

SOLID DSS Manual

The tool is freely available at: <https://zalf-lse.github.io/solid-dss/>

Technical advice: Best to use the web browser Google Chrome, some other may cause errors!

Introduction

The SOLID DSS is developed as a decision support system (DSS) which help to optimize the management of feed resources and feed supply systems within organic and low input dairy systems in Europe to minimize the risk of feed shortages.

It was developed within the framework of the EU-Project „Sustainable Organic and Low-input Dairying (SOLID)“ at the Leibniz - Centre for Agricultural Landscape Research (ZALF) e. V. in collaboration with the BOKU Wien and the Natural Resources Institute in Finland.

The model will serve both organic and low input farms as long as they depend mainly on on-farm produced forages. Restrictions concerning external feeds for organic farms resulting from the EU directives can be considered in the DSS.

Because of necessary simplifications (limited crop spectrum, only one mean soil type per farm, limited to not groundwater influenced soils, simplified cutting and grazing regime, no grazing for dry cows) and limitations of the model outputs of non-site-specific calibrated plant-soil simulation models in absolute terms could only be used restrictedly under real farm conditions.

Nevertheless the SOLID-DSS provides a deeper understanding of the complex relationships and dependencies of sustainable organic and low input dairy systems. And thus it is well suited for agricultural extension, training and teaching.

On basis of integrated European wide weather data base (1997 -2007) annual site- and farm-specific yield calculations of arable forage crops and permanent grassland forage yields for conservation and grazing can be assessed. This helps to provide a risk assessment of potential annual forage shortages within the above mentioned decade.

The SOLID DSS is structured around two main models:

1. Crop and Grassland Model within the SOLID-DSS (Crop.js) based on:

- The crop and crop rotation model is based on MONICA (<http://monica.agrosystem-models.com/>)
- The grassland model is based on the Sustainable Grazing Systems SGS Pasture Model (<http://imj.com.au/sgs/>)

It allows for a site and annual weather specific yield calculation of crops within three to five year crop rotations and of permanent grassland (harvested and grassed) using a European wide weather data base implemented in the DSS.

2. Dairy model (dairy.js)

It is built as an open-source JavaScript library built to simulate dairy cows and young stock, their growth, requirements and diets¹. The implemented modules allow for simulating:

- herd structure
- milk yield and solids
- energy and protein requirements (expressed in different European systems)

- feed evaluation (expressed in different European systems) ²
- dry matter intake (fill value based)
- growth and mobilization
- cow grouping
- diets

¹ Vaillant, J. and Baldinger, L. (2016). Application note: An open-source JavaScript library to simulate dairy cows and young stock, their growth, requirements and diets. *Computers and Electronics in Agriculture*, 120, 7–9

² Baldinger, L., J. Vaillant, W. Zollitsch and M. Rinne (2015). Making a decision-support system for dairy farmers usable throughout Europe: the challenge of feed evaluation. *Advances in Animal Biosciences*, 6, pp 3-5

The following guideline should help you using the DSS

At most icons, input boxes and graphs some additional information or data are provided by popup windows when moving the cursor over!

Location and Weather

Soil

Choose the mean soil texture of your farm.

For both arable and permanent grassland crop growth models the same chosen soil type is used. The water availability within the rooting depth is calculated without and ground water influence.

Map

If you click on your location at the European map which can be increased or decreased with + - the corresponding weather data will be provided by the implemented data base of daily weather data from 1996 to 2011 all over. It is based on the open source data base developed by the EU project ECA&D (<http://www.ecad.eu/>).

Choose the location of your farm on the map and with the pop-up window “weather data available”, weather data exist in this area.

Simulation settings

The period of the multi-year modelling is fixed through the length of the crop rotation. The first year of available weather data is 1996 and the last is 2011. Because the crop growth models need one year in advance, the earliest start year which can be chosen is 1997 and the last is set to 2007 to allow for a maximal five year crop rotation.

To save settings use  bottom at the headline. They will be saved in the download folder of your PC where you can rename it and reload it in your next session via .

Dairy Herd

Cow

For mean milk yields lower than 6500 kg per cow no standard lactation curve (Wood lactation curve) was found in the literature. Therefore if the milk yield of your herd is lower than 6500 kg please delete the default date in the box 'Milk yield data' and insert mean weekly milk yield data from your milk recording. Your data will be fitted to a Wood lactation curve (using a Levenberg–Marquardt least-squares minimization module) and plotted in the figure 'Milk yield' at the section 'Input summary'.

Herd

To calculate the age structure of the herd, the structure of parities, depending on the chosen calving interval, the young stock culled and the lactation replacement rate is calculated with a simple deterministic approach.

The simulation is initialized with an arbitrary distribution and loops over time with a monthly increment until parity distribution is stable and target herd size has been reached. This stable herd is used for the diet calculation. The calving pattern is fixed as continuous.

Ration

Evaluation system

At Evaluation system you can choose between the German NEL, the Finnish ME, the French UFL and the British ME. For diet calculating the selected system will be used within the diet optimization.

The protein calculations for all evaluation systems are based on the German protein system.

Ruminal nitrogen balance upper and lower bound

If you answer 50 you accept some overfeeding of nitrogen. Sometimes this is necessary if all feeds available contain more N than the cows would actually need. If you choose 0, in that case the DSS will find no solution.

Purchased or Produced Supplementary Feedstuff

For closing the pop-up menu of a chosen feedstuff (produced at the farm or purchased) click on the name of the feedstuff. Insert the annual available amount.

The default values of feed quality parameters can be changed.

Supplementary Feedstuff can be added and defined at 'Custom concentrate' or through changing the default values of an unused feedstuff.

Crop and Forage Production

Total arable area

Insert the total area of arable land of the farm

Total permanent grassland area

Insert the total area of permanent grassland of the farm

Permanent grassland legume share

Give a rough estimation of legume portion of legumes (mainly clover) within your permanent grassland. It needed for the model internal calculation of the nitrogen fixation and the grassland growth.

Grassland cut threshold (for both arable and permanent grassland)

There you define the minimum DM yield for a single cut. To make sure that the last cut will be harvested we recommend not using threshold values lower than 2000 kg DM/ha. The Threshold value doesn't interact with the grassland yield.

Grassland hay share (for both arable and permanent grassland)

Insert the portion harvested as hay after the first cut.

The first cut of all grassland swards is set to be harvested as silage.

Seasonal harvesting of green fodder from grassland has to be excluded to reduce complicity of the diet optimization.

The second up to the fourth cut are summarized as grass silage-late or hay at the Result area.

Yearly nitrogen input on permanent grassland

Insert the annual nitrogen fertilizer input (mineral and organic)

Crop rotation

In this window up to five-year rotations divided into max. two sub rotations starting with the same crop can be selected using the outlined crops. Wheat, barley and rye are winter crops. Crop failure caused by frost damages are excluded within the crop model.

To allow for annual yield calculations of each crop within the rotation, annually staggered permutations of the crop rotation are calculated within the crop model.

- 1. For removing crops click on the x within the crop boxes*
- 2. Drag and drop new crops from the head area into the rotation window starting with the first crop on the left. It will be replicated automatically at the right to allow for closing the rotational cycle.
!!! Grass-legume cannot be selected as first crop!!!*
- 3. Interlink the crops within the rotation through drag and drop between left to right red bottom*
- 4. For entering the fertilization and irrigation click on the crop within the selected crop rotation. The selected crop is colored in darker grey and displayed in the window below. Insert the annual nitrogen fertilizer input for the selected crop and activate or deactivate irrigation. For solid or liquid manure insert the amount of available N kg/ha (solid; 20-25 %, liquid; 35-50 % of the total nitrogen applied)*

Advanced model settings

These settings of crop specific temperature sums for different crop stages would allow for experts to adapt the crop model for cultivars of different maturity groups. Currently values for silage maize of early, medium or last maturity groups are provided from the EU project MACSUR.

Silage maize maturity group	Early	Middle	Late
growth stage	accumulated temperature (°C)		
Emergence to shooting	240	284	284
Shooting to tasseling	150	170	190
tasseling to flowering	190	210	250
Flowering to corn filling	140	160	200
corn filling	230	300	400

Pasture

Pasture share indicates the percentage of permanent grassland used as pasture

Different pasture systems couldn't be implemented because of capacity limits of the optimization module

Input Summary:

Milk yield data

By moving the cursor over any of the input summary and the output graphs you will get the corresponding figures within a popup table. The selected value of the X axis is indicated by a vertical black line.

Results:

Progress

Resultcharts of the calculation for the rations can only be displayed when no more error messages appear.

Yields arable

In the selection window you can choose the different sub crop rotations and the annual yield results will be shown in the graph.

Water-/ nitrogen deficits and irrigation on arable land

Seasonal nitrogen and water deficits are displayed using a qualitative stress index averaged over every 10 days. Additional water supply through irrigation is indicated with green bars if activated at the crop rotation section.

Yields permanent grassland

Dry matter intake from pasture

This graph shows the temporal dry matter intake averaged over all groups limited by the seasonal regrowth rate of the pasture for the different years and the selected time at pasture.

Diets

Total mixed rations (including grazing) are calculated with a linear program for an average cow per group in fortnightly or monthly time steps. Diets are optimized so that the total sum of relative (to the cow's requirements) violations (nutrients in diet / nutrients required) is minimized (nutrients covered are energy and protein) subject to the following constraints:

- *feed intake equals intake capacity,*
- *the Ruminant Nitrogen Balance (RNB) of the diet is within or equals the upper and lower bound of the RNB*
- *concentrate dry matter in diet is below or equals the maximum (chosen in settings).*

Group 1,2,3

Each cow within the modelled herd is allocated to the different selected groups depending on its age, its parity and lactation stage.

Group Dry

For the grazing module the simplification was needed to exclude dry cows from grazing.

Feedstuff surplus

This graph shows the annual surplus of selected supplementary feedstuffs and of the different conserved forages produced in the previous year.

Beside the optimization failure message for different years which indicates critical annual forage shortages this graph helps to provide a risk assessment of potential annual forage shortages within the above mentioned decade. Therefore different model runs have to be executed by changing the start year at the simulation settings.