**INTRODUCTION**

Projection of future drought scenario indicated an increasing drought frequency and intensity across Europe by the end of 21st century as simulated by climate models (Hari et al., 2020; Suarez-Gutierrez et al., 2023). A large areas of Europe experienced prolonged drought events as a result of climate change and global warming, which primarily caused by anthropogenic activities (Hari et al., 2020; Min et al., 2011). Notable drought severities had been reported in 2018-2019, and recently, in 2022 with around 30 % of the European continent was significantly affected (Barker et al., 2024; Blauhut et al., 2022; van der Woude et al., 2023). Drought, as one of the most prominent environmental stresses in terrestrial ecosystem, shapes the status of soil microbiomes because water potential controls their viabilities, activities, and functions (Schimel, 2018). The consequences of extreme drought on soil communities and biodiversity may be more detrimental than we could estimate, due to its cascading effects to the ecosystem functions and processes. It is plausible that major biogeochemical cycles and fluxes are dominantly mediated by microbes, including nitrogen (N) cycle (Falkowski et al., 2008; Madsen, 2011). Nitrogen (N) cycling is fundamental for ecosystem productivity because it links to crops production as N is an essential limiting nutrient for plants growth (Gruber & Galloway, 2008). Unfortunately, drought can lead to unfavorable condition for the N-cycling communities, limits N mineralization and transformation rates (Deng et al., 2021), as well as reduces plant N uptake (Flynn et al., 2023), which potentially affects agricultural output. As the climate fluctuates and severe droughts are inevitable, understanding the effect of drought on N-cycling communities is crucial to quantify its potential impacts on ecosystem services.

It is widely reported that land management practices can directly or indirectly alter soil physicochemical properties, as well as the structure and composition of functional groups related to N-cycling (Philippot et al., 2024; Romdhane et al., 2022; Zhao et al., 2020). Furthermore, soil physicochemical properties regulate the resilience and resistance of microbial communities in the respective soil when exposed to disturbances, including drought (Griffiths & Philippot, 2013). These underpins that the effect of drought on N-cycling communities may also potentially be determined by fertilization regimes and management practices. Previous studies demonstrated that long-term organic farming improved soil quality, such as higher soil organic carbon and total N compared to conventional system (Krause et al., 2022; Mayer et al., 2022), as well as exhibited higher soil moisture (Kundel et al., 2020; Schärer et al., 2022), which may then buffer the deleterious effect of drought on the communities. Another study assessing microbial community in the DOK trial, found distinct microbial diversity between organic and conventional systems (Hartmann et al., 2015). These distinctive soil and microbial characteristics between organic and conventional systems, may also reflect differences in the response of N-cycling communities to drought between the two systems. Moreover, agricultural intensification plays a major role in biodiversity loss in soil (Peng et al., 2024; Sala et al., 2000), and biodiversity loss harms ecosystem functions, including N cycling (Wagg et al., 2014). Organic amendment has been reported to increase the diversity of microbial communities and enhance their resilience to drought (Sun et al., 2022). Microbial communities with higher diversity are reported to have greater stability to disturbances because they are more likely to select persistent members, that are able to maintain their functions (Philippot et al., 2021). Therefore, taking management practices into account when analyzing the impact of drought on N-cycling communities is highly relevant, particularly in developing sustainable agriculture amidst ongoing changing climate.

Nitrification has a major role in global N cycle because it determines the fate of N and controls the availability of N for microbes and plants (Kuypers et al., 2018; Prosser, 2014). It consists of two steps: ammonia (NH4+) oxidation to nitrite (NO2-) and followed by oxidation of NO2- to nitrate (NO3-) (Kuypers et al., 2018). Ammonia oxidation is the rate-limiting process mediated by specific groups of microbes via ammonia monooxygenase (*amoA*) gene: ammonia oxidizing bacteria (AOB), archaea (AOA), as well as complete ammonia oxidizers (comammox *Nitrospira*) that are recently discovered (Daims et al., 2015). Despite its importance for ecosystem and plant productivity, nitrification can also lead to N loss through NO3- leaching and N2O emission (Prosser et al., 2020), which negatively affect the environment. It has been reported that the nitrification process is sensitive to drought with reduced nitrification rate, as well as inhibited substrates diffusion, thereby reducing NO3- leaching and substrates accessibility to nitrifiers (Séneca et al., 2020; Stark & Firestone, 1995). Reports on the response of ammonia-oxidizing (AO) communities to drought are inconsistent among studies regarding the sensitivity of different AO groups, which is potentially related to niche specialization of AO groups and their affinity to NH4+. For example, some studies showed that AOA and comammox clade B are more sensitive to drought than AOB (Bello et al., 2019; Séneca et al., 2020), while another found that AOB is more responsive to drought (Krüger et al., 2021). Nonetheless, studies investigating the responses of AO communities to drought stress are scarce, and even fewer studies have examined their drought-responses under different agricultural management systems (Fuchslueger et al., 2014; Kaurin et al., 2018; Xu et al., 2024). Fuchslueger et al., (2014) found that drought effect on AO communities was modulated by land management, with decreased AOA abundance in managed meadow, while the AO abundances in abandoned site remained unaffected. Another study demonstrated the resistance of AO groups to drought regardless of management practices (Kaurin et al., 2018). Our study adds fundamental information on the impact of drought on the AO structure and abundance under organic and conventional systems in the long-term DOK field trial.

Here, we performed assessment of AO communities, mineral N pools, as well as N2O emissions when exposed to rain shelter-simulated drought in the DOK field, one of the oldest field trial site comparing organic and conventional cropping systems in Europe. Our hypotheses are: (1)drought will alter the structure and diversity of AO communities; (2) drought will reduce the abundance of AO communities; (3) the effect of drought on AO communities is specific depending on the cropping systems, and given the differences in drought-sensitivities among AO groups, we assumed that the effect of drought will also group specific; (4) there will be distinct responses of mineral N pools and N2O emissions to drought under different cropping systems and fertilization regimes. Based on the contrasting soil physicochemical properties between organic and conventional systems in the DOK-trial, we expected that the conventional system will exhibit more pronounced drought effect than the organic system. Conversely, the AO communities will be less-affected or even more stable in the organic cropping system.

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For example, a recent study found drought reduced growth rate of more than 90 % of bacterial and archaeal taxa, while selected specific drought-tolerant communities . Reduced precipitation and soil moisture decreases microbial mobility and mineral N substrates diffusion, thus…

and eventually threatens global food security

.

For example, reduced precipitation eventually forces microbial communities

Increasing temperatures and warming inevitably lead to extreme drought, which worsened by anthropogenic activities.

**1st paragraph:**

**Drought severity is increasing across Europe +Drought on microbes and may end by functional communities (N)**

1. **paragraph:**

**The effect of drought on N-cycling communities could potentially influenced by fertilization regime and agricultural management practices.**

1. **paragraph:**

**Importance of nitrification and why drought on AO (nitrate leaching, N2O)**

**Literatures on the effect of drought on AO communities (under different management systems)**

**The gap of knowledge:**

**Last paragraph**

**Objectives:**

**(Hypotheses)**

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* **Drought alters the structure and diversity of AO community**
* **Drought affects the abundance of AO community**
* **The effect of drought on AO community differs by cropping system**
* **Key findings and suggestions**