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Growing energy cover crops in double cropping: which ecosystem services or environmental impacts associated?

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Energy cover crops are currently being developed in France and Europe to provide biogas through anaerobic digestion and thus contribute to renewable energy production. These crops have the double advantage of (1) not competing with food crops, as they do not occupy the soil at the same time, and (2) providing the ecosystem services expected from a cover crop (e.g. reduction of nitrate leaching, reduction of erosion, carbon storage).

However, if agronomic issues related to their management and methanogenic potential have been addressed (Molinuevo-Salces et al. 2013*; Wannasek et al. 2019**), issues related to their environmental impact have been very little explored, particularly coupled with digestate return to the field. We focused on ecosystem services related to nitrogen recycling (reduction of nitrate leaching, reduction of nitrous oxide and ammonia emissions) and soil carbon storage. We also studied whether energy cover crops could compete with food production by inducing nitrogen or water stress on the following main crops, which could lead to yield loss.

We conducted a two-year field experiment in southwestern France. Two main crop sequences were implemented: wheat [Triticum turgidum subsp. Durum (Desf.) Husn.] - Winter barley [Hordeum vulgare L.] - winter peas [Pisum sativum L.] and wheat [Triticum turgidum subsp. Durum (Desf.) Husn.] – Sunflower [Helianthus annuus L.] - grain sorghum [Sorghum bicolor (L.)]. Summer energy cover crops (sorghum [Sorghum bicolor (L.) Moench] – vetch [Vicia benghalensis L.] mixture) were grown on the short fallow period of the first rotation and winter energy cover crops (rye [Secale cereale L.] – fababean [Vicia faba L.] mixture) on the long fallow period of the second crop sequence. These energy cover crops were exported from the plot at harvest to produce biogas and fertilized with digestate produced during anaerobic digestion. They were compared to the same unfertilized and non-exported cover crop and to a soil left bare. For the long fallow period, the comparison was also made with a white mustard, growing over the autumn and plowed into the soil earlier. The biomass and yield of cover and main crops, ammonia volatilization and soil water and nitrogen content were regularly monitored. This experiment was then simulated with the STICS crop model in order to assess unmeasured variables (i.e. nitrate leached, nitrous oxide emissions carbon stored over 30 years, crop stress indices) and to extend the simulated period from 2020 to 2050.

About competition with food crops, our study shows that in 2021, energy cover crops did not decrease the yield of the main crops. Repeating the trial over several climatic years using the model will allow us to confirm whether this result is isolated or generic. Secondly, with regard to ecosystem services, we observed a decrease in leaching during long cover crop period that was lower than with fast-growing mustard, and a decrease in nitrous oxide emissions compared to bare soil. Conversely, spreading digestate increased ammonia emissions, particularly when spread on the crop and not burried in the soil as done before sowing. According to biomass produced and incorporated to the soil (including digestate) in the different treatments, we expect a similar carbon storage that would be verified through simulation results. A greenhouse gas (GHG) balance will allow us to assess if the reduction of direct and indirect N2O emissions and increased in carbon storage compensate for higher ammonia emissions. Finally, the GHG balance of these energy cover crops, if negative, and the assessment of potential other environmental impacts would make possible to ensure that the gas produced is renewable.

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