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Acta fytotechn. zootechn., 18, 2015(Special Issue): 56-58

Short Communication

doi:http://dx.doi.org/10.15414/afz.2015.18.si.56-58

Greenhouse gases emissions from selected crops growing within organic farming

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As part of the study, growing of selected crops (strawberries, garlic, carrot) in conventional and organic farming systems in the Czech Republic was evaluated. For evaluation, the simplified LCA analysis was used. It is focused on the production of greenhouse gases expressed in the carbon dioxide equivalent (CO_2e) per one unit of production. Emissions were calculated for agricultural phases – agricultural technology, fertilizers, pesticides and field emissions – using the IPCC methodology. There are evident differences in subprocesses and in the total emission load between conventional and organic farming systems. With strawberry growing, the GHG emission production is higher within the organic farming system due to low yields. With carrot and garlic growing, the organic farming system is more environmental friendly in terms of GHG emissions.

Keywords: organic farming, GHG emissions, plant production, LCA

1 Introduction

During the twentieth century, the population grew from 1.6 billion to 6.1 billion (Lutz et al., 2013). This brings the increasing consumption of natural resources and agricultural products (Foley et al., 2011). Berner and Berner (2012) assume that human activities have also their share of the climate change. Just the anthropogenic share of changes, especially in terms of GHG (Greenhouse gases) emission production, may be regulated while this activity is one of the priorities of sustainability. Svendsen (2011) states that, within the European Union, the largest polluters are energetics, which releases 27.8 % of anthropogenic greenhouse gas emissions, transport with 19.5 % and industry with 12.7 %. Agriculture is with 9.2 % in fourth place. In the Czech Republic, the share of agricultural emissions in total greenhouse gas emissions is calculated at 6.4 % (Miňovský et al., 2013). One of the goals of sustainable agriculture should therefore be limiting GHG emissions.

2 Material and Methods

To compare the production of GHG emissions in conventional and organic farming, the simplified LCA analysis was used. In the first phase of the analysis, a system boundary was set, as a functional unit, one kg of the final product (strawberries, garlic, carrot) was given and data quality geographically corresponds primarily to the Czech Republic. The analysis is supplemented by data from the Ecoinvent database representing data for Central Europe, in terms of time, primary data corresponds to the period 2011–2014, secondary data 2000–2014. From a technological point of view, it concerns the use of average technologies. Strawberries and garlic were selected as typical representatives of imported crops, carrots are the most commonly grown vegetable within the organic farming system.
In the second phase of the analysis, all energy, matter and material inputs, outputs and flows in the system were defined. For these flows, primary data was acquired through personal

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interviews with farmers, acquired data was supplemented by secondary data from expert appraisals, literature and available databases.

Data for calculation of emission load differences in conventional and organic farming systems includes agricultural processes used for growing of selected crops in both farming systems. Agriculture was defined by that of inputs and outputs related to one hectare (fuel consumption, pesticides, fertilizers / yield per hectare).

Production of seed/seedlings is outside the scope of the calculation of emission load and is not included in the calculation. Into the process of agriculture, N_2O emissions after application of nitrogen fertilizers calculated according to the IPPC methodology were included (De Klein, 2006). Emissions of involved greenhouse gases are expressed in relation to their effect on climate changes by an equivalent CO_2e (CO_2e = 1x CO_2 + 23 x CH_4 + 298 x N_2O).

3 Results

A basic emission load resulting from agriculture involves the calculation of greenhouse gases in the field phase. When comparing the production of GHG within cultivation of selected crops in conventional and organic farming systems, the total GHG emissions expressed as CO_2e were observed. This sum was divided into subgroups – agricultural engineering, fertilizers, pesticides, field emissions and other inputs (only with carrot growing). The conventional farming system differs from the organic one in the total CO_2e emissions production as well as in the production within subgroups.

The impact of the organic system on the mitigation is usually measured per unit area. However, it is important to convert it also to the production unit because of the objectivity. Greenhouse gas emissions are usually lower in organic systems per unit area but also per unit of production. However, environmental savings per unit area are due to lower yields within organic farming roughly double as compared with the calculation per unit of production (Knudsen, 2010). Within the monitored group of crops, the total emission load per one hectare with strawberries, garlic and carrots is higher within conventional framing. However, after conversion to the production unit, the emission load of strawberry growing in the organic farming system is higher due to a low yield (0.718 kg CO_2e as compared with 0.654 kg CO_2e per one kilogram of strawberries in the conventional farming system). In some cases, the negative effect is also stated by Mondelaers et al. (2009), it can be assumed that with increasing yield of strawberries, the emission load will be the same, respectively, there will be a positive effect of organic farming. With garlic and carrots, greenhouse gas emissions remain lower even when calculated per unit area – 0.248 kg CO_2e per kg of garlic in the organic and 0.431 kg CO_2e / kg of garlic in the conventional farming system and 0.042 kg CO_2e per kg of carrots in the conventional and 0.098 kg CO_2e per kg carrots in the conventional farming system. Differences in emission load are affected by other factors, especially lower yield and specific agricultural rules of organic farming that is stated also by Wood et al. (2006).

The fundamental difference between the conventional and organic farming system in terms of GHG emissions is obvious within fertilization. While organic farming uses organic fertilizers (especially manure or slurry), the use of synthetic fertilizers within the conventional farming system increases significantly the share of emissions. This is confirmed also by Gasol et al. (2007) who states that this share of emission load from fertilization to the total emission load is 40-50 % for rape growing or De Backer et al. (2009) who found that when growing leeks in the organic farming system, by 66.39 % emissions per kilogram of product less than in the conventional farming system was produced, while the majority of the load (87 %) in the conventional farming system comes from the use of synthetic fertilizers. We can assume that the extensification of agrochemical use can be a tool for mitigation of greenhouse gas emissions. It is also one of the principles of organic farming that contributes to the emission load reduction.

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Table 1 CO_2e emissions from selected crop growing in organic and conventional farming system (kg of CO_2e per kg of product)

Crop	Strawberries		Garlic		Carrot	
Farming system	Organic	Conv.	Organic	Conv.	Organic	Conv.
Agrotechnical operations	0.056	0.041	0.200	0.125	0.016	0.017
Fertilizers	0.116	0.240	0.010	0.184	0.007	0.039
Pesticides	0.000	0.018	0.000	0.004	0.000	0.001
Field emissions	0.404	0.271	0.038	0.118	0.019	0.041
Other inputs	0.142	0.084	0.000	0.000	0.000	0.000
In total	0.718	0.654	0.248	0.431	0.042	0.098

4 Conclusions

The need to reduce greenhouse gas emissions touches virtually all anthropogenic activities, including agriculture. In addition to savings in post and pre-farm stage which can be achieved eg. by reducing transport and encouraging regional production or using fresh and seasonal products, it is important to explore the scope for mitigation of greenhouse gas emissions in actual farm stage. As it is apparent from the results, organic farming systems are a suitable tool for this purpose in growing a number of crops.

5 Acknowledgements

Supported by the University Of South Bohemia grant GAJU 063/2013/Z.

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