

Description and development Soil Carbon Tool

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1 Introduction

1.1 Sector interest

As part of its goal to make the agricultural sector climate neutral by 2050, the Netherlands has set itself the target of sequestering an additional 0.5 megatonnes of CO₂ per year in its mineral agricultural soils from 2030 onwards. According to Lesschen et al. (2021), the Dutch mineral agricultural soils have the potential to sequester additional CO₂, but this potential differs per individual farm, as does the viability of including carbon measures in a farm's business plan. It is therefore important to provide farmers with insight into the effects of various carbon measures for maintaining and improving soil organic matter at both the field and farm level. Interviews and discussions with representatives of the sector have revealed that both arable and livestock farmers currently often lack this insight. The Soil Carbon Tool delivers this information and in so doing encourages farmers to introduce carbon measures in their farm management plans.

1.2 Aim

The aim of this project is to develop, document and test a practical tool together with the sector. The tool will provide insight into: (1) changes in the soil carbon content over time, (2) the annual carbon balance and carbon sequestration at the field and farm level, and (3) the carbon input and output sources. These aspects need to be clearly understood in order to make decisions about current and future carbon management practices based on carbon management scenarios.

1.3 Background

In 2019, an exploratory study was conducted into carbon models that could potentially serve as a basis for a practical tool (Lesschen et al., 2020a). Three models were considered to be suitable for such a tool: RothC, NDICEA and CCB. The RothC model (Coleman and Jenkinson, 2014) was eventually selected to form the arithmetic core for the tool. Compared to the other two models, the RothC model requires relatively little input data, the required data is readily available, the source code is easy to modify, and the model can process large datasets (farms with many fields) over long periods of time. The RothC model is also used for the national programme that monitors changes in the soil carbon stock of mineral agricultural soil. When used to calculate the effects of a number of long-term experiments in the Netherlands, the RothC model showed similar results to the other two models (Lesschen et al., 2020a).

Additional carbon can be fixed in the soil by limiting the decomposition of organic matter in the soil, or by a net supply of organic matter from within or outside the farm. There are various measures for improving soil carbon sequestration (Lesschen et al., 2021). For a positive carbon balance, there must be a net supply of organic matter. There are major differences in the composition of the various sources of organic matter (organic manure, crop residues, compost and green manure) (Van Groenigen and Zwart, 2007).

The potential for carbon sequestration differs by type of farm and location. In some agricultural soils it will be difficult to achieve a positive carbon balance, for example because they have developed a high organic matter content, either naturally or as a result of manure application in the past. Depending on the soil type (e.g. clay or sand), this can greatly influence the potential for carbon sequestration.

2 Description of the tool

2.1 Conceptual model

A conceptual model was developed based on the insights gained from the interviews and discussions with representatives of the sector (Figure 1). The conceptual model can be divided into three sections: 1) the input of farm data, 2) the calculation model and 3) the results. Each section is explained in detail.

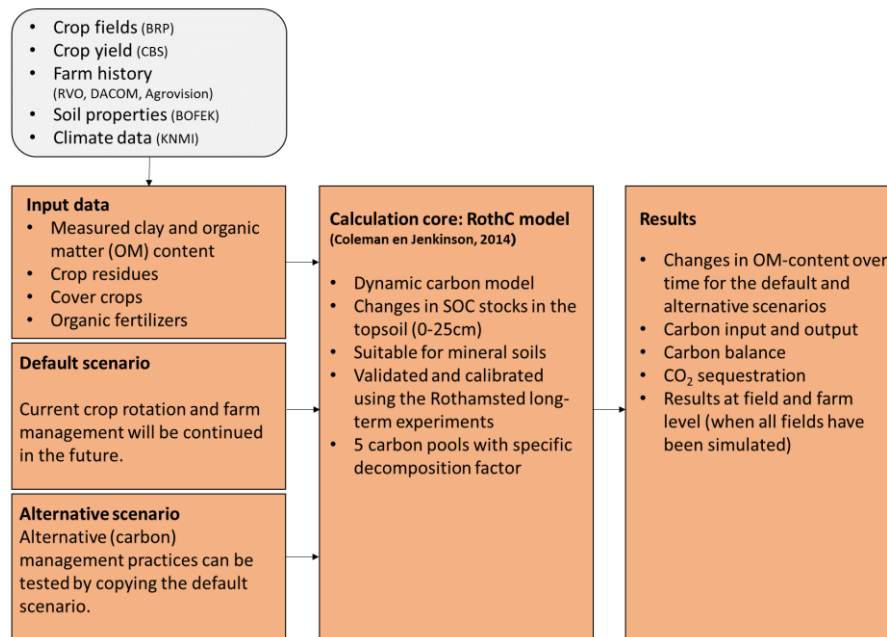


Figure 1. The conceptual model of the Soil Carbon Tool comprises: 1) the input of farm data and the development of a standard scenario and alternative scenarios, 2) the arithmetic core and 3) the results.

2.2 Inputting crop and farm management data

2.2.1 Crop and farm management history

To make the tool more user-friendly, input data are linked to existing databases wherever possible. Fields can be automatically retrieved from the Field Records Database (*Basisregistratie Percelen*, BRP) and crop histories can be retrieved from the Netherlands Enterprise Agency (RVO), DACOM or Agrovision. Average crop yields per province are available from Statistics Netherlands (CBS, 2022). As the crop yields are farm-specific, this data can always be adjusted if the user has more reliable data available. Soil data (soil type, clay content and organic matter (OM) content) are obtained from the Dutch physiographic soil map (*Bodemfysische Eenhedenkaart*, BOFEK2020) (Heinen et al., 2021). The soil data in BOFEK2020 are unsuitable for use at the field level, but will be used for the meantime due to a lack of better data. A direct link between Eurofins and FarmMaps will probably be established in 2022, allowing soil analyses to be directly linked to the tool. A further aim is to replace general data sources such as those of Statistics Netherlands with farm-specific databases such as AgroVision. This will improve the accuracy of the calculations.

In addition to the data that is automatically retrieved, the user will need to enter some data manually. For example, the user will be asked to enter the results of clay and organic matter analyses. The year in which these analyses were carried out is essential, as this forms the baseline for all further calculations. The user can also choose to enter the results of analyses carried out over several years instead of only the most recent one. The advantage of this is that they will also be able to evaluate their past management practices. In addition to these soil data, a certain amount of farm management data will also be required. This is

because the organic matter content of the soil can also be increased by incorporating crop residues, sowing green manure crops after the harvest or applying organic manure. Conversion tables are used to calculate the carbon inputs by crop residues based on the total wet weight (Annex A). The carbon inputs by crop residues is calculated for straw crops using the Garcia-Condado method (2019) (Annex A). The proportion of above-ground straw (in kg of dry weight/ha) is calculated using [For.1]:

$$Crop\ residues_{aboveground} = \left(\frac{crop\ yield}{harvest\ index} \right) - crop\ yield \quad [1]$$

where the harvest index is the ratio of the harvested crop to the total crop biomass. The aboveground crop residues comprise straw and stubble. The ratio of straw to stubble is estimated to be 55:45. Underground carbon sequestration by straw crops is calculated using Taghizadeh-Toosi et al. (2014) in [For.2]:

$$Crop\ residues_{underground} = \frac{(Crop\ yield + (stubble + straw) * DM) * CB}{\left(\frac{1}{FracC} \right) - 1} \quad [2]$$

where DM is the dry matter content of the crop residues (in kg/ha), CB is the carbon biomass of 0.45, and FracC is the fraction of underground carbon sequestration of 0.25 (Kuzyakov and Domanski, 2000). The dry matter content of crop residues is calculated based on Scarlat et al. (2010). The fraction is 0.7 for grain maize and corn cob mix, 0.6 for sunflowers and rapeseed, and 0.85 for other straw crops. For all other crops, the amount of carbon sequestration by crop residues is a fixed value (Annex A).

2.2.2 Developing a standard scenario

After entering all their field data, the user is prompted to specify a standard crop rotation plan for the future. The standard scenario is then automatically populated with these crops and the relevant crop management plans. The scenario can be populated with the rotation plan up to the year 2050, or a shorter scenario period can be selected. This makes it possible to predict how the organic matter content will change over time if the current management plan is continued. No weather scenarios are currently included, but instead the year with the most average weather conditions over the past 30 years (1988-2018) has been taken. This year was 2012. (Analyses have shown that applying an average weather year produces more accurate results than averaging the weather over the past 30 years.)

2.2.3 Assessing carbon measures in the various scenarios

The standard scenario can be copied up to 5 times and populated with different data to produce alternative scenarios, so that the various carbon measures can be compared with each other. The following measures can be compared:

- The inclusion of grain crops in the crop rotation to make the current crop rotation less intensive.
- Add extra or replace current manure types for solid manure or compost.
- Sowing green manure/catch crops after the harvest (the biomass of a green manure crop depends on the type of crop that is sown and the period it is allowed to grow).
- Leaving the crop residues of straw crops in the field instead of removing them.
- Applying new techniques to increase crop yields (e.g. precision agriculture). The increased yield results in increased biomass production.
- For cattle farms, additional measures that can be included in the tool are: increasing the permanent grassland acreage, increasing the age of grassland, and improve crop rotation between maize and grass (60% permanent grassland, 20% temporary grassland, 20% maize; Van Eekeren, 2020). The tool currently distinguishes between temporary grassland (≤ 5 years) and permanent grassland (> 5 years). Increasing the age of permanent grassland is an effective measure, but this effect cannot be calculated at present.

The measures 'non-inversion tillage', 'herb-rich grassland' and 'deep-rooting crops' cannot be calculated yet because their effect on carbon sequestration in the soil cannot yet be adequately substantiated (Schepens et al., 2022). Tillage methods are not part of the RothC model, so their effects should be calculated indirectly (e.g. by changing the carbon degradation rate). This does bring additional

uncertainties, however. These measures will be incorporated in the tool once their effect can be demonstrated for Dutch clayey and/or sandy soils (for example because more data becomes available).

2.3 Calculation model

The calculation model for the tool is based on the RothC model (Coleman and Jenkinson, 2014). This dynamic process model calculates the annual carbon degradation in mineral soils. The model can calculate carbon degradation in five carbon pools, each with a different degradation rate: Decomposable Plant Material (DPM), Resistant Plant Material (RPM), Microbial Biomass (BIO), Humified Organic Matter (HUM) and Inert Organic Matter (IOM) (Figure 2). The degradation rate depends on the soil moisture content, temperature, vegetation cover and the source and amount of carbon sequestration.

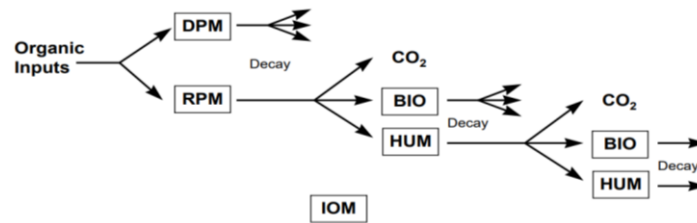


Figure 2. Organic matter degradation in the RothC model. The five carbon pools are: RPM (Resistant Plant Material), DPM (Decomposable Plant Material), BIO (Microbial Biomass), HUM (Humified Organic Matter) and IOM (Inert Organic Matter).

The Soil Carbon Tool distinguishes four sources of carbon sequestration: crop and grass residues, green manure crops, compost and organic manure. Figure 3 displays the four sources of carbon sequestration and their distribution across three carbon pools.

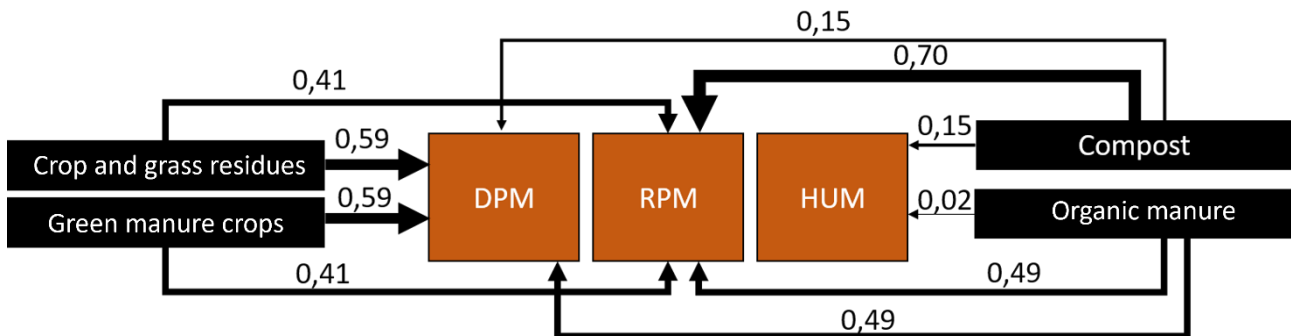


Figure 3. Organic matter sources and their distribution across three of the five carbon pools. DPM (Decomposable Plant Material), RPM (Resistant Plant Material) and HUM (Humified Organic Matter).

According to Coleman and Jenkinson (2014), carbon degradation is an exponential process and is influenced by the factors temperature (a), moisture content (v) and vegetation cover (b). The influence of temperature on the degradation rate (a) is determined by [For.3]:

$$a = \frac{47.9}{1 + e^{\left(\frac{106}{T+18.3}\right)}} \quad [3]$$

where T is the temperature (in °C).

The growing season is determined for each crop. It is assumed that the soil is covered with vegetation during these months (Annex B). A cover factor (b) of 0.6 is used to include the effect of vegetation cover on the degradation rate during the months when the soil is covered by a crop. A factor of 1.0 is applied during the other months. It is not yet possible to calculate the effect of sowing green manure crops to cover the soil after harvest.

To determine the influence of moisture content on the degradation rate, the maximum moisture deficit ($moisture\ deficit_{max}$) is calculated over a year in [For.4]. However, this formula assumes a situation of vegetation cover. If this is not the case, the $moisture\ deficit_{max}$ is divided by 1.8 (Farina et al., 2013) to correct for the reduced evapotranspiration of fallow land:

$$moisture\ deficit_{max} = -(20 + (1.3 * clay) - (0.01 * clay^2)) * (\frac{soil\ depth}{23}) \quad [4]$$

where $clay$ is the clay content (in %), and $soil\ depth$ is the depth at which the soil sample was taken (in cm). In Dutch arable farming, soil samples are taken at a standard depth of 25 cm, but grassland soil samples are often taken at a depth of 10 cm. The RothC model has been calibrated and validated for a depth of 23 cm. In the tool, the organic matter content is corrected for the soil sample depth, so the carbon degradation of the topsoil (0-25 cm) can be calculated for both arable and grassland soils. For temporary grassland sampled at 10 cm depth, the organic matter content is corrected by a factor of 0.97. This grassland is ploughed regularly, which makes it more homogeneous than natural or permanent grassland and so only a minimal correction factor is applied. For natural and permanent grassland, a correction factor of 0.67 is applied for clayey soils and 0.81 for sandy soils (Lesschen et al., 2020b).

The soil moisture deficit is calculated on a monthly basis (there is a deficit if the amount of evapotranspiration is higher than the amount of rainfall). If there is a deficit, an accumulative soil moisture deficit ($moisture\ deficit_{acc}$) is determined for the following months, whereby the deficit of the previous months is added to the deficit of the current month. If the accumulative soil moisture deficit is greater than 0.444, the influence of soil moisture content on the degradation rate is determined using [For.5]. Otherwise a factor of 1 is applied. The actual evaporation of open water is determined by multiplying the Makkink reference evaporation (1957) by 1.25 (STOWA, 2009).

$$v = 0.2 + 0.8 * \frac{(moisture\ deficit_{max} - moisture\ deficit_{acc})}{(moisture\ deficit_{max} - 0.444 * moisture\ deficit_{max})} \quad [5]$$

where v is the moisture factor. To calculate the soil carbon stock (SOC_{ini}) in the first year, the bulk density (BD) of the soil (in kg/m³) is multiplied by the (corrected) organic matter content (in %) and the soil depth (in cm). To convert the organic matter stock in the topsoil to a carbon stock, it is multiplied by 0.54, which is the average C/OM ratio in the Netherlands (Tol-Leenders et al., 2019). The BD of the clay mineral soils is calculated based on Wösten (2001) in [For.6]. Sandy soils are calculated based on Hoekstra and Poelman (1982) in [For.7].

$$BD_{clay} = \frac{1}{0.6117 + (0.003601 * clay) + (0.002172 * OM^2) + 0.01715 * \log(OM)} \quad [6]$$

$$BD_{sand} = \frac{1}{0.667 + (0.021 * OM)} \quad [7]$$

where the $clay$ and (corrected) organic matter (OM) content are percentages.

Carbon degrades in each carbon pool by $1 - e^{-(a*b*v*k)}$. Here, k is a standard degradation constant, namely $k_{DPM} = 10$, $k_{RPM} = 0.3$, $k_{BIO} = 0.66$ and $k_{HUM} = 0.02$. The carbon stock is distributed over the five carbon pools as follows in [For.8-13]:

$$DPM_{ini} = \left(\frac{DPM_{in}}{\frac{1}{12} * \sum a*b*v} \right) * k_{DPM}^{-1} \quad [8]$$

$$RPM_{ini} = \left(\frac{RPM_{in}}{\frac{1}{12} * \sum a*b*v} \right) * k_{RPM}^{-1} \quad [9]$$

$$IOM_{ini} = 0.049 * SOC_{ini}^{1.139} \quad [10]$$

$$BIO + HUM_{ini} = SOC_{ini} - (DPM_{ini} + RPM_{ini} + IOM_{ini}) \quad [11]$$

$$BIO_{ini} = \frac{BIO + HUM_{ini}}{1 + 0.66/0.02} \quad [12]$$

$$HUM_{ini} = \frac{BIO + HUM_{ini}}{1 + 0.02/0.66} \quad [13]$$

Degraded RPM is converted into CO₂, BIO and HUM. The ratio of CO₂ to BIO+HUM is calculated using [For.14]:

$$Ratio_{CO_2:BIO+HUM} = 1.67 * (1.85 + 1.60 * e^{(-0.0786 * clay)}) \quad [14]$$

The annual emissions of CO₂ to the atmosphere can be calculated based on this formula. Of the BIO and HUM, 46% enters the BIO pool and 54% the HUM pool.

The carbon balance is calculated by subtracting the initial soil carbon stock from the new soil carbon stock. A positive balance (in t C/ha/year) indicates net carbon sequestration, and a negative balance indicates net CO₂ emissions. Carbon sequestration (in t CO₂/ha/year) is calculated by multiplying the carbon balance by a factor of 3.7 (CO₂ molar mass/C molar mass). A positive or negative trend can be observed by calculating the average carbon balance and carbon sequestration over a longer period of time (assuming that the bulk density does not change).

2.4 Results

The results can be displayed at the field and farm level. The outcomes at the field level can be scaled up to the farm level by applying weighted averages. The model can be applied to various periods between 2011 and 2050. Only years in which data was collected for all the farm's fields are included in the calculation of the total farm results. The results can be used to produce three types of information (see example in Figure 4):

1. The change in organic matter content of the topsoil (0-25 cm) over the selected years, a standard scenario and alternative scenarios. The model starts calculating from the year in which the soil sample was collected and analysed. Changes in the organic matter content of the soil occur only slowly, which is why more insight is required into the long-term effects of various soil management practices.
2. The carbon balance and carbon sequestration and CO₂ emission per year. This result can be used to compare the standard scenario with the alternative scenarios (not included in Figure 4).
3. An overview of the average carbon balance and carbon sequestration in recent years for the standard scenario and the alternative scenarios is displayed in a table.

The input data and results can be downloaded, however the figures cannot. The data of both individual fields and the total farm result can be downloaded (including the various scenarios).



Figure 4. Example of how the results are displayed in the tool.

2.5 Sensitivity and uncertainty of the calculation model

Uncertainties in the results may affect the input data, conversion tables, model parameters and model assumptions. A sensitivity analysis of the calculation model (based on the results of 37 dairy farms) revealed that the model is most sensitive to uncertainties in: 1) moisture availability, 2) the soil depth over which the organic matter is calculated, and 3) the sequestration of carbon by crop residues (Figure 5) (Lesschen et al., 2020b). It is not known whether this also applies to the arable farm sector, which has its own specific characteristics (crop rotation, organic fertilisation, soil tillage practices). It is important that the input data on the various parameters is accurate.

The availability of moisture is determined using local meteorological data supplied by KNMI. The average weather year 2012 was used to calculate the various scenarios. The results of the model could be improved by an option to calculate weather scenarios and select an extremely dry or wet year, or a year that represents average weather conditions during the growing season (rather than the entire year).

The RothC model has been calibrated and validated for a soil depth of 23 cm. The model applies a correction factor to calculate the results for the topsoil (0-25 cm). Other correction factors apply for grassland, which is often sampled at 10 cm depth, depending on the type of grassland and soil. The sequestration of carbon by crop residues is calculated using a fixed value. In straw crops, carbon sequestration is only dependent on actual crop yields. Garcia-Condado (2019) revealed that in some non-straw crops there is no relationship between the crop yield and the amount of crop residues. For crops where crop residues do depend on the crop yield, it is important that these input data are accurate. Currently, the model uses regional data supplied by Statistics Netherlands to estimate crop yields. A user can modify this data if better data are available. The results could be improved if the tool could automatically be populated with farm data from other platforms. This would also increase the user-friendliness of the tool. In the tool, carbon sequestration by green manure crops is dependent on the type of crop and the period it is allowed to grow. The amount of biomass produced by a green manure crop can be highly variable and is rarely measured (if at all)

(Koopmans et al., 2020). The sequestration of carbon by mixed green manure crops is particularly uncertain (Selin Norén et al., 2021).

The tool currently bases the composition of organic manures and compost on the indicators published in the Dutch soil and fertilisation manual (*Handboek Bodem en Bemesting*, CBAV, 2017), which was partially revised in 2019 (Hanegraaf et al., 2019). However, the composition of organic manures and compost can vary greatly between the types of manures. Currently, the carbon content is not routinely determined during analyses of manure samples, so it is not yet possible to improve carbon sequestration by organic manures. The nitrogen content is determined however, so the estimation of the amount of carbon sequestration by organic manures could be improved if the various manures prove to have a relatively constant C:N ratio.

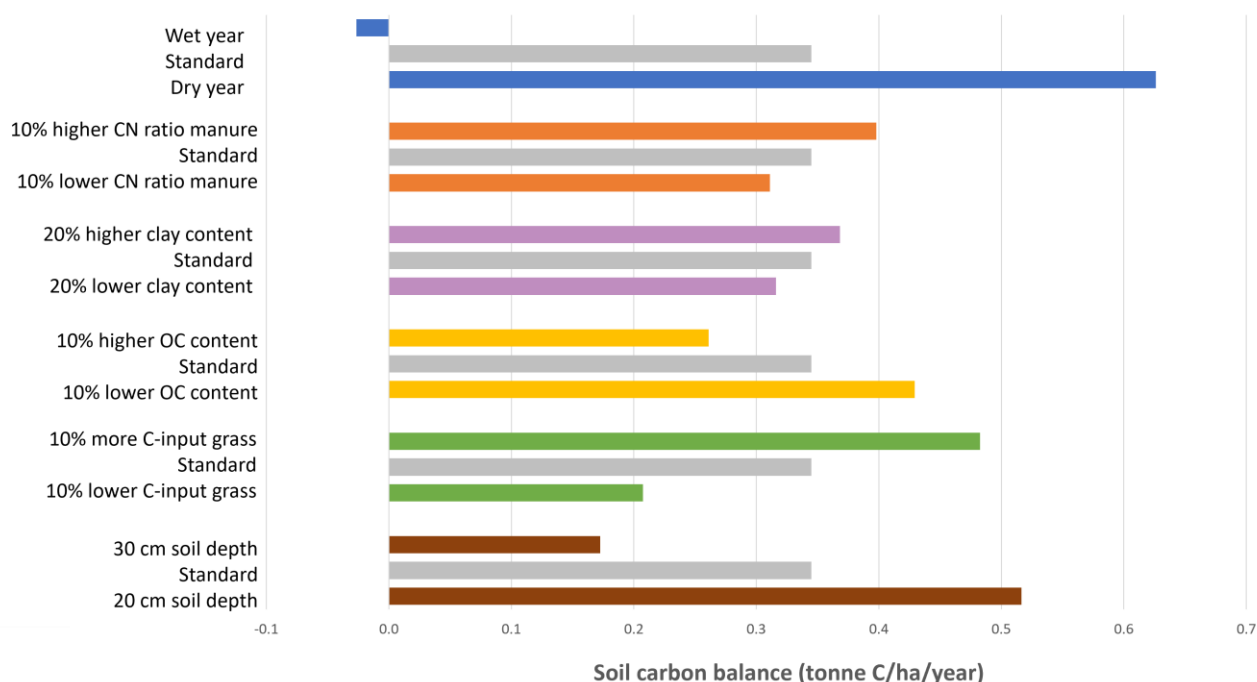


Figure 5. Sensitivity analysis of key model parameters. The results are based on the average soil carbon balance of 37 dairy farms (grey bars) (Lesschen et al., 2020b).

The RothC model is applied around the world at various scales and so it has been extensively calibrated and validated in long-term experiments (Coleman and Jenkinson, 1996; Skjemstad et al., 2004; Zimmermann et al., 2007). Zimmermann et al. (2007) found strong correlations between the organic matter fractions measured and the carbon pools modelled (0.82 for DPM, 0.76 for RPM, 0.99 for HUM and BIO, and 0.73 for IOM). Unfortunately, there is insufficient long-term data available in the Netherlands to validate the model for the Dutch situation. We therefore assume that the validations carried out in neighbouring countries with the same climate and similar farming systems can also be applied to Dutch farmland. Various methods were tested for the initialisation of the RothC model. The smallest margin of error was achieved with a method in which carbon sequestration is included when calculating a steady distribution of soil carbon among the various carbon pools (Klumpp et al., 2017). The RothC model was originally designed for arable farms, but is now also suitable for grassland.

2.6 FarmMaps web platform

The tool was launched as an app on the independent platform FarmMaps, which is managed by WUR. FarmMaps was selected because it is a growing platform that can be connected to a range of apps relevant to farm management systems (in addition to the Soil Carbon Tool). Furthermore, FarmMaps uses a system that gives users control over their own data, which is widely appreciated. Data is only made available to

third parties, for example for research purposes, with the consent of the user and they can retract this consent at any time. Users can create a free account on FarmMaps (go to www.farmmaps.eu and click on 'TO FARM MAPS') and then add the Soil Carbon Tool to your personal account (*BodemCoolstof*, also free of charge). The tool includes a [user guide](#) and [instruction video](#) with step by step instructions for using the tool.

2.7 Improvements to the Soil Carbon Tool

User interviews and tests have revealed several possible areas of improvement. These mainly concern improvements in data input and user-friendliness. The requested improvements include:

- Incorporate climate scenarios to calculate the impact of climate change in the future.
- Link farm data (results of soil analyses, crop yields, sowing of green manure crops, type and amount of organic manure applied, crop residues left in the field, etc.) to other data platforms such as DACOM, AgroVision, Eurofins and RVO.
- Include buttons or pop-ups to make it easier for the user to find their way around the tool.
- Provide an alternative way to calculate the effects of measures so that the user is more aware of the different options that are available.
- Incorporate new measures or improve how some existing measures are calculated (such as increasing the age of grassland or sowing silage maize with a strip cultivator).
- Incorporate irrigation schemes (irrigation has a strong effect on the moisture content of the soil, and the sensitivity analysis revealed that the model is very sensitive to changes in moisture content).
- Include an option to enter more than one crop per field per growing season (request of vegetable farmers, among others).
- Dairy farmers have indicated that the effect of grazing is currently insufficiently calculated by the tool.
- Including uncertainty analyses in the tool will encourage more farmers to use it. To date, the tool has been used mainly to predict the effect of various soil carbon measures, whereby the relative difference between the standard scenario and the alternative scenarios is important. However, to monetise the results of carbon measures, for example in the form of carbon credits, the absolute effects of these measures must be calculated. This means it will be more important for farmers to know what the uncertainties are (in input, model calculations and results).
- In terms of climate targets, the tool could be improved by simulating knock-on effects such as N₂O production in addition to carbon sequestration. Some users also indicated that they would like the tool to integrate other biological, physical and chemical soil processes.
- Agricultural consultants indicated that they would like to be able to enter data from several fields and/or farms simultaneously.

The aim is to develop a tool that will appeal to a large part of the agricultural sector, but it will not be possible to meet the requirements of every individual user (for example because important data is lacking, or the data is not compatible with the existing model, or certain data will make the calculation model too complex, and so either necessitate more assumptions or more input data). Points for improvement will be prioritised based on the needs of the sector and the feasibility of implementing them in the calculation model and the interface.

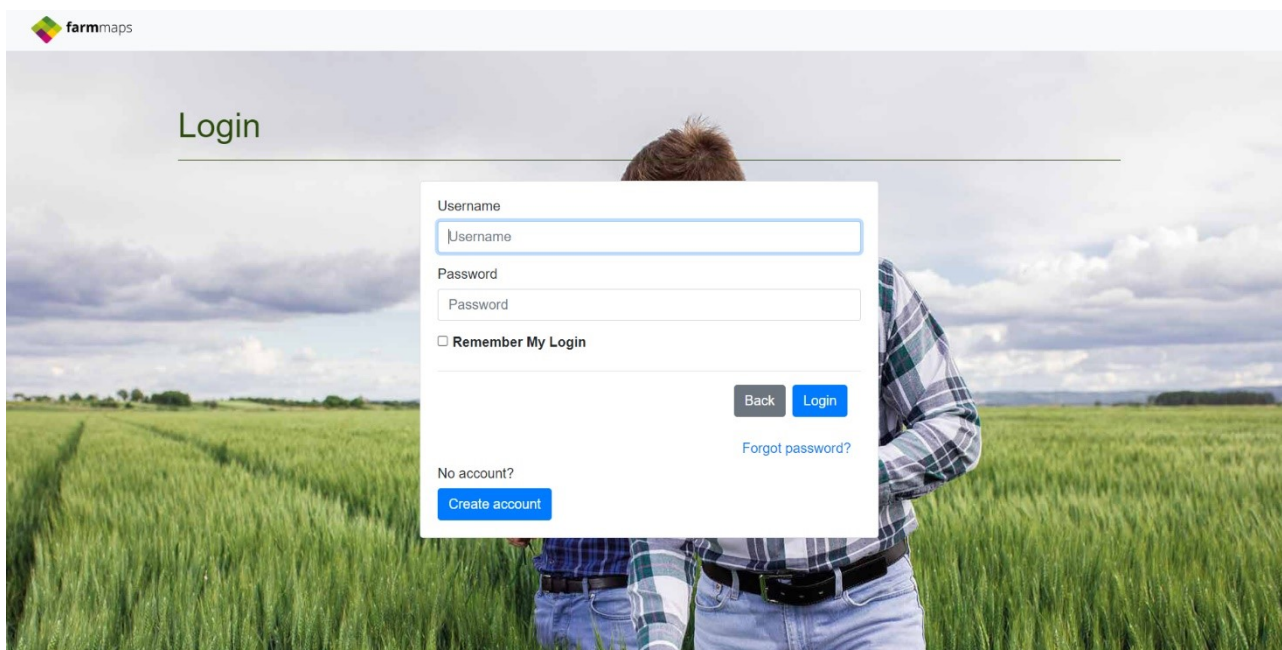
3 User guide

3.1 FarmMaps

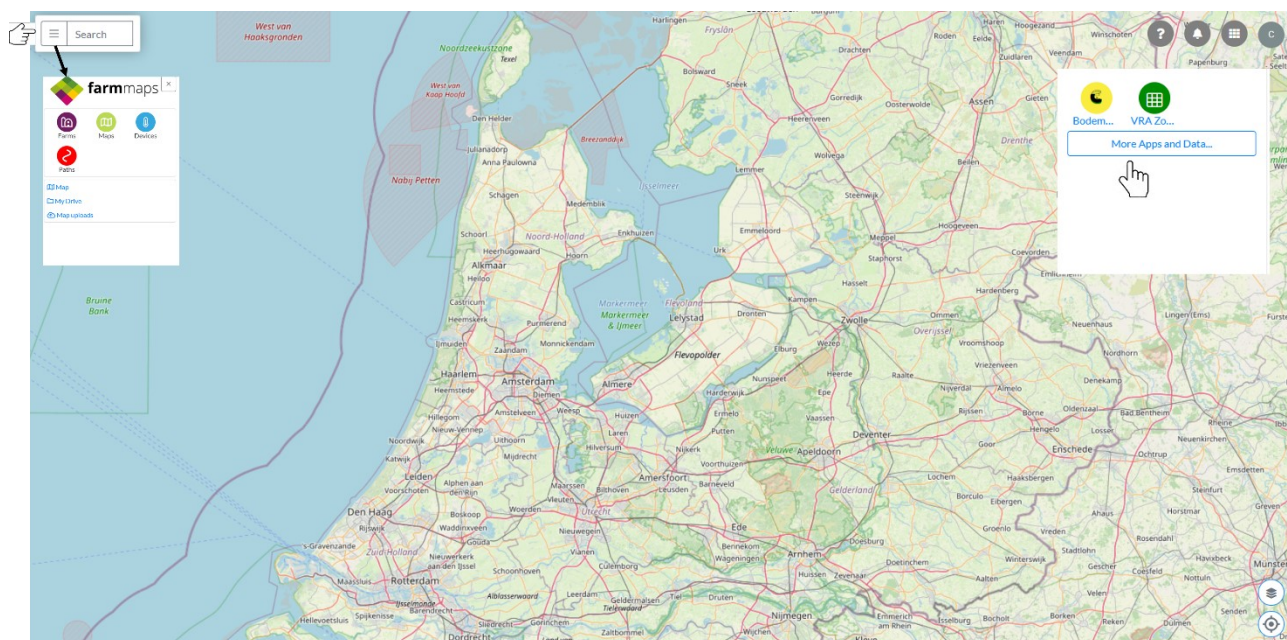
Open the FarmMaps home page (www.farmmaps.eu) and click on 'TO FARM MAPS' to go to the login screen.




If you are logging into FarmMaps for the first time, you will need to create an account (free of charge) by clicking on 'create account'. If you already have a login name and password, fill those in as seen below and click on 'Login'.

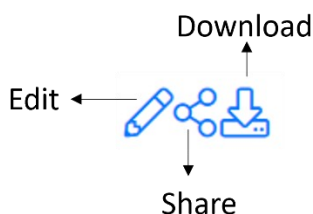


Once you are in the home screen, you can go to 'More Apps and Data...' at the top right or add a new farm by clicking on the purple 'Farms' icon at the top left.



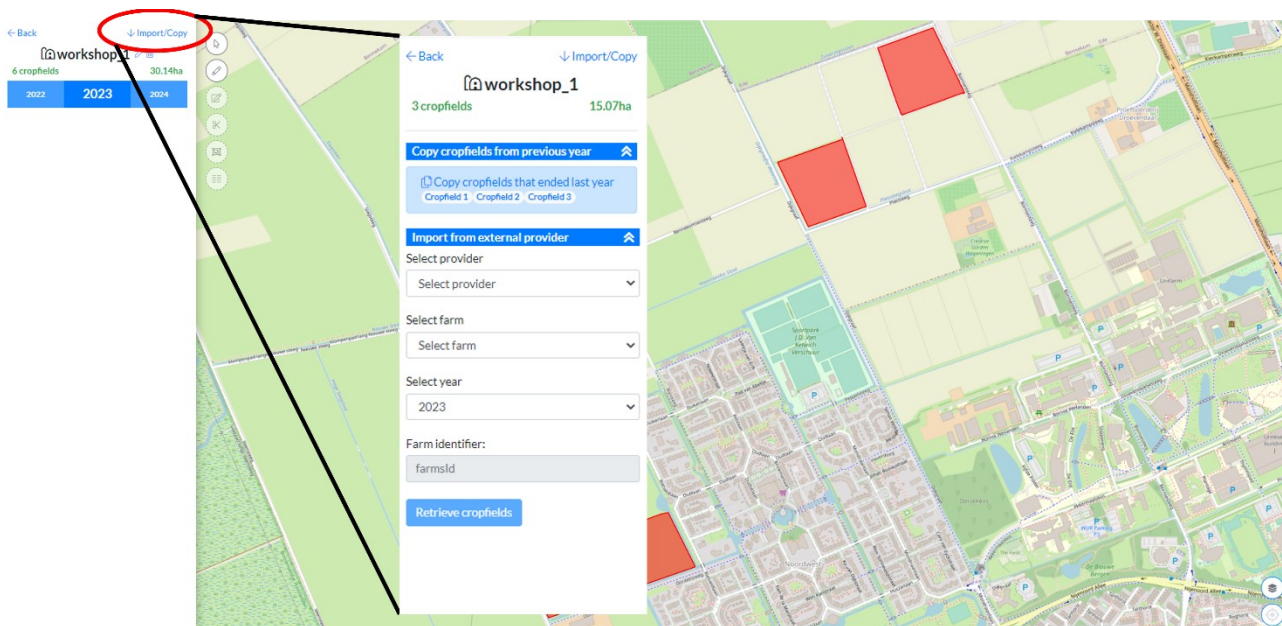
If you click on the purple 'Farms' icon, you can add a farm to your FarmMaps account. You do this by clicking on the  icon.

Give your farm a name and enter the address details and then click on 'Save'. Now you have the choice to edit, share or download your farm details.



Click on the pencil icon 'Edit' to add your fields, which can be done in several ways. You can import the fields from RVO, Dacom, or AgroVision by clicking on 'Import' (circled in red in the figure on the next page), or add them manually. First we will explain how to import fields automatically, followed by an explanation on the manual application of fields.






Click on 'Import/Copy' to 1) copy crop fields from previous years, and import field data from an external provider. If you cannot select a provider, you first need to provide permission for connection. This is explained on the next page.



To select a provider, you go to 'Apps en Data' on the top right of the screen. Next, you click on the second sheet 'Connections'. Click on your provider and add the provider to your account by clicking on 'Add now'. Go to your provider (DACOM, Agrovision, or RVO) to confirm the connection.

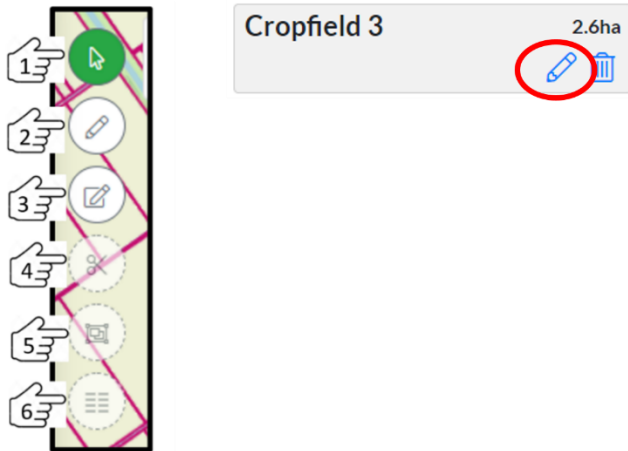
Apps and Data

Application **Connection** Data Package Deal

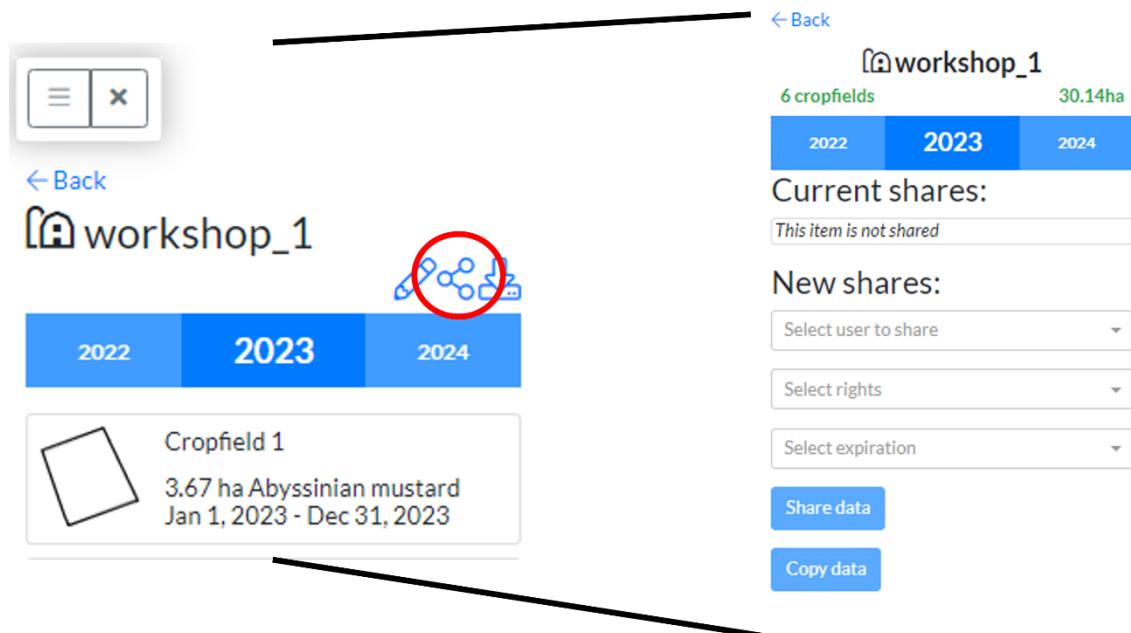
AGRIROUTER	AGROVISION	DACOM	EUROFINS	RVO
				
DKE Agrirouter simplifies data exchange and operational processes, reduces administrative overhead, and...	FARMMAPS With this app you make a connection with your Agrovision farm management system. Get your cropping...	FARMMAPS With this app you make a connection with your Dacom farm management system. Get your cropping scheme or...	FARMMAPS Met deze app maak je een koppeling met Eurofins. Alle bemonsteringen die Eurofins voor zijn klanten uitgevoerd zij...	FARMMAPS With the RVO connection you can download your cropping scheme from the RVO. Use eHerkenning to sign in and...
€100 / 12M €121.00 INCL. 21% VAT	€0 €0.00 INCL. 21% VAT	€0 €0.00 INCL. 21% VAT	€0 €0.00 INCL. 21% VAT	€0 €0.00 INCL. 21% VAT
Read more	Read more	Read more	Read more	Read more

Fields can also be added manually. For this you can use the six icons on the left side of the screen. The first icon (1) shows the RVO fields. Select your fields one by one. You can also draw your own field boundaries (2) or edit existing ones (3). The functions split a field (4), join fields (5) and create strips in a field (6) will become soon available.

For each field, you have to click on the pencil on the right (circled in red). Fill in the obligatory information, scroll down and click on 'Save' to add the field to the tool.



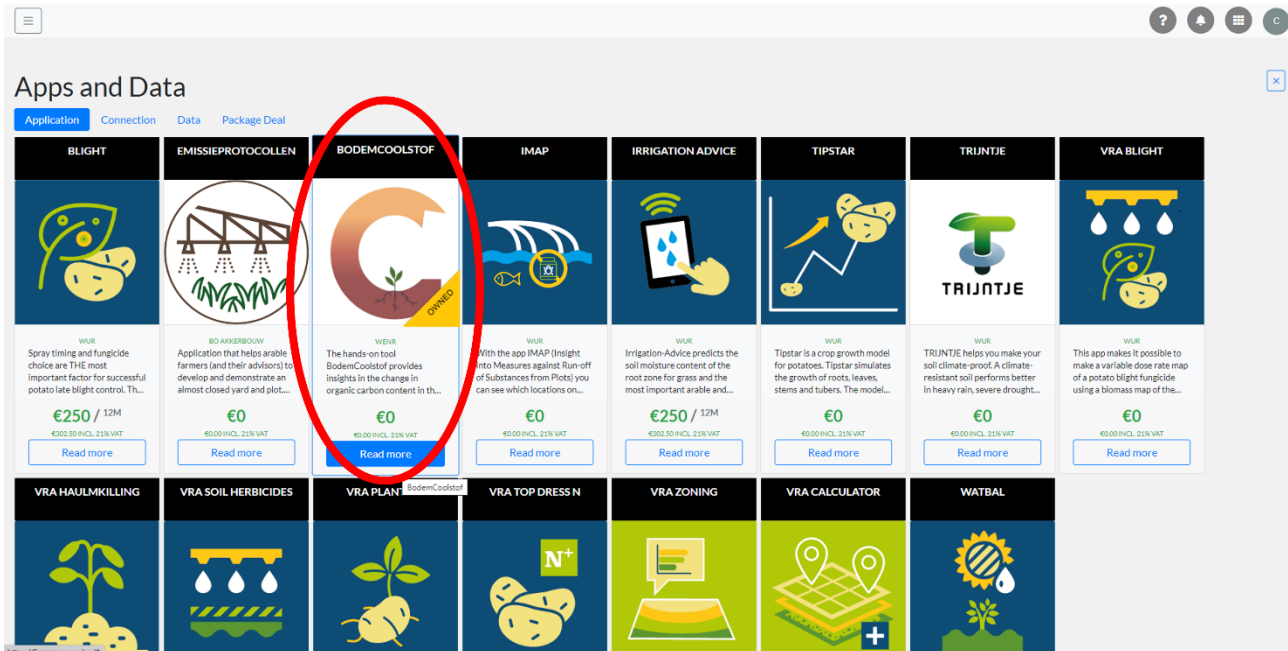
After completing a field, it is possible to copy and share this data using the 'Share'-button (circled in red). In this way it is possible to share data with other users on the platform. The 'Download'-button can be used to download your data.



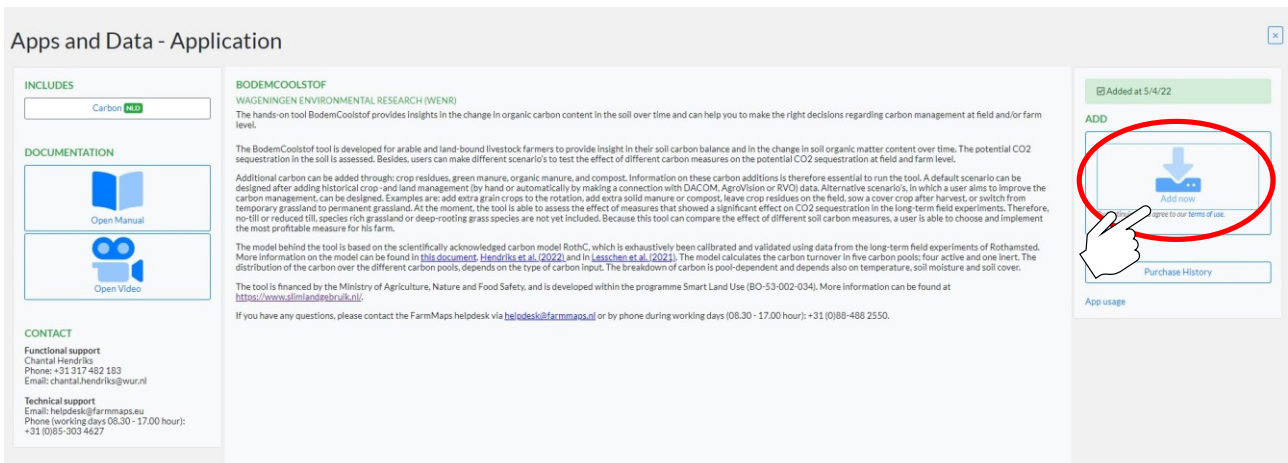
When all fields have been loaded, you can add the Soil Carbon Tool to your account by clicking on 'Apps and data'.


3.2 Input data

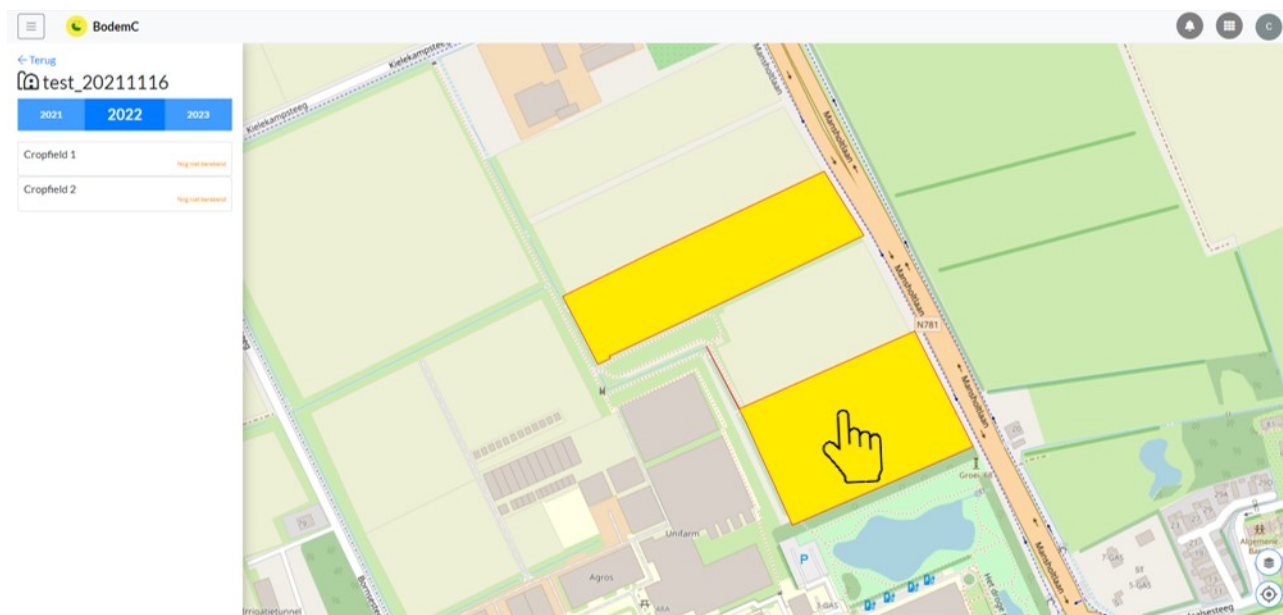
Navigate to 'Apps and data' on the right corner of your home screen to add the Soil Carbon Tool to your account. Go to the Soil Carbon Tool by clicking on the 'read me' circled in red. Here you can find the user guide and an instruction video.



Click on 'Add now' on the right of the screen to add the Soil Carbon Tool to your account.



Open the Soil Carbon Tool by navigating again to the 'Apps and data'-button on the right side of your screen, and click on the icon of the tool that now became visible: . The fields below are still shaded yellow because the carbon balance has not been calculated yet. Once the calculations have been done, the field will colour green (positive carbon balance) or red (negative carbon balance). Click on one of the fields to go to the input screen.



The input screen has already been populated with some of the data. Check this data to ensure it is correct and replace the numbers with your own data if possible. Then enter the clay and organic matter content and the year in which you took the soil sample (circled in red). The tool will subsequently use this year as the baseline. We recommend that you enter the most recent analysis if you want to calculate the effects of various scenarios in the future. If you want to evaluate your past management of this field, you can use an older analysis for comparison.

Cropfield 1

Input | Default scenario | Result

Organic manures **Common data**

Area: 3.67

Soil: Zand

Clay content (%):

Organic matter (%): 4.27 measured in year:

Year	Crop	Yield (ton/ha)	Green manure	Period green manure	Organic manure (ton vers/ha)	Straw withdraw	Crops in standard rotation
2011	Fodder maize	46.6	Enter search text	Enter search text	Click on button to add or edit organic manure	<input checked="" type="checkbox"/>	<input type="checkbox"/>
2012	Starch potato	43.5	Enter search text	Enter search text	Click on button to add or edit organic manure	<input checked="" type="checkbox"/>	<input type="checkbox"/>
2013	Winter wheat	8.9	Enter search text	Enter search text	Click on button to add or edit organic manure	<input checked="" type="checkbox"/>	<input type="checkbox"/>
2014	Sugarbeet	86.3	Enter search text	Enter search text	Click on button to add or edit organic manure	<input checked="" type="checkbox"/>	<input type="checkbox"/>
2015	Rapeseed	3.3	Enter search text	Enter search text	Click on button to add or edit organic manure	<input checked="" type="checkbox"/>	<input type="checkbox"/>
2016	Starch potato	44	Enter search text	Enter search text	Click on button to add or edit organic manure	<input checked="" type="checkbox"/>	<input type="checkbox"/>
2017	Winter wheat	8.7	Enter search text	Enter search text	Click on button to add or edit organic manure	<input checked="" type="checkbox"/>	<input type="checkbox"/>
2018	Other crops	35.3	Enter search text	Enter search text	Click on button to add or edit organic manure	<input checked="" type="checkbox"/>	<input type="checkbox"/>
2019	Summer wheat	7.4	Enter search text	Enter search text	Click on button to add or edit organic manure	<input checked="" type="checkbox"/>	<input type="checkbox"/>
2020	Sugarbeet	78.2	Enter search text	Enter search text	Click on button to add or edit organic manure	<input checked="" type="checkbox"/>	<input type="checkbox"/>
2021	Starch potato	40.3	Enter search text	Enter search text	Click on button to add or edit organic manure	<input checked="" type="checkbox"/>	<input type="checkbox"/>
2022	Winter wheat	7.9	Enter search text	Enter search text	Click on button to add or edit organic manure	<input checked="" type="checkbox"/>	<input type="checkbox"/>

Save

Check your crop and yield data and then enter the type of green manure crop you sowed after the harvest and how long this crop was left to grow:

Cropfield 1

Input Default scenario Result

Organic manures **Common data**

Area: 3.67

Soil: Zand

Clay content (%): 6

Organic matter (%): 4.27 measured in year:

Year	Crop	Yield (ton/ha)	Green manure	Period green manure	Organic manure (ton vers/ha)	Straw withdraw	Crops in standard rotation
2011	Fodder maize	46.6	Enter search text	Enter search text	Click on button to add or edit organic manure		
2012	Starch potato	43.5	Enter search text	Enter search text	Click on button to add or edit organic manure		
2013	Winter wheat	8.9	Enter search text	Enter search text	Click on button to add or edit organic manure		
2014	Sugarbeet	86.3	Enter search text	Enter search text	Click on button to add or edit organic manure		
2015	Rapeseed	3.3	Enter search text	Enter search text	Click on button to add or edit organic manure		
2016	Starch potato	44	Enter search text	Enter search text	Click on button to add or edit organic manure		
2017	Winter wheat	8.7	African Marigold	<2 maanden	Click on button to add or edit organic manure		
2018	Other crops	35.3	Barley	2-4 maanden	Click on button to add or edit organic manure		
2019	Summer wheat	7.4	Cereal	4 maanden	Click on button to add or edit organic manure		
2020	Sugarbeet	78.2	Common vetch	Enter search text	Click on button to add or edit organic manure		
2021	Starch potato	40.3	English ryegrass	Enter search text	Click on button to add or edit organic manure		
2022	Winter wheat	7.9	Fodder radish	Enter search text	Click on button to add or edit organic manure		
			Grassland	Enter search text	Click on button to add or edit organic manure		

Save

Enter the manure data by clicking on the pencil icon (1), then the types and quantities of organic manure applied (2) and then close this data entry screen (3). Manure should be entered as a total wet weight per hectare (in tonnes). The Annual Nutrient Cycling Assessment (*Kringloopwijzer*) gives the amount of grassland fertiliser in kg N/ha. You can divide this amount by 0.18 for a good estimate of the application of fresh manure per hectare. 1 m³ of slurry is equivalent to 1 tonne in total wet weight.

Period green manure

Organic manure (ton vers/ha)

Enter search text Click on button to add or edit organic manure

Enter search text Click on button to add or edit organic manure

Enter search text Click on button to add or edit organic manure

Enter search text Click on button to add or edit organic manure

Enter search text Click on button to add or edit organic manure

Enter search text Click on button to add or edit organic manure

1

3

Organic manure

Quantity (ton vers/ha)

0

Varkensdrijfmest

Pluimveemest

Compost

Dunne Fractie

Dikke Fractie

Mineralenconcentraat

Digestaat

Compost (8);

2

To enter a common practice in your rotation for one or more crops in one go, click on the 'Common data' button (1), complete the required fields, and click on 'Apply' (2). In the example below, the same manure application and cover crop has been entered for all years in which 'Oats' were grown:

Cropfield 1

Input Default scenario Result

Organic manures

Common data

Green manure Quality Organic manure Quantity (ton vers/ha) Straw withdrawal Crops in standard rotation

Apply

For the years when straw crops (e.g. wheat or barley) were grown (shaded red), you must indicate whether the straw was removed (check the box in the column under the black arrow) or left on the field (do not check the box):

Cropfield 1

Input Default scenario Result

Organic manures

Common data

Area 3.67

Soil Zand

Clay content (%) 6

Organic matter (%) 4.27 measured in year:

Year	Crop	Yield (ton/ha)	Green manure	Period green manure	Organic manure (ton vers/ha)	Straw withdrawal	Crops in standard rotation
2011	Fodder maize	46.6	Enter search text	Enter search text	Click on button to add or edit organic manure	<input checked="" type="checkbox"/>	<input type="checkbox"/>
2012	Starch potato	43.5	Enter search text	Enter search text	Click on button to add or edit organic manure	<input checked="" type="checkbox"/>	<input type="checkbox"/>
2013	Winter wheat	8.9	Enter search text	Enter search text	Click on button to add or edit organic manure	<input checked="" type="checkbox"/>	<input type="checkbox"/>
2014	Sugarbeet	86.3	Enter search text	Enter search text	Click on button to add or edit organic manure	<input checked="" type="checkbox"/>	<input type="checkbox"/>
2015	Rapeseed	3.3	Enter search text	Enter search text	Click on button to add or edit organic manure	<input checked="" type="checkbox"/>	<input type="checkbox"/>
2016	Starch potato	44	Enter search text	Enter search text	Click on button to add or edit organic manure	<input checked="" type="checkbox"/>	<input type="checkbox"/>
2017	Winter wheat	8.7	Enter search text	Enter search text	Click on button to add or edit organic manure	<input checked="" type="checkbox"/>	<input type="checkbox"/>
2018	Other crops	35.3	Enter search text	Enter search text	Click on button to add or edit organic manure	<input checked="" type="checkbox"/>	<input type="checkbox"/>
2019	Summer wheat	7.4	Enter search text	Enter search text	Click on button to add or edit organic manure	<input checked="" type="checkbox"/>	<input type="checkbox"/>
2020	Sugarbeet	78.2	Enter search text	Enter search text	Click on button to add or edit organic manure	<input checked="" type="checkbox"/>	<input type="checkbox"/>
2021	Starch potato	40.3	Enter search text	Enter search text	Click on button to add or edit organic manure	<input checked="" type="checkbox"/>	<input type="checkbox"/>
2022	Winter wheat	7.9	Enter search text	Enter search text	Click on button to add or edit organic manure	<input checked="" type="checkbox"/>	<input type="checkbox"/>

Save

To build a default scenario, you are asked to select the crops in your standard crop rotation plan under the last column, 'Crops in standard rotation'.

Then click on 'Save' to not lose any data.

Cropfield 1

Input Default scenario Result

Organic manures

Common data

Area 3.67

Soil Zand

Clay content (%) 6



Organic matter (%) 4.27 measured in year:

Year	Crop	Yield (ton/ha)	Green manure	Period green manure	Organic manure (ton vers/ha)	Straw withdrawal	Crops in standard rotation
2011	Fodder maize	46.6	Enter search text	Enter search text	Click on button to add or edit organic manure	<input checked="" type="checkbox"/>	<input type="checkbox"/>
2012	Starch potato	43.5	Enter search text	Enter search text	Click on button to add or edit organic manure	<input checked="" type="checkbox"/>	<input type="checkbox"/>
2013	Winter wheat	8.9	Enter search text	Enter search text	Click on button to add or edit organic manure	<input checked="" type="checkbox"/>	<input type="checkbox"/>
2014	Sugarbeet	86.3	Enter search text	Enter search text	Click on button to add or edit organic manure	<input checked="" type="checkbox"/>	<input type="checkbox"/>
2015	Rapeseed	3.3	Enter search text	Enter search text	Click on button to add or edit organic manure	<input checked="" type="checkbox"/>	<input type="checkbox"/>
2016	Starch potato	44	Enter search text	Enter search text	Click on button to add or edit organic manure	<input checked="" type="checkbox"/>	<input type="checkbox"/>
2017	Winter wheat	8.7	Enter search text	Enter search text	Click on button to add or edit organic manure	<input checked="" type="checkbox"/>	<input type="checkbox"/>
2018	Other crops	35.3	Enter search text	Enter search text	Click on button to add or edit organic manure	<input checked="" type="checkbox"/>	<input type="checkbox"/>
2019	Summer wheat	7.4	Enter search text	Enter search text	Click on button to add or edit organic manure	<input checked="" type="checkbox"/>	<input type="checkbox"/>
2020	Sugarbeet	78.2	Enter search text	Enter search text	Click on button to add or edit organic manure	<input checked="" type="checkbox"/>	<input type="checkbox"/>
2021	Starch potato	40.3	Enter search text	Enter search text	Click on button to add or edit organic manure	<input checked="" type="checkbox"/>	<input type="checkbox"/>
2022	Winter wheat	7.9	Enter search text	Enter search text	Click on button to add or edit organic manure	<input checked="" type="checkbox"/>	<input type="checkbox"/>

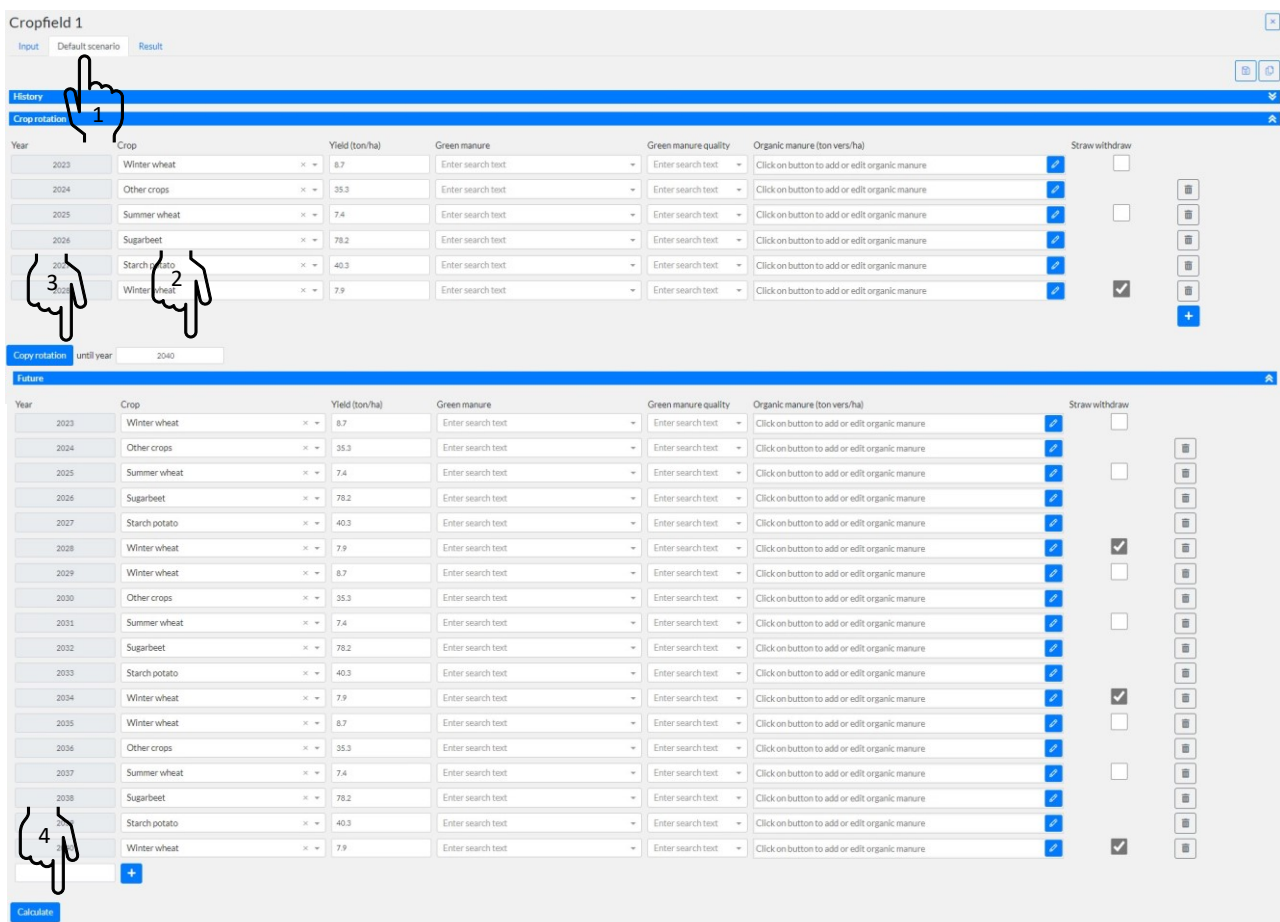
Save

Select the crops that define your default rotation to create a default scenario

3.3 Developing a default scenario

All the data required to calculate the effects of the carbon measures have now been entered. You can now proceed to the second tab called 'Default scenario' (i.e. the standard scenario) at the top of the screen (1). The default scenario is automatically populated with the crops you selected under 'Crops in standard rotation'. If the crops are not listed in the desired order, you can move them by left-clicking on the applicable year and dragging it to the desired position. You can also remove a year ( icon) or add a new year ( icon). Now you can enter the period for calculating this crop rotation (e.g. 10 or 20 years, or 1 or 2 crop rotations) (2). The scenario can be calculated up to the year 2050. Then click on 'Copy rotation' to copy the crop rotation up until the entered year.

The crop rotation will automatically be displayed. Then click on 'Calculate' at the bottom left of the screen (4).



Cropfield 1

Input **Default scenario** Result

History

Crop rotation

Year	Crop	Yield (ton/ha)	Green manure	Green manure quality	Organic manure (ton vers/ha)	Straw withdraw
2023	Winter wheat	8.7	Enter search text	Enter search text	Click on button to add or edit organic manure	<input type="checkbox"/>
2024	Other crops	35.3	Enter search text	Enter search text	Click on button to add or edit organic manure	<input type="checkbox"/>
2025	Summer wheat	7.4	Enter search text	Enter search text	Click on button to add or edit organic manure	<input type="checkbox"/>
2026	Sugarbeet	79.2	Enter search text	Enter search text	Click on button to add or edit organic manure	<input type="checkbox"/>
2027	Starch potato	40.3	Enter search text	Enter search text	Click on button to add or edit organic manure	<input type="checkbox"/>
2028	Winter wheat	7.9	Enter search text	Enter search text	Click on button to add or edit organic manure	<input checked="" type="checkbox"/>

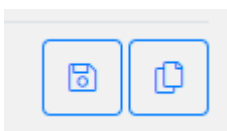
Copy rotation until year: 2040

Future

Year	Crop	Yield (ton/ha)	Green manure	Green manure quality	Organic manure (ton vers/ha)	Straw withdraw
2023	Winter wheat	8.7	Enter search text	Enter search text	Click on button to add or edit organic manure	<input type="checkbox"/>
2024	Other crops	35.3	Enter search text	Enter search text	Click on button to add or edit organic manure	<input type="checkbox"/>
2025	Summer wheat	7.4	Enter search text	Enter search text	Click on button to add or edit organic manure	<input type="checkbox"/>
2026	Sugarbeet	79.2	Enter search text	Enter search text	Click on button to add or edit organic manure	<input type="checkbox"/>
2027	Starch potato	40.3	Enter search text	Enter search text	Click on button to add or edit organic manure	<input type="checkbox"/>
2028	Winter wheat	7.9	Enter search text	Enter search text	Click on button to add or edit organic manure	<input checked="" type="checkbox"/>
2029	Winter wheat	8.7	Enter search text	Enter search text	Click on button to add or edit organic manure	<input type="checkbox"/>
2030	Other crops	35.3	Enter search text	Enter search text	Click on button to add or edit organic manure	<input type="checkbox"/>
2031	Summer wheat	7.4	Enter search text	Enter search text	Click on button to add or edit organic manure	<input type="checkbox"/>
2032	Sugarbeet	79.2	Enter search text	Enter search text	Click on button to add or edit organic manure	<input type="checkbox"/>
2033	Starch potato	40.3	Enter search text	Enter search text	Click on button to add or edit organic manure	<input type="checkbox"/>
2034	Winter wheat	7.9	Enter search text	Enter search text	Click on button to add or edit organic manure	<input checked="" type="checkbox"/>
2035	Winter wheat	8.7	Enter search text	Enter search text	Click on button to add or edit organic manure	<input type="checkbox"/>
2036	Other crops	35.3	Enter search text	Enter search text	Click on button to add or edit organic manure	<input type="checkbox"/>
2037	Summer wheat	7.4	Enter search text	Enter search text	Click on button to add or edit organic manure	<input type="checkbox"/>
2038	Sugarbeet	79.2	Enter search text	Enter search text	Click on button to add or edit organic manure	<input type="checkbox"/>
2039	Starch potato	40.3	Enter search text	Enter search text	Click on button to add or edit organic manure	<input type="checkbox"/>
2040	Winter wheat	7.9	Enter search text	Enter search text	Click on button to add or edit organic manure	<input checked="" type="checkbox"/>

Calculate

In the top right corner you will see 2 icons (see below). The first is the 'Save' icon. The second icon, 'Copy scenario', copies the default scenario so you can use it to populate the alternative scenarios with the standard data.



3.4 Alternative scenarios



The icon at the top right of the screen allows you to copy the default scenario. The alternative scenario is then populated with the standard data from the default scenario and can then be changed to



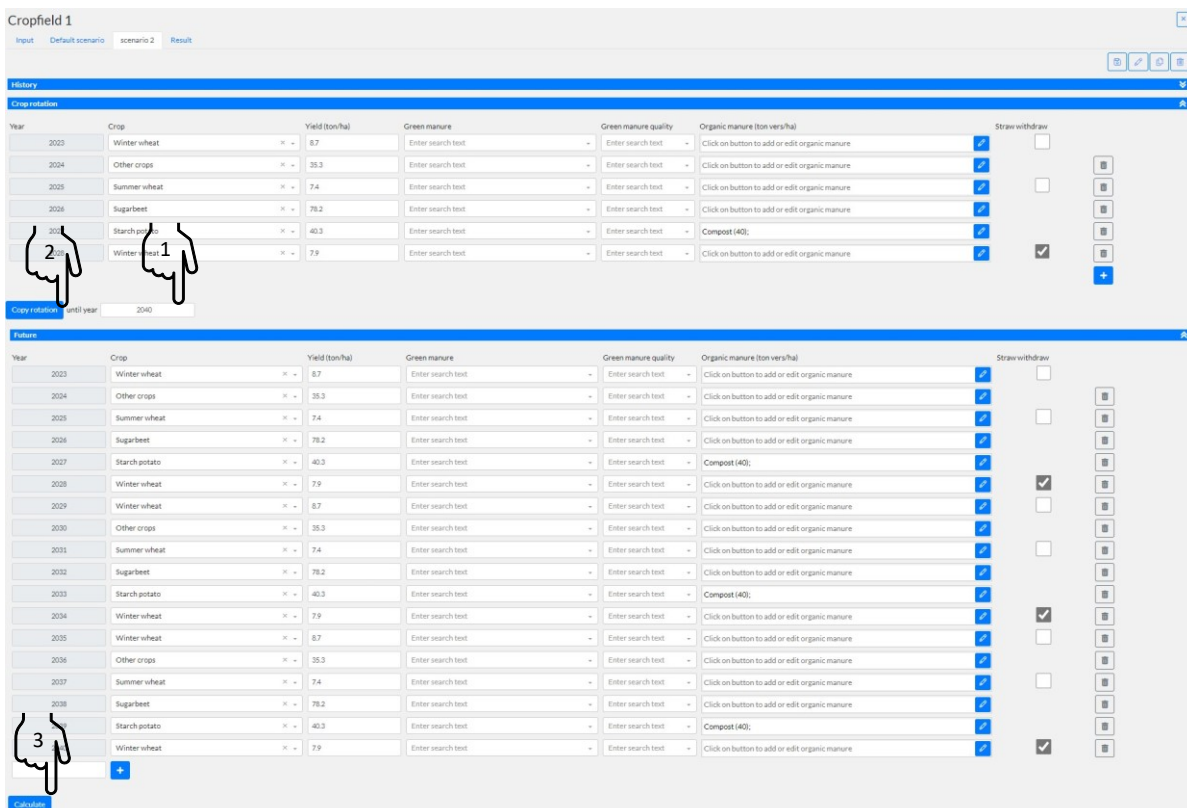
assess the effects of various alternative measures. Up to 5 alternative scenarios can be created. The allows you to give your scenario a different name and you can delete a scenario by clicking on the bin-



button .

For example, you could improve the carbon management plan by including a break crop in the crop rotation plan, by applying extra solid manure or compost, by leaving behind and ploughing under crop residues, by sowing green manure crops after the harvest, and/or by replacing temporary grassland with permanent grassland (Wageningen University & Research and the Louis Bolk Institute recommend 60% permanent grassland, 20% temporary grassland and 20% maize).

In the example below, an alternative scenario is created where compost is added (in addition to slurry) to a 'Starch Potatoes' crop. Again, you enter the period for which you wish to calculate the crop rotation plan (1), then click on 'Copy rotation' (2) and then click on 'Calculate' at the bottom left of the screen (3).



The screenshot shows the 'Cropfield 1' interface with tabs for 'Input', 'Default scenario', 'scenario 2', and 'Result'. The 'History' section is expanded, showing 'Crop rotation' and 'Future' data.

Crop rotation

Year	Crop	Yield (ton/ha)	Green manure	Green manure quality	Organic manure (ton vers/ha)	Straw withdraw
2023	Winter wheat	8.7	Enter search text	Enter search text	Click on button to add or edit organic manure	<input type="checkbox"/>
2024	Other crops	35.3	Enter search text	Enter search text	Click on button to add or edit organic manure	<input type="checkbox"/>
2025	Summer wheat	7.4	Enter search text	Enter search text	Click on button to add or edit organic manure	<input type="checkbox"/>
2026	Sugarbeet	78.2	Enter search text	Enter search text	Click on button to add or edit organic manure	<input type="checkbox"/>
2027	Starch potatoes	40.3	Enter search text	Enter search text	Compost (40)	<input checked="" type="checkbox"/>
2028	Winter wheat	7.9	Enter search text	Enter search text	Click on button to add or edit organic manure	<input type="checkbox"/>

Copy rotation until year: 2040

Future

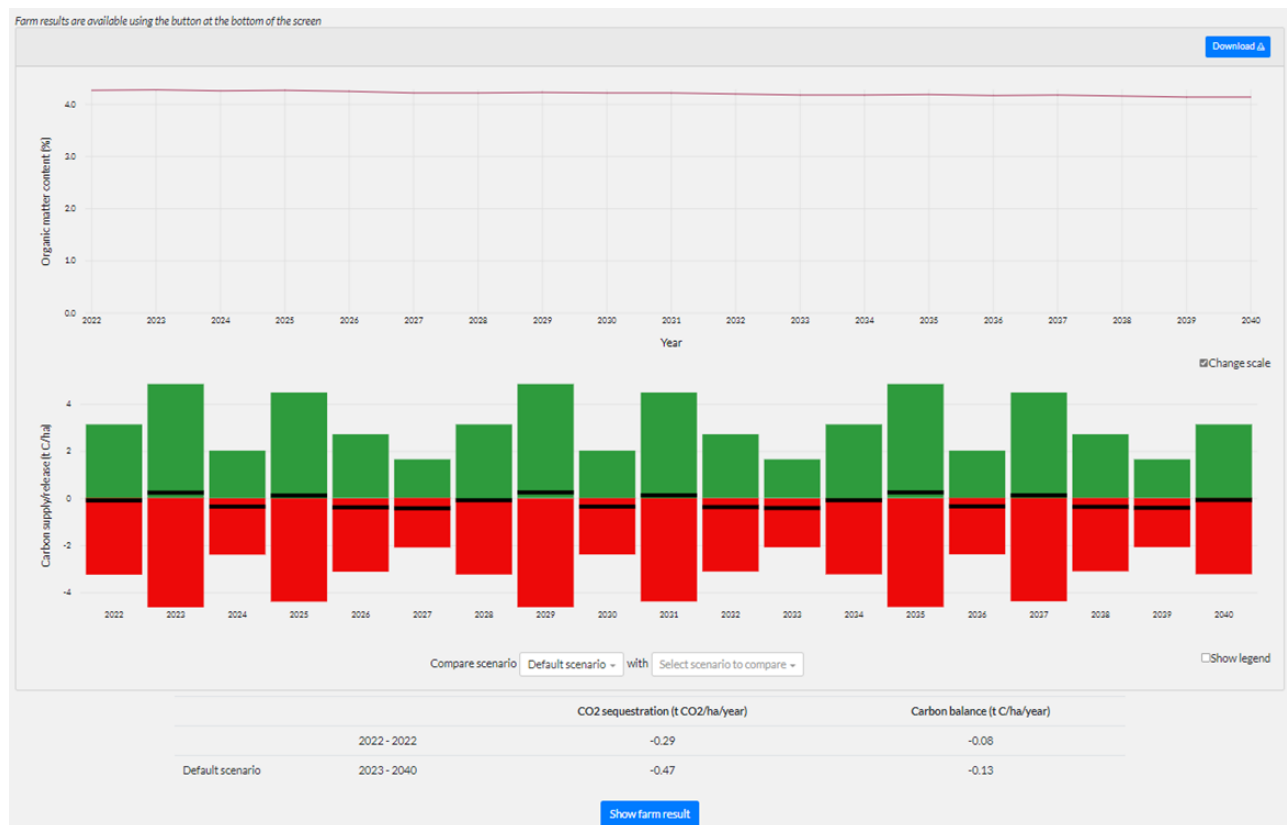
Year	Crop	Yield (ton/ha)	Green manure	Green manure quality	Organic manure (ton vers/ha)	Straw withdraw
2023	Winter wheat	8.7	Enter search text	Enter search text	Click on button to add or edit organic manure	<input type="checkbox"/>
2024	Other crops	35.3	Enter search text	Enter search text	Click on button to add or edit organic manure	<input type="checkbox"/>
2025	Summer wheat	7.4	Enter search text	Enter search text	Click on button to add or edit organic manure	<input type="checkbox"/>
2026	Sugarbeet	78.2	Enter search text	Enter search text	Click on button to add or edit organic manure	<input type="checkbox"/>
2027	Starch potatoes	40.3	Enter search text	Enter search text	Compost (40)	<input checked="" type="checkbox"/>
2028	Winter wheat	7.9	Enter search text	Enter search text	Click on button to add or edit organic manure	<input type="checkbox"/>
2029	Winter wheat	8.7	Enter search text	Enter search text	Click on button to add or edit organic manure	<input type="checkbox"/>
2030	Other crops	35.3	Enter search text	Enter search text	Click on button to add or edit organic manure	<input type="checkbox"/>
2031	Summer wheat	7.4	Enter search text	Enter search text	Click on button to add or edit organic manure	<input type="checkbox"/>
2032	Sugarbeet	78.2	Enter search text	Enter search text	Click on button to add or edit organic manure	<input type="checkbox"/>
2033	Starch potatoes	40.3	Enter search text	Enter search text	Compost (40)	<input checked="" type="checkbox"/>
2034	Winter wheat	7.9	Enter search text	Enter search text	Click on button to add or edit organic manure	<input type="checkbox"/>
2035	Winter wheat	8.7	Enter search text	Enter search text	Click on button to add or edit organic manure	<input type="checkbox"/>
2036	Other crops	35.3	Enter search text	Enter search text	Click on button to add or edit organic manure	<input type="checkbox"/>
2037	Summer wheat	7.4	Enter search text	Enter search text	Click on button to add or edit organic manure	<input type="checkbox"/>
2038	Sugarbeet	78.2	Enter search text	Enter search text	Click on button to add or edit organic manure	<input type="checkbox"/>
2039	Starch potatoes	40.3	Enter search text	Enter search text	Compost (40)	<input checked="" type="checkbox"/>
2040	Winter wheat	7.9	Enter search text	Enter search text	Click on button to add or edit organic manure	<input type="checkbox"/>

Calculate

In addition to comparing various carbon measures, you can also calculate a measure several times for various situations. This way, you can select the most effective measures for your field and farm.

3.5 Results

Click on the 'Results' tab at the top of the screen to see the results of the calculations. The results are displayed in two graphs and a table.



The topmost graph depicts the change in the organic matter content of the topsoil over time. As the changes will often be very small, you can also zoom in on the results by unchecking the 'Change scale' box. If you move your mouse over the line, you will see different values appear.

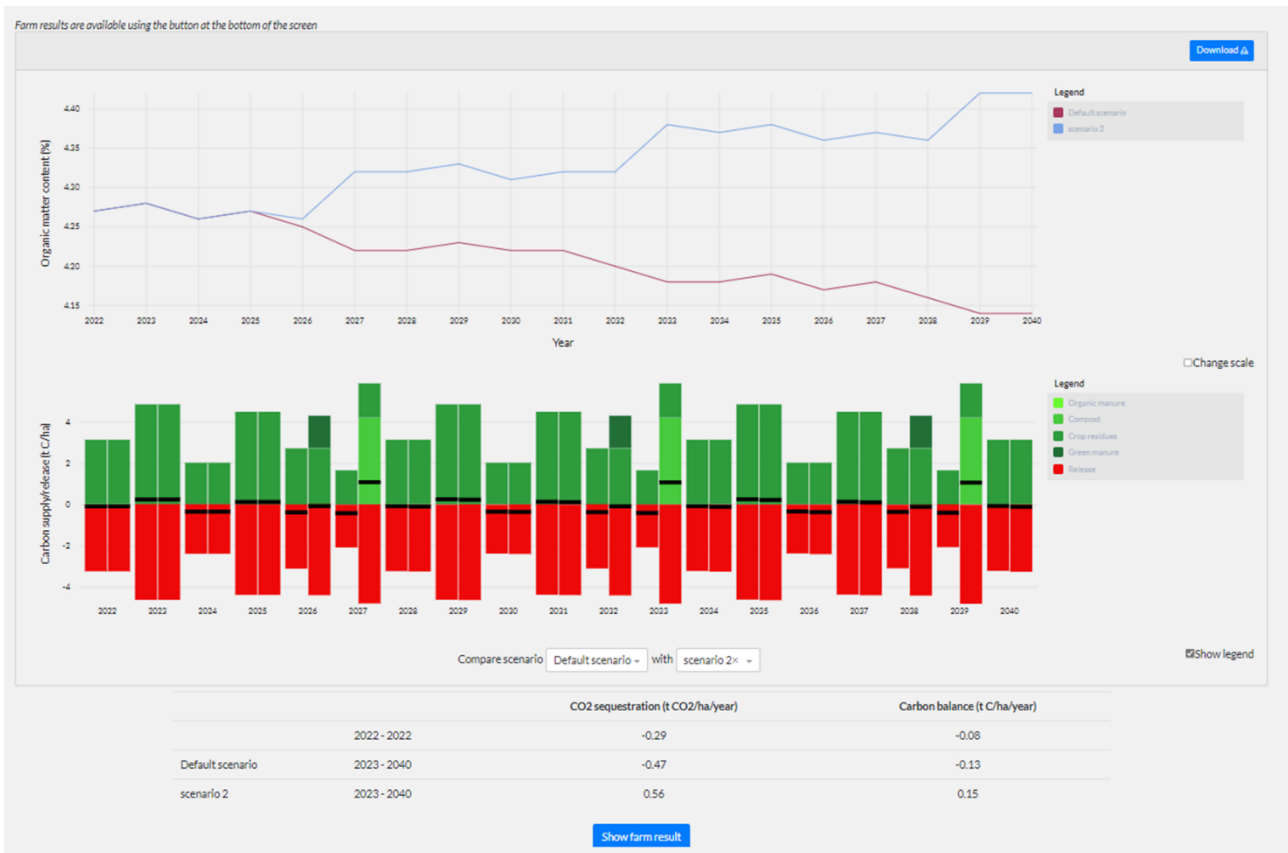
The middle graph displays the sources of carbon in- and output per year. Carbon sequestration is displayed in green and emissions in red. The legend provides more information on the sources of carbon in- and output. The black area is the carbon balance. Move the mouse over the bars to see the relevant crop, the amount of carbon in- or outputs and the carbon balance in each year.

The table at the bottom displays the average carbon sequestration and carbon balance over the previous years and the predictions for the standard scenario and the alternative scenarios.

It is always recommended to strive for a (more) positive carbon balance. A negative carbon balance means that CO₂ is being emitted and not sequestered. The example below displays the results of a standard scenario and an alternative scenario with additional compost. The alternative scenario shows a positive carbon balance.

You can also click on the 'Download' button in the top right corner to download the results. You can save this .CSV file and open it in Excel (open Excel, click on 'Data' in the menu bar and select 'From Text/CSV').

At the bottom of the page is a button called 'Show farm result'. This will take you to the comprehensive results of your farm.

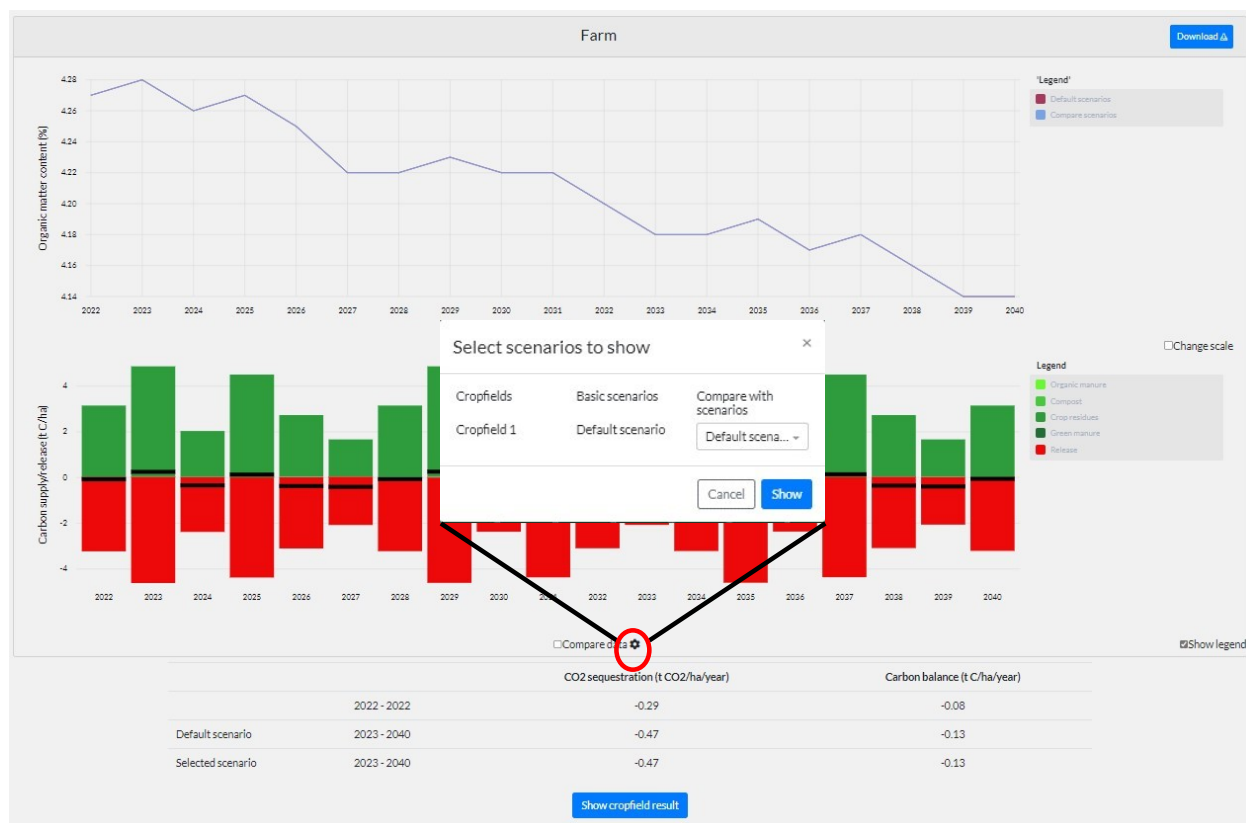


3.6 Farm result

The 'Show farm result' button at the bottom of the screen displays the total result of your farm based on all the fields for which you calculated the carbon balance. (We recommend that you use this button only after you have calculated the carbon balance of all your fields.)

You will see the same graphs and tables as described in section 5, but now at farm level rather than the field level.

If you click on the gear icon at the bottom of the second graph, a pop-up will appear in which you can select the scenarios you want to compare with the standard scenario at the farm level. Then check the box next to 'Compare data' to compare the results of the standard scenario with the results of the alternative scenario.



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Annex A

Conversion tables to calculate the carbon input based on the total wet weight.

Conversion table for crops:

	Dry matter content	Carbon input by crop residues (tonnes C/ha)*	Harvest index*
Strawberries	0.15	2	0.5
Other fruit	0.15	3	1
Other crops	0.7	2	0.5
Other cereal crops	0.85	2	0.46
Other vegetables	0.11	1.23	0.55
Other seed crops	0.85	3	0.5
Apples	0.14	3	1
Leafy vegetables	0.05	0.7	0.56
Bulbs	0.25	1	1
Tree nursery	0.25	2	0.85
Fallow		0	
Ware potatoes	0.24	2	0.69
Corn cob mix	0.8		
Courgettes	0.05	0.7	0.4
Grassland (natural)	1	5.1	0.444
Grassland (permanent)	1	5.1	0.444
Grassland (temporary)	1	3.4	0.444
Grass seed	0.85	3	0.2
Green manure crops	0.25	4	0.3
Oats	0.85		
Brassicas	0.08	2.8	0.47
Lucerne	0.25	2	0.5
Grain maize	0.85		
Pears	0.14	3	1
Legumes	0.85	2	0.69
Pumpkins	0.18	0.7	0.56
Seed potatoes	0.24	2	0.69
Miscanthus	1	5	0.444
Leeks	0.08	0.7	0.6
Rapeseed	0.85		
Rye	0.85	0	0.46
Sugar beet	0.25	3	0.69
Triticale	0.85	2	0.46
Onions	0.25	1	1
Fibre crops	0.85	0	0.92
Fodder beet	0.25	3	0.69
Silage maize	0.35	1.1	0.67
Vineyard	0.15	3	0.7
Willows	1	3	0.85
Winter barley	0.85		
Winter wheat	0.85		
Chicory	0.23	1.4	0.6
Root vegetables	0.1	1.6	0.63
Starch potatoes	0.24	2	0.69
Spring barley	0.85		
Spring wheat	0.85		
Sunflowers	0.85		

* The carbon input by crop residues and the harvest index are calculated for straw crops based on Garcia-Condado (2019), taking into account the crop yield (dry matter content in tonnes/ha):

Harvest index _{maize}	=	0.024 x crop yield _{maize} + 0.228
Harvest index _{corn cob mix}	=	0.024 x crop yield _{corn cob mix} + 0.228
Harvest index _{winter wheat}	=	0.0246 x crop yield _{winter wheat} + 0.3192
Harvest index _{spring wheat}	=	0.0246 x crop yield _{spring wheat} + 0.3192
Harvest index _{winter barley}	=	0.0256 x crop yield _{winter barley} + 0.3727
Harvest index _{spring barley}	=	0.0256 x crop yield _{spring barley} + 0.3727
Harvest index _{rapeseed}	=	0.008 x crop yield _{rapeseed} + 0.3037
Harvest index _{rye}	=	0.0256 x crop yield _{rye} + 0.3727

$$\begin{aligned}\text{Harvest index}_{\text{oats}} &= 0.0256 \times \text{crop yield}_{\text{oats}} + 0.3727 \\ \text{Harvest index}_{\text{sunflowers}} &= 0.0077 \times \text{crop yield}_{\text{sunflowers}} + 0.3045 \\ \text{Harvest index}_{\text{other cereals}} &= 0.0256 \times \text{crop yield}_{\text{other cereals}} + 0.3727\end{aligned}$$

Carbon input (in tonnes of C/ha/year) for green manure and catch crops*:

	Period of crop growth:		
	>4 months	2-4 months	<2 months
African marigolds	2.8	2	1.4
Fodder radish	3.6	2.5	1.8
Perennial ryegrass	3.2	2.2	1.6
Phacelia	0.3	0.2	0.1
White mustard	2.1	1.4	1
Barley	2.6	1.8	1.3
Cereals	2.2	1.5	1.1
Grassland	3.4	2.4	1.7
Oats	2.6	1.8	1.3
Italian ryegrass	3.2	2.2	1.6
Black oats	2.6	1.8	1.3
Mix _{green fallow}	2.8	2	1.4
Mix _{natural fallow}	3	2.1	1.5
Mix _{N crop}	2.8	2	1.4
Mix _{N catch crop}	2.8	2	1.4
Other	2.6	1.8	1.3
Red fescue	3.2	2.2	1.6
Rye	2.5	1.8	1.3
Fodder vetch	1.3	0.9	0.6

*Source: Selin Norén et al. (2021)

Carbon content of organic manures and compost:

Type of manure	Carbon/total wet weight (in tonnes)*
Spent mushroom compost	0.11
Compost	0.11
Digestate	0.02
Thick fraction	0.08
Dairy manure (slurry)	0.04
Thin fraction	0.02
Chicken manure	0.21
Fertiliser replacement	0.01
Other	0.02
Sheep/goat manure	0.09
Pig manure (slurry)	0.04
Dairy manure (solid)	0.08
Pig manure (solid)	0.08
Dairy manure (pasture)	0.04
Sow manure (slurry)	0.01

* Source: *Handboek Bodem en Bemesting* (CBAV, 2017)

Annex B

Growing season of crops to determine in which months the soil is covered with vegetation (indicated with a 1).

	January	February	March	April	May	June	July	August	September	October	November	December
Strawberries				1	1	1	1	1	1	1		
Other fruit	1	1	1	1	1	1	1	1	1	1	1	1
Other crops					1	1	1	1				
Other cereal crops					1	1	1	1				
Other vegetables					1	1	1	1	1	1		
Other seed crops					1	1	1	1				
Apples	1	1	1	1	1	1	1	1	1	1	1	1
Leafy vegetables					1	1	1	1	1			
Bulbs				1	1	1	1	1				
Tree nursery	1	1	1	1	1	1	1	1	1	1	1	1
Fallow												
Ware potatoes					1	1	1	1				
Corn cob mix						1	1	1	1			
Courgettes					1	1	1					
Grassland (natural)	1	1	1	1	1	1	1	1	1	1	1	1
Grassland (permanent)	1	1	1	1	1	1	1	1	1	1	1	1
Grassland (temporary)	1	1	1	1	1	1	1	1	1	1	1	1
Grass seed	1	1	1	1	1	1	1	1	1	1	1	1
Green manure crops	1	1	1						1	1	1	1
Oats					1	1	1	1				
Brassicas						1	1	1	1			
Lucerne	1	1	1	1	1	1	1	1	1	1	1	1
Grain maize						1	1	1	1			
Pears	1	1	1	1	1	1	1	1	1	1	1	1
Legumes					1	1	1					
Pumpkins						1	1	1	1			
Seed potatoes					1	1	1	1				
Miscanthus	1	1	1	1	1	1	1	1	1	1	1	1
Leeks					1	1	1	1	1	1		
Rapeseed	1	1	1	1	1	1	1					1
Rye				1	1	1	1					
Sugar beet						1	1	1	1	1		
Triticale					1	1	1	1				
Onions					1	1	1	1				
Fibres					1	1	1	1				
Fodder beet						1	1	1	1			
Silage maize						1	1	1	1			

	January	February	March	April	May	June	July	August	September	October	November	December
Vineyard	1	1	1	1	1	1	1	1	1	1	1	1
Willows	1	1	1	1	1	1	1	1	1	1	1	1
Winter barley	1	1	1	1	1	1	1					1
Winter wheat	1	1	1	1	1	1	1					1
Chicory					1	1	1	1	1	1		
Root vegetables					1	1	1	1	1			
Starch potatoes					1	1	1	1				
Spring barley					1	1	1	1				
Spring wheat					1	1	1	1				
Sunflowers					1	1	1	1				

