Optimising sugar beet management practices to reduce greenhouse gas emissions

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Introduction

With an UK target to reach net zero in agriculture by 2040 it is imperative that emissions are quantified and addressed on farm.

Carbon calculators are a starting point in getting growers to think about emissions and how they might reduce them. However, a significant limitation is that each calculator uses different values and methods to calculate emissions and it isn't often clear how they have been sourced.

There is a need to measure actual emissions to understand where we are, rather than relying on questionable data. This also needs to be taken further as there is little data on the impact of some key crop management decisions on emissions, for example we know reducing fertiliser input will reduce emissions but what impact do cover crops and ploughing have?

The aim of the project is to calculate carbon emissions from a sugar beet field under typical management practices and quantify the impact alternative approaches have on emissions.

Materials and methods

A pair of flux towers (Figure 1) in two neighbouring fields measured carbon emissions from and uptake into the sugar beet crop.

One field was manured and ploughed whilst the other had a cover crop. Unfortunately, the flux tower set up was delayed so no carbon emissions were measured at this point. Measurements started 9th February 2023 with the beet drilled on 8th April.

Supplementary measurements of biomass and emissions using a handheld gas analyser (Gasmet GT5000 Terra) to capture N_2O and methane as well as CO_2 are also being undertaken as well as general crop observations. Fuel use and crop inputs are also being recorded to give an overall emissions figure from each field.

The crop is due to be late lifted but yield will be recorded to understand the balance between optimising yield and reducing emissions.

The flux tower will stay in place after the harvest of the beet into the following spring barley crop to identify if there are longer term effects from the initial management practices on the emissions from the barley. After harvest the two flux towers will then be moved in preparation for the next sugar beet crop to be sown the following year.

Fig 1. The flux tower in the southern sugar beet field

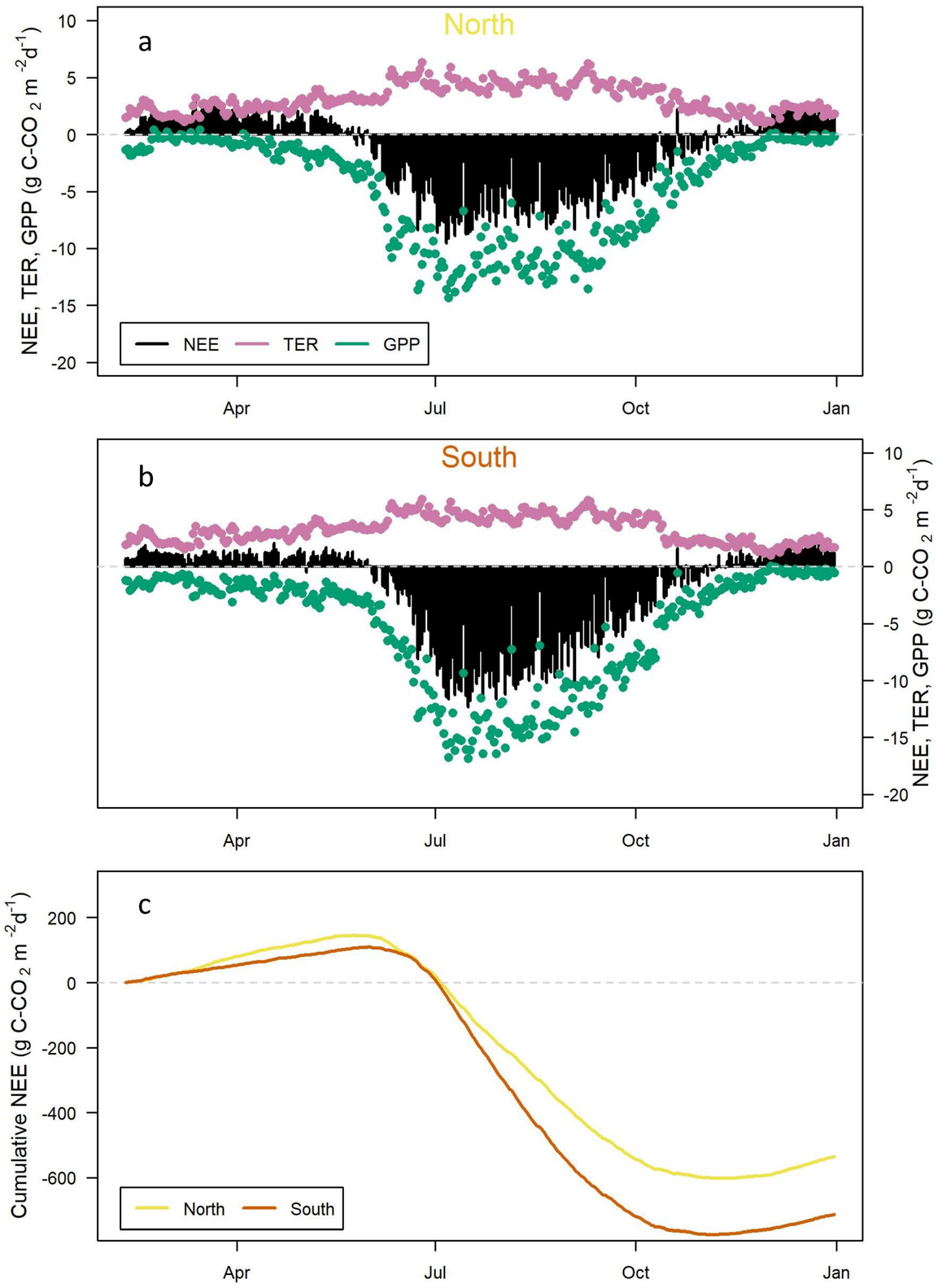

Fig 2. Carbon balance plots for the two flux systems at Morley, negative values reflect a loss of C-CO_2 from the atmosphere (i.e photosynthesis) and positive values represent a gain by the atmosphere (i.e respiration). Data from 09/02/23 to 01/01/24 with sugar beet sown 08/04/23.
a: total daily net ecosystem exchange for northern site of carbon in carbon dioxide C-CO_2 (represented by black bars, with partitioned values of gross primary productivity in green and total ecosystem respiration in purple).
b: total daily NEE for southern site of C-CO_2 (represented by black bars, with partitioned values of gross primary productivity in green and ecosystem respiration in purple.
c: cumulative NEE for both sites.

Results and discussion

Data for 2023 so far (up to 01/01/2024) shows that at the start of the year, late-winter to early spring, both sites follow a typical agricultural pattern of being a net daily source up to June of 1-2 g C-CO_2 m^{-2} (Figure 2a and 2b), equivalent to what was seen with previous observations made at the University of Lincoln in 2021, but less than sugar beet on peat soils.

Once the beet crop established a canopy both sites became a daily net sink of up around 10 g C-CO_2 m^{-2} during summer months, though greater uptake recorded on the southern site, again not dissimilar to net fluxes measured previously at Lincoln. In late-autumn as temperatures and daylight hours reduced both sites shifted back to being small net-sources of CO_2.

The southern field has sequestered 178 g C-CO_2 m^{-2} more than the northern field in 2023 (Fig 2c), despite the northern field having higher initial daily uptake in mid-June. This likely reflects the growth of weeds, on the site with high levels of ryegrass competing with the sugar beet. This does not yet take into account the amount of carbon that will be exported during harvest which is already expected to be in the region of 1-1.2 kg C m^{-2}, based on current beet weight.

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