker

**General information**
Publication status: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Ambus, P.
Publication date: 2002
Peer-reviewed: Unknown
Publication information
Journal: Økologisk Jordbrug
Issue number: 265
ISSN (Print): 0904-0595
Original language: Danish
URLs:
http://www.foejo.dk/aktuelt/ambus.html
Source: orbit
Source ID: 304263
Research output: Contribution to journal › Journal article – Annual report year: 2002 › Communication

Assessment of CH$_4$ and N$_2$O fluxes in a Danish Beech (Fagus sylvatica) forest and an adjacent N-fertilised barley (Hordeum vulgare)

Fluxes of CH$_4$ and N$_2$O were measured regularly in an agricultural field treated with 280 g m$^{-2}$ of sewage sludge. In a nearby beech forest N2O and CH$_4$ fluxes were measured in a well-drained (dry) area and in a wet area adjacent to a drainage canal. We observed brief increases of both CH$_4$ and N2O emissions immediately following soil applications of digested sewage sludge. Cumulated values for CH$_4$ emissions over the course of 328 days after sludge applications indicated a small net source in sludge treated plots (7.6 mg C m$^{-2}$) whereas sludge-free soil constituted a small sink (-0.9 mg C m$^{-2}$). The CH$_4$ emission amounted 0.01% of the sludge-C. Extrapolated to current rates of sludge applications in Danish agriculture this amounts to 0.1% of the total agricultural derived CH$_4$. Sludge applications did not affect cumulated fluxes of N$_2$O showing 312 mg N$_2$O-N m$^{-2}$ and 304 mg N m$^{-2}$ with and without sludge, respectively. Four months after the sludge applications a significant effect on CO2 and NO emissions was still obvious in the field, the latter perhaps due to elevated nitrification. Nitrous oxide emission in the beech forest was about six times smaller (45 mg N m$^{-2}$) than in the field and independent of drainage status. Methane oxidation was observed all-year round in the forest cumulating to -225 mg C m$^{-2}$ and -84 mg C m$^{-2}$ in dry and wet areas. In a model experiment with incubated soil cores, nitrogen amendment (NH$_4$Cl) and perturbation significantly reduced CH$_4$ oxidation in the forest soil, presumably as a result of increased nitrification activity. Sludge also induced net CH$_4$ production in the otherwise strong CH$_4$ oxidising forest soil. This emphasises the potential for CH$_4$ emissions from sewage sludge applications onto land. The study shows, however, that emissions of N$_2$O and CH$_4$ induced by sewage sludge in the field is of minor importance and that factors such as land use (agriculture versus forest) is a much stronger controller on the source/sink strengths of CH$_4$ and N$_2$O.

**General information**
Publication status: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Ambus, P., Jensen, J., Prieme, A., Pilegaard, K., Kjøller, A.
Pages: 15-21
Crop residue management strategies to reduce N-losses - Interaction with crop N supply

Degradation and plant uptake of organic contaminants in spiked soils and in soils treated with organic waste products

Denmark (DK)
Fluxes of $\text{NO}_3^-$, $\text{NH}_4^+$, NO, $\text{NO}_2$, and $\text{N}_2\text{O}$ in an old Danish beech forest

General information
Publication status: Published
Organisations: Risø National Laboratory for Sustainable Energy
Pages: 187-195
Publication date: 2001
Peer-reviewed: Yes

Publication information
Journal: Water Air Soil Pollut. Focus
Volume: 1
Issue number: 1
Original language: English
Source: orbit
Source ID: 302612
Research output: Contribution to journal › Journal article – Annual report year: 2001 › Research › peer-review

Gross N transformations after applications of domestic sewage sludge and household compost on agricultural soils

General information
Publication status: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Ambus, P., Kure, L., Jensen, E.
Pages: 19-20
Publication date: 2001
Peer-reviewed: Yes

Publication information
Journal: Journal of Environmental Quality
Volume: 30
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Scopus rating (2001): SJR 1.542 SNIP 1.546

Influence of plant growth on degradation of linear alkylbenzene sulfonate in sludge-amended soil

General information
Publication status: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Mortensen, G., Egsgaard, H., Ambus, P., Jensen, E., Grøn, C.
Pages: 1266-1270
Publication date: 2001
Peer-reviewed: Yes

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Journal: Journal of Environmental Quality
Volume: 30
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Ratings:
Scopus rating (2001): SJR 1.542 SNIP 1.546
Interspecific competition, N use and interference with weeds in pea-barley intercropping

General information
Publication status: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Hauggaard-Nielsen, H., Ambus, P., Jensen, E.
Pages: 101-109
Publication date: 2001
Peer-reviewed: Yes

Publication information
Journal: Field Crops Research
Volume: 70
ISSN (Print): 0378-4290
Ratings:
Scopus rating (2001): SJR 0.972 SNIP 1.373
Web of Science (2001): Indexed yes
Original language: English
Source: orbit
Source ID: 302396
Research output: Contribution to journal › Journal article – Annual report year: 2001 › Research › peer-review

Klimaforandringer effekt på det globale kulstofkredsløb

General information
Publication status: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Mikkelsen, T. N., Beier, C., Ambus, P., Bruhn, D., Pilegaard, K.
Pages: 8-13
Publication date: 2001
Peer-reviewed: Unknown

Publication information
Journal: Risønyt
Issue number: 4 (temanummer om bioproduktion)
Original language: Danish
URLs:
Source: orbit
Source ID: 303399
Research output: Contribution to journal › Journal article – Annual report year: 2001 › Communication

Nedbrydning af miljøfremmede stoffer i jord-plantesystemer og optag i planter

General information
Publication status: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Mortensen, G., Kure, L., Ambus, P., Laturnus, F., Grøn, C.
Pages: 9-11
Publication date: 2001
Peer-reviewed: Unknown

Publication information
Journal: Miljøforskning
Issue number: 49
ISSN (Print): 0907-4678
Original language: Danish
Nitrous oxide and N-leaching losses from agricultural soil: Influence of crop residue particle size, quality and placement

Incorporation of crop residues provides a source of readily available C and N, and previous works indicate that farming strategies where crop residues are used for soil fertility purposes may lead to increased emissions of N2O. Information on the importance of different residue management on the potential for N2O emissions, however, is missing. The objectives of this work were to determine the short-term effects of crop residue particle size and spatial distribution on soil-atmosphere fluxes of N2O. Implications for leaching losses of inorganic N were also assessed. The work included an experiment with lysimeters incubated in the field and an experiment with soil incubated under controlled conditions. The results show that finely ground pea material (<3 mm) evolved 50 % more N2O (33.8 mg N m(-2)) than coarse particles (25 mm) of pea material (22.7 mg N m(-2)) and twice as much N2O as residue-free soil (16.5 mg N m(-2)). Barley material, on the other hand, did not influence N2O emissions regardless of particle size (10-17 mg N m(-2)). The lack of N2O evolution with barley residue was likely due to N-limitations whereas with N-rich pea material the particle size obviously controlled N-availability. Carbon dioxide evolution increased about three-fold both with barley and pea residue, but apart from a transient initial depression in CO2 evolution with <3 mm particles there was no overall effect of particle size on CO2 evolution. Very likely the grinding to <3 mm was inadequate to achieve soil physical protection of the crop residue material against microbial attack. Leaching of N tended to be reduced about 40 % with barley and 20 % with pea, but the numbers were not significantly different from residue-free soil, which leached 4.7-4.9 g N m(-2). When wheat and alfalfa residues were mixed into the soil N2O emissions increased 6.5 and 1.6 times, respectively, compared with residue placed in a layer. Wheat residue in a layer evolved 3.4-times less N2O than alfalfa in a layer, whereas when mixed the two residue types evolved similar amounts of N2O. This difference was probably due to N-limitations in localised zones around the layered wheat. The results from this study should be extrapolated to the Field situation only after very careful consideration. Nevertheless, the study emphasizes the potential for residue management to restrain N2O emissions from agricultural soils. From a N2O mitigation point of view, incorporating of residues with low N-contents is advantageous over a homogeneous mixing of N-rich materials into the soil.

General information
Publication status: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Ambus, P., Jensen, E., Robertson, G.
Pages: 7-15
Publication date: 2001
Peer-reviewed: Yes

Plant uptake of LAS and DEHP from sludge amended soil

General information
Publication status: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Grøn, C., Laturnus, F., Mortensen, G., Egsgaard, H., Samsøe-Petersen, L., Ambus, P., Jensen, E.
Pages: 99-111
Publication date: 2001

Host publication information
Title of host publication: Persistent, bioaccumulative, and toxic chemicals. Vol. 1. Fate and exposure
Volume: 772
Place of publication: Washington, DC
Publisher: American Chemical Society
Editors: Lipnick, R., Hermens, J., Jones, K., Muir, D.
Temporal and spatial distribution of roots and competition for nitrogen in pea-barley intercrops - a field study employing P-32 technique

Root system dynamics, productivity and N use were studied in inter- and sole crops of field pea (Pisum sativum L.) and spring barley (Hordeum vulgare L.) on a temperate sandy loam. A P-32 tracer placed at a depth of 12.5, 37.5, 62.5 or 87.5 cm was employed to determine root system dynamics by sampling crop leaves at 0, 15, 30 and 45 cm lateral distance. N-15 addition was used to estimate N-2 fixation by pea, using sole cropped barley as reference crop. The Land Equivalent Ratio (LER), which is defined as the relative land area under sole crops that is required to produce the yields achieved in intercropping, were used to compare the crop growth in intercrops relative to the respective sole crops.

The P-32 appearance in leaves revealed that the barley root system grows faster than that of pea. P uptake by the barley root system during early growth stages was approximately 10 days ahead of that of the pea root system in root depth and lateral root distribution. More than 90% of the P uptake by the pea root system was confined to the top 12.5 cm of soil, whereas barley had about 25-30% of tracer P uptake in the 12.5 - 62.5 cm soil layer. Judging from this P uptake, intercropping caused the barley root system to grow deeper and faster lateral root development of both species was observed. Barley accumulated similar amounts of aboveground N when grown as inter- and sole crop, whereas the total aboveground N acquired by pea in the intercrop was only 16% of that acquired in the pea sole crop. The percentage of total aboveground N derived from N-2 fixation in sole cropped pea increased from 40% to 80% during the growth period, whereas it was almost constant at 85% in intercropped pea. The total amounts of N-2 fixed were 95 and 15 kg N ha(-1) in sole cropped and intercropped pea, respectively. Barley was the dominant component of the pea-barley intercrop, obtaining 90% of its sole crop yield, while pea produced only 15% of the grains of a sole crop pea. Intercropping of pea and barley improved the utilization of plant growth resources (LER > 1) as compared to sole crops. Root system distribution in time and space can partly explain interspecific competition. The P-32 methodology proved to be a valuable tool for determining root dynamics in intercropping systems.

Uptake and metabolization of sewage sludge associated organic contaminants in crop plants

General information
Publication status: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Hauggaard-Nielsen, H., Ambus, P., Jensen, E.
Pages: 63-74
Publication date: 2001
Peer-reviewed: Yes

Publication information
Journal: Plant and Soil
Volume: 236
Issue number: 1
ISSN (Print): 0032-079X
Ratings:
Scopus rating (2001): SJR 0.976 SNIP 1.198
Web of Science (2001): Indexed yes
Original language: English
DOIs: 10.1023/A:1011909414400
Source: orbit
Source ID: 302959
Research output: Contribution to journal › Journal article – Annual report year: 2001 › Research › peer-review

Uptake and metabolization of sewage sludge associated organic contaminants in crop plants
A $^{15}$N pool dilution approach to measure field gross N transformations following applications of domestic sludge and compost on to soils

**General information**
Publication status: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Ambus, P., Kure, L., Jensen, E.
Publication date: 2000
Peer-reviewed: No
Source: orbit
Source ID: 302054

Degradation of chlorinated solvents in unsaturated soils

**General information**
Publication status: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Borch, T., Ambus, P., Laturnus, F., Svensmark, B., Gren, C.
Pages: 767-768
Publication date: 2000

Fluxes of CH$_4$ and N$_2$O from soils with accelerated inputs of C and N: Influence of sewage sludge and inorganic fertilizer

**General information**
Publication status: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Ambus, P.
Publication date: 2000
Peer-reviewed: No
Event: Abstract from Meeting at Environmental Institute, Joint Research Centre, Ispra (IT), 24-25 Feb.
Source: orbit
Source ID: 302088

Hvordan kan det økologiske jordbrug producere større mængder foderkorn og protein

**General information**
Publication status: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Hauggaard-Nielsen, H., Ambus, P., Jensen, E.
Pages: 14-15
Publication date: 2000
Peer-reviewed: Unknown

Publication information
Journal: Økologisk Jordbrug
Issue number: 218
Miljøfremmede stoffers omsætning i jord og optag i planter

General information
Publication status: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Mortensen, G., Kure, L., Ambus, P., Laturnus, F., Grøn, C.
Pages: 143-147
Publication date: 2000
Peer-reviewed: No

Publication information
Journal: Vand & Jord
Volume: 7
ISSN (Print): 0908-7761
Original language: Danish
Source: orbit
Source ID: 301824
Research output: Contribution to journal › Journal article – Annual report year: 2000 › Research

Miljøfremmede stoffers omsætning og optag i planter

General information
Publication status: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Mortensen, G., Kure, L., Ambus, P., Laturnus, F., Grøn, C.
Publication date: 2000
Peer-reviewed: No
Event: Abstract from DAKOFA-konference om genanvendelse af organiske restprodukter i jordbrug, København (DK), 15 May, .
Source: orbit
Source ID: 301280
Research output: Contribution to conference › Conference abstract for conference – Annual report year: 2000 › Research

Modelling methane concentration and isotopic composition in soil

General information
Publication status: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Ambus, P., Andersen, B., Kemner, M., Arp, T., Ringgård, T.
Publication date: 2000
Peer-reviewed: No
Event: Abstract from 2. International conference on applications of stable isotope techniques to ecological studies, Braunschweig (DE), 8-11 May, .
Source: orbit
Source ID: 302052
Research output: Contribution to conference › Conference abstract for conference – Annual report year: 2000 › Research

Overvurderer VMP II nitratreduktionen i vådområder?

General information
Publication status: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Færge, J., Bastiansen, S., Højlund, L., Dam, R., Ambus, P.
Pages: 84-87
Publication date: 2000
Peer-reviewed: No
Prospects for manipulating crop residues to control nitrogen mineralisation-immobilisation in soil

General information
Publication status: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Jensen, E., Ambus, P.
Pages: 25-42
Publication date: 2000
Peer-reviewed: No

Removal of organic contaminants by crops grown in agricultural soil after sewage sludge application

General information
Publication status: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Laturnus, F., Mortensen, G., Grøn, C., Kure, L., Ambus, P.
Publication date: 2000
Peer-reviewed: No
Source: orbit
Source ID: 300986
Research output: Contribution to conference › Conference abstract for conference – Annual report year: 2000 › Research

Uptake of sewage sludge associated organic contaminants in crop plants

General information
Publication status: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Kure, L., Mortensen, G., Laturnus, F., Ambus, P.
Publication date: 2000
Peer-reviewed: No
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Source ID: 300987
Research output: Contribution to conference › Conference abstract for conference – Annual report year: 2000 › Research

Uptake of sewage sludge associated organic contaminants in crop plants

General information
Publication status: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Kure, L., Mortensen, G., Ambus, P.
Publication date: 2000
Peer-reviewed: No
Using $^{32}$P methodology to elucidate root distribution and competition for nutrients in intercropped plant communities

Bland afgrøderne og høst mange fordele

Degradation of organic contaminants in sludge-amended agricultural soil

Fluxes of CH$_4$ and N$_2$O in aspen stands grown under ambient and twice-ambient CO$_2$
oxidation activity was significantly (P < 0.05) greater with ambient CO2 (8.7 μg CH4-C m(-2) h(-1)) than with elevated CO2 (6.5 μg CH4-C m(-2) h(-1)) in the low N soil. Likewise, across dates and soil N treatments CH4 was oxidized more rapidly (P < 0.05) in chambers with ambient CO2 (9.5 μg CH4-C m(-2) h(-1)) than in chambers with elevated CO2 (8.8 μg CH4-C m(-2) h(-1)). Methane oxidation in soils incubated in serum bottles did not show any response to the CO2 treatment. We suggest that the depressed CH4 oxidation under elevated CO2 in the field chambers is due to soil moisture which tended to be higher in the twice-ambient CO2 treatment than in the ambient CO2 treatment.

Phase I denitrification (denitrification enzyme activity) was 12-26% greater under elevated CO2 than under ambient CO2 in the ‘high’ N soil; one sampling, however, showed a 39% lower enzyme activity with elevated CO2. In both soil N treatments, denitrification potentials measured after 24 or 48 h were between 11% and 21% greater (P < 0.05) with twice-ambient CO2 than with ambient CO2. Fluxes of N2O in the open-top chambers and in separate 44 cm(2) cores +/−N fertilization were not affected by CO2 treatment and soil N status.

Our data show that elevated atmospheric CO2 may have a negative effect on terrestrial CH4 oxidation. The data also indicated temporary greater denitrification with elevated CO2 than with ambient CO2. In contrast, we found no evidence for altered fluxes of N2O in response to increases in atmospheric CO2.

Fluxes of NO3−, NH4+, NO, NO2, HNO3−, N2O and organic N in an old Danish beech forest

Improved use of N sources by pea-barley intercropping in low-input systems
Intercropping of pea and barley to improve nitrogen use-efficiency in low-input agricultural systems

General information
Publication status: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Hauggaard-Nielsen, H., Ambus, P., Jensen, E.
Publication date: 1999

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Place of publication: Copenhagen
Publisher: Royal Veterinary and Agricultural University
Source: orbit
Source ID: 299047
Research output: Chapter in Book/Report/Conference proceeding → Conference abstract in proceedings → Annual report year: 1999 → Research

Methane emissions in sewage sludge amended agricultural soil and a nearby beech forest site

General information
Publication status: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Milandt, J., Ambus, P.
Publication date: 1999
Peer-reviewed: No
Source: orbit
Source ID: 299069
Research output: Contribution to conference → Conference abstract for conference → Annual report year: 1999 → Research

Planteoptag af miljøfremmede, organiske stoffer fra slam

General information
Publication status: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Grøn, C., Rasmussen, D., Samsøe-Petersen, L., Mortensen, G., Laturnus, F., Ambus, P., Jensen, E. S., Vejrup, K., Plöger, A.
Publication date: 1999

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Place of publication: København
Publisher: Miljøstyrelsen
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Original language: Danish
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URLs:
http://www.mst.dk/199911publikat/87-7909-363-9/default.htm
Source: orbit
Source ID: 299064
Research output: Book/Report → Book → Annual report year: 1999 → Research → peer-review

Plant uptake and soil degradation of organic contaminants in sludge amended soil

General information
Research on organic contaminants in soil-plant systems

General information
Publication status: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Grøn, C., Laturnus, F., Mortensen, G., Egsgaard, H., Bennetzen, S., Ambus, P., Jensen, E.
Publication date: 1999
Peer-reviewed: No

Volume: 217
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Original language: English
Source: orbit
Source ID: 300448
Research output: Contribution to journal › Journal article – Annual report year: 1999 › Research

Sewage sludge promotes growth of carrots and maintain a reduction of the inorganic N pool

General information
Publication status: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Laturnus, F., Grøn, C., Mortensen, G., Kure, L., Ambus, P.
Publication date: 1999
Peer-reviewed: No

Event: Abstract from Cost Action 837 meeting: Plant biotechnology for the removal of organic pollutants and toxic methods from waste water and contaminated sites, Chatham (GB), 4-5 Mar, .
Source: orbit
Source ID: 300570
Research output: Contribution to conference › Conference abstract for conference – Annual report year: 1999 › Research

Soil N dynamics as influenced by the spatial distribution of straw

General information
Publication status: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Ambus, P., Grøn, C., Jensen, E.
Publication date: 1999

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Title of host publication: Programme and abstracts. Vol. 1
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Publisher: Royal Veterinary and Agricultural University
Source: orbit
Source ID: 299045
Research output: Chapter in Book/Report/Conference proceeding › Conference abstract in proceedings – Annual report year: 1999 › Research

Host publication information
Title of host publication: Soil tillage and biology. Proceedings
Place of publication: Ås
Publisher: Agricultural University of Norway
Editor: Børresen, T.
(NJF-Utredning/Rapport, 124).
Source: orbit
Source ID: 299003
Trace gas fluxes from agricultural soil amended with sewage sludge

General information
Publication status: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Ambus, P., Milandt, J., Pilegaard, K., Priemé, A., Kjøller, A., Struwe, S.
Publication date: 1999
Peer-reviewed: No
Source: orbit
Source ID: 299071

Uptake and degradation of LAS in sludge amended and spiked soil - the importance of vegetation

General information
Publication status: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Mortensen, G., Egsgaard, H., Ambus, P., Grøn, C.
Publication date: 1999
Peer-reviewed: No
Event: Abstract from 9th Annual Meeting of SETAC-EUROPE, Leipzig, Germany.
Source: orbit
Source ID: 300248

Uptake of organic contaminants in plants

General information
Publication status: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Kure, L., Ambus, P., Jensen, E., Grøn, C.
Publication date: 1999
Peer-reviewed: No
Event: Abstract from 9th Annual Meeting of SETAC-EUROPE, Leipzig, Germany.
Source: orbit
Source ID: 299540

Automated near-continuous measurement of carbon dioxide and nitrous oxide fluxes from soil
Emission of nitric oxide (NO) and nitrous oxide (N₂O) from arable land

General information
Publication status: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Ambus, P.
Publication date: 1997
Peer-reviewed: No
Event: Abstract from EU-workshop, Petten (NL), 24 Oct, .
Source: orbit
Source ID: 296219

Nitrogen mineralization and denitrification as influenced by crop residue particle size
Managing the crop residue particle size has the potential to affect N conservation in agricultural systems. We investigated the influence of barley (Hordeum vulgare) and pea (Pisum sativum) crop residue particle size on N mineralization and denitrification in two laboratory experiments. Experiment 1: N-15-labelled ground (less than or equal to 3 mm) and cut (25 mm) barley residue, and microcrystalline cellulose+glucose were mixed into a sandy loam soil with additional inorganic N. Experiment 2: inorganic N-15 and C₂H₂ were added to soils with barley and pea material after 3, 26, and 109 days for measuring gross N mineralization and denitrification.

Net N immobilization over 60 days in Experiment 1 cumulated to 63 mg N kg⁻¹ soil (ground barley), 42 (cut barley), and 122 (cellulose+glucose). More N was seemingly net mineralized from ground barley (3.3 mg N kg⁻¹ soil) than from cut barley (2.7 mg N kg⁻¹ soil). Microbial biomass peaked at day 4 with the barley treatments and at day 14 with the cellulose+glucose whereafter the biomass leveled out at values 79 mg C kg⁻¹ (ground), 104 (cut), and 242 (cellulose+glucose) higher than for the control soil. Microbial growth yields were similar for the two barley treatments, ca. 60 mg C g⁻¹ substrate C added, which was lower than the 142 mg C g⁻¹ C added with cellulose+glucose. This suggests that the 75% (w/w) holocelluloses and sugars contained with the barley material remained physically protected despite grinding. In Experiment 2 gross mineralization on day 3 was 4.8 mg N kg⁻¹ d⁻¹ with ground pea, twice as much as for all other treatments. On day 26 the treatment with ground barley had the greatest gross N mineralization. In static cores ground barley denitrified 1.5-fold more than did cut barley, whereas denitrification was similar for the two pea treatments. In suspensions denitrification was similar for the two treatments both with barley and pea residue.

We conclude that the higher microbial activity associated with the initial decomposition of ground plant material is due to a more intimate plant residue-soil contact. On the long term, grinding the plant residues has no significant effect on N dynamics.

Production of N₂O in soil during decomposition of dead yeast cells with different spatial distributions
Production and Sources of N₂O were determined in soil columns amended with autoclaved yeast cells either mixed into or added as 0.5 cm³(3) lumps to the soil in combination with no or 200 µg NO₃-N(g⁻¹). At four occasions over a two-week study period, subsets of cores were measured for N₂O production during 4-hour incubations under atmospheres of ambient air, 10 Pa of C₂H₂, and N₂, respectively. Denitrification enzyme activity (DEA) was assessed in subsamples of cores that had been incubated continuously under air.
Autoclaved yeast provided a C-source readily available for denitrifying bacteria in the soil. Nitrous oxide production was negligible in unamended columns whereas accumulated N2O losses in the presence of yeast material were substantial, varying between 15 to 49 ng N2O-N g(-1) h(-1). Mixing yeast into the soil caused the highest production of N2O followed by the yeast lump and no yeast treatments. Incubation in the presence of 10 Pa C2H2 indicated that denitrification was the sole source of N2O, in accordance with an increase in DEA. Nitrous oxide production and DEA peaked after 4-7 days of incubation, and both were unaffected by additional NO3. Two to four-fold responses to anaerobiosis and accumulation of NO3- and NH4+ in proximity of the lumps indicated that N2O production here was limited by relatively low C-availability. In contrast, 10- to 12-fold responses to anaerobiosis and no accumulation of inorganic N suggested a higher C-availability where yeast was mixed into the soil.

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Publication status: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Ambus, P.
Pages: 7-12
Publication date: 1996
Peer-reviewed: No

Publication information
Journal: Plant and Soil
Volume: 181
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Original language: English
DOIs: 10.1007/BF00011285
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Source ID: 295017
Research output: Contribution to journal › Journal article – Annual report year: 1996 › Research

Measurement of N2O emission from a fertilized grassland: An analysis of spatial variability

General information
Publication status: Published
Organisations: Risø National Laboratory for Sustainable Energy
Contributors: Ambus, P., Christensen, S.
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Journal: Journal of Geophysical Research: Space Physics
Volume: 99
Issue number: D8
ISSN (Print): 2169-9380
Original language: English
Source: orbit
Source ID: 292871
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Micrometeorological and chamber methods for measurement of nitrous oxide fluxes between soils and the atmosphere. Overview and conclusions

General information
Publication status: Published
Organisations: Risø National Laboratory for Sustainable Energy
Pages: 16541-16548
Publication date: 1994
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Journal: Journal of Geophysical Research: Space Physics