PRODUCTION OF GREENHOUSE GASES WITHIN CULTIVATION OF GARLIC IN CONVENTIONAL AND ORGANIC FARMING SYSTEM

Jan MOUDRÝ jr.[1], Zuzana JELÍNKOVÁ[1], Jan MOUDRÝ [1], Marek KOPECKÝ[1], Jaroslav BERNAS[1]

e-mail: jmoudry@zf.jcu.cz

Abstract

Agriculture and related processes significantly contribute to the production of anthropogenic emissions. Considering the increasing pressure on the environment and an expected expansion of agricultural habitats and intensification of their cultivation, it is important to look for ways to reduce the environmental load, including also the reduction of greenhouse gases emissions. This reduction can be achieved, inter alia, by the proper choice of farming system and by reduction of some processes, especially transport and processing of agricultural commodities. Within the study, garlic growing within the conventional and organic farming system was evaluated. Garlic has been traditionally grown crop in the Czech Republic and now it is massively replaced by imported production from Spain and China. For evaluation, the simplified LCA analysis was used. This is focused on the production of greenhouse gases expressed in the carbon dioxide equivalent (CO2e). Emissions were calculated for agricultural phases - agricultural technology, fertilizers, pesticides and field emissions - using the IPCC methodology. Between conventional and organic farming systems, there are apparent differences in particular processes, where e.g. within the agrotechnical phase, there is a higher load within the organic farming system (0.19972 kg CO2e/kg of garlic as compared with 0.1251 kg CO2e/kg of garlic within the conventional farming system), which is due to different yields and a higher agrotechnical demand of the organic farming system. Conventional farming releases more CO_{2e} within fertilization, pesticide use and filed emissions. The overall results show that, after conversion to one kg of garlic production, organic farming is by 42.39% more environmentally friendly as compared with the conventional one in terms of GHG emissions production.

Key words: greenhouse gases emissions, farming systems, garlic

Climate changes and the anthropogenic share have still been a current topic. Increasing carbon dioxide emissions into the atmosphere are casually associated with the global warming and with global climate changes (Pretel, 2012). Agriculture contributes to the worldwide emissions production with the share of 10-12% (Friel et al., 2009), while until 2030, we can expect an increase of even half these values (Smith et al., 2007). In the Czech Republic, the total share of agricultural emission of the total GHG production is 6.42% (Minovsky et al., 2013). According to Cole et al. (1997), agriculture contributes to the increase of annual emissions by about one-fifth, similarly, Cerri et al. (2009) states 27%. Due to the population growing and subsequently increasing need for food production, it is necessary to look for possibilities of reduction of GHG by modifying a farming system as well. Environmentally friendly systems include also organic and integrated farming. Küstermann and Hülsbergen (2008), state that organic systems produce less N_2O and CO_2 emissions, generally due to lower inputs. A similar conclusion had been previously reached also by Haas et al. (1995), as well as Bos et al. (2007). The reduction of emissions due to selection of the organic farming system can be proved with a number of crops. Besides savings due to the farming system, it is possible to reduce emissions by eliminating some subsequent processes, such as transport. Because of globalization, a number of original and previously grown crops are imported. Under conditions of the Czech Republic, it is for example garlic. Therefore, it is possible to intensify the reduction of anthropogenic emission from agriculture by preference of regional and organic production (Moudrý jr. et al. 2013). To calculate emissions savings, the LCA analysis can be used. LCA is a transparent scientific tool (Weinzettel, 2008) which evaluates the environmental impact on the basis of inputs and outputs within the production system (Greadel and Allenby, 2003). The environmental impact includes also an evaluation of GHG emissions from monitored processes. Therefore, it is possible to find most problematic processes and to suggest

[1] University of South Bohemia in Č. Budějovice, Faculty of Agriculture, Studentská 13, České Budějovice, CZ 370 05

their modifications, respectively to recommend the change of a farming system.

MATERIAL AND METHOD

To compare the production of greenhouse gases 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 (garlic) 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 - 2013, secondary data 2000 - 2013. From a technological point of view, it concerns the use of average technologies.

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 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 garlic 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 CO2e (CO2e = 1x CO2 + 23x CH4 + 298x N2O).

Table 1

Monitored processes within conventional and organic farming systems

Process	Organic	Conventional	Process	Organic	Conventional
Fallow		X	Disking	X	
Tillage	X	X	Cleaning	X	X
Fertilizers application	X	X	Drying	X	X
Smoothing	X		Nitrogen fertilizer		X
Rolling	X		Potash fertilizer		X
Furrowing	X		Phosphatic fertilizer		X
Planting	X	X	Organic fertilizer	X	
Rolling after planting	X		Herbicides		X
Weeding	X	X	Insecticides		X
Spraying		X	Fungicides		X
Harvest	X	X	Field emissions	X	X

RESULTS AND DISCUSSIONS

Garlic is one of the crops traditionally grown in the Czech Republic. Although garlic is not a dominant crop in terms of growing area and it would be relatively easy to provide a domestic consumption from our own resources, currently, most of garlic for the Czech market is imported from other countries, especially from Spain and China. In addition, the global garlic production and consumption has been continuously growing for last 40 years (Havránek 2001). In addition to long-distance transport, also the choice of a farming system increases the environmental load caused by GHG. In the Czech Republic, garlic is grown within conventional as well as in organic farming. Just organic farming could be the way how to reduce emissions from agricultural processes.

Emission load has been calculated for normal cultivation processes within the organic and conventional farming system and for expected yield of 10 t/ha of garlic within the conventional farming system and 7,5 t/ha within the organic one. This yield may be considered higher but it is achievable under conditions of the Czech Republic. In terms of agricultural technologies, organic farming is more demanding as compared with the conventional one. Within the garlic growing, more emission load from the agrotechnical phase is produced within the organic farming system (0.19972 kg CO_2e/kg of garlic) as compared with the conventional farming system (0.1251 kg CO_2e/kg of garlic). This is due to different yields and greater need for agrotechnical inputs related with mechanical plant protection (see Figure 1). Eg. within weeding in organic farming, 0.12658 kg CO_2e/kg of garlic is produced, while it is only 0.02713 kg CO_2e/kg of garlic within the conventional system. Emission load within the agrotechnical phase in the organic farming system is increased also by some operations related to pre-seeding soil preparation.

In the next phase - fertilization - the trend is opposite and the significantly higher load is calculated in the conventional farming system where 0,18378 kg CO_2e/kg of garlic is released while in the organic one, it is only 0.0102 kg CO_2e/kg of garlic. The difference is due to the use of synthetic fertilizers in conventional farming which are, in terms of emissions, significantly more loading than organic fertilizers (manure) in the organic farming system. Higher greenhouse gases emissions from synthetic fertilization is stated also by Smith et al. (2008) and Johanson et al. (2007) who state the reduction of synthetic fertilization as one of the main tools for reducing emissions CO_2e.

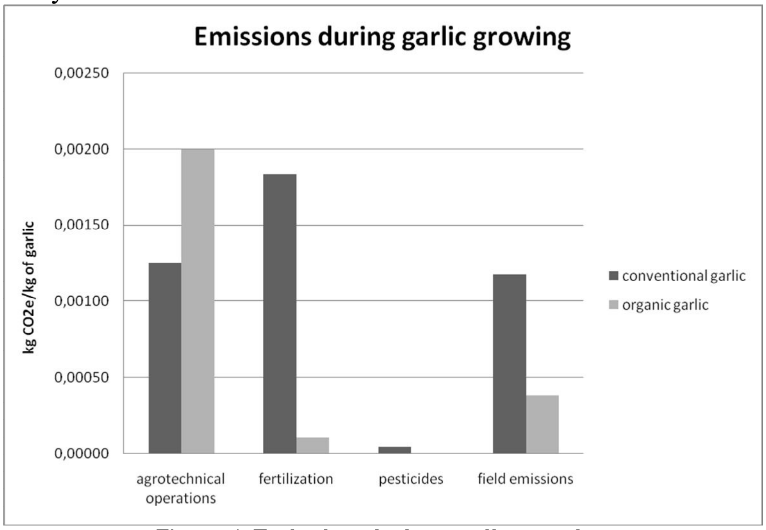

Figure 1 **Emission during garlic growing**

Another load within the conventional farming system comes from the use of pesticides. Particularly due to the use of herbicides and also insecticides (to a lesser extent), emissions (0,00412 kg CO_2e/kg of garlic) are produced. In organic farming, this load is completely eliminated, respectively, transferred to the agrotechnical phase in the form of mechanical plant protection. In relation to total emissions, it is a relative negligible amount, yet, e.g. Paustian et. al. (2004) stated the reduction of pesticides use as an opportunity to reduce the total GHG emissions production.

Significantly higher production CO_2e arises in conventional farming within field emissions. These arise within soil processes and fertilizers degradation and within conventional agriculture amount to 0.11754 kg CO2e/kg of garlic. This is significantly more than the value found in the organic farming system which is only 0.03811 kg CO2e/kg of garlic, it is by 67.58% less. This data is consistent with the claim of Zou et al. (2005) and Mori et al. (2005) who state that the use of synthetic fertilizers causes increased emissions of N_2O from the soil.

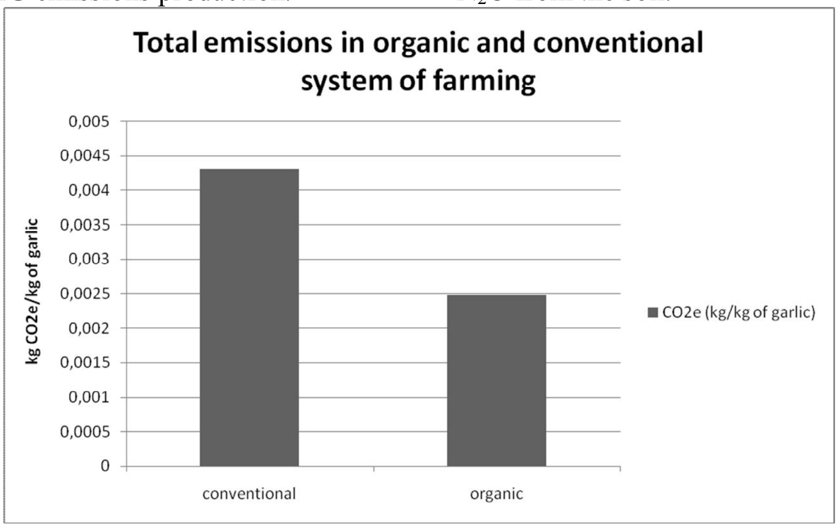

Figure 2 **Total emissions in organic and conventional farming system**

Higher total emission load within the cultivation of garlic is produced within the conventional farming system where the calculated values are 0.43055 kg CO_2e/kg of garlic (see Figure 2). Within the organic farming system despite the lower yield, the load is by 42.39% lower (0.24804 kg CO_2e/kg of garlic). Even in the case that the amount of organic fertilizers was doubled within organic farming, there would be an increase of 0.277293 kg CO_2e/kg which is still by 35.60% less than in the conventional farming system.

CONCLUSIONS

This study is a partial output of the GAJU 063/2013/Z project. The results show that the emission load in agriculture is influenced by the choice of the farming system. As with other crops, even with garlic, the choice of the organic farming system leads to emission savings, these are from 35.60% to 42.39%, depending on the intensity of fertilization within organic growing of garlic.

The opportunity for emissions savings within the conventional farming system can be seen mainly in synthetic fertilizers (especially the use of nitrogen fertilizers) and consequently, in the reduction of field emissions. Organic farming produces more greenhouse gas emissions within the agrotechnical phase which is mainly due to the increased need for mechanical protection against pathogens and some other agrotechnical operations. It is assumed that next to the choice of the farming system, the other major savings in the production of greenhouse gases could be achieved by a stronger preference of the regional production and transportation constraints.

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