IIRB SEMINAR CARBON FARMING OPTIONS IN SUGAR BEET CULTIVATION

THURSDAY, 11TH OF DECEMBER

Session 1: CHALLENGES IN AGRICULTURE AND POLICIES

1.1 An overview in carbon storage and GHG emissions, Toby Townsend (ADAS, UK)

Georgina Barratt (BBRO) opened the seminar by welcoming everyone. She gave a brief explanation about how the Plant & Soil group came to the idea of organizing this seminar and how the programme is structured. To avoid disruptions and ensure a stable network, cameras from participants were turned off and questions should be asked in the chat. After the opening words, André van Valen (IRS) introduced the first session. Together with Rémy Duval (ITB), he led the sessions for this afternoon.

Toby Townsend (ADAS UK) gave an overview of carbon storage and GHG emissions. He addressed the question of soil carbon storage measurement and argued in favour of simulation models rather than measurement. An important point he mentioned was the variation between different calculators for GHG emissions. These differences may come from bias in each calculator:

- Emission factors used for inputs,
- Different granularity of data entry,
- Different assessment boundaries: including capital goods (machine) or not,
- Different mitigation practices included,
- Different approaches to nitrous oxide emissions,
- Different approaches to modelling: carbon sequestration or not.

It is important to develop robust methods, which are harmonized with each other. He gave an insight into the work that ADAS did with the main goal to improve the quality of quantifying emissions and communication about data along the supply chain. At the end, he concluded with a look at the challenges that remain and the steps that are being undertaken to address these.

There was a question about a possible role for IIRB in harmonizing measurement methods and references. Because this requires a sector-wide approach, it is necessary to work together with other stakeholders in the sector.

1.2 Goals and policy from EU perspective, Edouard Lanckriet (Agrosolutions, F)

Edouard Lanckriet from Agrosolutions presented about regulations from the EU regarding carbon. He told about the expectations for the near future and how carbon credits or certificates could be implemented to pay for carbon farming. Currently, farmers face technical difficulties and costs to implement practices which are necessary to achieve this objective. The European Commission is developing a framework to certify carbon removals, farming and storage by so-called carbon credits (Carbon Removal and Carbon Farming Regulation, expected for the 1st summer 2026). CRCF regulation issues are:

- Harmonised framework → key to develop a market and have buyers for carbon credits. For now, every country uses a different methodology. Europe will be the first continent to do propose such a framework.
- Create economic model (private and public funding). For now, there's no clear picture of an economic design.

With an economic model, there should be a guarantee that carbon certificates are produced by farmers. CRCF rules should prioritize Tier 3 soil models for carbon storage monitoring, which will be constraining: time consuming, data needs, costs involved.

Financial global scheme will be designed by European commission for summer. Several options are explored to support the system, one being a "buyers' club" to which states could contribute.

There was a question about the potential value of carbon credits: what the minimum value should be to be interesting for farmers? → Current pricing depends on the project in which they are sold, they are around 60/t, but farmers need a minimum of approximately €100 to €120 per ton CO_2 to be able to compensate for the costs of practices.

1.3 Contribution from sugar beet cultivation in greenhouse gas emissions, Christel Roß (IfZ, D)

Christel Roß from IfZ presented about the contribution from sugar beets in perspective to arable farms. She addressed the variation between farmers in total GHG emissions and showed that practices may not have the expected impacts. The use of mineral nitrogen fertilizers has a significant contribution to the total emissions.

According to a data set for 10 years in Germany most greenhouse gas emissions are caused by fertiliser production and use. Related emissions increased in years 2010 and 2012 but has declined slightly since 2015 (due to legal regulations and rising costs) with organic fertilization relatively stable at 50 kg/ha. The use of catch crops, which deliver nitrogen to the following crop, increased over the last years, based on a long-term farm-survey from IfZ. However, farmers who grow a catch crop before sugar beet don't adjust their nitrogen dose. Growing a catch crop can lead to an increase of N_2O emissions, but on the other hand, a certain amount of carbon can be fixed in the soil and may compensate these emissions. The available measures differ from farm to farm, based on, for example, crop rotation and soil type. In addition, the effect of many measures is unclear, as many measures interact with each other.

Questions followed the presentation:

- Do farmers using cover crops adjust their fertilisation now? → they do, but slightly
- Are there legumes in cover crops? → Not so much, the most are mixtures, no pure legumes.

The presentation raises also a question about the upstream GHG emissions value for organic matter: it depends on the part you attribute to the upstream process, and the part you keep for the field, and can differ between calculations used (seem to be different France/Germany).

Session 2: CARBON SEQUESTRATION IN SUGAR BEET CROP ROTATIONS

2.1 Soil carbon balance under sugar beet cultivation, Anna Jacobs (IfZ, D)

Anna Jacobs starts with giving an overview of the carbon balance under crop rotations with sugar beet, and the effects of sugar beet on carbon storage. Despite the increase of catch crops, as presented by Christel Roß, this does not lead to higher SOC levels. According to the German soil data base, fields with sugar beet in the rotation have a slightly lower C stock (-5%) compared to others. It is hard to maintain the SOC level on arable farms. That is because a permanent sequestration of carbon is tough to realize under practical conditions. The dynamics of sequestration and mineralization of organic carbon makes measures difficult to affect these. Environmental parameters play a big role in these biological processes. Also forecasting carbon

storage based on crop rotation is difficult because of the variation within fields and analytical errors.

Sugar beet has a negative image when looking to the carbon balance, because of the low belowground harvest residue input and harvest erosion. The possibility of catch crops before sugar beet is an advantage, and generally sugar beet is included into cereal based crop rotations.

There's a question about what should be done to maintain SOC levels → answers will be given in the next presentation

2.2 Rotational effects on soil organic carbon stocks, Dennis Grunwald (IfZ, D)

Dennis Grunwald started by noting that sugar beet is generally seen as detrimental to soil carbon, leading to large emission factors in climate impact calculators. He also notes that hardly any actual numbers to back this are available, and that there are no recent and transparent trial results from current long-term trials.

He highlighted some relevant results from a long-term field trial (started in 2005-2006) with different crop rotations. In these crop rotations, with and without sugar beet, the SOC development has been monitored. There were no differences in the change of SOC levels between the different crop rotations including sugar beet (no differences between a 3 year and a 6 year sugar beet rotation). Only crop rotations with silage maize, without use of organic fertilization, led to lower SOC stocks, because of low above ground residues biomass). The contribution of sugar beet to belowground biomass was clearly lower than grains but including a cover crop before sugar beet could compensate this lower inputs. In general, a loss of SOC due to sugar beets in a crop rotation could not be found in this long-term trial. According to current allocation factors and measured yields in the trial, soil carbon contribution of wheat would be of 1,8 t C/ha, and 0,3 t C/ha for sugar beet. The first measurement results may lead to the conclusion that actual figures are closer between the two crops.

Jenny Bussell was supposed to give the final presentation of this session about regenerative agriculture and SOC sequestration, but unfortunately, she was unable to join the meeting on time. Therefore, the organization decided to end this first half-day of the seminar earlier, around 3 p.m.

FRIDAY, 12TH OF DECEMBER

Maarten Schut (IRS) opened the second day of the seminar by welcoming everyone and gave a brief overview of the topics of the day before. After that, Georgina Barratt introduced the first speaker.

Session 3: GHG emissions in sugar beet cultivation

3.1 GHG losses in sugar beet cultivation, Bernard Longdoz (University Liège, B)

Bernard Longdoz presented flux tower data looking at N_2O and CO_2 emissions throughout the rotation comparing winter wheat, mustard cover crop, potatoes, and sugar beet. The rotation is wheat, potatoes, wheat, sugar beet, in a luvisol. Measurement of N_2O and CO_2 started in 2004, data covers four growing seasons for sugar beet. Measurements are obtained with sensors, measuring a vertical wind, gas analysers. An "Eddy covariance" method makes it possible to get a value every half hour. One of the key observations were large fluxes of N_2O being emitted between fertilisation and drilling, particularly if there was a prolonged period between the two events. This prompted a discussion about the potential of reducing this time to minimise the amount of N_2O emitted. It was also apparent that more emissions occur from wet soils, so high

emissions were seen following heavy rainfall. For N_2O emissions, mean value was 1.83 kg N-N_2O/ha, corresponding to 1.2 % of N supplies. The carbon budget of the rotations was presented and concluded the ratio between carbon absorbed by the beet during the growing period is often almost completely equal to the amount of carbon released as emissions after harvest. This suggests the overall carbon balance of the soil is unchanged by sugar beet at this point in the rotation, as bare soil becomes a CO_2 emission source before drilling and after harvest. However, when temperatures were higher more soil respiration occurred resulting in greater CO_2 emissions during the season, which seems to be the tendency for recent years. This data highlighted the significance of soil moisture on N_2O emissions and of soil temperature on CO_2 emissions which need to be considered when measuring GHG emissions.

- A question was: since fluxes data are available, and exported and total crop biomass, is it possible to deduce the biomass of the secondary roots? The author replies that they did it for wheat, but for sugar beet, it's difficult to quantify because it is close to the uncertainty of the measurement.

3.2 Data from BBRO field trials, Georgina Barratt (BBRO UK)

Georgina Barratt started by highlighting the UK's aim to achieve net zero emissions in agriculture by 2040 and demonstrated that total GHG emissions in agriculture have naturally been falling already (-16% from 1990 to 2020), despite there being more to do. Agriculture represents 11% of total GHG emissions in the UK, 69% of total N_2O due to fertilisers. As highlighted in other presentations, more data on GHG emissions from sugar beet is needed to support carbon calculators and industry reporting. To collect this data the BBRO currently uses a combination of portable gas analyser measurements (Gasmet Terra 5000) and CO_2 flux towers (no N_2O fluxes measurement). The flux tower project aims to look at sugar beet carbon dynamics and the effect they have in a wider rotation. Two flux towers were positioned in neighbouring fields to assess different management practices, initially a bare stubble and manuring approach versus a cover crop and different tillage practices ahead of sugar beet. Net ecosystem exchange demonstrated that both sites were net carbon sources prior to drilling due to soil respiration but once the sugar beet was drilled this switched to carbon sink. Differences were initially seen due to resistant ryegrass in one of the fields (weeds) which highlighted the impact a compromised crop can have as the compromised crop sequestered less carbon. When compared to both of the following spring barley crops the sugar beet was seen to uptake double the amount of CO_2, this is likely due to a longer growing period.

Crop export demonstrated sugar beet export was about 50% of the total carbon fixed from photosynthesis but the barley was only 25% due to the amount of biomass left behind post-harvest. However, the need for more residue data was highlighted to be able to look at longer-term sequestration.

3.3 N_2O losses from crop residues, Klaus Dittert (University of Göttingen, D)

Klaus Dittert presented data focussing on N_2O emissions in two projects at IfZ.

The first project looked at N_2O emissions following different N fertiliser levels (up to 300 kg N/ha) and tillage intensities ahead of sugar beet. A big part of this project was the comparison of these treatments when leaves were left behind following sugar beet harvest or removed from the field as sugar beet leaves have a low C:N ratio so are known to emit N_2O. Leaving the leaves in the field resulted in a flux of N_2O particularly from the crop which had received more N fertiliser. Removing leaves post-harvest reduced N_2O emissions even in crops which had received higher rates of fertiliser showing the effect of high fertiliser rates on post-harvest emissions is mitigated by

removing the tops from the field. Sugar beet leaf incorporation reduces N_2O emissions. The different tillage intensities didn't influence N_2O emissions whether leaves were removed or not.

The second project measured N_2O emissions following different cover crops used ahead of sugar beet (fallow, oat, summer vetch and winter rye), based on gas chamber measurements. The project concluded that N_2O fluxes occur following frost events and these emissions were proportional to the biomass of the cover crop. Cover crops with higher biomass, such as rye, emitted more N_2O following a frost event than smaller cover crops. Biomass quantity comes out to be a major predictor, before C:N ratio. N_2O emission was further increased by the more intensive tillage required to incorporate the larger cover crop prior to drilling the sugar beet. Whilst frost susceptible cover crops required less intensive tillage and resulted in less emissions.

3.4 Measures to reduce GHG emission, Marisol Campoverde (ARTB, F) & Rémy Duval (ITB, F)

Marisol Campoverde and Rémy Duval presented a French methodology developed for all arable crops between multiple institutions and introduced in 2021. This method, implemented into a calculator, can be used at farm level for arable crops to calculate the carbon footprint and carbon balance of the cropping system and quantify improvements by applying carbon levers. A carbon footprint baseline of the farm is calculated considering management practices of all crops in the system using average data from the last 3 years. This is used to calculate GHG emission sources and soil carbon storage; upstream, at field level and downstream. From this baseline the method applies a range of low carbon levers which reduce GHG emissions or increase carbon storage in the soil to reduce the carbon footprint of the system. The model used to simulate soil organic carbon dynamics, Simeos AMG, was evaluated against long term arable experiments in France and experiments including a sugar beet rotation across Europe.

Experimental data from two projects putting carbon levers into practice and measuring the effects of these on GHG emissions was then presented and compared to a reference system. The data highlighted that even if a reduction in GHG emissions and increase in soil carbon storage occurs in most years one bad season can undo this and reduce the 5-year average. This highlights the risk of introducing crops with low C returned into a farming system, and the impact of climate and crops productivity on C balance. It also showed results can be variable by farm, in some cases adding a cover crop didn't cause significant improvement but in another adding organic compounds and more biomass from cover crops and incorporated straw increased soil organic carbon levels considerably. In general, there's a low effect on C storage for the strategy only based on cover crops and better efficiency needs to use multiple levers.

3.5 Calculation methods and tools, Gebhard Müller (BGD, D)

Gebhard Muller highlighted the importance of accurately assessing emissions from sugar beet cultivation and the need for harmonised methods and data. Comparison of common GHG calculation tools using the same dataset yielded different results demonstrating a lack of continuity. These differences occurred due to differences in calculating crop residuals, field emissions from fertilisation, soil emissions, fuel emissions, and carbon binding. It was concluded that none of the tools accurately reflect emissions from sugar beet cultivation, so Südzucker developed their own tool, which the author describes in the second part of the presentation

A practical questionnaire is used to quickly and easily collect data of the farm inputs and practices to be used to calculate GHG emissions. The information collected has shown that over half of the emissions in sugar beet cultivation occur from fertilisation and liming. This includes field emissions from the fertiliser and emissions from the manufacturing process. The significance of crop residues is also considered effectively as they contribute significantly to GHG emissions from the sugar beet crop. To do this the condition of the leaves at harvest is scored at harvest

and the calculations altered accordingly. An interesting discussion developed around the categorisation of tillage practices into three different intensities and whether this is accurate enough.

Mark Stevens gave some closing words about the topics in the seminar.

Thanking all speakers, and mentioning that for addressing carbon emissions, the whole crop rotation should be accounted for.

End of the seminar

60 persons attended the seminar.