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„Consequences of future precipitation patterns for agroecosystem C and N cycling - a stable isotope labelling study"

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1. Abstract

Zusammenfassung auf Deutsch

Niederschlagsmuster werden sich in Zukunft durch den Klimawandel ändern. Sie sind ein essentieller Parameter für die pflanzliche Produktion von Biomasse, da der Niederschlag die Prozesse der Mineralisation von organischem Material sowie die Freisetzung von Nährstoffen kontrolliert. Der Effekt zukünftiger Niederschlagsmuster wurde an zwei unterschiedlichen Bodentypen untersucht, seichtgründiger und tiefgründiger Tschernosem. Ein regional angepasstes Niederschlagsszenario, abgeleitet von Emissionen beschrieben im fünften IPCC Assessment Report (RCP 4.5 und RCP 8.5), wurden in einer Langzeit-Lysimeter Anlage in Wien untersucht.

Stabile Isotopenmarkierung ist ein geeignetes Verfahren um das Schicksal und das Verhalten von landwirtschaftlichen Böden zu analysieren. In dieser Studie wurde *Sinapis alba* (Gelber Senf) mit ^{13}C und ^{15}N stabilen Isotopen markiert und als Gründünger verwendet. Dieser Dünger wurde Lysimetern beigemischt, mit welchen zukünftige Niederschlagsszenarios mit gegenwärtigen Niederschlagsmustern verglichen wurden. Beide Szenarien wurden an zwei verschiedenen Bodentypen getestet.

Boden.-, Pflanzen.-, Gas.- und Grundwasserproben wurden zu unterschiedlichen Zeitpunkten während der gesamten Vegetationsperiode 2018 gesammelt und mithilfe von Isotopenmassenspektrometrie untersucht. Ergebnisse zeigen einen Rückgang in Pflanzenbiomasse des zukünftige Niederschlagsszenarios aufgrund von Trockenstress, was durch erhöhte Blatt $\delta^{13}C$ Werte im zukünftige Niederschlagsszenarios verglichen mit den gegenwärtigen Niederschlagsmustern festgestellt wurde. Mineralisation des Gründüngers und Aufnahme der Isotopenmarkierung in Bodenorganismen (^{13}C PLFA) begann innerhalb weniger Stunden nach der Applikation. Ergebnisse der Isotopenanalysen zeigen, dass die Mineralisation der Gründünger zu Beginn langsamer im zukünftige Niederschlagsszenarios ablaufen (Anorganisches Nitrat von Boden.- und Grundwasseranalysen, N_2O Emissionen), und dass sich dies während der Sommerzeit ändert. Diese Ergebnisse unterstreichen die Bedeutung der Produktion von Pflanzenbiomasse für die Nährstoffaufnahme in landwirtschaftlichen Systemen.

Zusammenfassend zeigt diese Studie, dass landwirtschaftliche Böden unterschiedlich auf veränderte Niederschlagsmuster reagieren. Außerdem wird die Bedeutung von interaktiven Prozessen zwischen Boden und Pflanzen hervorgehoben.

2. Introduction

Changes in climate have already caused impacts on both humans and ecosystems worldwide. Greenhouse gas emissions continue to increase, bringing along changes in global temperature and precipitation patterns, which can cause irreversible ecological damage (IPCC 2014). Extreme weather events such as extended drought periods and heavy rainfall events have already caused problems over the past decade, and they will most likely be more frequent in the future (Coumou and Rahmstorf 2012). For Europe, climate models predict an increase in precipitation amounts for the northern region and a decrease for the south, whereas for continental Europe patterns vary seasonally as well as regionally. As changes of average precipitation will not be uniform, with some areas experiencing an increase and others a decrease or sometimes even no change at all, regional climate models are used for developing proper mitigation strategies against effects of climate change locally (IPCC 2007, 2014).

Agriculture and climate change in Austria

Since the 1880s, Austria has experienced an increase in temperature by almost 2 °C, compared to a global temperature increase of 0.85 °C. In the future a further temperature increase is expected, accompanied by changes in rainfall amounts and patterns. In Austria, precipitation patterns of the previous 150 years show significant regional differences: in western Austria, an increase in annual precipitation of about 10-15 % was registered, compared to southeast Austria, where a decrease occurred, in a similar order of magnitude. Climate models show no clear trend for average annual rainfall; however, seasonal rainfall patterns show higher precipitations during the winter months while in the summer months rainfall will most likely decline. Moreover, models predict more extreme precipitation events, such as fewer but more intensive rainfalls, which lead to prolonged drought periods in summer and autumn and a decrease in soil moisture content (APCC 2014; Synthesis Report). In recent studies, a link between changes in soil moisture and extreme temperatures has been shown, resulting in more prolonged and intense heat waves (Christensen et al. 2013; Jaeger and Seneviratne 2011).

Climate change will also increase the water demand for agricultural crops in the long run. In Austria, crops are mainly rain-fed, except east and southeast Austria, where water for irrigation is already applied nowadays (APCC 2014). Especially summer crops will be affected by drought, and even more so in low precipitation regions, such as in the Pannonian area. The Marchfeld region in Austria is one of the most agriculturally fertile areas with high yields for cereals and vegetables. However, the Marchfeld receives less precipitation compared to other productive areas in Austria, and this, along with heat stress and extreme weather events will most likely affect the water balance and therefore have a negative impact on crop yields. In the Marchfeld, crop irrigation is well established, and in the future, additional irrigation will most probably be needed to sustain current food production, which could negatively affect the groundwater tables, local water availability and nutrient leaching (J Eitzinger et al. 2008; Josef Eitzinger 2010; Niedermayr et al. 2018). Winter crops, however, could benefit from increased soil moisture during winter months and improve their water use efficiency, and this, along with elevated CO_2 concentrations can lead to increased plant growth in the future (Stöckle et al. 2018).

Plant production and drought

Drought represents a threat to plant production; it influences the soil water availability, which plays an essential role in biochemical processes and plant nutrient acquisition (Briffa, van der Schrier, and Jones 2009; S. Lisar et al. 2012). Furthermore, under drought stress plants close their stomata to reduce their water loss, and thus by lowering their stomatal conductivity, they also reduce their photosynthetic carbon (C) uptake, which further decreases plant growth due to reduced photosynthesis (Arve et al. 2016). Though drought stress seems to be less critical for plant production and nutrient cycling when compared to overwatering (Wu et al. 2011), the impact of drought over long periods is still not well understood (McDowell et al. 2011). Apart from changes in soil water availability, soil characteristics along with plant species and cultivars and plant-soil-microbes interactions also influence plant production when crops are exposed to changing rainfall patterns. For example, Tataw et al. (2016) showed that soil type could significantly alter the response of crop yields to changing precipitation regimes. Plants and microorganisms (MOs) often form symbiotic relationships and benefit from each other, as plants release organic compounds (root exudates) into the soil that can be utilised by microorganisms, whereas MOs can degrade soil organic matter (SOM) and rapidly mobilise plant-available nutrients such as nitrogen (N) and phosphorus (P), thus facilitating plant growth. However, in nutrient-limited soils, plants and microbes can also compete for nutrients (Paterson 2003). MOs are, therefore, crucial for plant productivity, and drought likely affects the soil microbial community and its activity, which is essential for soil nutrient transformations (Fuchslueger et al. 2014). Plant production is essential for future food security, and changes in climate have already caused impacts not only on the quantity but also on the quality of food, which are determining factors for market crop prices and human well-being (Porter et al. 2015).

Soil carbon and nitrogen cycling in a changing climate

Soil C and N play a crucial role in soil biogeochemical cycles, as they influence (I) soil organic C storage, as atmospheric CO_2 is stored in soils after plant fixation and microbial metabolism, (II) soil microbial communities as they mineralise both organic C and N, (III) atmospheric gas exchange as soils have the potential to release potential greenhouse gases (GHG) such as CO_2, CH_4 and N_2O, and (IV) nutrient availability, especially N, as it represents a major plant nutrient and can influence the soil C sequestration process (C: N ratio) (Fuchslueger et al. 2019; LeBauer and Treseder 2008). Plants can take up N as organic N, e.g. as amino acids from soils; however inorganic N (NO_3^-, NH_4^+) is the preferred plant N source as it can be taken up by roots from soil solution (Gärdenäs et al. 2011). The soil C budget is influenced by changes plant and microbial biomass production and in soil respiration and therefore has a direct impact on climate, as soils represent a major C sink for atmospheric CO_2 (IPCC 2007, 2014).

Changes in climate will most likely alter decomposition rates of organic matter, either through direct effects such as changes in temperature and soil water content, or through indirect effects on soil biota, by changes in plant inputs by root and crop residues and changes in soil structure, thereby affecting soil – microbe - plant interactions (Classen et al. 2015). Soil moisture is an important parameter which controls nutrient cycling and therefore, processes of litter decomposition (Moro and Domingo 2000). Changes in both temperature and precipitation amount will influence soil water availability: less rainfall will reach the soil surface, and, at the same time, evaporation will increase as temperatures rise (Briffa, van der Schrier, and Jones 2009). Very often, a decrease in soil water availability will have a negative impact on litter decomposition and respiration rates (Bontti et al. 2009; Lensing and Wise 2007; van Meeteren et al. 2008; Risch, Jurgensen, and Frank 2007). Furthermore, soil biodiversity tends to decrease under drought conditions. (Sharma and Gobi 2016), which will further influence the cycling of C and N.

Soil amendments such as green manures (plant residues) are often added to increase soil fertility (Singh and Rengel 2007). Mineralisation of newly added organic matter will influence the soil C budget as well as nutrient availability of soils and is also susceptible to climate change. High input of organic matter accompanied by slow decomposition rates will lead to an increase in soil C storage, which could slow down climate change through C sequestration (Lal 2004). However, slow mineralisation also means a slow release of nutrients, which will negatively impact plant growth as well as microbial community activity. Furthermore, N is of particular importance as it can become the limiting nutrient for plant growth and soil processes;

as atmospheric CO_2 increases, the C: N ratio of plants and microbes will also change (Soussana and Lüscher 2007).

In general, soils react slowly to changes in climate, and usually, changes in temperature and precipitation patterns have a higher impact on agricultural soils compared to grassland soils (APCC 2014). Moreover, agricultural practices can influence the SOM mineralisation process, and on a local scale even mitigate the effects of climate change (Kaisermann et al. 2013). Therefore, long-term local soil manipulation experiments are required to assess the sensitivity of SOM decomposition and nutrient turnover rates concerning future food security.

Aim and hypothesis

This research project aims to assess the precipitation patterns affecting the mineralisation process of green manure in model agroecosystems with regard to C and N cycling, by using different agricultural soils and simulating future/drier precipitation patterns of the Marchfeld region. One of the objectives of this study was to determine which process has a higher impact on organic matter turnover under future precipitation patterns, whether it is impeded plant biomass production or delayed mineralisation. In order to evaluate the fate of SOM under different precipitation conditions, green manure labelled with the stable isotopes ^{13}C and ^{15}N was applied to the soils and traced in plants, bulk soils, soil MOs, inorganic and organic N, as well as in N_2O gas emissions. Furthermore, crop biomass was assessed for differences in yield between the two treatments.

Hypothesis to be tested:

(i) The turnover of C and N will be slower under decreased rainfall due to decreased soil water availability.

(ii) Uptake of ^{13}C and ^{15}N will be lower for MOs under drought stress compared to well-watered control communities.

(iii) Altered release and transformation of nutrients will change the soil fertility and therefore affect plant productivity.

(iv) Decreased plant production will impact the cycling of soil C and N.

3. Materials and Methods

All used chemicals were of the highest purity, and all solutions were freshly prepared using pure deionized MilliQ water. Microsoft Excel Office 365 and IBM SPSS Statistics 24 were used for assessing the results.

3.1 Study site

The experiment took place at the lysimeter station at Ages (Austrian Agency for Health and Food Safety), located in Hirschstetten, Vienna, Austria (48° 15' 22" N, 16° 289 3" E, 160 m a.s.l.). The station offers the possibility to investigate the impact of precipitation on soil/plant systems in the field under changing climatic conditions since 1995. Field measurements and sampling were carried out at the lysimeter station, which consists of three different soil types, namely sandy calcaric Phaeozem, calcic Chernozem and gleyic Phaeozem, representing the dominant soil types of the Marchfeld region in Austria. Soil characteristics can be found in **Table 3.1** and in Tataw et al. (2014).

Soil Parameters	Calcaric phaeozem	Calcic chernozem
pH ($CaCl_2$)	7.93 ± 0.02	7.94 ± 0.03
Calcium carbonate (%)	13.9 ± 0.3	20.9 ± 0.9
Phosphor (mg kg^{-1})	134.3 ± 3.5	81.0 ± 5.7
Potassium (mg kg^{-1})	57.0 ± 7.8	73.5 ± 7.3
Total Organic Carbon (%)	1.13 ± 0.05	2.91 ± 0.03
Humus content (%)	1.93 ± 0.11	5.03 ± 0.04
Total Nitrogen (%)	0.10 ± 0.004	0.22 ± 0.004
Nitrogen, mineralisation (mg kg^{-1} 7 $days^{-1}$)	37.5 ± 5.0	59.2 ± 4.1
Calcium (cmolc kg^{-1})	10.8 ± 0.2	22.7 ± 0.4
Magnesium (cmolc kg^{-1})	2.48 ± 0.12	5.39 ± 0.20
Sodium (cmolc kg^{-1})	0.32 ± 0.04	0.59 ± 0.07
Cation Exchange Capacity (cmolc kg^{-1})	13.8 ± 0.3	28.9 ± 0.3
C:N ratio	11.1 ± 0.3	12.9 ± 0.2

Table 3.1 Characteristics of the two experimental soil types at the lysimeter station analysed by AGES in 2019 and used in this specific study. Values represent means ± SD, n=3.

For this experiment, only two of the three soil types were used, the sandy calcaric Phaeozem (S) and the calcic Chernozem (T), in a total of 12 lysimeters arranged in two rows – making a total of two soil types, two treatments, and three replicates each. Each lysimeter has a surface area of 3.02 m^2 and a soil depth of 2.45 m. The station is situated under a tunnel covered with transparent plastic foil during the vegetation period to exclude natural precipitation and allow controlled irrigation and is usually left open during winter time for technical reasons (freezing water pipes). Six of the studied lysimeters were subjected to a current rainfall regime (control treatment) and the other six to a forecasted future rainfall regime (drought treatment).

The precipitation scenarios were calculated using the software LARS-WG (Version 3.0, Semenov and Barrow 2002) by Prof. Dr Herbert Formayer from the Institute of Meteorology and Climatology (BOKU-Met). The current rainfall pattern (control/reference) was calculated by averaging the amount and frequency of precipitation between the years 1971 - 2000 from a weather station in Grossenzersdorf, Marchfeld (approximately 10 km distant from the lysimeter station). Until the start of our experiment (2018), the remaining six lysimeters were watered according to precipitation patterns calculated based on local climatology and climate change predictions from the ensemble mean of the regional climate model scenarios from the EC-project ENSEMBLES (Chrisensen et al., 2007). Starting 2018 the future precipitation regime changed to a slightly more pessimistic scenario, calculated from four regionalised scenarios from Euro-Cordex (Jacob et al. 2014) out of the ÖKS 15 ensemble (Leuprecht et al. 2017), with different GHG emission scenarios (RCP 4.5 and RCP 8.5, IPCC 2014). **Figure 3.1** summarises the different precipitation patterns used at the lysimeter station before and during our experiments.

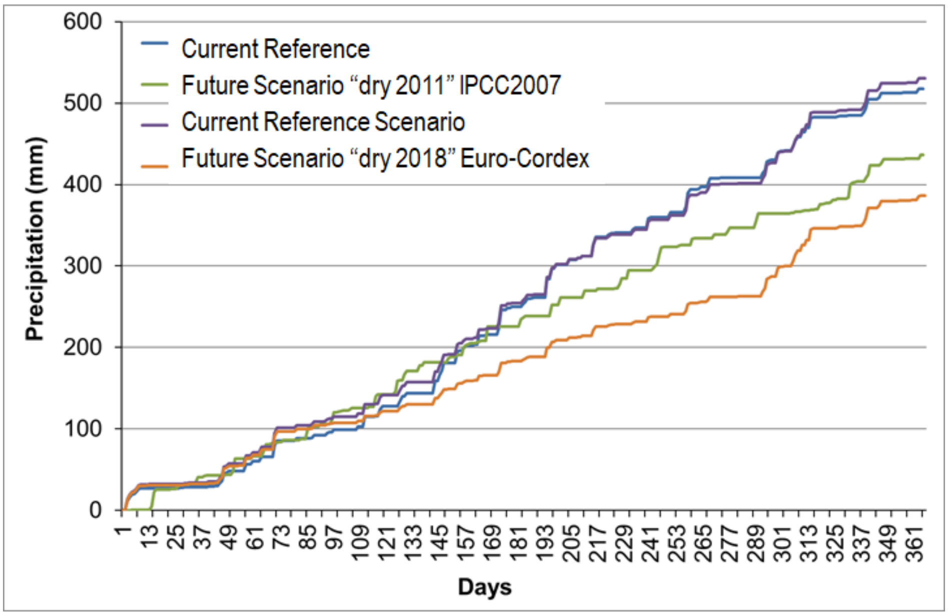

Figure 3.1. Precipitation patterns according to different scenarios.

3.2 Experimental design

Every year at the lysimeter station a crop rotation was applied between autumn/spring which corresponds to standard agricultural practice in the Marchfeld region. The crop rotation for the duration of the experiment included mustard as catch crop (summer-spring 2017) and barley (spring-summer 2018). Mustard was harvested, dried and used as a soil amendment on the seeding day of barley (09/04/2018). Plant residues of white mustard (*Sinapis alba*), labelled in a control laboratory environment with ^{13}C ($\delta^{13}C$ ~ 65 ± 12 ‰, n=4) and ^{15}N ($\delta^{15}N$ ~ 170 ± 10 ‰, n=4), were applied as organic fertilizer on a small framed portion of the lysimeters (0.2500 m^2), on 9th of April 2018, and distributed within the upper 10 cm of the topsoils. Inorganic N fertilizer was applied according to conventional agricultural practices on 08th of May 2018 (50 kg N /ha). A heavy rainfall event was simulated on 25th of April 2018 with precipitation reaching 60 mm. Rhizon samplers (10 cm soil depth) were buried within the labelled plots and were used for sampling of NO_3^- in the soil solution. As the lysimeter design permitted the collection of soil water at different soil depths, soil water samples were taken when available, specifically after the heavy rainfall simulation. Soil, plant and gas samples were collected from inside the labelled plots. Throughout this thesis, sampling times are referred to as days according to the table below.

Table 3.2. Timeline of the experiment including sampling events.

Date	**9/4/18**	**9/4/18**	**11/4/18**	**13/4/18**	**18/4/18**	**25/4/18**	**26/4/18**	**27/4/18**	**30/4/18**	**8/5/18**	**9/5/18**	**11/5/18**	**20/6/18**	**23/7/18**
days	0	6h	2d	4d	9d	16d	17d	18d	21d	29d	30d	32d	72d	105d
event	labelled material					heavy rainfall				commercial fertilizer				harvest
Soil	√	√	√	√	√				√			√	√	
Plant									√			√	√	√
Gas	√	√	√	√	√	√	√	√	√	√	√	√		
Water	√	√				√	√							

3.3 Barley biomass, element content and isotope analysis

At plant maturity (23/07/2018), barley crops were harvested and separated into three different plant components – stem, grain and ear. Aboveground plant biomass was oven-dried at 60 °C overnight and analysed for yield differences between the two treatments. Leaf samples were collected throughout the growing period to determine the uptake of labelled green manure. The youngest fully developed leaves were taken randomly within the framed plot and brought back to the laboratory for drying and analysis. Barley leaf samples were collected at three different time points starting on the 30th of April 2018 (*21d*) and compared with values obtained from harvested barley. Isotopic values and contents of C and N were subsequently analysed for all plant components from inside and outside the labelled plot by Elemental Analyser - Isotope Ratio Mass Spectrometry (EA – IRMS; elemental analyser coupled to Delta V Advantage, Thermo Scientific, Germany). High purity N_2 and CO_2 reference gases were calibrated to the atmospheric N_2 (at-air) standard using IAEA-NO-3, IAEA-N-1 and -2 and to the Vienna-Pee Dee Belemnite (V-PDB) standard using IAEA-CH-6 and IAEA-CH-7 reference materials (International Atomic Energy Agency, Vienna, Austria) and run with each sample analysis. The average precision for the batch runs was better than 0.1% for both isotope signatures in a laboratory standard. The natural ^{15}N abundance ($\delta^{15}N$ vs at-air) and ^{13}C abundance ($\delta^{13}C$ vs V-PDB) were calculated as follows: $\delta^{H}X$ (in ‰) = $(R_{sample}/R_{standard} - 1) * 1000$, where X is C or N, H refers to the heavy isotope, and R depicts the ratio of heavy (H) to light (L) isotope, i.e. ^{13}C:^{12}C and ^{15}N:^{14}N, respectively.

3.4 Soil bulk ^{13}C and ^{15}N analysis

Soil samples were collected with a soil corer (0.6 cm diameter) at a depth of 0-10 cm from the A - horizon. The soil was sampled from randomised locations inside the plot frame and were mixed well. Soil water content was measured by drying 2 g of fresh weight of each sample at 105 °C overnight. Soil samples used for elemental and isotopic analysis were oven-dried at 60 °C and homogenised using a ball mill. Aliquots (3 – 12 mg soil dry mass) were weighed into tin capsules and measured for the content and isotope signatures of C and N by EA – IRMS. Prior to soil $\delta^{13}C_{org}$ measurements, soil aliquots were fumigated using a concentrated (12 M) HCl solution to remove carbonates (Harris, Horwáth, and Van Kessel 2001).

3.5 Micro-diffusion of ammonium and nitrate for isotope analysis

Inorganic nitrogen was extracted using 15 mL 0.5 M K_2SO_4 from two grams of fresh soil. Samples were shaken for 60 min, centrifuged and filtered using a cellulose acetate Minisart syringe filter (0.45 μM). Extractions were done at different days, mainly after 14 h of each sampling event, and K_2SO_4 blanks were prepared each time. The extracts were used subsequently for micro-diffusion of NO_3^- and NH_4^+ on acidified filter traps (Heiling et al. 2006). No internal standards were used for this method as full recovery, and no isotope fractionation was assumed.

Preparation of acid traps

Ashfree filter paper (Whatman) was cut into discs with a diameter smaller than PTFE tape (1 cm width) with a paper puncher. Each filter disc was then placed in the centre of the PTFE tape, and 10 μL 2.5 M $KHSO_4$ pipetted onto each disc for acidification. A second layer of PTFE tape was used to enclose the discs. By sealing the acidified traps with a 1 mL pipette tip, the trap became watertight while still allowing diffusion of inorganic nitrogen gaseous forms.

Trapping ammonium

The samples (12 mL K_2SO_4 extracts) were pipetted into 20 mL scintillation vials, and one acid trap was added into the vial. After the trap was placed in each vial, 0.1 g MgO was added (or more, until pH > 9) and the vial was immediately closed. The samples were incubated for 5 to 7 days at room temperature. After incubation, the filters were removed with tweezers and placed in a microtiter plate. Samples were kept in a desiccator containing silica gel and concentrated H_2SO_4 to dry the filter discs, until ready for isotope analysis. $\delta^{15}N$ values were then measured by EA – IRMS after transferring the filter discs into tin capsules.

Trapping of nitrate

After ammonium was captured, another acid trap was added to each sample along with 0.1 g Devarda’s alloy. The vial was immediately closed and left for incubation at room temperature for another seven days. After seven days, the traps were removed, stored and analysed as described above.

3.6 ^{15}N incorporation in soil microbial biomass N and DON

After removal of readily plant-available nitrogen, the remaining soil was washed twice with 10 mL 0.5 M K_2SO_4; the supernatant was collected and discarded. Then, 15 mL 0.1 M K_2SO_4 were added in the centrifuge tubes containing the two grams of washed soil. To determine soil microbial biomass N (SMBN), the samples were then treated with ethanol-free chloroform (0.5 mL $CHCl_3$) on a shaker for 24 hours. Total dissolved nitrogen (TDN) was subsequently converted to NO_3^- by alkaline persulfate digestion (Doyle, Weintraub, and Schimel 2004). The VCl_3 - azide method was used to convert the NO_3^- to N_2O (Lachouani, Frank, and Wanek 2010). Isotope ratios of N_2O were measured by purge-and-trap IRMS (PT-IRMS, Gasbench II headspace analyser coupled to Delta V Advantage, Thermo Fisher, Bremen, Germany) as described by Lachouani et al. (2010). Dissolved organic nitrogen (DON) was calculated by subtracting the inorganic nitrogen content (NH_4, NO_3^-) from TDN in the unfumigated soils. This step was possible only for the first two sampling time points (0 and 6 h), as the K_2SO_4 extracts of all the other sampling times were used entirely for micro-diffusion of inorganic N.

3.7 $\delta^{15}N$ - NO_3^- in soil and drainage water

When available, drainage water and soil water samples were collected and brought back to the laboratory where they were frozen at -20 ºC until ready for analysis. Concentrations of soil and drainage water NO_3^- were measured colourimetrically, and samples and standards were afterwards diluted/prepared at concentrations in the range of the used PT - IRMS method. NO_3^- was converted to N_2O using the same VCl_3-azide method as described above (Lachouani, Frank, & Wanek, 2010). Isotope ratios of N_2O were measured and corrected, as described by Lachouani et al. (2010).

3.8 In situ N_2O flux measurements

Soil N_2O fluxes were measured in the lysimeters by using a gastight Plexiglas chamber (volume 0.6075 m^3) fitted to the metal frame defining the labelled plot on each lysimeter. The chamber had a built-in fan to ensure proper mixture of gases. N_2O concentration and nitrogen isotope abundances were measured with an LGR isotopic N_2O analyser (Model 914-0027, using Off-Axis Integrated Cavity Output Spectroscopy (OA-ICOS)) connected via tubing to the Plexiglas chamber. The measurement sequence of all 12 lysimeters was of approximatively 30 minutes (without taking into account reference gas analysis and chamber transport), and it was repeated at different time points throughout the experimental duration. Additional repeated N_2O measurements were done after the heavy rainfall simulation and after application of commercial fertilizer on four of the lysimeters, each one representing a soil type and a treatment.

Data processing

The N elemental flux was calculated according to the following equations:

$$Flux = \frac{\frac{\Delta gas}{\Delta time} \times V_{chamber} \times M \times n}{A_{plot} \times V_{molar}} \qquad (1)$$

Where:

Δgas / $\Delta time$ is the slope of the linear regression of gas concentration vs time of measurement (ppm/h), $V_{chamber}$ (L) is the volume of the chamber after temperature correction ($V_1T_2 = V_2T_1$), M (g/mol) refers to the elemental molar mass (e.g. 14.0067 for N), n is the number of N atoms in the gas molecule (e.g. 2 N in N_2O), A_{plot} is the area of the plot (m^2), and V_{molar} is the molar volume, temperature corrected (L/mol)

The $\delta^{15}N$ source was then determined through locating the intercept of Keeling plots of $\delta^{15}N_2O$ values plotted against inverted concentrations of N_2O (1/concentration).

R^2, *p*-values as well as the number of data points of all linear regressions are provided in the appendix.

3.9 Soil phospholipid fatty acid (PLFA) analysis

For investigating differences in soil microbial communities, PLFAs analysis and calculations were conducted according to Watzinger (2015). Briefly, PLFAs from two grams of fresh soil were extracted overnight by a Bligh & Dyer mixture of chloroform/methanol/citrate buffer (1:2:0:8, v:v:v). After extraction, the solvent was transferred into clean 12 mL glass tubes, and the soil was re-extracted with 2 mL of Bligh & Dyer solution. Extraction solvents of the two steps were combined and 1.5 mL chloroform and 1.5 mL H_2O (MilliQ) were added to induce phase separation. Samples were centrifuged, and the chloroform fraction of each sample was transferred for lipid separation to solid-phase extraction columns (Isolute SI, 500 mg Silica 5 mL, Biotage). Phospholipids were eluted with 5 mL methanol and the solvent was evaporated under an N_2 stream at 40 °C. Conversion to fatty acid methyl esters (FAMEs) was done by adding 1 mL methanolic KOH. Internal standards (PLFA 13:0 and 19:0) were used for quantification. Carbon isotope ratios were then measured by gas chromatography-IRMS (GC-IRMS; Agilent HP 5890 Series II GC coupled with Finnigan DeltaS IRMS).

3.10 Statistical Analysis

Data were analysed using IBM SPSS Statistics 24. Outliers were assessed by inspection of a boxplot. Data were tested for normal distribution using the Shapiro-Wilk's test with $p > 0.05$, and tests were repeated with *ln*-transformed data in case of skewness. Statistical significance was analysed using analysis of variance (ANOVA) if there was homogeneity of variances (Levene's test for equality of variances with $p > 0.05$). Non-parametric tests such as the Kruskal-Wallis H test were run if the transformed data did not meet the assumptions of normal distribution and/or equality of variances. Tukey and Games-Howell post hoc analysis were run. Asterisks indicate significant differences between the current and future scenario for single sampling times. The sample size was three if not mentioned otherwise. If p-values are 0 it means that $p < 0.0005$. Two-way ANOVA was run to test for differences between the two treatments and soils; however, as the homogeneity assumption was often violated the results were not always used. Results from the two-way ANOVA tests are given in the appendix in **Table 8.11.** Statistical tables and additional graphs can be found in appendix.

4. Results

All plant and soil results are reported on a dry weight basis. The water content was calculated using the difference between fresh and dry weight in rapport to fresh weight.

4.1 Barley biomass, element contents and labelling kinetics

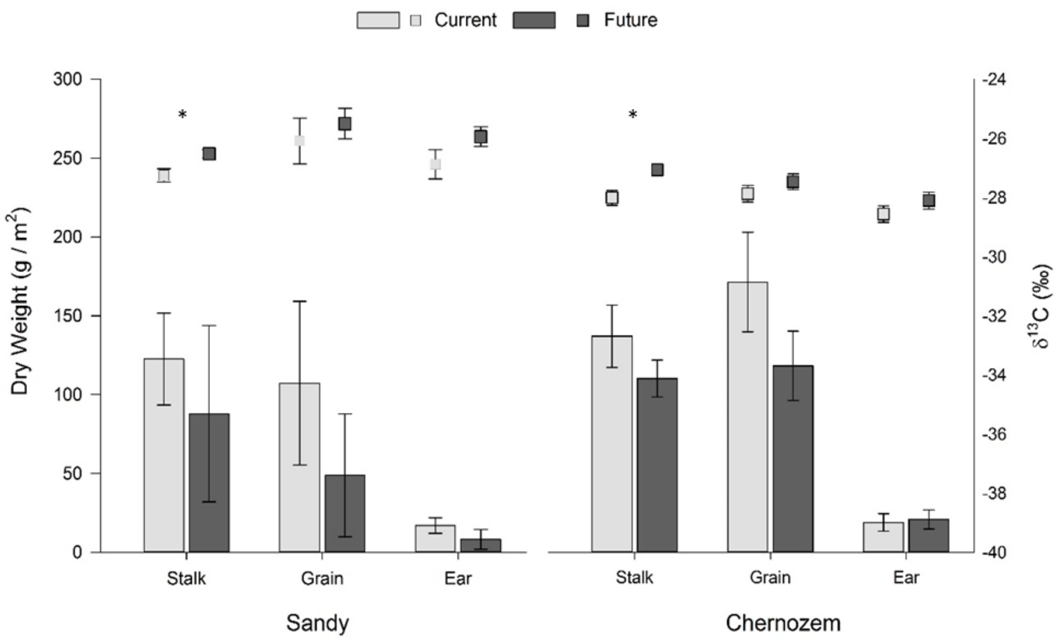

Figure 4.1. Bars represent barley yield results for different plant compartments and soil types (sandy Phaeozem and Chernozem), under current and future precipitation regimes; symbols represent $\delta^{13}C$ values for the respective plant compartments. The asterisks above symbols represent statistically significant differences between the two treatments. Values are means ± SD, n=3.

PlantCompartment	Soil Type	ANOVA
Stalk	Sandy	F(1,4) = 0.593, p = 0.484
	Chernozem	F(1,4) = 3.654, p = 0.129
Grain	Sandy	F(1,4) = 2.582, p = 0.183
	Chernozem	F(1,4) = 0.846, p = 0.410
Ear	Sandy	F(1,4) = 1.965, p = 0.234
	Chernozem	F(1,4) = 0.058, p = 0.821

Table 4.1. One-way ANOVA results for barley biomass; differences between dry mass under current and future precipitation regime. F (df1 – between-group degrees of freedom, df2 – within-group degrees of freedom) = F-statistic, p = p-value level of significance, n=3.

Measurements of $\delta^{13}C$ showed higher ^{13}C enrichment for all plant compartments and soil types **(Figure 4.1 scatter series**). One-way ANOVA tests showed statistically significant differences between the two treatments for barley stems, for both soil types: sandy Phaeozem with Welch's $F(1,4) = 15.448$, $p = 0.017$, with an increase in $\delta^{13}C$ for the future scenario from -26.45 ± 0.28 ‰ to -25.67 ± 0.18 ‰, and Chernozem ($F(1,4) = 26.29$, $p = 0.007$), from -28.00 ± 0.31 ‰ to -27.06 ± 0.70 ‰. Nitrogen isotope values tended to increase slightly, but not significantly in the future precipitation scenario inside and outside of the labelled plots **(Figure 4.2** and **Figure 4.3).** The leaf C and N contents did not change significantly for any plant part or soil type (additional graphs with C/N ratios and statistical tables can be found in *Appendix*, starting with **Table 8.1)**.

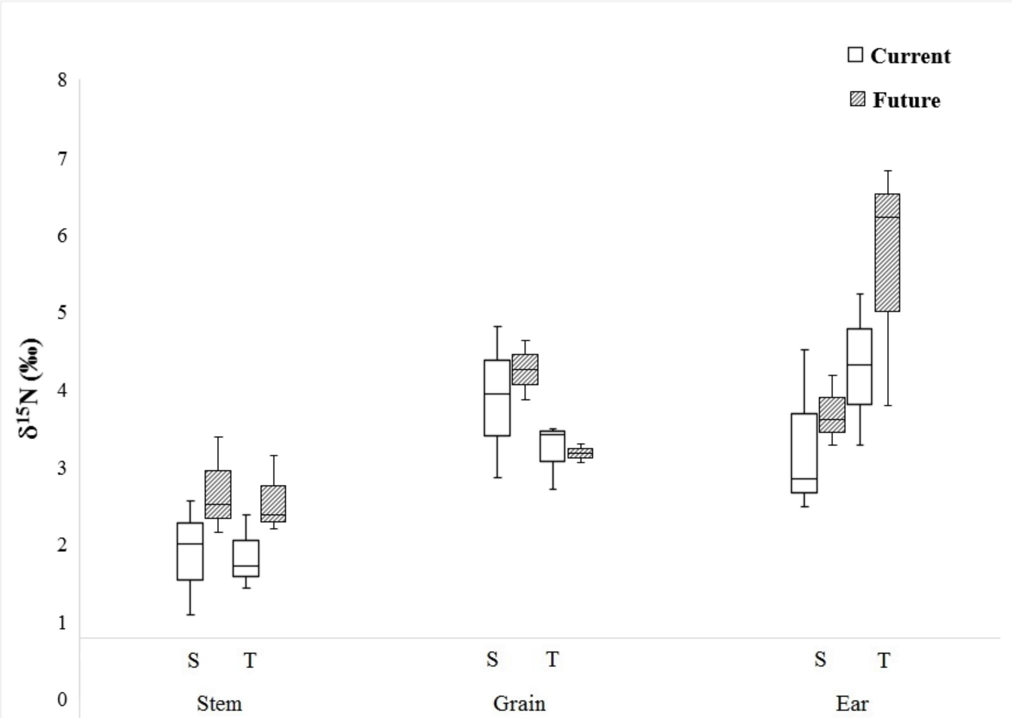

Figure 4.2. $\delta^{15}N$ values for all plant compartments and soil types outside labelled plot (S = sandy, T = chernozem) under current and future precipitation scenarios at the final harvest, n=3.

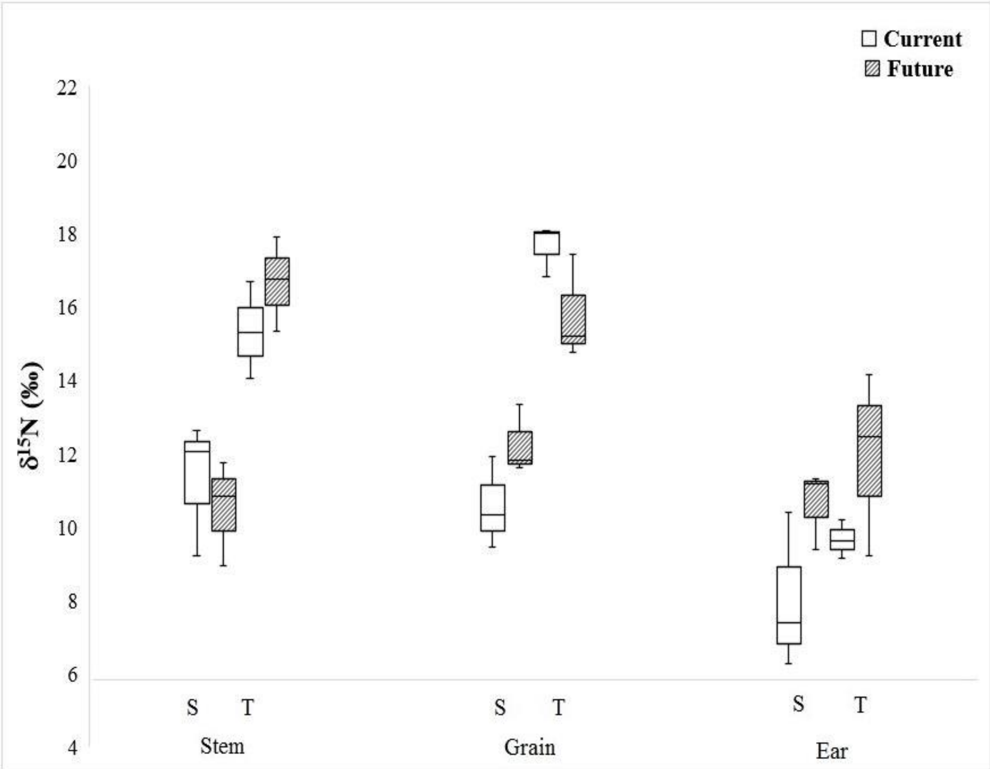

Figure 4.3. $\delta^{15}N$ values for all plant compartments and soil types inside the labelled plots (S = sandy, T = chernozem) under current and future precipitation scenarios at the final harvest, n=3.

Isotopic analysis of barley leaves taken across the labelling experiment showed an initial increase in $\delta^{15}N$, with starting values of ~34 ‰, followed by a fast decrease with time and growing biomass **(Figure 4.4).** Results generally showed higher $\delta^{15}N$ values for the future precipitation scenario, with significant differences for the Chernozem after 32 days, from $\delta^{15}N$ of 24.75 ± 4.24‰ in the current to 35.43 ± 3.33‰ in the future precipitation scenario. Additional information can be found in the Appendix.

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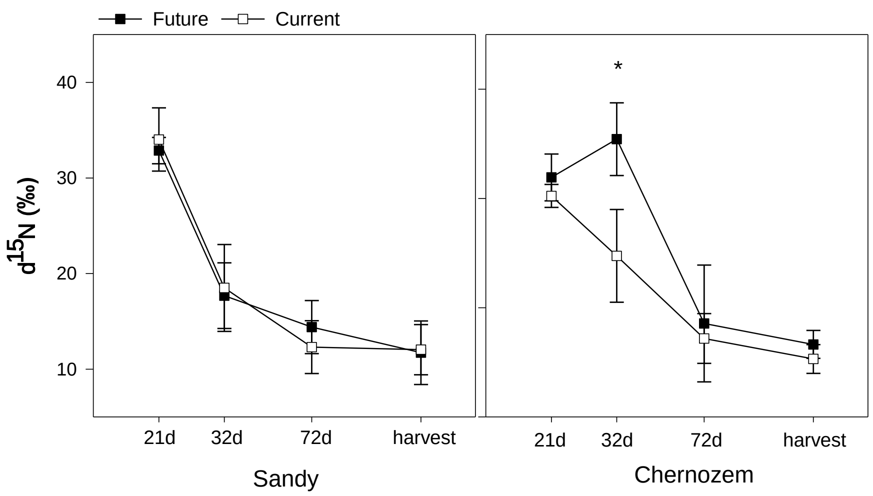

Figure 4.4. Time course of nitrogen isotopic values of barley leaves for both soil types under the current and future scenario, measured in labelled plots. Values are means ± SD, n=3.

4.2 Soil C_{org} and bulk N content and isotope signatures

Figure 4.6 (page 21) shows the results obtained from soil C_{org} and bulk N analysis by EA – IRMS. On the last sampling time point (more than two months after the application of labelled green manure) an increase in both soil C and N contents and isotopic values could be observed. Both soil types tended to have higher isotope values in the future scenario. Changes between the two treatments were compared using Kruskal-Wallis tests, showing few significant differences between the two treatments for single time points. Additional information, including significance levels, is given in **Table 8.3**.

4.3 ^{15}N kinetics in soil extractable nitrate

Figure 4.5 presents the experimental data of inorganic NO_3^- analysis. A sharp increase in $\delta^{15}N$ of the readily available inorganic NO_3^- fraction (extractable fraction) can be seen in both cases, with ^{15}N enrichment from natural background values of -7‰ to ~90‰. Panel **a**. and **b** both show a rapid formation by mineralisation coupled to nitrification and still higher than background values after 71 days (20/06/2018). Nitrate content was initially higher in the current scenario but then converged in both treatments over time. Kruskal-Wallis tests were used to assess for differences between the treatments. NO_3^- contents almost continuously increased in both soil types after the application of green manure and peaked after inorganic fertiliser amendment (**Figure 4.5.c** and **d**, sampling time 32d). Further information with significance levels and means can be found in the Appendix.

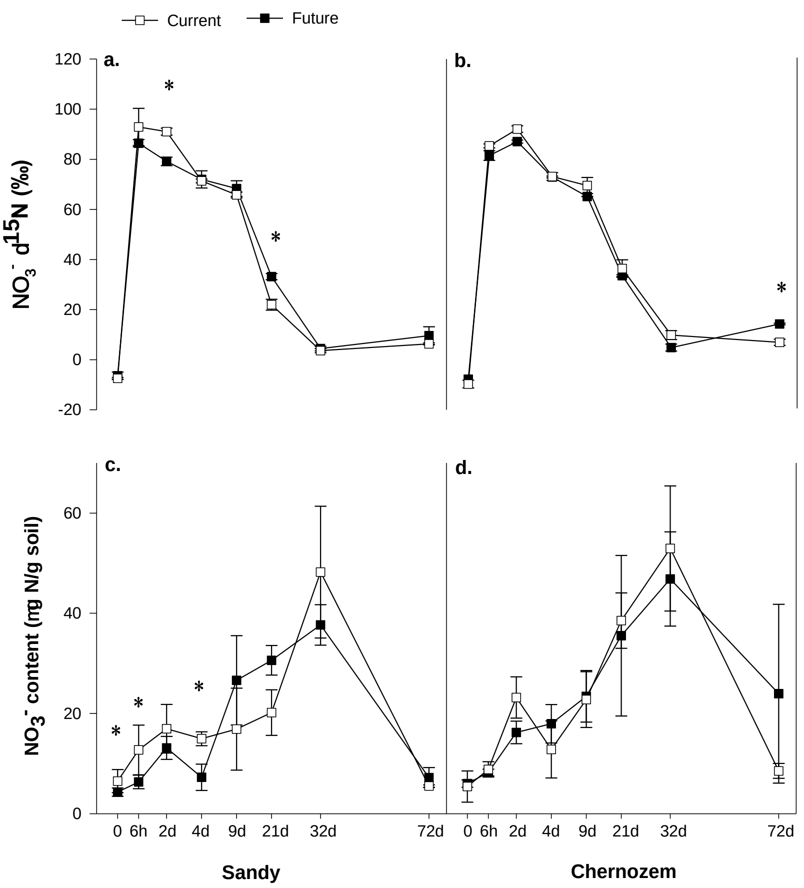

Figure 4.5. NO_3^- contents and isotopic values for both soil types (sandy Phaeozem – left, Chernozem – right) under current and future precipitation scenarios. Asterisks indicate significant differences between the treatments. Values are means ± SD (n=3).

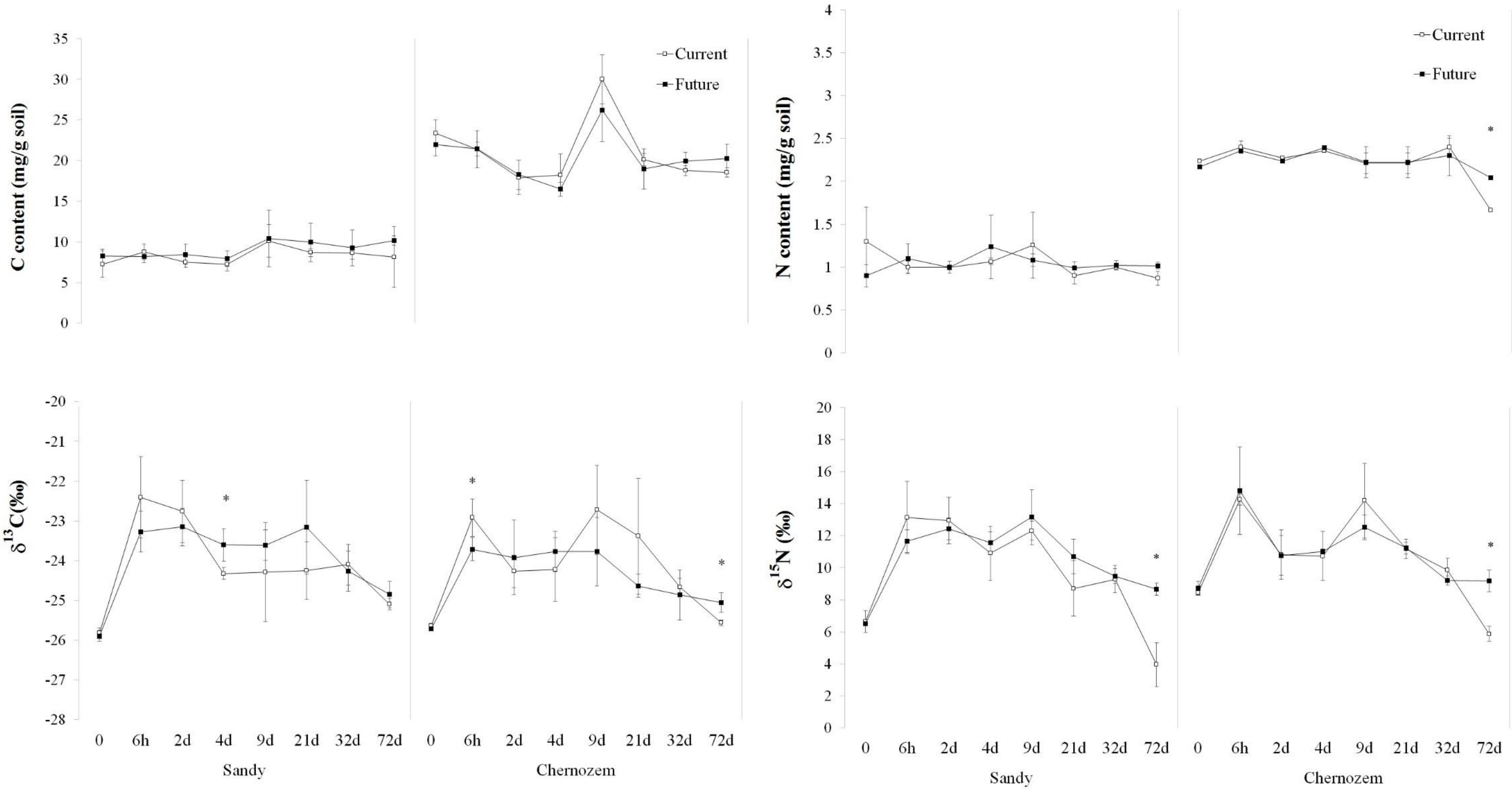

Figure 4.6. Soil organic C and bulk N contents and isotopic values for both soil types under current and future precipitation scenarios. Values represent averages ± SD (n=3). Asterisks indicate significant differences between the two treatments for single sampling time points.

4.4 Ammonium

Results from micro-diffusion of NH_4 showed similar temporal patterns as NO_3 (**Figure 4.5**, graphs c., d.), N content peaking two days after application of the green manure and again after 32 days, which represents the application of commercial inorganic fertilizer. NH_4 content was overall lower compared to NO_3. $\delta^{15}N$ values of NH_4 were unfortunately below the detection limit of EA - IRMS.

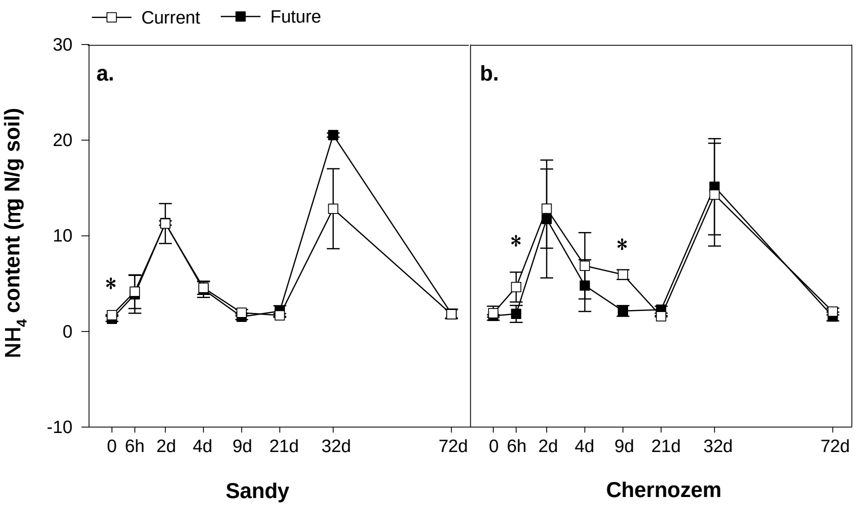

Figure 4.7. NH_4 content in µg/g dry soil for both soil types (sandy Phaeozem – left, Chernozem – right) under current and future precipitation scenarios. Asterisks indicate significant differences between the treatments. Values are means ± SD (n=3).

4.5 Soil microbial biomass N and DON

Overall microbial biomass N (SMBN) increased after green manure application, peaking 4-9 days after experimental start; then SMBN declined below post-treatment levels (**Figure 4.8**, graphs **c**. and **d**., after 32 and 72 days), being generally higher in the Chernozem. ^{15}N enrichment increased above pre-treatment level after amendment with green manure, being ~10‰ above reference values and showing little temporal patterns after that (**Figure 4.8**, graphs **a**. and **b**.). Kruskal-Wallis analysis was used to test for significant differences between the two treatments. Few were found, for single sampling time points: lower $\delta^{15}N_{mic}$ (from 11.2 ± 2.3 to 9.38 ± 0.6 ‰) but higher SMBN values (from 10.48 ± 0.65 to 13.89 ± 1.24) in the future scenario in sandy Phaeozem after nine days.

Soil Type	SamplingTime	Scenario	DON (µg/g soil)	*p-value*
Sandy	0	Current	4.39 ± 0.79	*0.083*
		Future	6.04 ± 1.49	
	6h	Current	10.58 ± 3.22	*0.439*
		Future	15.55 ± 4.45	
Chernozem	0	Current	8.07 ± 3.32	*0.827*
		Future	7.03 ± 1.17	
	6h	Current	15.31 ± 1.34	*0.275*
		Future	16.94 ± 1.54	

Table 4.2. DON content for the first two sampling time points under the current and future precipitation scenario, Kruskal-Wallis test. Values are means ± SD, n=3.

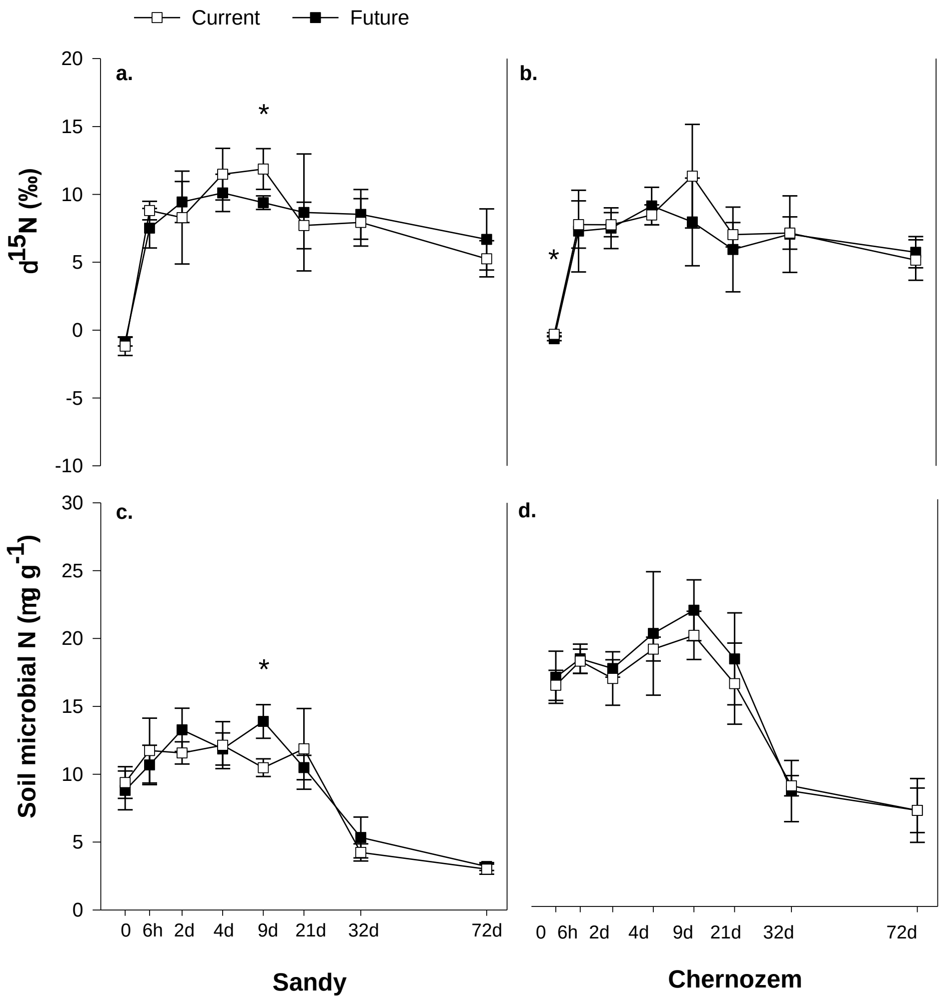

Figure 4.8. Means ± SD nitrogen isotopic values $\delta^{15}N$ (a, b) and nitrogen content (c, d) of extractable soil microbial pools for both soil types.

4.6 $\delta^{15}N$ of NO_3^- in soil and drainage water

Few samples could be collected from the lysimeter station for soil water analysis; results can be seen below in **Table 4.3**. It was possible to analyse for significant differences between the two treatments only for the samples collected on the 25th of April 2018 (rhizon water samples, 10 cm soil depth, labelled plots). An ANOVA (one-way) test was performed, and significant differences were found for $\delta^{15}NO_3$ ($p < 0.05$), with higher values for the current scenario in both soil types, which can be explained by slower mineralisation and nitrification rates in drier soil. It was not possible to perform further statistical analysis with the remaining data due to data scarcity.

Table 4.3. Lysimeter NO_3^- water analysis for both treatment systems at different soil depths and soil types, with significant levels provided as *p-values*. Values represent means ± SD.
-, missing samples or below the detection limit.

			09/04/2018 - before label				25/04/2018				26/04/2018			
Soil Type	**Depth (cm)**	**Scenario**	**n**	**$\delta^{15}N$**	**NO_3^- content (µgN /mL)**	***p value***	**n**	**$\delta^{15}N$**	**NO_3^- content (µgN /mL)**	***p value***	**n**	**$\delta^{15}N$**	**NO_3^- content (µgN /mL)**	***p value***
Sandy	10	Current	-	-	-		3	7.8 ± 0.97	17.9 ± 1.79	*0.001*	-	-	-	
		Future	-	-	-	-	3	1.5 ± 0.31	15.7 ± 0.21		-	-	-	-
	30	Current	-	-	-		-	-	-		1	32.58	22.25	
		Future	-	-	-	-	-	-	-	-	1	49.97	26.39	-
	60	Current	-	-	-		-	-	-		1	23.93	22.20	
		Future	-	-	-	-	-	-	-	-	3	2.9 ± 5.7	13.7 ± 1.86	-
	90	Current	-	-	-		-	-	-		2	-3.1 ± 2.59	17 ± 0.22	
		Future	-	-	-	-	-	-	-	-	2	1.6 ± 2.79	14 ± 0.58	-
	126	Current	-	-	-		-	-	-		1	2.98	23.72	
		Future	-	-	-	-	-	-	-	-	-	-	-	-
	210	Current	-	-	-		-	-	-		1	-5.47	18.60	
		Future	-	-	-	-	-	-	-	-	1	-	33.92	-
	250	Current	2	-7.8 ± 1.45	13.3 ± 0.82		-	-	-		-	-	-	
		Future	1	-8.30	11.91	-	-	-	-	-	-	-	-	-
Chernozem	10	Current	-	-	-		3	17.4 ± 1.74	20.7 ± 1.49		-	-	-	
		Future	-	-	-	-	1	10.60	15.59	-	-	-	-	-
	30	Current	-	-	-		-	-	-		2	-4.8 ± 2.97	9.1 ± 5.47	
		Future	-	-	-	-	-	-	-	-	1	87.76	32.64	-
	60	Current	-	-	-		-	-	-		2	8.6 ± 2.34	8.9 ± 4.17	
		Future	-	-	-	-	-	-	-	-	3	16.6 ± 31.08	10.3 ± 11.38	-
	90	Current	-	-	-		-	-	-		2	3 ± 8.09	7.3 ± 0.66	
		Future	-	-	-	-	-	-	-	-	1	7.75	14.30	-

4.7 Soil phospholipid fatty acid (PLFAs) analysis

Overall soil microbial biomass – based on PLFA analysis - was dominated by the Gram-negative bacteria markers 16:1ω7+16:1ω6 (10 %), i17:1ω8+ 10Me16:0 (6 %), 18:1ω9c (11 %), 18:1ω7c / 9t+8 (20 %), the fungal biomarkers 18:2ω6 + 18:2ω9 (9 %) and the ubiquitous PLFA 16:0 (13 %) (identification according to Kaur et al. (2005)). The remaining PLFAs stayed below 5% throughout the experiment. Total PLFA content showed no clear trend; the content varied with time, soil type and treatment (**Fig. 4.9**). Higher total PLFAs were found hours after the application of labelled material, for the future scenario, in both soil types ($p < 0.05$, **Fig. 4.9**, sampling time 6h). Total PLFA ^{13}C enrichment increased after the application of green manure in both soil types (**Fig. 4.9**, line and scatter plot), peaking after two days and decreasing then towards 72 days, still being elevated compared to background values. Significant differences in total PLFA $\delta^{13}C$ values between the two treatments were registered at day 21 for the sandy Phaeozem (Fig. 2.10, $p < 0.05$), with ^{13}C enrichment in the future scenario (increase from -16.1 ± 1.8 to -11.2 ± 1‰) , driven by significant differences in multiple single PLFAs (additional information can be found in Appendix). Assignments of phospholipid fatty acid (PLFA) bioindicators can be found in Appendix in **Table 8.8**.

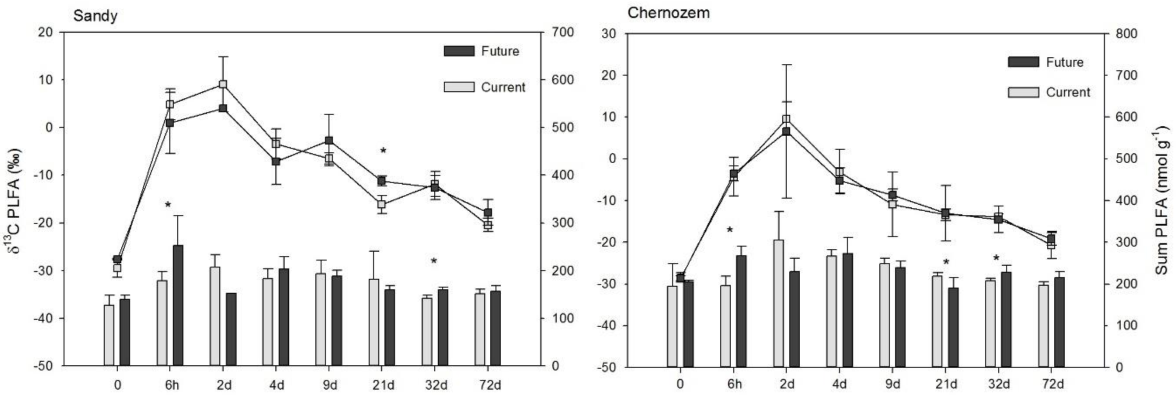

Figure 4.9. Bars represent microbial biomass as total PLFA (right secondary axis - Sum PLFA in nmol g^{-1}) and symbols represent average ^{13}C isotopic signatures of total PLFAs for both soil types under current and future precipitation scenarios. Values are means ± SD (n=3).

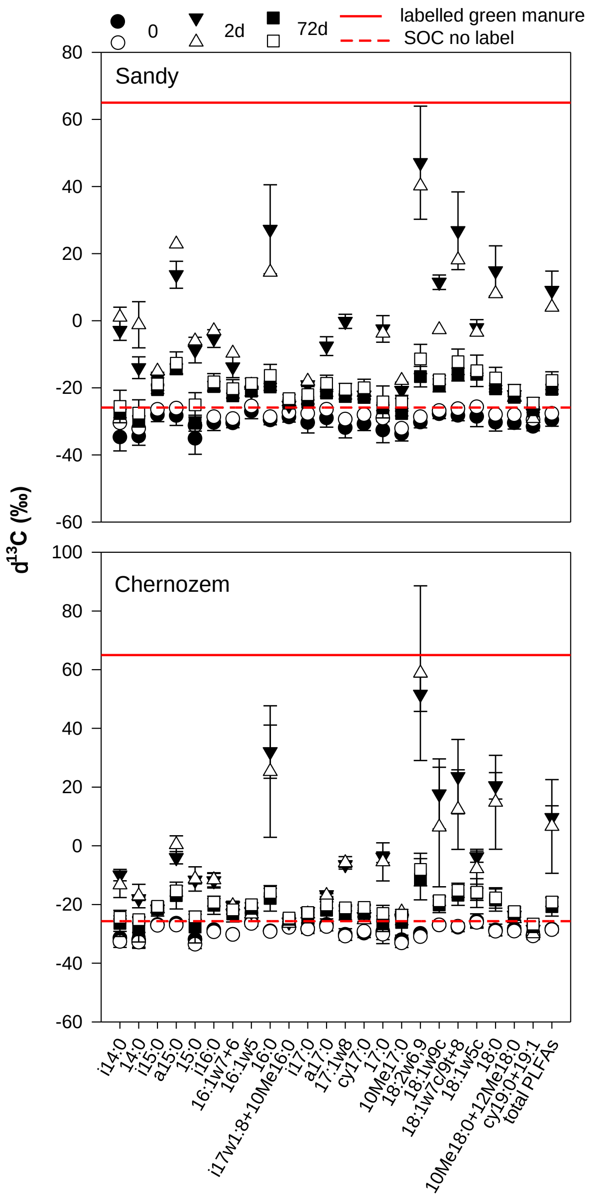

Figure 4.10. Carbon isotope ratios ($\delta^{13}C$) of all individually measured PLFAs and of their sum at selected times (before label – 0, after two days and after 72 days) for both soil types, under current (open symbols) and future (closed symbols) precipitation scenarios. Isotopic reference is provided to native soil organic carbon (dashed red line) and to ^{13}C labelled green manure (solid red line). Values are means ± SD.

^{13}C isotopic values of individual PLFAs also peaked two days after manure amendment in both soil types (figure on the left). The most pronounced shift in ^{13}C compared to the initial –conditions was recorded for the PLFAs 16:0, 18:1ω9c, 18:1ω7c/9t+8, 18:0 and the fungal marker 18:2ω6+9. However, no clear differences can be seen between the two precipitation treatments. At the end of the experiment, almost all PLFAs exhibited slightly higher $\delta^{13}C$ values when compared to the initial –signatures, though very few of them were significant (additional information with means and significance levels can be found in the Appendix).

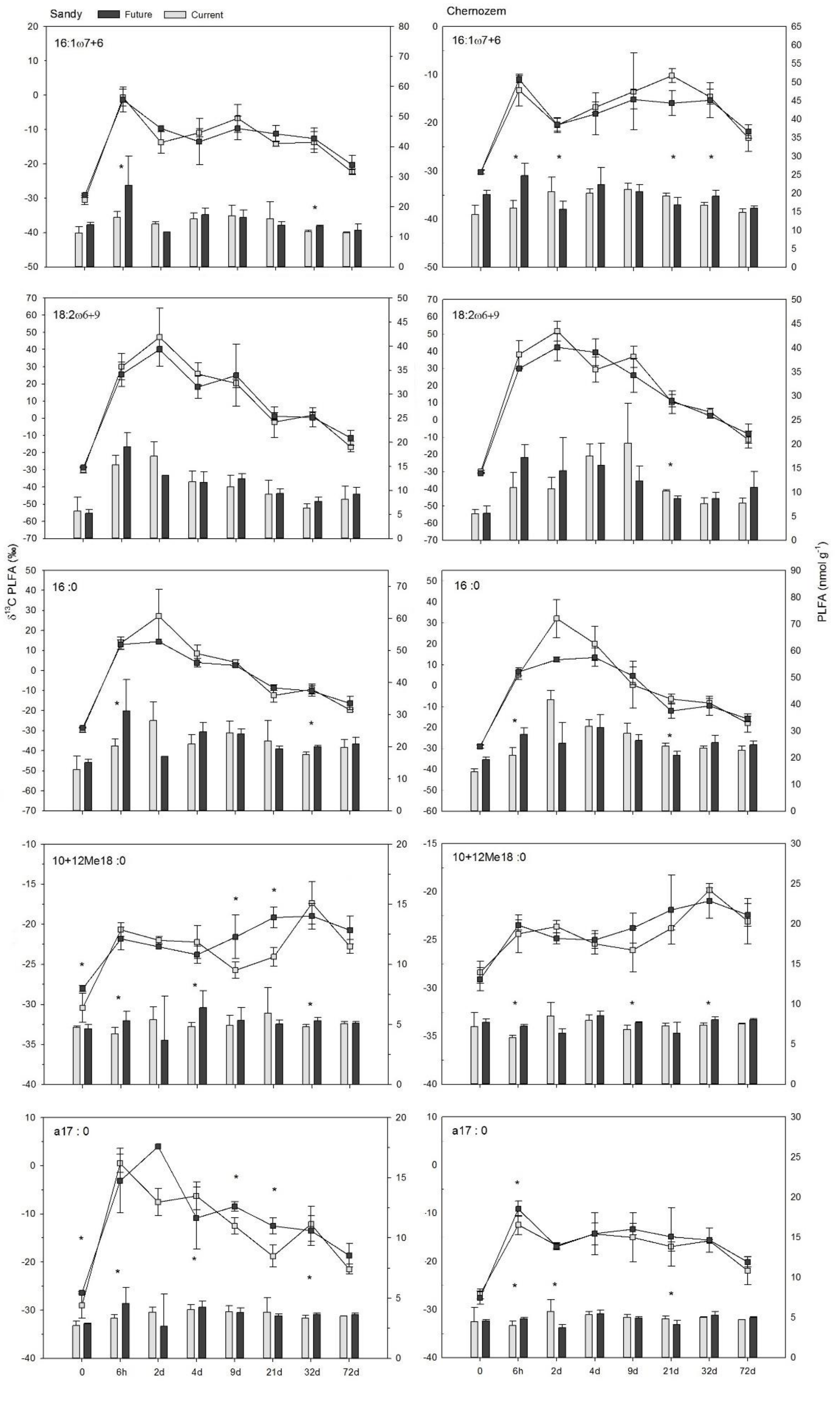

Figure 4.11. Contents (bars, right axis) and $\delta^{13}C$ values (lines and scatter, left axis) of selected individual PLFAs over time. Asterisks above symbols represent significant differences between treatments for single sampling times; values are means ± SD (n=3).

4.8 N_2O gas emissions

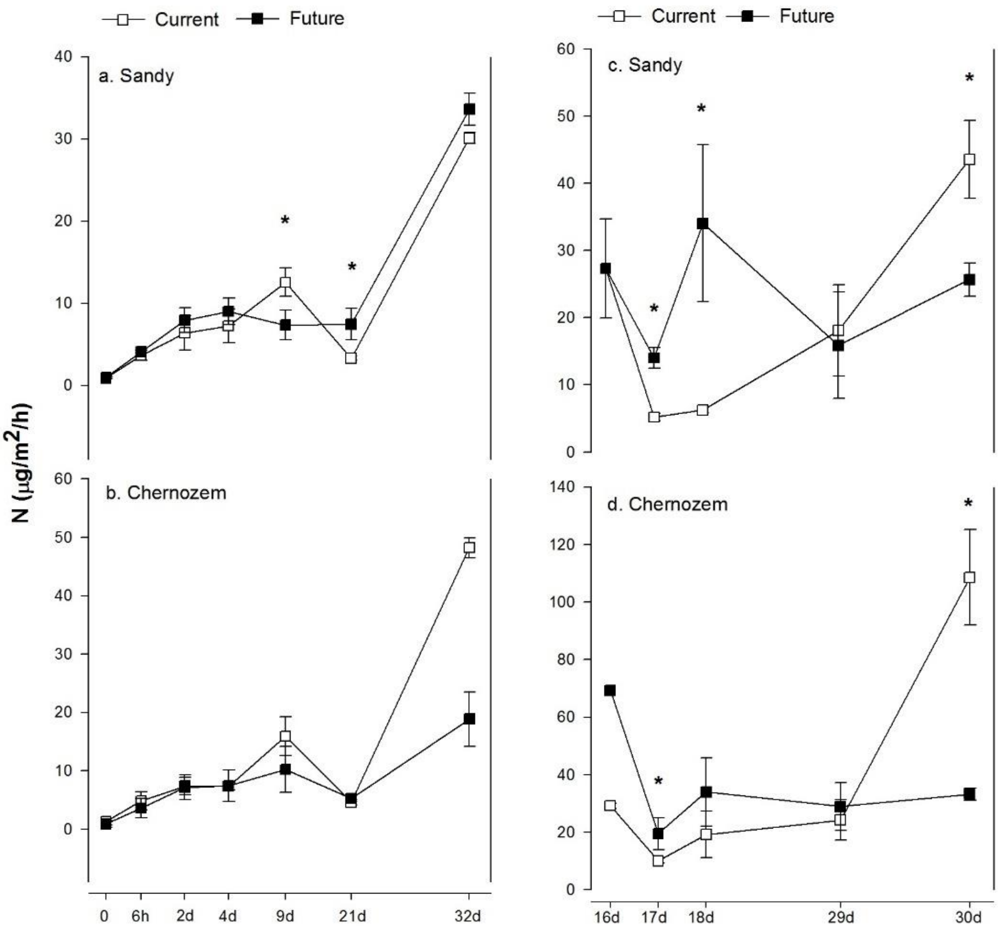

Figure 4.12. N_2O emissions for both soil types under current and future precipitation scenarios, for individual sampling times (figures a and b) and repeated individual lysimeter measurements after heavy rainfall simulation and after fertilisation (figures b and c).

Soil N_2O emissions were positive throughout the experiment and during the first 21 days increased from 3 µg/m^2/h to 15 µg/m^2/h. One day after the application of the synthetic fertiliser (added at day 29), a substantial increase in N_2O emissions was recorded which was still present at lower levels after three days (**fig. 4.12.a.** and **b.**). Significant differences between the two treatments for single sampling times were found for sandy Phaeozem (days 9 and 21). **Fig. 4.12 c.** and **d.** shows the effects of heavy rainfall (16d) and N fertilisation (29d). A clear drop in N_2O emissions occurred one day after the heavy rainfall simulation (on day 16) in both soils, but N_2O emissions remaining higher in the future scenario. In contrast, N fertilisation triggered stronger increases in N_2O emissions in the current than in the future precipitation scenario in both soils. Results of $^{15}N_2O$ signatures cannot be presented in this thesis, as difficulties have arisen when attempting to identify $\delta^{15}N_{sources}$ by using keeling plot analysis (high variation within lysimeter groups, possible interference with CO_2). Further investigation will be needed testing other possibilities of correcting the data (Mohn et al. 2019).

5. Discussion

Barley biomass

This study was designed to assess the effect of climate change-induced precipitation reductions on crop production concerning future food security and environmental impact in the Marchfeld region. One of the objectives of the study was to compare plant productivity between the current and the future reduced precipitation regimes. Overall, we found a reduction by 20-50% in crop biomass, particularly in stalks and grains, in the future precipitation scenario compared to the current one, though these were not statistically significant. Unsurprisingly, barley yield was overall higher for Chernozem (due to higher water holding capacity and nutrient provisioning capacity), similar to the findings of Tataw et al. (2016), who used the same lysimeter facility with the same types of soils to assess differences in wheat biomass production of different irrigation regimes. Higher plant $\delta^{13}C$ signatures in the future scenario indicated increased plant drought stress. Plants experiencing drought reduce their stomatal conductivity, thus balancing their needs between CO_2 uptake for photosynthesis and water loss, which results in increased $\delta^{3}C$ values due to decreased photosynthetic ^{13}C isotope fractionation (Arve et al. 2016; Barbour et al. 2011; Farquhar et al. 1989; Ma et al. 2012). Plant $\delta^{15}N$ signatures tended to increase in stalks and ears, indicating greater soil N losses in the future scenario, but these changes were not statistically significant, as the relation between soil and plant $\delta^{15}N$ and water availability is not always straightforward. It is though generally accepted that plant $\delta^{15}N$ values mainly reflect the soil $\delta^{15}N$ signatures, however, it is difficult to discern the underlying processes, due to the multiple processes involved and the varying ^{15}N isotope fractionation effects they express on soil available N forms underlying the processes of plant N acquisition (decomposition, mineralisation and nitrification by MOs, and plant uptake processes) (Amundson et al. 2003; Ma et al. 2012). As drought frequencies and amplitudes are expected to increase in the future, localised mitigation strategies for farmers need to be ensured. One possible action would be the use of modified engineered or bred crops which are more resistant to drought stress (Chen et al. 2014). Farmers could also change planting times, as, some studies found that crops that are seeded either earlier or later (e.g. April instead of March) according to regional climate regimes produce higher yields (Babel and Turyatunga 2014; Wang et al. 2015). As the Marchfeld region has a well-established irrigation system, in the future farmers will most likely irrigate more to get better crop yields, which could lead to other environmental problems (e.g. NO_3^- leaching, N_2O emissions, drop of groundwater tables).

Soil C and N processes

One of the hypotheses of this study was that mineralisation of newly added organic matter (green manure) will be slower in the future precipitation scenario. Analyses of contents and isotopic signatures of C and N in different plant and soil pools before and after labelling showed that despite enhanced drought stress, plants, as well as soil MOs decomposed and assimilated the isotopically labelled green manure, though precipitation reduction had little effect on this (inorganic NO_3^- - **Figure 4.5**, soil bulk analysis - **Figure 4.6**, SMBN - **Figure 4.8),** and lower decomposition and mineralisation rates of green manure were evident only during the first few days in the future precipitation scenario (Classen et al. 2015)**.**

Initially, slower green manure decomposition and mineralisation rates in the future scenario were also reflected in the isotopic composition of soil solution NO_3^- (**Table 4.3** soil water NO_3^- analysis, upper 10 cm), indicating lower decomposition and lower proportional nitrification under reduced precipitation. Moreover, –lysimeter NO_3^- isotope analysis at deeper soil depths showed high $\delta^{15}N$ values (e.g. **Table 4.3**, Chernozem $\delta^{15}N$ = 88‰ at 30 cm depth and significantly ^{15}N-enriched NO_3^- in sandy Phaeozems up to 60 cm soil depth), indicating NO_3^- leaching due to possible matrix preferential water flow (Akhtar et al. 2003). In the future, due to intense rainfall events and intermittent dry periods, the soils will most certainly change their physical structure and aggregate stability. Possible cracks in topsoils may form, which could lead to preferential water flow, and therefore higher leaching rates (APCC 2014). To combat impacts of climate change on crop yields, farmers will eventually increase the amount of synthetic N fertiliser applied to crops, as well as to irrigate more in the future, which can lead to additional NO_3^- leaching. Increased NO_3^- leaching will have an adverse impact on the environment, especially in the Marchfeld region, as there are already problems with groundwater pollution due to N leaching, and groundwater needs to be treated in order to be potable (Niedermayr et al. 2018).

Overall, we observed a more rapid initial decomposition and mineralisation of labelled green manure in the current compared to the future precipitation scenario (NO_3^- was initially released more slowly from green manure in the future scenario), which shifted during the experiment towards higher NO_3^-production rates in the future scenario. One explanation for this is that in the future scenario the initial mineralisation was slower, and therefore, that more organic matter from the remaining green manure was available for decomposition when the soils were rewetted (heavy rainfall event) in the future scenario compared to the current precipitation scenario (Kostyanovsky et al. 2019).

The release of the GHG N_2O is controlled by multiple parameters and processes in soils (temperature, water and oxygen content, dissolved organic C content, rates of mineralisation, nitrification, denitrification and abiotic N_2O formation, and N_20 reduction, etc.); however, one major parameter controlling soil N_2O emissions is the availability of NO_3^- (Signor and Cerri 2013), which we also clearly observed in our experiments (e.g. higher NH_4^+ and NO_3^- contents after application of synthetic fertilizer triggered higher soil N_2O emissions). Furthermore, higher N_2O emissions for the current precipitation scenario towards the end of the experiment emphasise that nitrification and denitrification were most likely lowered in the future precipitation scenario. Similar results were also found by Homyak et al. (2017) and Paul, Robertson, and Groffman (2015). Higher N_2O emissions (**Fig. 4.12 c.** and **d.)** after the heavy rainfall event (rewetting of dry soils) in the future precipitation regime further highlight the importance of available N in soils, which is co-determined by decomposition and mineralisation rates of the remaining green manure where such mulching amendments are applied (Kostyanovsky et al. 2019).

Composition of the microbial community

Our hypothesis concerning the microbial community was that incorporation of labelled green manure would be less significant in the future scenario as drought can reduce microbial activity and growth (Castro et al. 2010; De Vries and Shade 2013). However, we found little effects of reduced precipitation on microbial community structure and ^{13}C incorporation into PLFA biomarkers. Overall, the labelled carbon was rapidly incorporated by the microbial community in both soil types, peaking two days after the application of labelled green manure in both soil types (**Figure 4.10**). Higher levels of total PLFAs, as well as individual PLFAs, were measured in the Chernozem compared to the sandy Phaeozem, which is consistent with other studies showing a link between microbial community size and soil organic C content (Liu et al. 2019; Pajares et al. 2018). Even though soil microbial activity can decline under conditions of reduced precipitation, some individual subpopulations, such as fungi and gram-positive bacteria have been reported to better tolerate drought stress (Carson et al. 2010; Fuchslueger et al. 2014; Lennon et al. 2012; Schimel, Balser, and Wallenstein 2007). Indeed, in the studied soils 9 % of the total PLFAs was represented by the fungal biomarker 18:2ω6,9, and fungi are assumed to better explore the soil volume through hyphal growth which makes them better adapted to drought (Frey et al. 2008). High incorporation of ^{13}C was also measured for the ubiquitous PLFA 16:0 and intermediate levels of ^{13}C incorporation for the Gram-positive bacterial PLFAs a17:0, i16:0, and 15:0 (**Figure 4.10**).

The time sequence of ^{13}C incorporation into PLFA followed the order G- (gram-negative bacteria) ≥ G+ (gram-positive bacteria) > F (fungal) /General > Actinobacteria, i.e. rapid bacteria (G-) used labile C faster than G+, while fungi and Actinobacteria as major complex organic matter decomposers were slower (**Figure 8.4**, Appendix). On the other hand, the ^{13}C incorporation into PLFA was highest for F > General > G-/G+ > Actinobacteria. Fungi therefore were the most important decomposers of the labelled green manure.

We also found rapid incorporation of green manure-derived ^{15}N into microbial biomass, peaking at 6 hours, and then decreasing very slowly over 72 days. This indicates that labile, low-molecular weight N in green manure is highly accessible to soil microbes, and that decomposition of manure keeps ^{15}N incorporation high in soil microbes. However, overall soil microbial communities very highly resistant against the reduced precipitation regime, both in terms of microbial community structure and activity (green manure decomposition, mineralisation, nitrification, C and N immobilisation).

Limitations of the current work

One limitation of the presented study was the relatively small replicate number (n=3), which at times made the data analysis difficult. Our results, therefore, need to be interpreted with caution, as all our measurements showed high variability among lysimeters. One possible explanation for that might be that during winter time the lysimeter station is left open to natural precipitation, which diminishes the summer effect of different rainfall patterns. However, even with higher replication effect sizes of reduced precipitation were small in most soil C and N pools and processes such as in PLFAs, DON, ammonium, nitrate and microbial biomass, and their labelling kinetics. Plant biomass, plant $\delta^{13}C$, soil N_2O emissions and soil water NO_3^- labelling were the most drought-sensitive parameters, indicating high plant drought sensitivity and that reduced precipitation can markedly affect soil N losses by gaseous and hydrological pathways. Furthermore, we only investigated the effect of altered precipitation. On the long run, precipitation patterns differ interannually, even more than temperature or atmospheric CO_2 levels, which both can sometimes even have positive impacts on plant biomass and soil biogeochemical processes such as organic matter turnover (Andresen et al. 2016; Brevik 2013; Karmakar et al. 2016).

6. Conclusion

This study investigated the effect of decreased precipitation (-25% relative to current mean rainfall) on crop performance and soil C and N mineralisation. The stable isotope labelling technique proved to be successful for tracing and identifying drought stress effects on plants and soil MOs under future precipitation patterns. Higher –shoot $\delta^{13}C$ values showed that barley was indeed drought-stressed, causing a decrease in shoot biomass components by -20 to -50% (though non-significant due to high variability). In contrast, soil MOs and soil C and N pools were weakly affected by reduced precipitation, highlighting their high resistance against future changes in precipitation as predicted for the region. We though found that N losses through NO_3^- leaching and N_2O emissions were most sensitive to reduced precipitation, pointing to future aggravating environmental problems. Finally, the reduction in precipitation may have relatively weak effects on organic matter decomposition during normal years, but in dry years and with heatwaves this level of precipitation reduction might cause the systems to pass tipping points, above which system behaviour might be less resistant and resilient, and less predictable. Long-term research on these effects is therefore mandatory to understand interannual changes in system behaviour and to devise sustainable mitigation strategies for the farmers.

7. References

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8. Appendix

The water-filled pore space (WFPS, %) was calculated according to the following equation:

100 x (gravimetric moisture content x soil bulk density) / total soil porosity

where total soil porosity = 1− (soil bulk density/soil particle density)

The soil particle density was assumed to be 2.66 g cm^{-3} for both soil types.

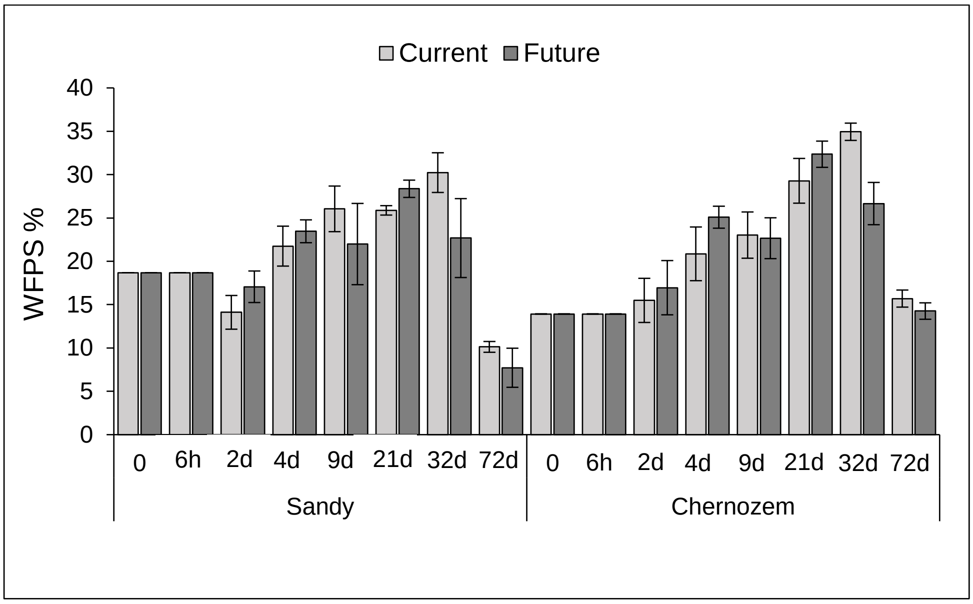

Figure 8.1.Water-filled pore space (WFPS, %) calculated according to Huang et al. 2015 for all sampling time points.

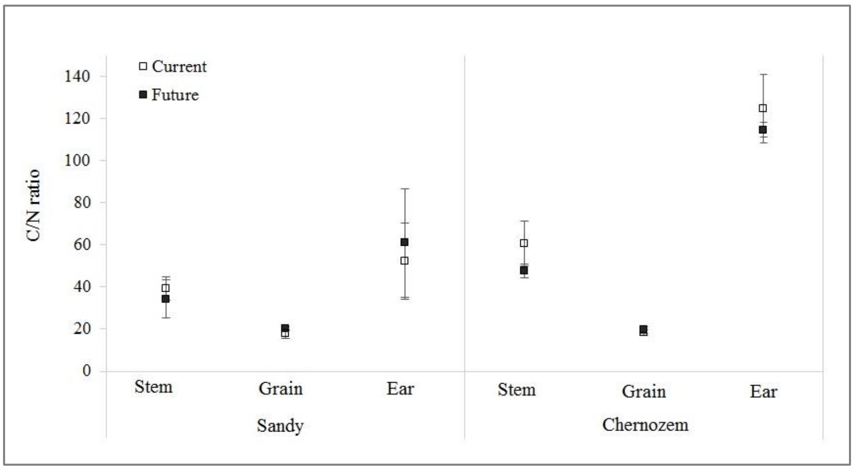

Figure 8.2. C/N ratio of harvested barley for stem, grain and ear for both soil types (S = sandy, T = chernozem) under current and future scenario. Means ± SD, n=3.

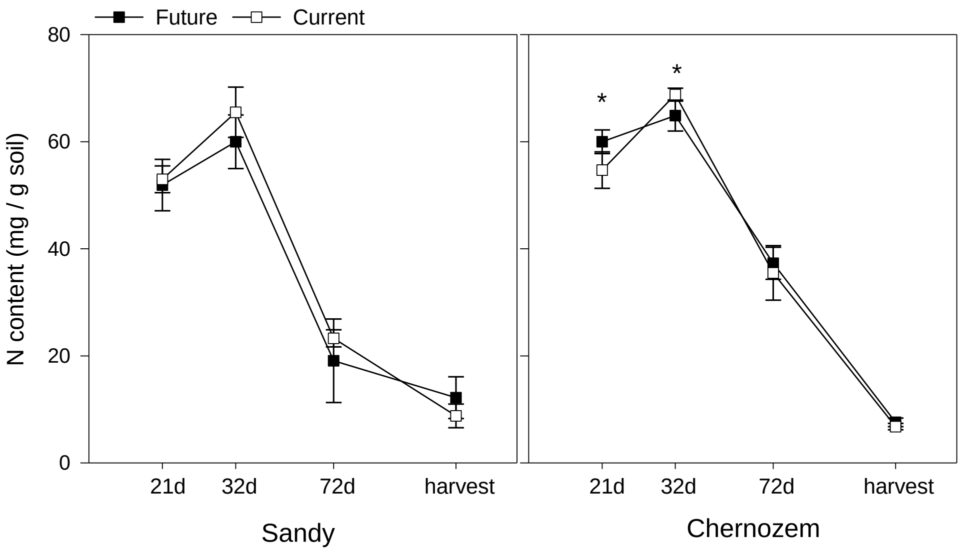

Figure 8.3. Nitrogen content of barley leaves for both soil types under the current and future scenario. Asterisks represent statistical significance. Values are means ± SD, n=3.

Analysis	Variable measured	Soil Type	Statistics	Degree of freedom (df)	F	*p*
Plant Stalk	$\delta^{13}C$	Sandy	Between Groups	1	15.4484534	0.017096505
			Within Groups	4		
		Chernozem	Between Groups	1	26.29785987	0.006847316
			Within Groups	4		
	$\delta^{15}N$	Sandy	Between Groups	1	2.016	0.229
			Within Groups	4		
		Chernozem	Between Groups	1	3.361	0.141
			Within Groups	4		
	C content	Sandy	Between Groups	1	0.135687968	0.731272391
			Within Groups	4		
		Chernozem	Between Groups	1	2.073306244	0.223314167
			Within Groups	4		
	N content	Sandy	Between Groups	1	0.591365582	0.484782494
			Within Groups	4		
		Chernozem	Between Groups	1	3.534537133	0.133275601
			Within Groups	4		
Plant Grain	$\delta^{13}C$	Sandy	Between Groups	1	0.777388713	0.427737034
			Within Groups	4		
		Chernozem	Between Groups	1	2.192571535	0.212790041
			Within Groups	4		
	$\delta^{15}N$	Sandy	Between Groups	1	0.399	0.562
			Within Groups	4		
		Chernozem	Between Groups	1	0.003	0.957
			Within Groups	4		
	C content	Sandy	Between Groups	1	2.42471E-05	0.996306917
			Within Groups	4		
		Chernozem	Between Groups	1	0.571612934	0.491701509
			Within Groups	4		
	N content	Sandy	Between Groups	1	4.082811517	0.113420598
			Within Groups	4		
		Chernozem	Between Groups	1	0.056347338	0.824027513
			Within Groups	4		
Plant Ear	$\delta^{13}C$	Sandy	Between Groups	1	4.899640651	0.091268489
			Within Groups	4		
		Chernozem	Between Groups	1	2.675435065	0.177247696
			Within Groups	4		
	$\delta^{15}N$	Sandy	Between Groups	1	0.358	0.582
			Within Groups	4		
		Chernozem	Between Groups	1	1.555	0.28
			Within Groups	4		
	C content	Sandy	Between Groups	1	0.083228412	0.787301506
			Within Groups	4		
		Chernozem	Between Groups	1	0.157406286	0.711812497
			Within Groups	4		
	N content	Sandy	Between Groups	1	0.17251277	0.699201193
			Within Groups	4		
		Chernozem	Between Groups	1	0.384910342	0.568586713
			Within Groups	4		

Table 8.1. Statistical table output for different plant compartments (stalk, grain and ear) of harvested barley for both soil types; Degrees of freedom obtained *F*-statistic value and level of significance (*p*-value) in terms of $\delta^{13}C$, $\delta^{15}N$, C and N content in mg/g.

Plant Compartment	SamplingTime	Soil Type	Scenario	δ15N (‰)	*p-value*	N content (mg /g soil)	*p-value*
leaves	21d	S	Current	34.03 ± 3.31	*0.513*	53 ± 0.25	*0.513*
			Future	32.87 ± 1.38		51.9 ± 0.48	
		T	Current	30.23 ± 1.05	*0.275*	54.7 ± 0.34	*0.05*
			Future	31.93 ± 2.14		60 ± 0.22	
	32d	S	Current	18.5 ± 4.55	*0.827*	65.5 ± 0.47	*0.127*
			Future	17.69 ± 3.43		60 ± 0.5	
		T	Current	24.75 ± 4.24	*0.05*	68.8 ± 0.12	*0.05*
			Future	35.43 ± 3.33		64.9 ± 0.29	
	72d	S	Current	12.31 ± 2.76	*0.513*	23.3 ± 0.16	*0.513*
			Future	14.4 ± 2.78		19.1 ± 0.78	
		T	Current	17.18 ± 2.28	*0.513*	35.5 ± 0.51	*0.513*
			Future	18.56 ± 5.34		37.3 ± 0.3	
	harvest (105d)	S	Current	12.04 ± 2.63	*0.827*	8.8 ± 0.22	*0.275*
			Future	11.72 ± 3.33		12.2 ± 0.39	
		T	Current	11.89 ± 3.52	*0.127*	19.5 ± 0.14	*0.376*
			Future	13.32 ± 2.82		21.7 ± 0.15	
grain	harvest (105d)	S	Current	6.24 ± 4.79	*0.275*	5.3 ± 0.24	*0.127*
			Future	10.6 ± 1.07		6.8 ± 0.26	
		T	Current	15.31 ± 1.32	*0.127*	6.8 ± 0.06	*0.513*
			Future	16.64 ± 1.28		7.6 ± 0.08	
ear	harvest (105d)	S	Current	16.8 ± 2.1	*0.127*	23.9 ± 0.38	*0.275*
			Future	14.74 ± 2.28		24 ± 0.09	
		T	Current	9.12 ± 2.88	*0.275*	4.3 ± 0.12	*0.827*
			Future	14.14 ± 5.01		4 ± 0.14	

Table 8.2. SPSS output for nitrogen content and isotopic values of barley leaves samples (means ± SD), at different sampling times and plant compartments for S- sandy soil and T- chernozem, including *p-values* (Kruskal-Wallis H test, n=3).

Soil Type	SamplingTime	Scenario	δ13C (‰)	n	*p-value*	δ15N (‰)	n	*p-value*	C content (mg/g soil)	n	*p-value*	N content (mg/g soil)	n	*p-value*
Sandy	0	Current	-25.8 ± 0.16	3		6.62 ± 0.81	3		7.27 ± 1.62	3		1.3 ± 0.55	3	
		Future	-25.8 ± 0.13	3	*0.513*	6.51 ± 0.13	3	*0.827*	8.28 ± 0.79	3	*0.513*	0.9 ± 0.12	3	*0.513*
	6h	Current	-22.4 ± 1.25	3		12.9 ± 2.75	3		8.78 ± 0.93	2		1.0 ± 0.06	3	
		Future	-23.2 ± 0.62	3	*0.275*	11.6 ± 0.86	3	*0.827*	8.18 ± 0.74	3	*0.564*	1.1 ± 0.17	3	*0.127*
	2d	Current	-22.7 ± 0.96	3		13.2 ± 1.39	3		7.5 ± 0.64	3		1.0 ± 0.03	3	
		Future	-23.1 ± 0.58	3	*0.513*	12.4 ± 0.83	3	*0.275*	8.47 ± 1.23	3	*0.275*	1.0 ± 0.07	3	*0.827*
	4d	Current	-24.3 ± 0.18	3		10.9 ± 2.06	3		7.25 ± 0.82	3		1.0 ± 0.04	3	
		Future	-23.6 ± 0.49	3	*0.127*	11.5 ± 0.82	3	*0.827*	7.96 ± 0.94	3	*0.275*	1.2 ± 0.37	3	*0.827*
	9d	Current	-24.2 ± 1.52	3		12.3 ± 0.72	3		10.12 ± 2	2		1.2 ± 0.38	3	
		Future	-23.6 ± 0.46	3	*0.827*	13.1 ± 2.10	3	*0.513*	10.44 ± 3.47	2	*0.564*	1.0 ± 0.02	3	*0.827*
	21d	Current	-24.2 ± 0.88	3		8.70 ± 0.88	3		8.7 ± 0.47	3		0.9 ± 0.10	3	
		Future	-23.1 ± 1.44	3	*0.275*	10.7 ± 1.33	3	*0.127*	9.97 ± 2.39	3	*0.513*	0.9 ± 0.07	3	*0.127*
	32d	Current	-24.0 ± 0.62	3		9.28 ± 1.04	3		8.63 ± 0.73	3		1.0 ± 0.03	3	
		Future	-24.2 ± 0.61	3	*0.513*	9.47 ± 0.57	3	*0.827*	9.28 ± 2.2	3	*0.827*	1.0 ± 0.05	3	*0.275*
	72d	Current	-25.0 ± 0.17	3		3.94 ± 1.68	3		8.15 ± 3.73	3		0.8 ± 0.09	3	
		Future	-24.8 ± 0.40	3	*0.513*	8.65 ± 0.48	3	*0.05*	10.17 ± 0.59	3	*0.513*	1.0 ± 0.04	3	*0.127*
Chernozem	0	Current	-25.6 ± 0.07	3		8.42 ± 0.20	3		23.38 ± 1.64	3		2.2 ± 0.03	3	
		Future	-25.7 ± 0.02	3	*0.127*	8.71 ± 0.51	3	*0.513*	21.95 ± 1.37	3	*0.275*	2.1 ± 0.12	3	*0.513*
	6h	Current	-22.9 ± 0.57	3		14.2 ± 0.42	3		21.39 ± 2.29	3		2.4 ± 0.17	3	
		Future	-23.7 ± 0.35	3	*0.05*	14.8 ± 3.34	3	*0.827*	21.44 ± 0.87	3	*0.827*	2.3 ± 0.16	3	*0.827*
	2d	Current	-24.2 ± 0.49	3		10.8 ± 1.88	3		17.93 ± 2.11	3		2.2 ± 0.08	3	
		Future	-23.9 ± 1.14	3	*0.827*	10.7 ± 1.52	3	*0.827*	18.28 ± 1.8	3	*0.827*	2.2 ± 0.25	3	*0.513*
	4d	Current	-24.2 ± 0.98	3		10.7 ± 1.87	3		18.21 ± 2.6	3		2.3 ± 0.07	3	
		Future	-23.7 ± 0.61	3	*0.513*	11.0 ± 0.19	3	*0.513*	16.49 ± 0.88	3	*0.275*	2.3 ± 0.09	3	*0.513*
	9d	Current	-22.7 ± 1.37	3		14.1 ± 2.87	3		30.02 ± 3.01	3		2.2 ± 0.06	3	
		Future	-23.7 ± 1.06	3	*0.275*	12.5 ± 0.95	3	*0.513*	26.19 ± 3.86	3	*0.127*	2.2 ± 0.17	3	*0.827*
	21d	Current	-23.3 ± 1.79	3		11.1 ± 0.74	3		20.15 ± 0.76	3		2.2 ± 0.12	3	
		Future	-24.6 ± 0.36	3	*0.275*	11.2 ± 0.46	3	*0.827*	19 ± 2.49	3	*0.513*	2.0 ± 0.08	3	*0.127*
	32d	Current	-24.6 ± 0.26	3		9.84 ± 0.91	3		18.77 ± 0.59	3		2.4 ± 0.10	3	
		Future	-24.8 ± 0.77	3	*0.827*	9.21 ± 0.35	3	*0.513*	19.96 ± 1.08	3	*0.127*	2.3 ± 0.23	3	*0.827*
	72d	Current	-25.5 ± 0.09	3		5.86 ± 0.56	3		18.54 ± 0.56	3		1.6 ± 0.16	3	
		Future	-25.0 ± 0.30	3	*0.05*	9.17 ± 0.83	3	*0.05*	20.23 ± 1.81	2	*0.083*	2.0 ± 0.15	3	*0.05*

Table 8.3 Statistical table output of bulk soil analysis including significance levels (*p-value*) and averages ± SD, Kruskal-Wallis H test.

Soil Type	SamplingTime	Scenario	NO_3^- content (µg N/g soil)	n	*p-value*	NO_3^- $\delta^{15}N$ (‰)	n	*p-value*
Sandy	0	Current	6.5 ± 2.32	3		-7.4 ± 0.51	2	
		Future	4.3 ± 0.83	3	*0.05*	-6.4 ± 1.83	3	*0.513*
	6h	Current	12.72 ± 4.96	3		92.9 ± 1.49	2	
		Future	6.33 ± 1.35	3	*0.05*	86.4 ± 1.77	3	*0.513*
	2d	Current	16.96 ± 4.85	3		91.0 ± 1.39	3	
		Future	13.13 ± 2.28	3	*0.275*	79.1 ± 1.72	3	*0.275*
	4d	Current	14.96 ± 1.39	3		71.4 ± 0.79	3	
		Future	7.26 ± 2.63	3	*0.05*	71.9 ± 3.42	3	*0.05*
	9d	Current	16.88 ± 8.18	2		65.7 ± 1.12	3	
		Future	26.61 ± 8.92	3	*0.248*	67.9 ± 3.17	3	*0.127*
	21d	Current	20.18 ± 4.55	2		21.9 ± 2.65	3	
		Future	30.61 ± 2.95	2	*0.121*	32.5 ± 1.67	3	*0.127*
	32d	Current	48.22 ± 13.16	2		3.71 ± 0.85	3	
		Future	37.67 ± 4.03	2	*0.439*	4.46 ± 1.09	3	*0.275*
	72d	Current	5.51 ± 0.24	2		6.36 ± 0.55	2	
		Future	7.21 ± 1.99	3	*0.248*	9.61 ± 5.03	2	*0.275*
Chernozem	0	Current	5.42 ± 3.11	2		-10. ± 2.19	2	
		Future	6 ± 0.74	3	*1*	-7.2 ± 1.43	2	*0.127*
	6h	Current	8.84 ± 1.53	3		84.7 ± 0.79	3	
		Future	8.22 ± 0.66	3	*0.513*	80.9 ± 2.70	2	*0.827*
	2d	Current	23.19 ± 4.12	3		91.5 ± 1.28	3	
		Future	16.21 ± 2.25	3	*0.127*	86.3 ± 0.68	3	*0.05*
	4d	Current	12.83 ± 5.69	3		72.5 ± 2.19	2	
		Future	17.95 ± 3.84	3	*0.127*	72.3 ± 0.49	2	*0.127*
	9d	Current	22.78 ± 5.56	3		68.9 ± 4.53	2	
		Future	23.42 ± 5.15	3	*0.827*	64.5 ± 0.08	2	*0.275*
	21d	Current	38.54 ± 5.53	3		35.8 ± 4.28	3	
		Future	35.52 ± 16.02	2	*1*	32.9 ± 0.54	2	*0.513*
	32d	Current	52.94 ± 12.5	2		9.28 ± 1.78	3	
		Future	46.85 ± 9.4	2	*0.439*	4.14 ± 1.42	3	*0.513*
	72d	Current	8.54 ± 1.49	2		6.56 ± 1.25	3	
		Future	23.95 ± 17.84	2	*0.121*	13.7 ± 0.33	3	*0.513*

Table 8.4. Statistical summary for micro-diffusion of ^{15}N NO_3^-, including *p-values* and means ± SD.

Soil Type	SamplingTime	Scenario	NH_4 content (µg N/g soil)	n	*p-value*
Sandy	0	Current	1.71 ± 0.03	3	
		Future	1.33 ± 0.27	3	*0.05*
	6h	Current	4.17 ± 1.76	3	
		Future	3.89 ± 1.98	3	*0.827*
	2d	Current	11.29 ± 2.09	2	
		Future	11.34 ± 0.22	3	*1*
	4d	Current	4.57 ± 0.69	3	
		Future	4.39 ± 0.82	3	*0.827*
	9d	Current	1.97 ± 0.33	3	
		Future	1.54 ± 0.3	2	*0.248*
	21d	Current	1.68 ± 0.19	3	
		Future	2.14 ± 0.56	3	*0.275*
	32d	Current	12.84 ± 4.18	2	
		Future	20.54 ± 0.21	2	*0.121*
	72d	Current	1.81 ± 0.47	3	
		Future	1.87 ± 0.47	3	*0.827*
Chernozem	0	Current	1.91 ± 0.73	3	
		Future	1.63 ± 0.12	3	*0.827*
	6h	Current	4.65 ± 1.56	3	
		Future	1.84 ± 0.89	3	*0.05*
	2d	Current	12.85 ± 4.14	3	
		Future	11.77 ± 6.16	3	*0.513*
	4d	Current	6.87 ± 3.47	2	
		Future	4.8 ± 2.89	3	*0.248*
	9d	Current	5.95 ± 0.51	3	
		Future	2.15 ± 0.56	3	*0.05*
	21d	Current	1.6 ± 0.06	3	
		Future	2.28 ± 0.36	3	*0.05*
	32d	Current	14.31 ± 5.37	3	
		Future	15.14 ± 5.03	2	*1*
	72d	Current	2.09 ± 0.35	3	
		Future	1.57 ± 0.46	3	*0.275*

Table 8.5. Statistical summary for micro-diffusion of ^{15}N NH_4, including *p-values* and means ± SD.

Soil Type	SamplingTime	Scenario	SMBN (µg/g soil)	*p-value*	SMBN δ^{15}N (‰)	*p-value*
Sandy	0	Current	9.39 ± 1.17	*0.564*	-1.18 ± 0.69	*0.564*
		Future	8.81 ± 1.43		-0.85 ± 0.32	
	6h	Current	11.74 ± 2.39	*0.564*	8.81 ± 0.68	*0.248*
		Future	10.69 ± 1.45		7.51 ± 1.46	
	2d	Current	11.57 ± 0.82	*0.275*	8.29 ± 3.42	*0.564*
		Future	13.27 ± 1.59		9.44 ± 1.51	
	4d	Current	12.14 ± 1.73	*0.564*	11.49 ± 1.9	*0.275*
		Future	11.86 ± 1.18		10.11 ± 1.37	
	9d	Current	10.48 ± 0.65	*0.05*	11.87 ± 2.36	*0.05*
		Future	13.89 ± 1.24		9.39 ± 0.61	
	21d	Current	11.87 ± 2.97	*0.827*	7.71 ± 1.71	*0.827*
		Future	10.49 ± 0.9		8.67 ± 4.31	
	32d	Current	4.24 ± 0.63	*0.275*	7.94 ± 1.75	*0.513*
		Future	5.34 ± 1.51		8.53 ± 1.83	
	72d	Current	3.01 ± 0.37	*0.564*	5.26 ± 1.33	*0.248*
		Future	3.2 ± 0.29		6.68 ± 2.25	
Chernozem	0	Current	16.29 ± 1.11	*0.275*	-0.31 ± 0.12	*0.05*
		Future	16.88 ± 1.92		-0.63 ± 0.15	
	6h	Current	18.07 ± 0.89	*0.275*	7.78 ± 1.74	*0.827*
		Future	18.25 ± 1.08		7.3 ± 3.01	
	2d	Current	16.79 ± 1.97	*0.827*	7.77 ± 0.89	*0.513*
		Future	17.53 ± 0.64		7.51 ± 1.5	
	4d	Current	18.96 ± 0.88	*0.275*	8.49 ± 0.74	*0.513*
		Future	20.11 ± 4.55		9.15 ± 1.38	
	9d	Current	19.97 ± 1.78	*0.275*	11.34 ± 3.82	*0.275*
		Future	21.82 ± 2.24		7.97 ± 3.23	
	21d	Current	16.41 ± 2.99	*0.827*	7.03 ± 0.9	*0.513*
		Future	18.24 ± 3.39		5.94 ± 3.12	
	32d	Current	8.89 ± 0.75	*0.513*	7.15 ± 1.19	*0.827*
		Future	8.5 ± 2.25		7.07 ± 2.82	
	72d	Current	7.08 ± 1.64	*0.513*	5.16 ± 1.49	*0.513*
		Future	7.07 ± 2.35		5.74 ± 1.15	

Table 8.6. Statistical output for extractable soil microbial biomass, values are means ± SD, n=3.

SoilType	Samplingtime	Scenario	Mean ± SD (µgN/m²/h)	p-value
Sandy	0	Current	0.91 ± 0.16, n=3	
		Future	0.98 ± 0.12, n=3	*0.275*
	6h	Current	3.65 ± 0.62, n=3	
		Future	4.12 ± 0.15, n=3	*0.513*
	2d	Current	6.4 ± 2.13, n=3	
		Future	7.94 ± 1.5, n=3	*0.275*
	4d	Current	7.25 ± 2.07, n=3	
		Future	9 ± 1.61, n=3	*0.513*
	9d	Current	12.55 ± 1.72, n=3	
		Future	7.36 ± 1.81, n=3	*0.05*
	21d	Current	3.3 ± 0.26, n=3	
		Future	7.45 ± 1.9, n=3	*0.05*
	32d	Current	30.07 ± 0.65, n=2	
		Future	33.58 ± 1.95, n=2	*0.827*
Chernozem	0	Current	1.3 ± 0.58, n=3	
		Future	0.89 ± 0.57, n=2	*0.513*
	6h	Current	4.85 ± 1.53, n=3	
		Future	3.6 ± 1.65, n=3	*1*
	2d	Current	7.4 ± 1.52, n=3	
		Future	7.14 ± 2.13, n=3	*0.827*
	4d	Current	7.34 ± 0.59, n=3	
		Future	7.43 ± 2.65, n=3	*0.513*
	9d	Current	15.92 ± 3.3, n=3	
		Future	10.25 ± 3.95, n=3	*0.127*
	21d	Current	4.63 ± 0.47, n=3	
		Future	5.27 ± 0.55, n=3	*0.275*
	32d	Current	48.22 ± 1.71, n=2	
		Future	18.85 ± 4.65, n=3	*0.083*
Sandy	16d	Current	27.31 ± 7.38, n=2	
		Future	0 ± 0, n=3	-
	17d	Current	5.18 ± 0.55, n=3	
		Future	14 ± 1.52, n=3	*0.05*
	18d	Current	6.22 ± 0.42, n=3	
		Future	34.04 ± 11.69, n=3	*0.05*
	29d	Current	18.09 ± 6.81, n=3	
		Future	15.87 ± 7.93, n=3	*0.827*
	30d	Current	43.57 ± 5.77, n=3	
		Future	25.68 ± 2.46, n=1	*0.05*
Chernozem	16d	Current	29.21 ± 0.95, n=2	
		Future	69.21 ± 0, n=3	*0.121*
	17d	Current	10.11 ± 0.88, n=3	
		Future	19.53 ± 5.55, n=3	*0.05*
	18d	Current	19.27 ± 8.05, n=3	
		Future	33.98 ± 11.79, n=3	*0.275*
	29d	Current	24.29 ± 7.12, n=2	
		Future	28.96 ± 8.28, n=3	*0.827*
	30d	Current	108.59 ± 16.63, n=3	
		Future	33.25 ± 2.17, n=3	*0.05*

Table 8.7. Statistical output for N_2O gas measurements

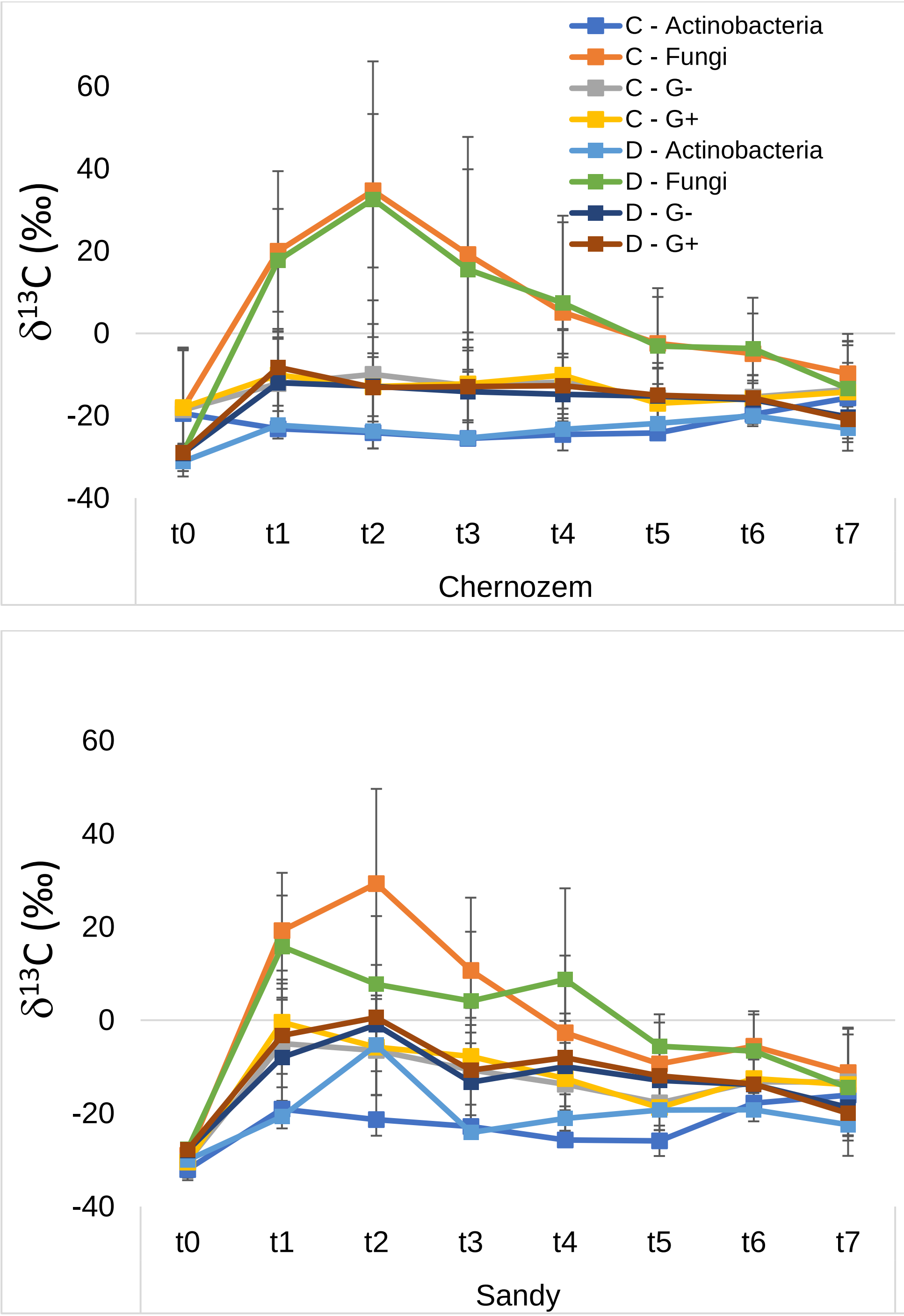

Figure 8.4. d13C time sequence incorporation for different biomarker groups (G- gram-negative bacteria; G+ gram-positive bacteria) under current and future scenario for both soil types.

Identification	Biomarker
13:0	ubiquitous
i14:0	G+
14:0	ubiquitous
i15:0	G+
a15:0	G+
15:0	ubiquitous
i16:0	G+
16:1ω7+6	G-
16:1ω5	Arbusular Mycorrhiza
16:0	ubiquitous
i17ω1:8+ 10Me16:0	G- / Actinobacteria
i17:0	G+
a17:0	G+
17:1ω8	G-
cy17:0	G-
17:0	ubiquitous
10Me17:0	Actinobacteria
18:2ω6,9	Fungi
18:1ω9c	Fungi
18:1ω7c/9t+8	G-
18:1ω5c	G-
18:0	ubiquitous
10Me18:0+ 12Me18:0	Actinobacteria
cy19:0+ 19:1	G-
19:0	ubiquitous

Table 8.8 Assignments of phospholipid fatty acid (PLFA) bioindicators.

Table 8.9. N_2O gas measurements results, including regression analysis slopes, R^2 and *p values*.

SoilType	Scenario	Date	Slope (ppm vs time)	R2 (ppm vs time)	p-value (ppm vs time)	R2 (δ15N vs 1/ppm)	p-value (δ15N vs 1/ppm)	N (μγ/m2/h)	δ15N source-intercept
Sandy	Current	06/04/2018	0.06090653	0.4962139	2.0662E-132	8.42E-07	0.978353949	0.7607	-25.4939565
Sandy	Current	06/04/2018	0.09132064	0.6749383	2.0611E-218	0.003536	0.076555159	1.14056	-200.20694
Sandy	Current	06/04/2018	0.06767013	0.5647075	9.5216E-161	1.71E-06	0.969078982	0.84518	-14.1584721
Chernozem	Current	06/04/2018	0.06087953	0.4713563	9.5829E-126	0.000278	0.618220902	0.76036	24.7001257
Chernozem	Future	06/04/2018	0.02549587	0.1544197	6.88283E-36	0.000151	0.707628201	0.31843	25.6281747
Chernozem	Current	09/04/2018	0.21813468	0.4051513	1.28872E-77	0.05365	1.23209E-09	2.72442	-260.276873
Chernozem	Current	06/04/2018	0.0830242	0.6799325	8.9696E-234	0.006224	0.015659774	1.03694	-254.334567
Chernozem	Current	06/04/2018	0.16916401	0.8773683	0	0.011453	0.002031866	2.1128	-216.13007
Chernozem	Current	11/05/2018	0.02029656	0.0005858	0.309387324	0.1094	2.38429E-46	0.2535	-55.7660461
Sandy	Future	06/04/2018	0.06558473	0.5373916	8.3693E-150	0.007437	0.010313669	0.81913	-312.475503
Sandy	Future	06/04/2018	0.08090254	0.6927612	9.3863E-229	0.014413	0.000341684	1.01044	331.589355
Sandy	Future	06/04/2018	0.08992832	0.6462659	3.0912E-201	0.286128	1.39999E-66	1.12317	-1838.7701
Chernozem	Future	09/04/2018	0.13739867	0.8006045	7.316E-300	0.023567	6.75948E-06	1.71606	-298.661035
Chernozem	Future	06/04/2018	-9.5326607	0.0152648	0.000232995	0.006225	0.019039962	-119.06	-245.302142
Chernozem	Future	09/04/2018	0.26838725	0.7732614	2.6258E-201	0.061649	3.64853E-10	3.35206	-329.981866
Chernozem	Future	06/04/2018	0.11835485	0.8042986	0	0.017988	6.58047E-05	1.47821	-332.96742
Sandy	Current	18/04/2018	0.83582517	0.9112302	0	0.001498	0.320105187	10.4391	21.4501873
Sandy	Current	30/04/2018	0.24325169	0.9373999	0	0.002922	0.094330344	3.03812	-64.878028
Sandy	Current	18/04/2018	1.17417719	0.9947458	0	0.000614	0.524343136	14.665	13.3293086
Sandy	Current	30/04/2018	0.25778262	0.9347139	0	8.22E-05	0.788681681	3.21961	7.76677394
Chernozem	Current	11/04/2018	0.4293711	0.9647859	0	0.00058	0.540295476	5.36269	-20.7578338
Chernozem	Current	13/04/2018	0.52049937	0.9733321	0	0.000726	0.51529174	6.50085	-12.7748649
Chernozem	Current	18/04/2018	1.53781413	0.997529	0	0.004857	0.055781213	19.2067	-9.67959509
Chernozem	Current	11/04/2018	0.72229435	0.9867688	0	4.57E-06	0.95541602	9.02119	3.33739359

Sandy	Future	11/04/2018	0.48711407	0.9752434	0	0.005603	0.056097508	6.08388	57.6095303
Sandy	Future	13/04/2018	0.5420213	0.9783056	0	0.004964	0.071560051	6.76965	-42.2894306
Sandy	Future	18/04/2018	0.64517278	0.9731871	0	6.54E-05	0.843840315	8.05797	-0.97516647
Sandy	Future	30/04/2018	0.44684616	0.9306271	0	0.000815	0.404442823	5.58094	17.7879784
Sandy	Future	18/04/2018	0.73383012	0.9822553	0	0.000115	0.781735734	9.16527	-0.61945798
Sandy	Future	11/04/2018	0.78314018	0.9901351	0	0.001979	0.255610857	9.78113	26.1167681
Sandy	Future	18/04/2018	0.39024065	0.9516089	0	0.004926	0.089893776	4.87396	-69.6100211
Chernozem	Future	11/04/2018	0.3565338	0.9547486	0	0.00027	0.674208327	4.45298	-18.2074906
Chernozem	Future	13/04/2018	0.44013204	0.963348	0	2.83E-05	0.896068323	5.49709	3.50376376
Chernozem	Future	18/04/2018	0.50421405	0.9412999	0	0.006022	0.053836321	6.29745	-51.581867
Chernozem	Future	11/04/2018	0.58673726	0.9785803	0	1.69E-06	0.974354803	7.32813	2.75550796
Chernozem	Future	09/04/2018	0.46058993	0.9687332	0	0.001076	0.419855672	5.7526	-27.479525
Chernozem	Future	13/04/2018	0.89638182	0.989771	0	0.000761	0.516388101	11.1955	-2.42504378
Chernozem	Future	18/04/2018	1.2535939	0.9946907	0	0.000303	0.67452865	15.6569	-0.4235788
Sandy	Current	27/04/2018	0.491223	0.9797772	0	5.75E-05	0.822634337	6.13519	-14.5293972
Sandy	Current	08/05/2018	0.71940173	0.9888383	0	0.000162	0.729648155	8.98506	-2.99161528
Sandy	Current	27/04/2018	0.5430017	0.9837319	0	0.003614	0.075528972	6.78189	-40.9579681
Sandy	Current	27/04/2018	0.46059847	0.9689259	0	1.5E-06	0.974114064	5.75271	-9.51706888
Chernozem	Current	27/04/2018	0.63125774	0.9881278	0	0.000654	0.448228591	7.88418	-22.6519959
Sandy	Future	26/04/2018	1.15685579	0.9966195	0	0.00398	0.052291828	14.4487	-26.6019303
Sandy	Future	08/05/2018	0.53256541	0.9776271	0	0.00032	0.625160729	6.65155	-18.5301774
Sandy	Future	26/04/2018	1.24913773	0.9983778	0	0.000342	0.522098368	15.6013	-8.73469144
Sandy	Future	27/04/2018	3.57554089	0.9928505	0	8.43E-05	0.787380987	44.6572	-9.87853175
Sandy	Future	08/05/2018	1.19848875	0.9955458	0	0.001216	0.32825276	14.9687	-18.0785633
Sandy	Current	09/04/2018	0.2611361	0.9106173	0	0.186317	4.02632E-29	3.26149	-703.496938
Sandy	Current	11/04/2018	0.3316347	0.9231017	0	0.008102	0.022244076	4.142	-101.465377
Sandy	Current	13/04/2018	0.39460106	0.9590995	0	0.013137	0.004176684	4.92842	-108.709585
Sandy	Current	11/05/2018	8.34356203	0.9998509	0	0.657242	3.0491E-194	104.208	-55.222102

Sandy	Current	09/04/2018	0.25348721	0.908478	0	0.12777	1.29985E-19	3.16596	-611.091123
Sandy	Current	11/04/2018	0.4663085	0.9703321	0	0.012318	0.00467583	5.82402	91.4832574
Sandy	Current	13/04/2018	0.55033463	0.9782867	0	0.027439	2.22391E-05	6.87348	-105.976358
Sandy	Current	11/05/2018	2.46081938	0.9992186	0	0.092051	1.21319E-19	30.7347	-33.6429048
Sandy	Current	09/04/2018	0.36362107	0.9398314	0	0.132332	2.67893E-22	4.54149	-396.681459
Sandy	Current	11/04/2018	0.74146324	0.989259	0	0.019996	0.000301871	9.2606	82.1962515
Sandy	Current	13/04/2018	0.79740773	0.984012	0	0.011879	0.010115646	9.95933	-50.2001674
Sandy	Current	18/04/2018	1.00561319	0.9682677	0	0.007668	0.035954615	12.5597	42.8276737
Sandy	Current	30/04/2018	0.29295825	0.9325746	0	0.008504	0.0088904	3.65894	-107.554544
Sandy	Current	11/05/2018	2.35586448	0.998526	0	0.048783	2.62525E-10	29.4239	-26.1570521
Chernozem	Current	18/04/2018	0.91300466	0.9423093	0	0.04506	8.83687E-09	11.4031	-73.9512808
Chernozem	Current	30/04/2018	0.32036718	0.9501141	0	0.017971	7.8803E-05	4.00127	-131.960862
Chernozem	Current	11/05/2018	3.72376007	0.9411977	0	0.415773	3.5708E-103	46.5084	-61.3707367
Chernozem	Current	09/04/2018	0.44566789	0.9550967	0	0.027992	3.64235E-05	5.56623	-162.81569
Chernozem	Current	11/04/2018	0.62586824	0.9696911	0	0.013429	0.003556932	7.81686	-72.9322561
Chernozem	Current	13/04/2018	0.62538572	0.9805168	0	0.037652	1.1957E-06	7.81084	-116.781773
Chernozem	Current	30/04/2018	0.41143639	0.9613985	0	0.041636	3.12134E-09	5.13869	-163.627912
Chernozem	Current	11/05/2018	3.99817672	0.9996424	0	0.400708	3.74945E-97	49.9358	-59.9370659
Chernozem	Current	09/04/2018	0.50139021	0.971511	0	0.017975	0.000947082	6.26218	-110.338385
Chernozem	Current	13/04/2018	0.61787595	0.9813229	0	0.011986	0.006575167	7.71704	-60.2626346
Chernozem	Current	18/04/2018	1.37406395	0.9951215	0	0.029521	2.18062E-06	17.1616	-38.2129462
Chernozem	Current	30/04/2018	0.38209829	0.9658818	0	0.0198	3.64361E-05	4.77227	-118.511533
Sandy	Future	09/04/2018	0.33061359	0.9609005	0	0.027173	6.06925E-07	4.12924	-131.417263
Sandy	Future	11/05/2018	2.84573403	0.9992253	0	0.242654	1.20173E-55	35.5422	-50.9720535
Sandy	Future	09/04/2018	0.31447025	0.9196714	0	0.050988	1.44486E-09	3.92762	-256.825206
Sandy	Future	11/04/2018	0.63921726	0.9791131	0	0.01639	0.001015287	7.98359	76.0561003
Sandy	Future	13/04/2018	0.77904923	0.9879191	0	0.028923	1.49817E-05	9.73004	-80.8004754
Sandy	Future	30/04/2018	0.53768121	0.9833582	0	0.026623	1.83447E-06	6.71544	-100.527509

Sandy	Future	11/05/2018	2.53256029	0.9989983	0	0.160952	1.24552E-34	31.6307	-46.4107813
Sandy	Future	09/04/2018	0.34536558	0.9573735	0	0.175568	2.64944E-28	4.31349	-545.568311
Sandy	Future	13/04/2018	0.84248112	0.9866149	0	0.009283	0.023086265	10.5223	-42.9480348
Sandy	Future	30/04/2018	0.80650153	0.9832658	0	0.055529	1.3551E-11	10.0729	-107.912178
Sandy	Future	11/05/2018	1.04971849	0.9929614	0	0.030291	4.45967E-07	13.1106	-46.4601406
Chernozem	Future	30/04/2018	0.35982615	0.9587042	0	0.027986	6.96863E-07	4.4941	-155.276554
Chernozem	Future	11/05/2018	1.73313787	0.9983671	0	0.081249	1.82413E-17	21.6463	-41.9738476
Chernozem	Future	13/04/2018	0.44948428	0.9655323	0	0.024206	9.52315E-05	5.61389	-132.500307
Chernozem	Future	18/04/2018	0.70539606	0.9780168	0	0.014761	0.001824393	8.81014	-63.0265697
Chernozem	Future	30/04/2018	0.45756461	0.9732911	0	0.021887	1.65007E-05	5.71481	-113.178193
Chernozem	Future	11/05/2018	1.81172204	0.9704088	0	0.132128	2.37509E-28	22.6277	-58.0049061
Chernozem	Future	11/04/2018	0.77359769	0.9888136	0	0.019714	0.000473921	9.66195	77.5514695
Chernozem	Future	30/04/2018	0.4493606	0.9746202	0	0.042858	2.9142E-09	5.61235	-163.486819
Chernozem	Future	11/05/2018	0.98499911	0.9886246	0	0.086421	4.5528E-18	12.3023	-89.4207017
Sandy	Current	25/04/2018	2.77878916	0.9934477	0	0.083015	2.03615E-18	34.7061	-42.9304013
Sandy	Current	26/04/2018	0.47169397	0.9804139	0	0.00689	0.014610359	5.89128	-61.8750815
Sandy	Current	09/05/2018	2.8354713	0.9989059	0	0.138439	2.59624E-30	35.414	-48.8612602
Sandy	Current	25/04/2018	1.59574513	0.9950732	0	0.018271	4.42667E-05	19.9303	-33.3188238
Sandy	Current	26/04/2018	0.41061591	0.976639	0	0.028693	3.82779E-07	5.12844	-121.510838
Sandy	Current	08/05/2018	1.59644813	0.9962212	0	0.018252	7.77637E-05	19.939	-34.2582202
Sandy	Current	09/05/2018	3.83645251	0.9994251	0	0.28552	7.04563E-65	47.9159	-54.6291888
Sandy	Current	26/04/2018	0.36363447	0.9692616	0	0.007956	0.008789058	4.54166	-80.1448082
Sandy	Current	08/05/2018	2.03121808	0.9975532	0	0.062283	2.99064E-13	25.3692	-48.5116637
Sandy	Current	09/05/2018	3.79549042	0.9991032	0	0.350511	2.60902E-80	47.4043	-65.8720302
Chernozem	Current	25/04/2018	2.26199804	0.9880138	0	0.083058	3.76015E-19	28.2515	-52.3111342
Chernozem	Current	26/04/2018	0.72436247	0.9897445	0	0.024243	4.54534E-06	9.04702	-75.7037634
Chernozem	Current	08/05/2018	1.37499072	0.9956489	0	0.061032	4.0583E-13	17.1731	-66.9395738
Chernozem	Current	09/05/2018	6.81990556	0.9987746	0	0.602957	1.0968E-175	85.1781	-69.3468369

Chernozem	Current	25/04/2018	2.41560848	0.9900941	0	0.085694	5.95711E-20	30.1701	-49.0536512
Chernozem	Current	26/04/2018	0.89834048	0.9922907	0	0.018676	6.66866E-05	11.2199	-58.1708862
Chernozem	Current	27/04/2018	2.010884	0.9959033	0	0.100226	3.40101E-21	25.1152	-62.8959134
Chernozem	Current	08/05/2018	2.51607984	0.9968624	0	0.07224	5.4992E-15	31.4249	-45.2325552
Chernozem	Current	09/05/2018	9.46972709	0.9996616	0	0.752173	9.449E-273	118.273	-71.4338377
Chernozem	Current	26/04/2018	0.80668537	0.992129	0	0.019872	2.4622E-05	10.0752	-62.115586
Chernozem	Current	27/04/2018	1.98850679	0.9953235	0	0.101352	7.53226E-22	24.8357	-61.6178999
Chernozem	Current	08/05/2018	5.61420747	0.9982479	0	0.465816	8.3152E-110	70.1194	-68.9101299
Chernozem	Current	09/05/2018	9.79411871	0.9995426	0	0.792005	1.8679E-294	122.325	-78.4173163
Sandy	Future	27/04/2018	1.42220972	0.9953238	0	0.008225	0.007857012	17.7629	-28.6780863
Sandy	Future	09/05/2018	1.79054655	0.998277	0	0.060489	1.02734E-13	22.3633	-48.4725389
Sandy	Future	09/05/2018	2.26409266	0.9989866	0	0.108984	5.52297E-23	28.2777	-51.7273272
Sandy	Future	26/04/2018	0.95691886	0.9952241	0	0.005221	0.032388576	11.9516	-34.3067873
Sandy	Future	27/04/2018	3.18097282	0.994384	0	0.017959	8.97867E-05	39.7292	-23.5185592
Sandy	Future	08/05/2018	2.08317868	0.9986882	0	0.140817	7.57355E-30	26.0181	-66.7520326
Sandy	Future	09/05/2018	2.11382266	0.9986832	0	0.094567	4.05803E-20	26.4009	-51.5038447
Chernozem	Future	25/04/2018	5.54215179	0.9872509	0	0.115116	2.17668E-25	69.2194	-33.2386742
Chernozem	Future	26/04/2018	2.14684877	0.9978798	0	0.047995	1.12789E-10	26.8134	-43.9692748
Chernozem	Future	27/04/2018	1.6755735	0.994734	0	0.054441	7.9807E-12	20.9273	-55.9732375
Chernozem	Future	08/05/2018	1.41904206	0.9974436	0	0.024315	7.54635E-06	17.7233	-45.3395843
Chernozem	Future	09/05/2018	2.53482812	0.9991557	0	0.147529	3.55371E-32	31.6591	-56.7034124
Chernozem	Future	25/04/2018	10.5424413	0.9884566	0	0.234928	2.17803E-53	131.671	-28.0573683
Chernozem	Future	26/04/2018	1.47983227	0.9974586	0	0.036417	1.48693E-08	18.4826	-49.9983147
Chernozem	Future	27/04/2018	3.96319398	0.9971496	0	0.099308	2.93995E-21	49.4988	-36.3487395
Chernozem	Future	08/05/2018	2.99746421	0.9993024	0	0.268373	5.31663E-59	37.4372	-73.8144308
Chernozem	Future	09/05/2018	2.90815353	0.9994041	0	0.270687	2.44944E-60	36.3218	-67.4690413
Chernozem	Future	26/04/2018	1.06670909	0.9949442	0	0.037819	7.93941E-09	13.3228	-67.2746303
Chernozem	Future	27/04/2018	2.52327302	0.9938865	0	0.086847	8.58875E-19	31.5148	-48.9647506

Chernozem	Future	08/05/2018	2.53987572	0.9921397	0	0.367045	8.59615E-86	31.7221	-104.346707
Chernozem	Future	09/05/2018	2.54424387	0.9969437	0	0.139868	2.53644E-21	31.7767	-74.9653029

		d13C						nmol/g					
PLFA	SamplingTime	Sandy Current	Sandy Future	*p value*	Chernozem Current	Chernozem Future	*p value*	Sandy Current	Sandy Future	*p value*	Chernozem Current	Chernozem Future	*p value*
i14:0	0	-34.64 ± 4.13	-30.42 ± 0.38	n.s.	-31.45 ± 2.27	-32.62 ± 1.97	n.s.	0.95 ± 0.28	0.7 ± 0.09	n.s.	1.73 ± 1.19	1.27 ± 0.19	n.s.
	6h	-1.17 ± 3.24	-3.98 ± 6.21	n.s.	-10.45 ± 1.17	-9.98 ± 2.2	n.s.	0.83 ± 0.06	1.67 ± 0.98	n.s.	0.78 ± 0.09	1.22 ± 0.15	0.05
	2d	-2.84 ± 2.97	1.04 ± 3.01	n.s.	-9.97 ± 1.95	-13.35 ± 4.27	n.s.	1.21 ± 0.18	0.6	n.s.	1.73 ± 0.7	0.89 ± 0.15	0.05
	4d	-12.16 ± 5.14	-13.02 ± 5.89	n.s.	-14.03 ± 1.99	-16.34 ± 2.58	n.s.	1.06 ± 0.19	1.21 ± 0.32	n.s.	1.26 ± 0.08	1.45 ± 0.21	n.s.
	9d	-15.33 ± 2.38	-9.16 ± 0.37	0.05	-18.68 ± 6.36	-14.72 ± 1.04	n.s.	1 ± 0.19	0.94 ± 0.05	n.s.	1.13 ± 0.17	1.17 ± 0.1	n.s.
	21d	-23.32 ± 4.93	-13.53 ± 1.4	0.05	-21.42 ± 1.77	-17.39 ± 8.55	n.s.	0.89 ± 0.3	0.85 ± 0.07	n.s.	1.07 ± 0.12	0.92 ± 0.02	0.05

	32d	-14.89 ± 4.51	-16.85 ± 5.46	n.s.	-19.01 ± 1.93	-17.6 ± 4.72	n.s.	0.88 ± 0.1	0.98 ± 0.05	n.s.	1.09 ± 0.03	1.13 ± 0.14	n.s.
	72d	-27.62 ± 1.28	-25.54 ± 4.84	n.s.	-26.42 ± 4.45	-24.4 ± 0.56	n.s.	0.91 ± 0.05	1.02 ± 0.19	n.s.	1.08 ± 0.02	1.19 ± 0.11	n.s.
14:0	0	-34.39 ± 2.72	-32.07 ± 0.35	n.s.	-32.03 ± 2.49	-32.88 ± 2.05	n.s.	1.15 ± 0.36	1.06 ± 0.12	n.s.	2.15 ± 1.28	1.65 ± 0.2	n.s.
	6h	-5.98 ± 3.24	-7.85 ± 4.45	0.05	-13.23 ± 3.14	-12.06 ± 1.74	n.s.	0.93 ± 0.07	1.82 ± 0.9	0.05	0.94 ± 0.1	1.45 ± 0.17	0.05
	2d	-13.97 ± 3.23	-1.18 ± 6.87	n.s.	-18.03 ± 0.61	-17.11 ± 3.98	n.s.	1.38 ± 0.21	0.77	n.s.	2.14 ± 1.17	1.04 ± 0.13	0.05
	4d	-18.81 ± 2.75	-18.89 ± 4.88	n.s.	-19.99 ± 2.1	-21.13 ± 2.62	n.s.	1.18 ± 0.18	1.54 ± 0.55	n.s.	1.46 ± 0.09	1.75 ± 0.27	n.s.
	9d	-19.61 ± 3.6	-15.2 ± 1.96	n.s.	-21.36 ± 7.35	-17.86 ± 0.79	n.s.	1.18 ± 0.16	1.23 ± 0.19	n.s.	1.23 ± 0.03	1.47 ± 0.16	0.05
	21d	-24.96 ± 5.11	-16.38 ± 0.52	0.05	-22.87 ± 2.15	-20.79 ± 5.99	n.s.	1.17 ± 0.34	1.18 ± 0.16	n.s.	1.41 ± 0.15	1.2 ± 0.09	n.s.
	32d	-19.94 ± 3.84	-20.3	n.s.	-20.27 ± 1.18	-19.05 ± 3.49	n.s.	1.12 ± 0.1	1.32 ± 0.05	0.05	1.42 ± 0.02	1.48 ± 0.16	n.s.

			2 ± 4.99										
	72d	-29.94 ± 1.59	-27.53 ± 3.98	n.s.	-28.63 ± 4.15	-25.2 ± 1.08	n.s.	1.24 ± 0.02	1.38 ± 0.25	n.s.	1.42 ± 0.03	1.6 ± 0.09	n.s.
i15:0	0	-28.03 ± 2.02	-26.42 ± 0.18	n.s.	-26.87 ± 0.32	-27.16 ± 0.69	n.s.	6.24 ± 0.81	6.98 ± 0.48	n.s.	8.03 ± 0.64	10.73 ± 0.12	n.s.
	6h	-9.37 ± 1.84	-10.16 ± 2.6	n.s.	-17.91 ± 1.32	-16.01 ± 1.05	0.05	6.79 ± 0.7	11.7 ± 5.98	0.05	8.03 ± 1.04	11.05 ± 0.4	0.05
	2d	-17.11 ± 1.78	-	n.s.	-21.56 ± 0.71	-21.54 ± 0.36	n.s.	8 ± 0.7	5.04	n.s.	14 ± 6.26	8.04 ± 0.57	0.05
	4d	-12.84 ± 2.36	-16.41 ± 4.09	n.s.	-19.48 ± 1.58	-19.42 ± 2.83	n.s.	8.91 ± 1.04	10.37 ± 1.66	n.s.	12.05 ± 0.33	12.92 ± 1.1	n.s.
	9d	-16.57 ± 1.06	-14.67 ± 2.16	n.s.	-18.61 ± 3.04	-18.4 ± 0.48	n.s.	9.12 ± 1.01	8.49 ± 0.78	n.s.	11.35 ± 1.01	11.73 ± 0.33	n.s.
	21d	-19.37 ± 1.42	-13.86 ± 1.65	0.05	-18.14 ± 0.57	-16.3 ± 5.23	n.s.	9.19 ± 2.58	7.89 ± 0.24	n.s.	11.27 ± 0.43	9.18 ± 1.2	0.05
	32d	-13.38 ± 2.64	-14.62 ± 2.12	n.s.	-16.7 ± 0.18	-17.71 ± 2.2	n.s.	7.47 ± 0.34	8.52 ± 0.04	0.05	10.98 ± 0.68	12.15 ± 0.67	n.s.

	72d	-20.5 ± 1.16	-18.85 ± 1.88	n.s.	-21.54 ± 2.4	-20.64 ± 0.79	n.s.	9.03 ± 0.16	9.21 ± 1.89	n.s.	11.67 ± 0.26	11.36 ± 0.94	n.s.
a15:0	0	-28.27 ± 2.92	-26.05 ± 0.33	n.s.	-26.44 ± 0.54	-27.04 ± 0.6	n.s.	4.32 ± 0.56	4.84 ± 0.31	n.s.	5.34 ± 0.71	7.93 ± 0.55	n.s.
	6h	23 ± 4.58	18.39 ± 11.31	n.s.	7.83 ± 3.85	11.29 ± 4.52	n.s.	7.81 ± 0.95	12.33 ± 4.89	n.s.	8.02 ± 1.42	11.64 ± 1.67	0.05
	2d	13.72 ± 4	-	n.s.	-4.06 ± 2.11	0.34 ± 3.02	0.05	8.83 ± 0.75	5.78	n.s.	14.08 ± 3.76	7.26 ± 0.96	0.05
	4d	14.36 ± 3.87	7.38 ± 12.04	n.s.	5.65 ± 1.81	3.58 ± 9.67	n.s.	9.33 ± 1.46	9.77 ± 1.43	n.s.	11.69 ± 0.49	12.8 ± 3.52	n.s.
	9d	3.49 ± 2.45	8.56 ± 3.89	n.s.	0.5 ± 6.95	1.35 ± 3.97	n.s.	7.89 ± 1.25	7.97 ± 0.21	n.s.	10.55 ± 2.1	10.04 ± 1.27	n.s.
	21d	-10.3 ± 2.52	-1.33 ± 3.77	0.05	-7.78 ± 2.6	-6.35 ± 8.56	n.s.	6.74 ± 2.25	5.99 ± 0.37	n.s.	8.34 ± 0.44	6.83 ± 0.61	0.05
	32d	-3.12 ± 4.32	-4.03 ± 3.18	n.s.	-8.96 ± 0.49	-8.78 ± 3.86	n.s.	5.72 ± 0.64	6.32 ± 0.16	n.s.	7.85 ± 0.38	8.68 ± 0.96	n.s.
	72d	-14.31 ± 1.4	-12.64 ± 3.38	n.s.	-16.95 ± 4.56	-15.4 ± 1.73	n.s.	5.97 ± 0.22	6.12 ± 1.05	n.s.	8.02 ± 0.38	7.76 ± 0.54	n.s.

15:0	0	-35.04 ± 4.73	-31.23 ± 0.72	n.s.	-31.93 ± 1.04	-33.6 ± 1.42	n.s.	0.97 ± 0.19	0.74 ± 0.09	n.s.	1.82 ± 1.36	1.08 ± 0.07	n.s.
	6h	1.1 ± 4.29	-2.81 ± 3.03	n.s.	-8.14 ± 4.31	-6.03 ± 2.79	n.s.	0.79 ± 0.06	1.34 ± 0.61	0.05	0.83 ± 0.08	1.19 ± 0.11	0.05
	2d	-8.71 ± 3.81	-	n.s.	-11.69 ± 1.28	-11.31 ± 4.12	n.s.	1.01 ± 0.1	0.6	n.s.	1.52 ± 0.59	0.85 ± 0.17	n.s.
	4d	-15.19 ± 5.25	-14.06 ± 5.37	n.s.	-15.43 ± 2.81	-15.75 ± 2.68	n.s.	0.95 ± 0.11	1.14 ± 0.28	n.s.	1.13 ± 0.02	1.28 ± 0.17	n.s.
	9d	-17.18 ± 3.15	-10.78 ± 1.06	0.05	-19.69 ± 9.52	-15.01 ± 0.84	n.s.	0.91 ± 0.05	0.94 ± 0.11	n.s.	0.94 ± 0.04	1.07 ± 0.08	0.05
	21d	-24.45 ± 5.04	-16.51 ± 3.3	n.s.	-21.73 ± 1.59	-18.92 ± 6.37	n.s.	0.9 ± 0.29	0.92 ± 0.12	n.s.	1.04 ± 0.15	0.92 ± 0.04	n.s.
	32d	-17.55 ± 3.58	-19.18 ± 5.08	n.s.	-18.93 ± 1.15	-16.91 ± 4.42	n.s.	0.82 ± 0.05	0.96 ± 0.01	0.05	1.09 ± 0.05	1.12 ± 0.13	n.s.
	72d	-30.51 ± 2.39	-25.04 ± 3.62	n.s.	-27.66 ± 5.42	-24.21 ± 0.88	n.s.	0.94 ± 0.07	0.98 ± 0.09	n.s.	1.06 ± 0.02	1.17 ± 0.04	n.s.
i16:0	0	-30.35 ± 2.34	-28.6 ± 0.17	n.s.	-28.63 ± 0.68	-29.35 ± 0.58	n.s.	3.76 ± 0.43	4.15 ± 0.42	n.s.	4.43 ± 0.53	6.27 ± 0.43	n.s.

	6h	0.97 ± 2.23	-1.96 ± 5.58	n.s.	-7.41 ± 1.98	-6.66 ± 2.27	n.s.	4.76 ± 0.77	7.73 ± 2.72	n.s.	5.24 ± 0.69	7.62 ± 0.71	0.05
	2d	-5.28 ± 2.63	-	n.s.	-11.91 ± 2.48	-11.6 ± 2.43	n.s.	5.67 ± 0.53	3.78	n.s.	8.53 ± 2.95	5.59 ± 1.04	n.s.
	4d	-5.08 ± 2.1	-9.26 ± 6.17	n.s.	-9.31 ± 2.49	-11.02 ± 3.58	n.s.	5.66 ± 0.64	6.56 ± 0.97	n.s.	7.66 ± 0.32	8.27 ± 1.33	n.s.
	9d	-9.39 ± 0.87	-6.76 ± 1.04	0.05	-9.56 ± 5.36	-10.33 ± 1.43	n.s.	5.49 ± 0.87	5.79 ± 0.43	n.s.	6.9 ± 0.66	7.25 ± 0.59	n.s.
	21d	-16.76 ± 2.17	-10.48 ± 2.09	0.05	-13.97 ± 1.46	-12.76 ± 5.77	n.s.	5.58 ± 1.91	5.09 ± 0.28	n.s.	6.77 ± 0.35	5.78 ± 0.64	0.05
	32d	-10.35 ± 3.85	-11.89 ± 2.56	n.s.	-12.5 ± 0.26	-13.92 ± 2.86	n.s.	4.63 ± 0.32	5.38 ± 0.11	0.05	6.77 ± 0.28	7.31 ± 0.83	n.s.
	72d	-19.59 ± 1.48	-18.22 ± 2.47	n.s.	-20.26 ± 3.07	-19.24 ± 1.26	n.s.	5.06 ± 0.11	5.29 ± 0.65	n.s.	6.44 ± 0.27	6.78 ± 0.26	n.s.
16:1w7+6	0	-30.47 ± 1.39	-29.17 ± 0.53	n.s.	-30.2 ± 0.41	-30.25 ± 0.34	n.s.	11.24 ± 2.15	14.05 ± 0.79	n.s.	14.16 ± 2.58	19.68 ± 0.99	n.s.
	6h	-0.66 ± 2.47	-1.33 ± 3.65	n.s.	-13.21 ± 3.29	-10.97 ± 0.74	n.s.	16.41 ± 2.05	27.07 ± 9.7	0.05	15.95 ± 2.06	24.76 ± 3.25	0.05
	2d	-13.75 ± 3.16	-	n.s.	-20.48 ± 1.59	-20.44 ± 1.34	n.s.	14.2 ± 0.79	11.63	n.s.	20.3 ± 4.01	15.69 ± 2.08	0.05

	4d	-10.96 ± 1.19	-13.55 ± 6.71	n.s.	-16.77 ± 1.07	-18.14 ± 4.35	n.s.	15.98 ± 2.03	17.4 ± 2.09	n.s.	19.9 ± 1.25	22.28 ± 4.64	n.s.
	9d	-6.77 ± 4.02	-9.62 ± 3.46	n.s.	-13.47 ± 7.98	-15.16 ± 1.96	n.s.	17.02 ± 3.43	16.35 ± 2.55	n.s.	20.99 ± 1.69	20.4 ± 1.87	n.s.
	21d	-14.11 ± 0.79	-11.2 ± 2.32	n.s.	-10.2 ± 1.44	-15.915 ± 2.565	n.s.	16.1 ± 5.61	13.89 ± 1.15	n.s.	19.28 ± 0.76	16.8 ± 2.06	0.05
	32d	-13.66 ± 3.09	-12.62 ± 3.08	n.s.	-14.59 ± 1.51	-15.3 ± 3.61	n.s.	11.76 ± 0.41	13.5 ± 0.4	0.05	16.69 ± 0.83	19.17 ± 1.6	0.05
	72d	-22.34 ± 0.77	-20.25 ± 2.69	n.s.	-23.2 ± 2.76	-21.83 ± 1.45	n.s.	11.33 ± 0.21	12.25 ± 2.03	n.s.	14.75 ± 0.98	15.95 ± 0.63	n.s.
16:1w5	0	-26.94 ± 2.21	-25.43 ± 0.17	n.s.	-26.19 ± 1.14	-26.52 ± 0.9	n.s.	4.85 ± 0.94	5.54 ± 0.03	n.s.	5.69 ± 0.36	7.66 ± 0.39	n.s.
	6h	-13.42 ± 2.35	-13.63 ± 2.58	n.s.	-20.65 ± 1.78	-17.87 ± 0.89	0.05	5.14 ± 0.6	8.22 ± 3.28	0.05	5.83 ± 0.56	7.84 ± 0.23	0.05
	2d	-20.88 ± 1.49	-	n.s.	-22.51 ± 0.24	-23.27 ± 0.41	0.05	5.32 ± 0.25	4.16	n.s.	8.01 ± 3.08	5.53 ± 0.48	n.s.
	4d	-18.14 ± 2.31	-20.11 ± 3.35	n.s.	-23.05 ± 1.35	-22.72 ± 1.07	n.s.	5.43 ± 0.64	6.42 ± 1.22	n.s.	7.02 ± 0.37	7.39 ± 0.14	n.s.

	9d	-18.94 ± 0.71	-17.75 ± 2.81	n.s.	-21.43 ± 2.8	-20.11 ± 0.48	n.s.	5.65 ± 0.75	5.69 ± 0.76	n.s.	6.37 ± 0.39	7.11 ± 0.27	0.05
	21d	-19.33 ± 2.11	-14.41 ± 1.72	0.05	-18.13 ± 0.19	-16.25 ± 5.34	n.s.	6.16 ± 1.57	5.42 ± 0.23	n.s.	7.16 ± 0.47	6.3 ± 0.73	n.s.
	32d	-13.84 ± 2.8	-14.54 ± 2.68	n.s.	-16.22 ± 0.56	-17.16 ± 2.71	n.s.	4.94 ± 0.19	5.69 ± 0.17	0.05	7.04 ± 0.37	7.62 ± 0.2	n.s.
	72d	-20.95 ± 1.4	-18.71 ± 1.58	n.s.	-21.32 ± 1.85	-20.1 ± 0.73	n.s.	5.8 ± 0.03	5.73 ± 0.92	n.s.	7.8 ± 0.41	7.34 ± 0.49	n.s.
16:0	0	-29.57 ± 1.39	-28.6 ± 0.13	n.s.	-29.02 ± 0.8	-29.24 ± 0.77	n.s.	12.84 ± 4.23	15.04 ± 1.06	n.s.	14.65 ± 1.23	19.3 ± 0.86	n.s.
	6h	13.8 ± 3.08	12.93 ± 2.48	n.s.	5.14 ± 2.26	6.5 ± 1.96	n.s.	20.2 ± 2.19	31.2 ± 9.78	0.05	20.82 ± 2.85	28.64 ± 2.55	0.05
	2d	27.27 ± 13.25	14.45 ± 0	n.s.	32.03 ± 9.05	12.37 ± 1.25	n.s.	28.17 ± 5.82	16.97	n.s.	41.7 ± 13.41	25.32 ± 7.83	n.s.
	4d	8.42 ± 4.22	3.89 ± 2.17	n.s.	20.04 ± 8.25	13.47 ± 4.42	n.s.	20.81 ± 2.86	24.56 ± 2.95	n.s.	31.71 ± 2.47	31.23 ± 4.92	n.s.
	9d	4.16 ± 1.03	2.61 ± 0.77	n.s.	0.33 ± 11.13	4.69 ± 4.29	n.s.	24.29 ± 3.68	23.99 ± 1.57	n.s.	29.13 ± 3.73	26.41 ± 2.16	n.s.

	21d	-12.43 ± 3.47	-8.66 ± 1.43	n.s.	-6.45 ± 2.33	-12.06 ± 3.76	n.s.	21.8 ± 6.32	19.3 ± 0.76	n.s.	24.22 ± 1.3	20.93 ± 1.46	0.05
	32d	-9.29 ± 2.48	-10.19 ± 2.59	n.s.	-8.25 ± 1.91	-9.66 ± 4.45	n.s.	17.55 ± 0.76	20.04 ± 0.35	0.05	23.53 ± 0.86	25.62 ± 2.68	n.s.
	72d	-19.7 ± 1.04	-16.3 ± 3.31	n.s.	-17.92 ± 4.35	-15.92 ± 1.42	n.s.	19.8 ± 2.47	20.82 ± 2.17	n.s.	22.77 ± 1.67	24.8 ± 1.52	n.s.
i17w1:8+10Me16:0	0	-28.71 ± 1.47	-27.33 ± 0.17	n.s.	-27.69 ± 0.77	-27.82 ± 0.64	n.s.	10.83 ± 2.15	12.09 ± 0.69	n.s.	16.53 ± 0.7	20.14 ± 0.53	n.s.
	6h	-22.22 ± 0.29	-21.52 ± 1.28	n.s.	-25.93 ± 1.43	-24.62 ± 0.59	n.s.	10.86 ± 1.28	15.93 ± 5.13	0.05	16.1 ± 2.15	20 ± 0.37	0.05
	2d	-25.17 ± 0.7	-	n.s.	-26.01 ± 0.26	-26.46 ± 0.58	n.s.	11.73 ± 0.93	9.21	n.s.	21.37 ± 6.43	15.22 ± 1.31	n.s.
	4d	-23.98 ± 0.91	-25.13 ± 1.34	n.s.	-25.88 ± 0.53	-26.36 ± 0.75	n.s.	12.06 ± 0.78	13.27 ± 1.32	n.s.	19.74 ± 0.46	20.33 ± 0.57	n.s.
	9d	-25.3 ± 0.27	-24.11 ± 1.59	n.s.	-26.48 ± 1.33	-25.5 ± 0.44	n.s.	12.82 ± 1.53	11.95 ± 0.8	n.s.	18.31 ± 0.83	19.47 ± 0.41	n.s.
	21d	-25.5 ± 0.56	-22.35 ± 0.66	0.05	-25.25 ± 0.8	-23.9 ± 2.45	n.s.	14.86 ± 4.87	11.28 ± 0.34	n.s.	19.41 ± 0.73	15.66 ± 4.17	0.05

	32d	-21.38 ± 1.58	-22.03 ± 1.46	n.s.	-23.3 ± 0.1	-24.08 ± 1.48	n.s.	10.45 ± 0.13	11.48 ± 0.28	0.05	18.66 ± 0.35	20.47 ± 0.95	0.05
	72d	-24.55 ± 0.98	-23.2 ± 1.17	n.s.	-25.06 ± 1.46	-24.62 ± 0.39	n.s.	11.56 ± 0.09	11.89 ± 1.62	n.s.	17.92 ± 0.12	19.2 ± 1.29	n.s.
i17:0	0	-30.35 ± 3.07	-27.63 ± 0.35	n.s.	-28.27 ± 1.62	-28.4 ± 1	n.s.	2.35 ± 0.3	2.35 ± 0.1	n.s.	4.08 ± 1.61	3.96 ± 0.17	n.s.
	6h	-14.24 ± 1.43	-15.6 ± 2.49	n.s.	-21.06 ± 1.74	-19.37 ± 1.4	n.s.	2.2 ± 0.24	3.11 ± 1.05	0.05	2.99 ± 0.36	3.68 ± 0.08	0.05
	2d	-19.04 ± 0.56	-	n.s.	-22.38 ± 0.09	-23.25 ± 0.27	0.05	2.88 ± 0.38	1.73	n.s.	4.68 ± 1.5	2.95 ± 0.38	n.s.
	4d	-19.19 ± 1.76	-20.22 ± 3.09	n.s.	-22.97 ± 1.64	-22.64 ± 1.26	n.s.	2.86 ± 0.25	3.4 ± 0.68	n.s.	4.16 ± 0.14	4.4 ± 0.41	n.s.
	9d	-21.34 ± 1.92	-17.69 ± 2.19	n.s.	-23.05 ± 3.44	-20.94 ± 0.67	n.s.	3.05 ± 0.37	2.96 ± 0.42	n.s.	3.96 ± 0.29	4.13 ± 0.18	n.s.
	21d	-23.34 ± 2.38	-17.85 ± 1.05	n.s.	-22.08 ± 0.62	-20.22 ± 4.1	n.s.	3.46 ± 0.97	3.08 ± 0.16	n.s.	4.23 ± 0.32	3.66 ± 0.51	n.s.
	32d	-17.23 ± 2.12	-18.45 ± 2.72	n.s.	-19.19 ± 0.34	-19.86 ± 2.31	n.s.	2.98 ± 0.08	3.18 ± 0.06	0.05	4.72 ± 0.11	4.77 ± 0.23	n.s.

	72d	-24.25 ± 0.69	-22.03 ± 2.63	n.s.	-24 ± 2.22	-22.78 ± 0.74	n.s.	3.2 ± 0.02	3.26 ± 0.27	n.s.	4.61 ± 0.02	4.72 ± 0.19	n.s.
a17:0	0	-28.99 ± 2.72	-26.39 ± 0.21	n.s.	-26.81 ± 1.01	-27.55 ± 1.4	n.s.	2.72 ± 0.35	2.87 ± 0.05	n.s.	4.5 ± 1.75	4.57 ± 0.19	n.s.
	6h	0.51 ± 1.89	-3.1 ± 6.69	n.s.	-12.46 ± 2.41	-9.11 ± 1.92	0.05	3.31 ± 0.32	4.55 ± 1.31	n.s.	3.98 ± 0.55	4.86 ± 0.16	0.05
	2d	-7.53 ± 2.81	4.02	n.s.	-16.7 ± 0.58	-16.94 ± 0.64	n.s.	3.82 ± 0.43	2.67	n.s.	5.73 ± 1.51	3.71 ± 0.42	0.05
	4d	-6.25 ± 2.9	-10.86 ± 6.46	n.s.	-14.31 ± 2.29	-14.25 ± 4.4	n.s.	4.05 ± 0.4	4.24 ± 0.51	n.s.	5.35 ± 0.37	5.46 ± 0.46	n.s.
	9d	-12.51 ± 1.72	-8.45 ± 0.94	0.05	-15.05 ± 5.12	-13.32 ± 1.21	n.s.	3.85 ± 0.53	3.8 ± 0.38	n.s.	5.01 ± 0.35	4.92 ± 0.17	n.s.
	21d	-18.78 ± 2.28	-12.53 ± 1.65	0.05	-16.93 ± 1	-14.93 ± 6.04	n.s.	3.84 ± 1.19	3.53 ± 0.14	n.s.	4.83 ± 0.31	4.13 ± 0.48	0.05
	32d	-12.1 ± 3.67	-13.48 ± 3.05	n.s.	-15.73 ± 0.23	-15.6 ± 2.5	n.s.	3.35 ± 0.21	3.66 ± 0.12	n.s.	5 ± 0.07	5.27 ± 0.47	n.s.
	72d	-21.49 ± 1	-18.64 ± 2.43	n.s.	-21.95 ± 2.95	-20.16 ± 1.06	n.s.	3.51 ± 0.03	3.63 ± 0.15	n.s.	4.72 ± 0.01	4.99 ± 0.12	n.s.

17:1w8	0	-31.87 ± 3.03	-29.32 ± 0.18	n.s.	-30.2 ± 1.96	-30.82 ± 1.35	n.s.	2.23 ± 0.14	2.7 ± 0.17	0.05	3.58 ± 1.67	4.24 ± 0.39	n.s.
	6h	1.58 ± 0.56	-1.87 ± 4.57	n.s.	-2.76 ± 2.46	-3.11 ± 1.42	n.s.	3.21 ± 0.44	4.61 ± 0.86	0.05	3.45 ± 0.49	5.07 ± 0.73	0.05
	2d	-0.16 ± 2.08	-	n.s.	-6.44 ± 0.91	-5.81 ± 2.12	n.s.	3.79 ± 0.38	2.86	n.s.	5.42 ± 0.78	4.11 ± 0.98	n.s.
	4d	-5.83 ± 1.08	-9.34 ± 5.89	n.s.	-4.96 ± 3.54	-8.32 ± 2.45	n.s.	3.57 ± 0.22	3.8 ± 0.58	n.s.	5.32 ± 0.27	5.11 ± 1.29	n.s.
	9d	-10.12 ± 1.53	-5.62 ± 0.73	0.05	-8.21 ± 5.5	-9.47 ± 1.85	n.s.	3.05 ± 0.49	3.46 ± 0.19	n.s.	3.88 ± 0.35	4.55 ± 0.72	n.s.
	21d	-17.84 ± 2.04	-12.64 ± 1.16	0.05	-15.21 ± 0.83	-14.5 ± 4.69	n.s.	2.76 ± 1.09	2.71 ± 0.33	n.s.	3.39 ± 0.22	3.12 ± 0.51	n.s.
	32d	-13.57 ± 3.13	-13.93 ± 2.18	n.s.	-14.33 ± 0.29	-14.56 ± 2.54	n.s.	2.13 ± 0.13	2.64 ± 0.14	0.05	3.09 ± 0.08	3.6 ± 0.4	0.05
	72d	-22.55 ± 0.74	-20.41 ± 1.75	n.s.	-22.97 ± 2.29	-21.15 ± 1.01	n.s.	2.28 ± 0.05	2.32 ± 0.09	n.s.	2.91 ± 0.18	3.32 ± 0.04	n.s.
cy17:0	0	-30.69 ± 2	-27.98 ± 0.74	n.s.	-29.79 ± 1.49	-29.18 ± 0.35	n.s.	2.79 ± 0.38	3.04 ± 0.3	n.s.	4.91 ± 2.06	4.87 ± 0.6	n.s.

	6h	-16.72 ± 1.32	-18.66 ± 3.67	n.s.	-24.71 ± 2.59	-22.76 ± 0.83	n.s.	2.77 ± 0.2	4.14 ± 1	0.05	3.6 ± 0.41	4.56 ± 0.03	0.05
	2d	-22.15 ± 1.03	-	n.s.	-24.13 ± 0.18	-25.25 ± 0.94	0.05	3.4 ± 0.51	2.15	n.s.	4.69 ± 0.98	3.56 ± 0.31	n.s.
	4d	-19.32 ± 0.8	-20.65 ± 1.79	n.s.	-24.23 ± 1.79	-25.14 ± 1.8	n.s.	3.52 ± 0.27	3.81 ± 0.62	n.s.	4.87 ± 0.35	4.9 ± 0.2	n.s.
	9d	-20.43 ± 0.94	-17.5 ± 3.17	n.s.	-22.4 ± 3.44	-22.46 ± 1.02	n.s.	3.68 ± 0.83	3.67 ± 0.52	n.s.	4.38 ± 0.38	4.56 ± 0.12	n.s.
	21d	-20.21 ± 0.38	-14.8 ± 1.51	0.05	-18.22 ± 0.64	-17.62 ± 6.74	n.s.	4.22 ± 1.33	3.91 ± 0.3	n.s.	5.52 ± 0.55	4.77 ± 0.4	n.s.
	32d	-13.64 ± 2.86	-15.15 ± 3.36	n.s.	-16.44 ± 1.4	-17.58 ± 4.12	n.s.	3.81 ± 0.22	3.95 ± 0.16	n.s.	5.53 ± 0.26	5.7 ± 0.36	n.s.
	72d	-22.8 ± 0.67	-19.99 ± 2.56	n.s.	-23.07 ± 2.69	-21.02 ± 1.1	n.s.	4.02 ± 0.11	3.92 ± 0.22	n.s.	5.3 ± 0.12	5.71 ± 0.2	n.s.
17:0	0	-32.57 ± 3.75	-29.01 ± 0.96	n.s.	-29.3 ± 4.01	-30.18 ± 1.78	n.s.	1.12 ± 0.39	0.8 ± 0.07	n.s.	1.49 ± 0.63	1.13 ± 0.07	n.s.
	6h	-2.76 ± 1.11	-6.45 ± 5.04	n.s.	-9.23 ± 1.13	-7.8 ± 4.17	n.s.	1.01 ± 0.04	1.31 ± 0.29	n.s.	1.05 ± 0.14	1.34 ± 0.1	0.05

	2d	-2.42 ± 3.96	-	n.s.	-3.9 ± 1.79	-5.49 ± 6.49	n.s.	1.37 ± 0.24	0.83	n.s.	1.91 ± 0.58	1.15 ± 0.18	n.s.
	4d	-13.15 ± 3.5	-12.61 ± 2.36	n.s.	-11.32 ± 6.01	-10.1 ± 2.45	n.s.	1.15 ± 0.12	1.37 ± 0.23	n.s.	1.48 ± 0.13	1.56 ± 0.14	n.s.
	9d	-15.97 ± 4.71	-8.1 ± 1.28	0.05	-18.62 ± 6.84	-12.49 ± 3.75	n.s.	1.25 ± 0.1	1.25 ± 0.08	n.s.	1.42 ± 0.06	1.36 ± 0.1	n.s.
	21d	-19.34 ± 4.36	-14 ± 2.38	n.s.	-18.43 ± 1.2	-17.14 ± 5.54	n.s.	1.1 ± 0.26	1.16 ± 0.07	n.s.	1.29 ± 0.09	1.22 ± 0.07	n.s.
	32d	-16.8 ± 2.9	-16.59 ± 3.91	n.s.	-18.6 ± 2.92	-16.13 ± 2.95	n.s.	1.06 ± 0.08	1.17 ± 0.03	n.s.	1.36 ± 0.08	1.39 ± 0.22	n.s.
	72d	-25.94 ± 0.82	-24.18 ± 4.76	n.s.	-26.53 ± 2.68	-23.09 ± 2.79	n.s.	1.06 ± 0.11	1.17 ± 0.09	n.s.	1.25 ± 0.04	1.41 ± 0.01	n.s.
10Me17:0	0	-33.67 ± 2.14	-32.06 ± 0.33	n.s.	-32.03 ± 0.83	-33.15 ± 1.49	n.s.	2.06 ± 0.97	1.38 ± 0.13	n.s.	1.92 ± 0.69	2.25 ± 0.5	n.s.
	6h	-17.55 ± 1.36	-19.62 ± 3.66	n.s.	-21.95 ± 2.88	-21.11 ± 0.84	n.s.	1.35 ± 0.07	1.78 ± 0.28	n.s.	1.65 ± 0.16	2.06 ± 0.23	0.05
	2d	-20.73 ± 2.41	-	n.s.	-24.63 ± 2.23	-22.58 ± 0.16	n.s.	1.83 ± 0.27	1.22	n.s.	2.37 ± 0.32	1.84 ± 0.22	0.05
	4d	-23.44 ± 1.16	-24.4	n.s.	-25.57 ± 1.9	-25.89 ± 0.52	n.s.	1.68 ± 0.17	2.13 ± 0.5	n.s.	2.33 ± 0.24	2.57 ± 0.3	n.s.

			4 ± 2.11										
	9d	-25.64 ± 2.06	-20.62 ± 3.49	n.s.	-26.59 ± 6.32	-22.87 ± 1.31	n.s.	1.6 ± 0.17	1.66 ± 0.15	n.s.	1.89 ± 0.18	2.14 ± 0.04	0.05
	21d	-27.7 ± 4.55	-19.43 ± 1.88	0.05	-24.49 ± 0.67	-21.75 ± 4.07	n.s.	1.69 ± 0.53	1.66 ± 0.1	n.s.	2.12 ± 0.22	1.96 ± 0.24	n.s.
	32d	-18.3 ± 2.57	-19.47 ± 3.96	n.s.	-19.5 ± 0.62	-19.06 ± 3.6	n.s.	1.46 ± 0.11	1.68 ± 0.01	0.05	2.1 ± 0.14	2.26 ± 0.22	n.s.
	72d	-27.61 ± 0.73	-24.17 ± 1.96	n.s.	-26.09 ± 4.36	-23.7 ± 0.72	n.s.	1.52 ± 0.03	1.43 ± 0.25	n.s.	1.87 ± 0.02	2.11 ± 0.16	n.s.
18:2w6,9	0	-30.2 ± 1.69	-28.61 ± 0.32	n.s.	-29.91 ± 0.52	-31.01 ± 0.28	n.s.	5.65 ± 2.92	5.27 ± 0.71	n.s.	5.54 ± 0.81	5.62 ± 1.54	n.s.
	6h	30.02 ± 7.68	25.53 ± 7.19	n.s.	38.03 ± 8.04	29.93 ± 0.23	0.05	15.31 ± 1.97	19.07 ± 2.87	n.s.	10.94 ± 3.11	17.19 ± 2.63	n.s.
	2d	47.12 ± 16.85	-	n.s.	51.62 ± 5.84	42.22 ± 7.96	n.s.	17.09 ± 3.01	13.11	n.s.	22.26 ± 5.05	14.4 ± 6.94	n.s.
	4d	25.81 ± 6.48	18.17 ± 6.61	n.s.	29.26 ± 7.31	39.27 ± 7.79	n.s.	11.79 ± 2.2	11.69 ± 2.19	n.s.	17.54 ± 2.41	15.58 ± 4.55	n.s.

	9d	20.41 ± 2.52	25.03 ± 17.88	n.s.	36.75 ± 6.22	25.93 ± 9.83	n.s.	10.68 ± 2.43	12.42 ± 1.03	n.s.	20.11 ± 8.32	12.34 ± 3.09	n.s.
	21d	-2.25 ± 9	1.14 ± 2.15	n.s.	10.24 ± 6.66	11.19 ± 3.62	n.s.	9.2 ± 2.95	9.32 ± 1.01	n.s.	10.26 ± 0.17	8.64 ± 0.53	0.05
	32d	1.78 ± 1.98	0.46 ± 5.52	n.s.	4.74 ± 2.05	2.37 ± 1.41	n.s.	6.27 ± 0.88	7.73 ± 0.88	n.s.	7.59 ± 1.18	8.68 ± 1.21	n.s.
	72d	-16.63 ± 3.06	-11.37 ± 4.35	n.s.	-11.41 ± 7.01	-8.11 ± 5.55	n.s.	8.15 ± 2.69	9.2 ± 1.44	n.s.	7.68 ± 1.07	10.97 ± 3.29	n.s.
18:1w9c	0	-27.73 ± 1.4	-26.77 ± 0.38	n.s.	-27 ± 0.66	-27.02 ± 0.39	n.s.	12.82 ± 1.52	15.19 ± 1.2	n.s.	19.65 ± 3.8	21.67 ± 1.23	n.s.
	6h	8.34 ± 7.29	6.05 ± 4.87	n.s.	1.92 ± 9.4	5.55 ± 4.67	n.s.	19.57 ± 5.14	26.13 ± 4.9	n.s.	21.94 ± 3.6	31.25 ± 4.47	0.05
	2d	11.5 ± 2.16	-	n.s.	17.66 ± 11.93	6.36 ± 20.35	n.s.	18.34 ± 1.08	17.42	n.s.	29.73 ± 7.91	24.12 ± 5.46	n.s.
	4d	-4.47 ± 1.48	-9.93 ± 5.14	n.s.	-5.15 ± 1.24	-8.23 ± 4.89	n.s.	17.01 ± 1.46	17.38 ± 2.26	n.s.	26.88 ± 2.27	25.15 ± 5.36	n.s.
	9d	-12.88 ± 2.13	-7.54 ± 5.59	n.s.	-13.53 ± 8.91	-11.14 ± 4.9	n.s.	16.7 ± 1.8	17.25 ± 1.54	n.s.	25.33 ± 5.47	24.16 ± 2.86	n.s.
	21d	-16.56 ± 1.74	-12.3	0.05	-15.12 ± 3.61	-13.69 ± 6.1	n.s.	16.74 ± 5.94	14.31 ± 2.08	n.s.	19.95 ± 0.4	18.19 ± 3.75	n.s.

			9 ± 0.48										
	32d	-12.93 ± 1.47	-13.76 ± 1.94	n.s.	-14.62 ± 0.78	-14.84 ± 2.18	n.s.	12.41 ± 0.79	14.92 ± 0.9	0.05	19.25 ± 0.5	22.32 ± 0.94	0.05
	72d	-19.21 ± 1.95	-17.61 ± 1.32	n.s.	-20.1 ± 2.65	-18.72 ± 1.63	n.s.	13.59 ± 0.59	15.17 ± 1.32	n.s.	18.42 ± 1.13	22.3 ± 3.47	n.s.
18:1w7c/9t+8	0	-28.2 ± 1.59	-26.2 ± 0.9	n.s.	-27.78 ± 1.46	-27.46 ± 0.35	n.s.	18.87 ± 4.48	21.89 ± 1.29	n.s.	26.51 ± 6.47	29.74 ± 0.16	n.s.
	6h	14.09 ± 4.04	4.48 ± 12.25	n.s.	4.63 ± 4.02	1.91 ± 0.7	n.s.	35.71 ± 1.32	45.57 ± 6.32	0.05	36.13 ± 1.9	49.44 ± 4.08	0.05
	2d	26.84 ± 11.58	-	n.s.	23.54 ± 12.67	12.33 ± 13.56	n.s.	44.62 ± 7.61	34.2	n.s.	57.98 ± 10.56	41.74 ± 8.98	n.s.
	4d	5.8 ± 4.1	3.24 ± 3.67	n.s.	7.19 ± 6.64	7.11 ± 5.35	n.s.	33.62 ± 4.86	35.91 ± 5.09	n.s.	50 ± 3.93	50.95 ± 9.72	n.s.
	9d	-2.99 ± 11.06	7.63 ± 10.22	n.s.	1.02 ± 6.66	1.47 ± 3.83	n.s.	41.04 ± 11.95	35.42 ± 1.3	n.s.	43.18 ± 7.89	41.93 ± 3.4	n.s.
	21d	-10 ± 0.85	-5.39 ± 0.57	0.05	-6.52 ± 1.76	-7.79 ± 7.61	n.s.	29.54 ± 9.92	26.2 ± 2.98	n.s.	34.49 ± 1.66	31.29 ± 3.42	n.s.

	32d	-6.82 ± 2.68	-7.67 ± 2.47	n.s.	-7.99 ± 0.96	-9.5 ± 3.56	n.s.	22.23 ± 0.92	24.79 ± 1.75	0.05	31.52 ± 0.96	34.91 ± 3.14	0.05
	72d	-16.01 ± 1.92	-12.22 ± 3.8	n.s.	-16.84 ± 3.43	-15.17 ± 2.41	n.s.	20.52 ± 1.84	20.36 ± 0.67	n.s.	25.96 ± 1.44	27.65 ± 0.77	n.s.
18:1w5c	0	-28.55 ± 2.97	-25.64 ± 0.36	n.s.	-25.62 ± 2.44	-26.14 ± 1.5	n.s.	2.55 ± 0.26	2.41 ± 0.1	n.s.	4.14 ± 0.98	4.38 ± 0.28	n.s.
	6h	-0.45 ± 2.49	-2.75 ± 5.06	n.s.	-6.31 ± 3.89	-7.44 ± 3.9	n.s.	3.23 ± 0.18	3.76 ± 0.42	0.05	4.48 ± 0.11	5.21 ± 0.95	n.s.
	2d	-2.05 ± 2.38	-	n.s.	-3.73 ± 1.87	-7.82 ± 6.62	n.s.	3.64 ± 0.35	3.15	n.s.	5.55 ± 0.8	4.79 ± 0.5	n.s.
	4d	-6.37 ± 2.3	-10.78 ± 6.33	n.s.	-6.96 ± 4.13	-9.82 ± 3.92	n.s.	3.48 ± 0.45	4.14 ± 0.73	n.s.	5.4 ± 0.59	5.67 ± 0.26	n.s.
	9d	-12.26 ± 4.57	-7.68 ± 3.9	n.s.	-15.2 ± 4.65	-13.74 ± 1.21	n.s.	3.39 ± 0.4	3.33 ± 0.32	n.s.	4.52 ± 0.1	4.79 ± 0.15	0.05
	21d	-15.98 ± 2.88	-9.55 ± 1.28	0.05	-14.56 ± 0.94	-12.74 ± 7.12	n.s.	3.62 ± 1.42	3.15 ± 0.23	n.s.	4.66 ± 0.31	4.19 ± 0.88	n.s.
	32d	-9.7 ± 4.21	-10 ± 3.48	n.s.	-13.53 ± 0.77	-12.94 ± 2.65	n.s.	2.76 ± 0.22	3.31 ± 0.31	0.05	4.24 ± 0.26	4.9 ± 0.09	0.05
	72d	-15.95 ± 0.32	-14.8	n.s.	-16.1 ± 4.92	-15.84 ± 2.75	n.s.	3.05 ± 0.13	2.83 ± 0.07	n.s.	4.57 ± 0.25	4.82 ± 0.16	n.s.

			9 ± 4.68										
18:0	0	-30.27 ± 2.56	-27.92 ± 0.49	n.s.	-28.72 ± 2.01	-29.14 ± 1.44	n.s.	4.03 ± 0.44	4.64 ± 0.58	n.s.	5.25 ± 1.4	5.83 ± 0.27	n.s.
	6h	7.77 ± 2.42	2.55 ± 5.66	n.s.	3.3 ± 6.75	2.24 ± 1.64	n.s.	5.11 ± 0.37	6.07 ± 1.11	n.s.	5.65 ± 0.36	6.85 ± 0.72	0.05
	2d	14.88 ± 7.47	-	n.s.	20.42 ± 4.49	14.81 ± 15.97	n.s.	7.44 ± 1.91	4.4	n.s.	9.73 ± 2.31	6.51 ± 1.31	n.s.
	4d	0.74 ± 4	-4.47 ± 3.69	n.s.	6.87 ± 9.5	3.79 ± 2.33	n.s.	5.26 ± 0.92	6.71 ± 1.02	0.05	8.14 ± 0.43	8.32 ± 0.7	n.s.
	9d	-7.42 ± 7.55	3.58 ± 9.1	n.s.	-8.64 ± 12.66	-1.51 ± 1.9	n.s.	6.95 ± 1.24	6.16 ± 0.32	n.s.	8.97 ± 2.76	6.95 ± 0.09	n.s.
	21d	-12.6 ± 3.35	-8.94 ± 1.79	n.s.	-8.56 ± 1.66	-10.3 ± 6.81	n.s.	5.46 ± 1.43	5.23 ± 0.51	n.s.	6.41 ± 0.39	5.84 ± 0.53	n.s.
	32d	-8.46 ± 2.51	-11.07 ± 2.93	n.s.	-9.8 ± 0.24	-11.37 ± 3.87	n.s.	4.85 ± 0.14	5.21 ± 0.16	0.05	6.56 ± 0.6	6.85 ± 0.57	n.s.
	72d	-20.24 ± 0.94	-17.07 ± 3.22	n.s.	-18.48 ± 3.77	-17.78 ± 3.47	n.s.	5.16 ± 0.39	5.49 ± 0.17	n.s.	6.28 ± 0.58	7.89 ± 1.96	n.s.
10Me18:0+12Me18:0	0	-30.42 ± 1.82	-28.01 ± 0.37	0.05	-28.38 ± 1.15	-29.1 ± 1.2	n.s.	4.77 ± 0.08	4.63 ± 0.36	n.s.	7.2 ± 1.72	7.73 ± 0.39	n.s.

	6h	-20.69 ± 0.84	-21.8 ± 1.41	n.s.	-24.4 ± 1.98	-23.48 ± 0.54	n.s.	4.24 ± 0.52	5.32 ± 0.77	0.05	5.78 ± 0.3	7.22 ± 0.22	0.05
	2d	-22 ± 0.43	-22.81	n.s.	-23.64 ± 0.64	-24.87 ± 0.56	n.s.	5.38 ± 1.09	3.68	n.s.	8.5 ± 1.68	6.37 ± 0.56	n.s.
	4d	-22.24 ± 2.06	-23.79 ± 1.07	n.s.	-25.44 ± 1.05	-25 ± 0.92	n.s.	4.82 ± 0.32	6.38 ± 1.42	0.05	7.93 ± 0.7	8.53 ± 0.58	n.s.
	9d	-25.73 ± 1.02	-21.58 ± 2.73	0.05	-26.07 ± 2.27	-23.79 ± 1.56	n.s.	4.93 ± 0.81	5.33 ± 1.09	n.s.	6.81 ± 0.56	7.67 ± 0.09	0.05
	21d	-24.07 ± 1.18	-19.15 ± 1.3	0.05	-23.81 ± 0.2	-21.89 ± 3.58	n.s.	5.94 ± 2.14	5.05 ± 0.3	n.s.	7.27 ± 0.32	6.38 ± 1.34	n.s.
	32d	-17.34 ± 2.64	-18.99 ± 1.6	n.s.	-19.83 ± 0.2	-20.97 ± 1.81	n.s.	4.78 ± 0.21	5.3 ± 0.27	0.05	7.37 ± 0.26	8.03 ± 0.37	0.05
	72d	-22.77 ± 0.85	-20.72 ± 1.75	n.s.	-23.08 ± 2.34	-22.43 ± 1.16	n.s.	5.08 ± 0.16	5.09 ± 0.15	n.s.	7.51 ± 0.1	8.04 ± 0.13	n.s.
cy19:0+19:1	0	-31.48 ± 1.29	-29.46 ± 0.34	0.05	-30.49 ± 1.39	-30.76 ± 1.16	n.s.	8.34 ± 0.12	7.55 ± 0.41	0.05	13.64 ± 2.36	13.68 ± 0.34	n.s.

	6h	-27.95 ± 0.33	-27.62 ± 0.94	n.s.	-30.77 ± 1.85	-29.6 ± 0.91	n.s.	7.03 ± 0.43	7.97 ± 0.58	0.05	11.58 ± 0.34	13.06 ± 0.13	0.05
	2d	-27.53 ± 1.03	-	n.s.	-28.48 ± 0.93	-30.01 ± 0.49	0.05	8.03 ± 0.92	6.28	n.s.	12.73 ± 1.12	11.28 ± 0.68	n.s.
	4d	-29 ± 0.52	-28.73 ± 0.39	n.s.	-30.48 ± 0.12	-30.5 ± 0.99	n.s.	8.02 ± 0.46	9.08 ± 1.21	n.s.	13.46 ± 0.91	14.37 ± 0.41	n.s.
	9d	-30.15 ± 0.42	-26.97 ± 2.48	0.05	-30.95 ± 0.73	-29.39 ± 1.68	n.s.	8 ± 0.85	7.73 ± 0.56	n.s.	12.63 ± 0.87	13.27 ± 0.1	n.s.
	21d	-28.39 ± 0.56	-24.05 ± 0.86	0.05	-28.72 ± 0.92	-27.1 ± 3.65	n.s.	10.53 ± 3.91	8.19 ± 0.36	n.s.	13.67 ± 0.32	11.87 ± 3.38	n.s.
	32d	-22.18 ± 1.83	-23.42 ± 1.64	n.s.	-25.64 ± 0.04	-26.62 ± 1.08	n.s.	7.96 ± 0.06	8.13 ± 0.08	0.05	13.78 ± 0.49	14.8 ± 0.95	n.s.
	72d	-26.51 ± 0.8	-24.55 ± 1.65	n.s.	-27.55 ± 1.59	-26.71 ± 0.78	n.s.	8.17 ± 0.09	7.5 ± 0.65	n.s.	13.18 ± 0.71	13.36 ± 0.51	n.s.

Table 8.10. PLFA statistical output, including p-values; n.s. means not significant. Values are means ± SD, Kruskal-Wallis H test.

Measurement		Homogeneity of variances (*p*-value)		df	df Error	F	p
Barley Harvest	C content Stalk	0.442	Treatment	1	8	0.757	0.41

			Soil	1	8	7.019	0.029
			Soil*Treatment	1	8	1.8	0.217
	C content Grain	0.035	Treatment	1	8	0.536	0.485
			Soil	1	8	0.227	0.646
			Soil*Treatment	1	8	0.533	0.486
	C content Ear	0.292	Treatment	1	8	0.232	0.643
			Soil	1	8	13.172	0.007
			Soil*Treatment	1	8	0.057	0.818
	$d^{13}C$ Stalk	0.218	Treatment	1	8	40.56	0
			Soil	1	8	118.4	0
			Soil*Treatment	1	8	0.364	0.563
	$d^{13}C$ Grain	0.256	Treatment	1	8	1.853	0.211
			Soil	1	8	53.996	0
			Soil*Treatment	1	8	0.079	0.786
	$d^{13}C$ Ear	0.48	Treatment	1	8	7.534	0.025
			Soil	1	8	108.9	0
			Soil*Treatment	1	8	0.999	0.347
	$d^{15}N$ Stalk	0.833	Treatment	1	8	4.922	0.057
			Soil	1	8	0.046	0.836
			Soil*Treatment	1	8	0.01	0.924
	$d^{15}N$ Grain	0.182	Treatment	1	8	0.312	0.592
			Soil	1	8	6.878	0.031
			Soil*Treatment	1	8	0.364	0.563
	$d^{15}N$ Ear	0.216	Treatment	1	8	1.888	0.207
			Soil	1	8	5.259	0.051
			Soil*Treatment	1	8	0.541	0.483
	N content Stalk	0.142	Treatment	1	8	1.764	0.221
			Soil	1	8	7.763	0.024
			Soil*Treatment	1	8	0.017	0.9
	N content Grain	0.228	Treatment	1	8	2.236	0.173

			Soil	1	8	0.175	0.687
			Soil*Treatment	1	8	1.288	0.289
	N content Ear	0.01	Treatment	1	8	0.116	0.742
			Soil	1	8	9.615	0.015
			Soil*Treatment	1	8	0.235	0.641
	Weight (g/m^2) Stalk	0.173	Treatment	1	8	1.678	0.231
			Soil	1	8	0.601	0.461
			Soil*Treatment	1	8	0.027	0.874
	Weight (g/m^2) Grain	0.594	Treatment	1	8	4.373	0.07
			Soil	1	8	6.26	0.037
			Soil*Treatment	1	8	0.01	0.924
	Weight (g/m^2) Ear	0.968	Treatment	1	8	0.671	0.437
			Soil	1	8	3.124	0.115
			Soil*Treatment	1	8	1.803	0.216
Barley Leaves	$d^{15}N$ 21d	0.35	Treatment	1	8	0.047	0.834
			Soil	1	8	3.591	0.095
			Soil*Treatment	1	8	1.316	0.285
	$d^{15}N$ 32d	0.971	Treatment	1	8	4.736	0.061
			Soil	1	8	28.033	0.001
			Soil*Treatment	1	8	6.425	0.035
	$d^{15}N$ 72d	0.167	Treatment	1	8	0.738	0.415
			Soil	1	8	4.974	0.056
			Soil*Treatment	1	8	0.032	0.863
	N content 21d	0.38	Treatment	1	8	1.144	0.316
			Soil	1	8	6.227	0.037
			Soil*Treatment	1	8	2.584	0.147
	N content 32d	0.291	Treatment	1	8	4.599	0.064
			Soil	1	8	3.414	0.102
			Soil*Treatment	1	8	0.125	0.733
	N content 72d	0.169	Treatment	1	8	0.177	0.685

			Soil	1	8	27.676	0.001
			Soil*Treatment	1	8	1.098	0.325
Soil	DON 0d	0.15	Treatment	1	8	0.06	0.814
			Soil	1	8	3.408	0.107
			Soil*Treatment	1	8	1.123	0.324
	DON 6h	0.02	Treatment	1	8	4.054	0.091
			Soil	1	8	3.472	0.112
			Soil*Treatment	1	8	1.041	0.347
	NH_4^+ content 0d	0.024	Treatment	1	8	2.079	0.187
			Soil	1	8	1.197	0.306
			Soil*Treatment	1	8	0.043	0.842
	NH_4^+ content 6h	0.324	Treatment	1	8	2.796	0.133
			Soil	1	8	0.711	0.424
			Soil*Treatment	1	8	1.878	0.208
	NH_4^+ content 2d	0.036	Treatment	1	7	0.042	0.843
			Soil	1	7	0.16	0.701
			Soil*Treatment	1	7	0.052	0.826
	NH_4^+ content 4d	0.02	Treatment	1	7	0.76	0.412
			Soil	1	7	1.106	0.328
			Soil*Treatment	1	7	0.541	0.486
	NH_4^+ content 9d	0.537	Treatment	1	7	55.808	0
			Soil	1	7	65.805	0
			Soil*Treatment	1	7	35.351	0.001
	NH_4^+ content 21d	0.139	Treatment	1	8	7.842	0.023
			Soil	1	8	0.018	0.897
			Soil*Treatment	1	8	0.287	0.607
	NH_4^+ content 32d	0.058	Treatment	1	8	1.968	0.22
			Soil	1	8	0.416	0.547
			Soil*Treatment	1	8	1.279	0.309
	NH_4^+ content 72d	0.864	Treatment	1	8	0.807	0.395

			Soil	1	8	0.001	0.972
			Soil*Treatment	1	8	1.254	0.295
	NO3- content 0d	0.012	Treatment	1	8	0.529	0.491
			Soil	1	8	0.08	0.785
			Soil*Treatment	1	8	1.563	0.251
	NO3- content 6h	0.015	Treatment	1	8	5.044	0.055
			Soil	1	8	0.404	0.543
			Soil*Treatment	1	8	3.422	0.102
	NO3- content 2d	0.298	Treatment	1	8	6.868	0.031
			Soil	1	8	5.103	0.054
			Soil*Treatment	1	8	0.584	0.467
	NO3- content 4d	0.143	Treatment	1	8	0.357	0.567
			Soil	1	8	3.916	0.083
			Soil*Treatment	1	8	8.797	0.018
	NO3- content 9d	0.691	Treatment	1	8	1.469	0.265
			Soil	1	8	0.1	0.761
			Soil*Treatment	1	8	1.127	0.324
	NO3- content 21d	0.004	Treatment	1	8	0.431	0.541
			Soil	1	8	4.252	0.094
			Soil*Treatment	1	8	1.421	0.287
	NO3- content 32d		Treatment	1	8	0.89	0.399
			Soil	1	8	1.275	0.322
			Soil*Treatment	1	8	0.092	0.777
	NO3- content 72d	0	Treatment	1	8	3.244	0.132
			Soil	1	8	2.431	0.18
			Soil*Treatment	1	8	1.563	0.267
	d15N-NO3 0d	0.107	Soil	1	5	2.725	0.16
			Treatment	1	5	3.172	0.135
			Soil*Treatment	1	5	0.758	0.424
	d15N-NO3 6h	0	Soil	1	6	5.338	0.06

			Treatment	1	6	3.057	0.131
			Soil*Treatment	1	6	0.199	0.671
	d15N-NO3 2d	0.788	Soil	1	8	24.977	0.001
			Treatment	1	8	123.807	0
			Soil*Treatment	1	8	19.259	0.002
	d15N-NO3 4d	0.261	Soil	1	8	0.292	0.608
			Treatment	1	8	0.012	0.916
			Soil*Treatment	1	8	0.056	0.821
	d15N-NO3 9d	0.035	Soil	1	6	0.003	0.957
			Treatment	1	6	0.414	0.544
			Soil*Treatment	1	6	3.547	0.109
	d15N-NO3 21d	0.079	Soil	1	7	16.978	0.004
			Treatment	1	7	4.902	0.062
			Soil*Treatment	1	7	14.811	0.006
	d15N-NO3 32d	0.753	Soil	1	8	11.532	0.009
			Treatment	1	8	8.104	0.022
			Soil*Treatment	1	8	14.552	0.005
	d15N-NO3 72d	0	Soil	1	6	2.31	0.179
			Treatment	1	6	13.452	0.01
			Soil*Treatment	1	6	1.902	0.217
	SMBN N content 0d	0.47	Soil	1	7	70.957	0
			Treatment	1	7	0	0.997
			Soil*Treatment	1	7	0.442	0.527
	SMBN N content 6h	0.089	Soil	1	7	64.726	0
			Treatment	1	7	0.255	0.629
			Soil*Treatment	1	7	0.508	0.499
	SMBN N content 2d	0.271	Soil	1	8	35.747	0
			Treatment	1	8	2.361	0.163
			Soil*Treatment	1	8	0.376	0.557
	SMBN N content 4d	0.246	Soil	1	7	21.713	0.002

			Treatment	1	7	0.072	0.796
			Soil*Treatment	1	7	0.197	0.671
	SMBN N content 9d	0.409	Soil	1	8	89.188	0
			Treatment	1	8	8.166	0.021
			Soil*Treatment	1	8	0.716	0.422
	SMBN N content 21d	0.34	Soil	1	8	15.049	0.005
			Treatment	1	8	0.019	0.893
			Soil*Treatment	1	8	1.025	0.341
	SMBN N content 32d	0.158	Soil	1	8	21.925	0.002
			Treatment	1	8	0.182	0.681
			Soil*Treatment	1	8	0.798	0.398
	SMBN N content 72d	0.023	Soil	1	7	17.426	0.004
			Treatment	1	7	0.009	0.929
			Soil*Treatment	1	7	0.011	0.918
	SMBN d15N 0d	0.215	Soil	1	7	4.923	0.062
			Treatment	1	7	0	0.987
			Soil*Treatment	1	7	1.727	0.23
	SMBN d15N 6h	0.217	Soil	1	7	0.245	0.636
			Treatment	1	7	0.512	0.497
			Soil*Treatment	1	7	0.106	0.754
	SMBN d15N 2d	0.021	Soil	1	7	1.246	0.301
			Treatment	1	7	0.161	0.7
			Soil*Treatment	1	7	0.411	0.542
	SMBN d15N 4d	0.246	Soil	1	7	5.943	0.045
			Treatment	1	7	0.2	0.668
			Soil*Treatment	1	7	1.579	0.249
	SMBN d15N 9d	0.113	Soil	1	8	0.368	0.561
			Treatment	1	8	3.302	0.107
			Soil*Treatment	1	8	0.077	0.789
	SMBN d15N 21d	0.176	Soil	1	8	1.083	0.329

			Treatment	1	8	0.002	0.968
			Soil*Treatment	1	8	0.392	0.549
	SMBN d15N 32d	0.431	Soil	1	8	0.96	0.356
			Treatment	1	8	0.048	0.832
			Soil*Treatment	1	8	0.084	0.779
	SMBN d15N 72d	0.51	Soil	1	7	0.322	0.588
			Treatment	1	7	1.178	0.314
			Soil*Treatment	1	7	0.205	0.664
	Bulk N content 0d	0.063	Treatment	1	8	2.27	0.17
			Soil	1	8	39.011	0
			Soil*Treatment	1	8	1.229	0.3
	Bulk N content 6h	0.466	Treatment	1	8	0.525	0.489
			Soil	1	8	213.051	0
			Soil*Treatment	1	8	1.569	0.246
	Bulk N content 2d	0.019	Treatment	1	8	0.065	0.805
			Soil	1	8	214.064	0
			Soil*Treatment	1	8	0.043	0.84
	Bulk N content 4d	0.006	Treatment	1	8	0.811	0.394
			Soil	1	8	113.205	0
			Soil*Treatment	1	8	0.347	0.572
	Bulk N content 9d	0.012	Treatment	1	8	0.425	0.533
			Soil	1	8	71.222	0
			Soil*Treatment	1	8	0.561	0.475
	Bulk N content 21d	0.711	Treatment	1	8	0.828	0.389
			Soil	1	8	461.94	0
			Soil*Treatment	1	8	5.853	0.042
	Bulk N content 32d	0.015	Treatment	1	8	0.038	0.849
			Soil	1	8	322.654	0
			Soil*Treatment	1	8	0.257	0.626
	Bulk N content 72d	0.185	Treatment	1	8	13.603	0.006

			Soil	1	8	162.819	0
			Soil*Treatment	1	8	2.616	0.144
	Bulk C content 0d	0.688	Treatment	1	8	0.071	0.797
			Soil	1	8	337.323	0
			Soil*Treatment	1	8	2.274	0.17
	Bulk C content 6h	0.326	Treatment	1	7	0.099	0.763
			Soil	1	7	221.932	0
			Soil*Treatment	1	7	0.142	0.718
	Bulk C content 2d	0.269	Treatment	1	8	0.536	0.485
			Soil	1	8	127.057	0
			Soil*Treatment	1	8	0.123	0.735
	Bulk C content 4d	0.05	Treatment	1	8	0.332	0.58
			Soil	1	8	124.876	0
			Soil*Treatment	1	8	1.945	0.201
	Bulk C content 9d	0.717	Treatment	1	7	0.034	0.859
			Soil	1	7	48.092	0
			Soil*Treatment	1	7	2.031	0.197
	Bulk C content 21d	0.211	Treatment	1	8	0.003	0.957
			Soil	1	8	98.557	0
			Soil*Treatment	1	8	1.384	0.273
	Bulk C content 32d	0.036	Treatment	1	8	1.485	0.258
			Soil	1	8	187.637	0
			Soil*Treatment	1	8	0.124	0.734
	Bulk C content 72d	0.14	Treatment	1	7	1.977	0.202
			Soil	1	7	59.914	0
			Soil*Treatment	1	7	0.017	0.901
	Bulk d15N 0d	0.202	Treatment	1	8	0.091	0.771
			Soil	1	8	48.442	0
			Soil*Treatment	1	8	0.5	0.5
	Bulk d15N 6h	0.056	Treatment	1	8	0.083	0.781

			Soil	1	8	3.072	0.118
			Soil*Treatment	1	8	0.512	0.494
	Bulk d15N 2d	0.666	Treatment	1	8	0.255	0.627
			Soil	1	8	5.865	0.042
			Soil*Treatment	1	8	0.205	0.663
	Bulk d15N 4d	0.125	Treatment	1	8	0.315	0.59
			Soil	1	8	0.184	0.679
			Soil*Treatment	1	8	0.053	0.824
	Bulk d15N 9d	0.065	Treatment	1	8	0.143	0.715
			Soil	1	8	0.328	0.583
			Soil*Treatment	1	8	1.336	0.281
	Bulk d15N 21d	0.351	Treatment	1	8	3.759	0.089
			Soil	1	8	8.125	0.021
			Soil*Treatment	1	8	3.461	0.1
	Bulk d15N 32d	0.219	Treatment	1	8	0.256	0.627
			Soil	1	8	0.115	0.743
			Soil*Treatment	1	8	0.843	0.385
	Bulk d15N 72d	0.069	Treatment	1	8	47.302	0
			Soil	1	8	4.393	0.069
			Soil*Treatment	1	8	1.428	0.266
	Bulk d13C 0d	0.235	Treatment	1	8	1.384	0.273
			Soil	1	8	8.09	0.022
			Soil*Treatment	1	8	0.015	0.907
	Bulk d13C 6h	0.415	Treatment	1	8	3.414	0.102
			Soil	1	8	1.137	0.317
			Soil*Treatment	1	8	0.006	0.94
	Bulk d13C 2d	0.297	Treatment	1	8	0.002	0.968
			Soil	1	8	5.47	0.048
			Soil*Treatment	1	8	0.57	0.472
	Bulk d13C 4d	0.276	Treatment	1	8	2.486	0.154

			Soil	1	8	0.008	0.93
			Soil*Treatment	1	8	0.131	0.727
	Bulk d13C 9d	0.207	Treatment	1	8	0.077	0.789
			Soil	1	8	1.053	0.335
			Soil*Treatment	1	8	1.609	0.24
	Bulk d13C 21d	0.107	Treatment	1	8	0.012	0.915
			Soil	1	8	0.177	0.685
			Soil*Treatment	1	8	2.644	0.143
	Bulk d13C 32d	0.475	Treatment	1	8	0.288	0.606
			Soil	1	8	2.796	0.133
			Soil*Treatment	1	8	0.002	0.967
	Bulk d13C 72d	0.102	Treatment	1	8	5.647	0.045
			Soil	1	8	4.533	0.066
			Soil*Treatment	1	8	0.69	0.43
Gas	N2O emission 0d	0.069	Treatment	1	5	0.144	0.72
			Soil	1	5	23.298	0.005
			Soil*Treatment	1	5	0.61	0.47
	N2O emission 2d	0.865	Treatment	1	8	0.243	0.635
			Soil	1	8	0.005	0.944
			Soil*Treatment	1	8	0.47	0.512
	N2O emission 4d	0.152	Treatment	1	8	0.476	0.51
			Soil	1	8	0.307	0.595
			Soil*Treatment	1	8	0.385	0.552
	N2O emission 9d	0.293	Treatment	1	8	7.179	0.028
			Soil	1	8	2.385	0.161
			Soil*Treatment	1	8	0.014	0.909
	N2O emission 16d		Treatment	1	0	7.386	0.073
			Soil	1	0	0.005	0.947
			Soil*Treatment	1	0	.	.
	N2O emission 17d	0.051	Treatment	1	8	19.394	0.002

			Soil	1	8	6.386	0.035
			Soil*Treatment	1	8	0.022	0.886
	N2O emission 18d	0.083	Treatment	1	8	10.612	0.012
			Soil	1	8	0.989	0.349
			Soil*Treatment	1	8	1.011	0.344
	N2O emission 21d	0.024	Treatment	1	8	10.821	0.011
			Soil	1	8	0.342	0.575
			Soil*Treatment	1	8	5.832	0.042
	N2O emission 29d	0.097	Treatment	1	8	0.485	0.506
			Soil	1	8	3.521	0.097
			Soil*Treatment	1	8	0.208	0.661
	N2O emission 30d	0.007	Treatment	1	8	54.16	0
			Soil	1	8	32.825	0
			Soil*Treatment	1	8	20.557	0.002
	N2O emission 32d	0.009	Treatment	1	7	3.821	0.092
			Soil	1	7	0.243	0.637
			Soil*Treatment	1	7	0.002	0.965

Table 8.11. Statistical Output from two way ANOVA for different parameters under future and current scenario.

CV - Andreea Spiridon | BSc

EXPERIENCE

Nov'19 – present '19 Institute of Soil Research, BOKU, Tulln, Austria – project worker

Aug '19 – Oct '19 Austrian Agency for Health and Food Security, Vienna, Austria – INTERN

May '18 – Nov '18 Austrian Agency for Health and Food Security, Vienna, Austria – INTERN

Nov '17 – Apr '18 Austrian Institute of Technology, Tulln, Austria - INTERN

Apr '18 – Present GEBL – Gelsenbekämpfung Leithaauen – PART TIME SUMMER JOB

Apr '16 – Jun '17 Veterinärmedizinische Universität Wien, Austria – TECHNICAL ASSISTANT

EDUCATION

Oct '10 – Feb '14 Faculty of Chemistry, University of Bucharest, Romania

Oct '15 – Present Environmental Sciences Master, University of Vienna, Austria

LANGUAGES & IT SKILLS

Languages English (B2), German (A1/A2), Romanian (Native)

IT skills Proficient in MS Office, IBM SPSS Statistics, Sigma Plot