EGU22-4766
https://doi.org/10.5194/egusphere-egu22-4766
EGU General Assembly 2022

Crop diversification effect on CO_2 and N_2O soil emissions in Mediterranean semiarid conditions

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Carbon dioxide (CO_2) and nitrous oxide (N_2O) are two of the most important greenhouse gases (GHG) resulting from agricultural activity. Production, emission and consumption of these gases are regulated by structural and chemical soil properties along with biological processes. Therefore, agricultural soils can act as GHG emitters but also as potential sinks.

Water scarcity added to a low soil quality, represent a challenge for agricultural sustainability in Mediterranean semiarid regions. Additionally, winter cereal cultivation followed by a summer fallow period has been the main extensive farming system in rainfed Mediterranean areas of Spain. No-tillage systems preserve more efficiently soil moisture and boost soil organic carbon storage in comparison with conventional tillage systems. Diversifying cropping systems may have several benefits on crop productivity and sustainability, such as an efficient control of weed seed bank, the prevention of possible crop diseases, the increase of the soil organic matter and the improvement of the soil water storage capacity. Due to the ability of legume crops to establish bacterial symbiosis for N fixation, crop rotations with cereal and legume crops may lead to a reduction of nitrogen fertilizers application. Minimizing N-fertilization is often associated with a decrease in GHG soil emissions. Henceforth, selecting adequate agricultural practices and cropping systems are key to minimize soil GHG emissions contributing to mitigate climate change. Accordingly, this study aims to evaluate the effect of diversified cropping systems compared to cereal monoculture systems on GHG soil emissions (CO_2 and N_2O) in Mediterranean semiarid conditions.

For this purpose, it was conducted a long-term field experiment in rainfed conditions located in Zaragoza, Spain. Two crop rotations under direct sowing system were compared (wheat-barley and barley-pea) for the evaluation of possible alternatives to the traditional barley monoculture. The soil CO_2 and N_2O emissions were quantified every two weeks since sowing (October) until harvest (June) and every three weeks from harvest to the next sowing (summer fallow) during three growing seasons: 2018-2019, 2019-2020 and 2020-2021. In addition, soil surface temperature and moisture were measured as well as bulk density.

During the first growing season, there was not effect of cropping diversification on CO_2 and N_2O emissions. However, in the following two seasons, the results obtained showed significative differences on the soil CO_2 and N_2O emission rates depending on the different cropping systems. A significant temporal variability was also observed in the soil emission rates of CO_2 and N_2O.The temporal variability found in the GHG emissions were mostly explained by the wide range of soil temperature and moisture found among years.