Farming Practices

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1. Description of Farming Practices

Farming practices are performed with the purpose of producing agricultural crops. In general, these involve field preparation, planting, field operations and harvesting, as well as other particular cultivation methods depending on the region or the crop.

2. Field preparation

A good field preparation is important for the development of the planted crop. The aim is to provide the necessary soil conditions for the establishment of young offshoots, adapted to the type of crop, climate and soil (Klein & Zaid Date, 2002).

Tillage is a method that can be used for field preparation, in order to break up and rearrange the topsoil structure to be suitable for the germination of cereal crops, as well as for weed control and incorporation of nutrients from crop residues. It consists of mechanical agitation, requiring working inputs, such as labor, tractors, or draft animals, and the respective equipment for the intended task. In the AgBalance® Model, tillage is related to fuel consumption, and soil erosion rates. Depending on the level of soil disturbance (FAO, 2003), the AgBalance® Model considers three types of tillage systems:

- Conventional tillage comprises tillage practices which entirely rearrange the topsoil by turning and breaking up the soil. Usually, more than one pass is required.
- Minimum tillage refers to one tillage operation to break up the entire soil surface, which is simultaneously performed with planting in one pass.
- No tillage consists of a one pass operation in combination with planting as well, except that only parts of the soil surface are disturbed.

3. Planting

In general, it consists of planting seeds, seedlings, cuttings or other reproductive materials in the soil to grow crops and establish plantations of permanent crops. This process follows the field preparation and can be performed manually or mechanically with tractors or draft animals. Farmers can acquire seeds from merchants or save their own seeds. Also, seeds may be treated before being planted to be protected from pests and diseases during the establishment of the crop (International Seed Federation, 2009).

Green manure or cover crops are plants that are grown to provide soil cover and improve the physical, chemical, and biological properties of soil. In some regions, sowing of green manure or cover crops is a common practice. They may be sown independently to prepare the soil; between harvest and planting of commercial crops to improve the soil properties; or together with the main crop as a ground cover (Food and Agriculture Organization of the United Nations, 2019) (Florentín, Peñalva, Calegari, & Derpsch, 2011). In the first case, they are either incorporated in the soil with tillage methods before they die off or left on the soil surface. If they are planted simultaneously with the main crop, they are usually left on the soil. Generally, cover crops are not harvested (Florentín, Peñalva, Calegari, & Derpsch, 2011).

4. Field operations

It refers to all activities performed on the field to support the crop growth, that is, between planting and harvesting of the crop. These operations are often repeated during the growing season.

- Irrigation, to supply water for plant growth and simultaneously transport essential nutrients. The distribution of water in irrigation systems can be through pressurized mechanisms such as pumps, by gravity flow with an overland flow regime, or through drainage flow to raise groundwater level and reach the crops' roots (Walker, 1989). Water and energy requirements for irrigation will vary, depending on the irrigation system, local conditions and the crop being grown.
- Fertilization, to supplement nutrients and improve their availability for better plant growth. It consists of the application of mineral and/or organic fertilizers to the soil as inputs of the cultivation system (Roy, Finck, Blair, & Tandon, 2006). The task can be performed manually or with different machinery equipment, depending on the fertilizer form e.g. liquid or solid.
- Crop protection, to control pest populations and diseases. It involves the application of crop protection agents and other management practices (e.g. manual or mechanical removal of weeds), to reduce losses in amount and quality of crop yield caused by harmful organisms, such as insects, weeds or pathogens (FAO and ITPS, 2017). Usually, a solution consisting of water and the crop protection product is applied to the field with special equipment.

5. Particular cultivation methods

Other specific farming practices for land cultivation are available in the model, which can be used if relevant in the goal and scope of the sustainability analysis. Not all cultivation systems involve these farming practices, as they may be performed only in certain cases, when biomass is burnt on the field, or for specific crops, for example flooding of paddy rice fields.

- Biomass combustion

In some regions, the combustion of biomass on-field (e.g. fire clearing, slash and burn, burning of harvesting residues) is a common practice. This practice leads to air emissions.

- Flooding for cultivation of rice

Flooding is a typical farming practice when it comes to paddy rice cultivation. “The main reason for flooding the rice fields is that most rice varieties maintain better growth and produce higher yields when grown in flooded soils, than when grown in dry soils. The water layer also helps to suppress the weeds.” (FAO, 1989). However, flooding regimes lead to air emissions.

6. Harvesting

Harvest consists of gathering the useful part or parts of the plant (product and by-product), once they have reached the appropriate maturity for further processing (de Lucia & Assennato, 1994). The task can be performed manually or with machinery. Depending on the crop, harvesting may be performed in one or two consecutive days, or it may take place for several days within a time interval. For example, a combine harvester[1] harvests one hectare of cereal crop in less than one day, while the harvesting process for fruits grown on trees usually takes more than one day to be completed, since the ripening time of the fruits is variable, and the fruits are manually picked.

7. Tractor

The Tractor belongs to the most commonly used agricultural machinery when performing farming practices. In the AgBalance® Model, the dataset “AgBalance Tractor” is used to model the fuel consumption of a tractor during farming practices. Here, the amount and the type of fuel, e.g. diesel or biodiesel (based on rape seed methyl ester) can be entered. In the case of diesel, a dataset covering the production of diesel available at the filling station is automatically selected for the corresponding region, whereas LPG, biodiesel and gasoline cannot be regionalized in the model. In the AgBalance® Model the fuel consumption by the tractor can be either manually entered or calculated using “fuel estimator” according to the number of field operations performed during farming practices. In terms of transportation of inputs using tractors, the transportation of organic fertilizers from farm to the field is additionally modeled in the AgBalance® Model[2]. In this case, the fuel consumption is automatically calculated when distance and transported load is inserted into the model, based on the publication from (Brökeland, 2000).

The production of lubricants used in engines are also considered, based on a fixed ratio of 1% of the total amount of fuel used in the tractor (Kuratorium für Technik und Bauwesen in der Landwirtschaft e.V., 2012).

The modelling of processes involving significant fuel and electricity consumption within the AgBalance® Model are described in detail below.

[1] A combine harvester is an equipment used for harvesting of grain cereals, which simultaneously cuts, threshes and winnows the crop in one pass (de Lucia & Assennato, 1994)

[2] The transportation of organic fertilizers is considered in the AgBalance® Model, since it usually involves the transportation of significant loads. Together with an increasing distance between farm and field, this can have a strong influence in the economic and environmental LCIA results of the sustainability analysis.

6.1 Fuel consumption of farming practices:

The total amount of fuel used for field operations during farming practices must be entered into the model. If primary data on the amount of energy consumed on the field is not available, a fuel estimator is implemented in the model based on information from the Colorado State University (Downs & Hansen, 1996). The estimator calculates the total consumption of diesel, gasoline or LPG based on the frequency of the tasks for field preparation and operations (plowing, fertilizing, mowing, harvesting etc.), which are entered by the user. The effect of soil conditions on the energy demand of the tractor can be selected between normal, high and low conditions resulting in a 20% higher or lower fuel consumption, respectively.

6.2 Fuel consumption of transportation of inputs

In general, all inputs must be transported from the production site to the farm. However, most of these transportation processes can be neglected for light loads (e.g. transportation of crop protection agents). For that reason, only the transportation of following inputs is modeled using default values in the AgBalance® Model:

- Transportation of organic fertilizers from farm to the field (default 3 km)

If organic fertilizer is used for fertilization, the AgBalance Tractor dataset is used to model its transportation between farm and field. The total amount of organic fertilizer to be transported is taken as the sum of the organic fertilizer input flows in tons. Based on this and the distance (in kilometer) between farm and field, the diesel consumed by the AgBalance Tractor is automatically calculated in the AgBalance® Model according to (Brökeland, 2000). The default distance of 3km can be adjusted if primary data is available. The distance should be set to zero if the process is not applicable for the sustainability analysis (e.g. organic fertilizer is not applied or the distance between farm and field is less than 3km).

- Mineral fertilizers and seeds from their production site to the farm (500 km)

The default value of transportation distances assumed for the mineral fertilizer and seeds can be changed if these are known for the selected sustainability analysis. The processes use a diesel driven truck dataset. The transportation of mineral fertilizers and seeds from farm to field is neglected, since the load is significantly lighter compared to organic fertilizers.

- Fuel transportation from filling station to the farm (10 km).

This default value used for fuel transportation distance can be changed if it is known for the selected sustainability analysis. The process uses a diesel driven truck dataset.

8. Draft animals

In some regions, field work is done using buffalos, horses or oxen instead of tractors. In this case, the energy intake requirements of the animals for draft power to perform field work is calculated in the AgBalance® Model. This is of special relevance for the calculations of emissions from manure excretion and enteric fermentation of the animal. Therefore, the weight of the animal and the number of hours it spends on field work per hectare are required as input data. By default, the energy requirement for animal husbandry is not included in the analysis, but it can be considered by entering the additional number of working hours for the animal husbandry. However, emissions occurring in the animal husbandry and manure management are not included in the model. For reasons of simplicity, the feed and water provision for the animal is excluded from the model.

9. Bibliography

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