# GREENHOUSE GASES EMISSIONS FROM OAT PRODUCTION WITHIN CONVENTIONAL AND ORGANIC FARMING

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**Abstract**

Climate changes and the anthropogenic impact have been a frequently discussed issue in recent years. The GHG production is significantly influenced by industry, transport, as well as by agriculture which ranks among the five largest producers. Agriculture produces 9,2 % of the total GHG and therefore it is the fourth largest producer of anthropogenic greenhouse gas emissions in the EU. Agriculture is considered one of the sectors where it is possible to look for mitigation possibilities. Oat grown in organic and conventional farming systems is evaluated within this study. The oat life cycle was assessed in the SIMAPro software (the ReCiPe Midpoint (H) Europe method). The functional unit was 1 kg of grain. This method includes a farming stage (field emission, seeds and seedlings, fertilizers, pesticides, agrotechnical operations). Basic data from the farms was supplemented from the Ecoinvent database. The conversion of GHG emissions to $CO_2e$ is based on the formula $CO_2e = 1x\ CO_2 + 23x\ CH_4 + 298x\ N_2O$. The total emissions in the agricultural phase within the conventional farming system are 0,650 kg $CO_2e$ / kg of oat grains, within the organic one, they are 0,303 kg $CO_2e$ / kg of oat grains. Therefore, we can achieve a significant reduction in the emission load per the production unit if the farming system is changed.

**Key words**: greenhouse gases, organic farming, conventional farming, oat, LCA

Climate changes and an anthropogenic contribution to them have become a frequently discussed issue in recent years. Many questions have not been answered yet and the discussion on whether the climate change is determined by natural evolution or negative consequences of human activity is still held (Nemešová and Pretel, 1998). However, many authors, e.g. Berner and Berner (2012), assume that human activities have also an influence on the climate change. The state of our environment has significantly deteriorated in recent decades, and in addition to other environmental threat, air pollution is also getting worse according to Acot (2005) and Middleton (2013). Braniš (2006) expects an increase in anthropogenic greenhouse gas emissions in the coming decades. The anthropogenic greenhouse gas emissions may be regulated and it is one of the priorities for sustainability. Besides the energy industry, industry and transport, agriculture, which has currently a share of almost 10% - 12% in the creation of greenhouse gas emissions, ranks among the controllable areas (Fried et al., 2009).

It is necessary, among the other things, to determine the share of green gas emissions resulting from specific agricultural processes in order to reduce them effectively. The LCA method (Life cycle assessment) seems to be a suitable assessment tool for the quantification of GHG emissions in agriculture (Thomassen and De Boer, 2005, Van Der Werf and Petit, 2002, Halberg et al., 2005). The LCA method may be briefly characterized as an assessment of all inputs, outputs and possible impacts on the environment during the entire life cycle (Remtová, 2003). Social or economic aspects may be included as well, however, the calculation of their impacts has only just begun (Griesshammer et al., 2006, Jørgensen et al., 2008) and the main focus is on the environmental component which evaluates, according to Kočí (2009), the environmental impact of a product based on the assessment of the material and energy flows, that the monitored system shares with its surrounding space. Garnett (2003) states that the LCA is an appropriate instrument because it enables to express the relationships between the food production, transport and production of $CO_2$.

Besides the individual operations, the whole farming systems, usually conventional and organic, are also compared in relation to the mitigation of greenhouse gas emissions. Organic farming

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systems create more potential to reduce greenhouse gas emissions than conventional. The biggest difference is due to the absence of synthetic fertilizers. It is very significant if emission reductions relate to the unit area. When converted to the production unit, the difference is partially reduced (Brandt and Svendsen, 2011). The Farming Systems Trial at Rodale Institute, an American long-term research comparing organic and conventional agriculture, states that the introduction of organic farming nationwide in the USA would manage to reduce $CO_2$ emissions by up to a quarter due to increased carbon sequestration in soils ((LaSalle and Hepperly, 2008).

Cereal crops belong among the most important agricultural crops in terms of both sown areas, as well as its importance in human nutrition. The greenhouse gas emissions within the production of cereals vary in different regions due to differences in species, climatic conditions, soil conditions and production system (Barton et al., 2008). Traditional cereal crops grown in central Europe include also oats. In 2000, 54.000 hectares were used to grow oats in the Czech Republic which corresponds to less than 4% of the total sown area of cereals (Moudrý, 2003). Apart from the food applications (Neuerburg and Padel, 1994, Chatenoud et al. (1998) or Liu et al. (1999) describe its beneficial nutritional qualities), oats are included in the rations, especially of young and breeding animals (Prugar, 2008, Ahmad et al., 2014). Although oat-growing areas cannot be compared, for example, with the wheat growing areas in terms of the size, it is still an important crop and the potential of conversion the conventional system into the ecological one may be demonstrated as an instrument to mitigate greenhouse gas emissions.

## MATERIAL AND METHOD

The SIMAPro Software was used to calculate the $CO_{2e}$ emissions. This software uses the Ecoinvent database and is used to model the life cycle of the product in accordance with the standards ČSN EN ISO 14040 and ČSN EN ISO 14044. The impact category "Climate change" was assessed within the simplified LCA method. The method focused on the agricultural phase of oat growing in conventional and organic farming systems. The inputs and outputs were referenced to the unit of one hectare and the resulting value was converted to a functional unit of 1 kg of oats. The outcome was the yield per hectare and the input included technology operations, the amount of seeds, fertilizers and plant protection products. The calculation also comprises the calculation of field emissions. The input data coming from the Ecoinvent database were adjusted in accordance with the principles of farming in Central Europe. The most common agrotechnical practises used within the conventional and organic farming and the chains of operations included in the calculation of GHG emissions in the agricultural phase of growing oats were determined according to the data obtained from a sample of 40 conventional and organic farms from the Czech Republic. Greenhouse gas emissions were expressed in $CO_{2e}$ when $CO2e = 1x\ CO_2 + 23x\ CH_4 + 298x\ N_2O$.

Table 1

**Monitored processes within conventional and organic farming systems**

| Process | Organic | Conventional | Process | Organic | Conventional |
|---|---|---|---|---|---|
| Fallow | X | X | Harvest (straw - bedding) | X | |
| Tillage | X | X | Harvest + straw shredding | | X |
| Seedbed preparation | X | X | Nitrogen fertilizer | | X |
| Rolling | X | | Potash fertilizer | | X |
| Rock picking | X | X | Phosphatic fertilizer | | X |
| Sowing | X | X | Organic fertilizer | X | |
| Rolling after seeding | X | | Herbicides | | X |
| Harrowing for weed control | X | | Insecticides | | X |
| Fertilization (synthetic) | | X | Fungicides | | X |
| Fertilization (organic) | X | | Field emissions | X | X |
| Pesticide treatment | | X | | | |

## RESULTS AND DISCUSSION

The oats is one of the crops traditionally grown in the Czech Republic. Although it is not a dominant crop in terms of the growing area and the acreage may not be compared with, for example, the wheat growing area, it still belongs among the economically important crops. The oat, a crop that requires less additional inputs and that is resistant to the effects of habitat conditions and effects of pathogenic agents and has a number of other positive characteristics, may contribute to the sustainability of farming systems with fewer inputs and in environmentally sensitive areas (Moudrý et al., 2014). It may also also contribute to reducing GHG emissions by optimizing its cultivation or choosing more environmentally friendly farming systems. In the Czech Republic, oats are grown within the conventional, as well as organic farming system and the organic system may be the way to reduce emissions resulting from agricultural processes.

Emission load was calculated for common cultivation processes within the organic and conventional farming system and for the expected yield of 4.9 t/ha of oats within the conventional farming system and 2,8 t/ha within the organic one. Yields in the conventional agriculture may be considered higher which may be influenced by the vintage year and the choice of agricultural practices.

In terms of agricultural technologies, organic farming is more demanding as compared with the conventional one. Within the oats growing, higher emission load from the agrotechnical phase is produced within the organic farming system (0,116 kg of $CO_2$e / kg of oats) as compared with the conventional farming system (0,045 kg of $CO_2$e / kg of oats). This is due to lower yields, as well as greater need for agrotechnical inputs related mainly with mechanical plant protection (see Figure 1). In organic farming systems, an additional burden arises from repeated rolling and harrowing and the application of manure, which is less environmentally friendly from the perspective of GHG than the application of synthetic fertilizers in conventional farming systems.

A higher emission burden is also evident within the category of seed, although the differences are lower (0,018 kg of $CO_2$e / kg of oats in conventional farming systems and 0,027 kg of $CO_2$e / kg of oats in organic farming systems). This difference is in particular the result of the lower yields within the organic farming system which, after the conversion to a production unit, cause a greater burden, although the sowing rates are similar. If the calculation is based on an area unit instead of a production unit, the burden is similar in this phase.

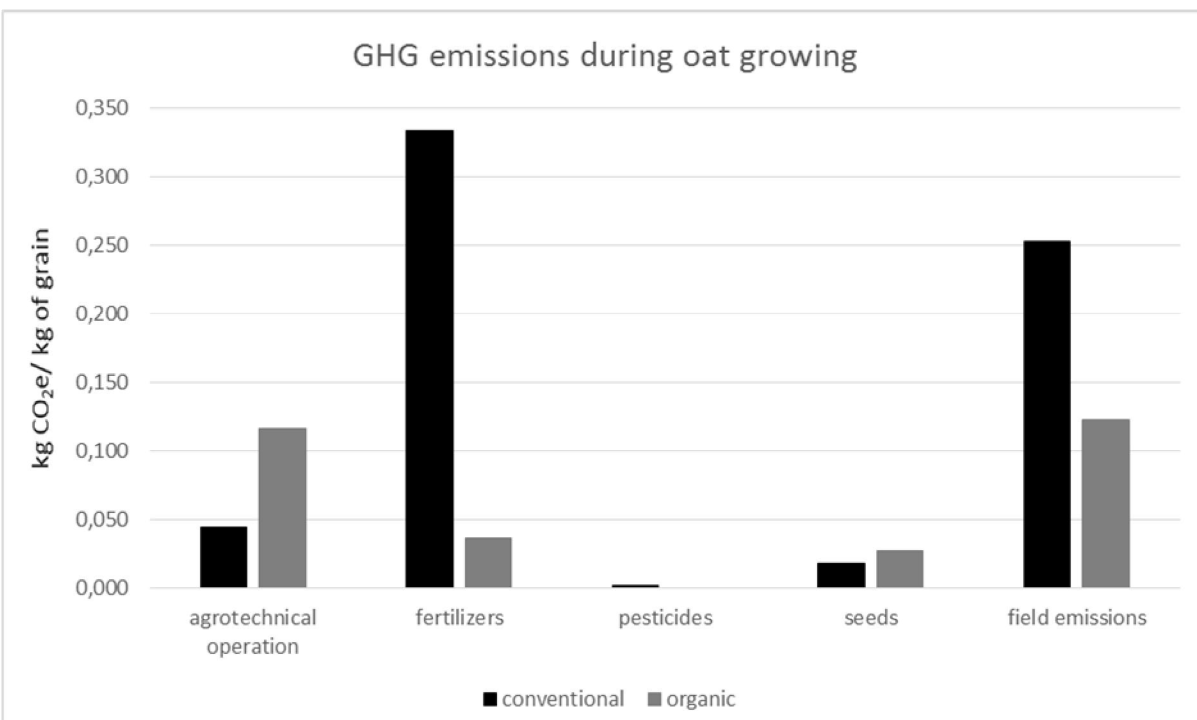


Figure 1 **GHG Emission during oat growing in conventional and organic farming**

Another load within the conventional farming system comes from the use of pesticides. Particularly due to the use of herbicides, emissions of 0,002 kg of $CO_2$e/kg of oats are produced. In organic farming, this load is completely transferred to the agrotechnical phase in the form of mechanical plant protection.

A significantly higher amount of GHG emissions is produced in the conventional farming system. In the conventional farming system, 0,333 kg of $CO_2$e / kg of oats is produced, while it is only 0,036 kg of $CO_2$e / kg of oats within the organic system. The use of organic fertilizer (manure) results in lower greenhouse gas emissions in organic agriculture in this phase, whereas synthetic, particularly nitrogen, fertilizers are used in conventional agriculture. A number of authors, namely Biswas et al. (2008), Küstermann and Hülsbergen (2008), Haas et al. (1995) or Bos et al. (2007), has noted their influence on the increase of greenhouse gas emissions. Therefore, a reduced use of synthetic fertilizers may be one of the main tools to reduce $CO_2$e emissions (Smith et al., 2008, Johnson et al., 2007).

A higher production of $CO_2$e also arises from field emissions in the conventional farming system. These arise within soil processes and fertilizers degradation and the use of synthetic fertilizers in the conventional farming system has an impact on it, as well. Synthetic and organic fertilizers are considered as key variables in the regulation of $N_2O$ and NO emissions from the soil, eg. Mosier et al., 1998. In the conventional farming system, field emissions reach 0,253 kg of $CO_2$e / kg of oats, while in the organic farming system about a half less, i.e. 0,123 kg of $CO_2$ e/ kg of oats, and the difference is even more significant after the conversion to the area unit.

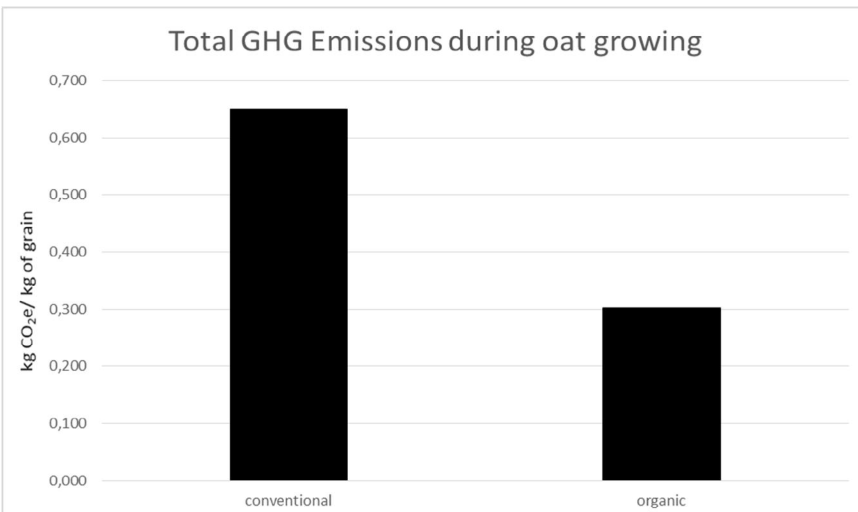


Figure 2 **Total GHG emissions during oat growing in conventional and organic farming**

Despite the considerably lower yields of oats in the organic farming system, the emission load from one kilogram of production is lower and the difference is more significant after the conversion to the unit area in favour of the organic farming system. While 0,650 kg of $CO_2$e / kg of oats is produced within the conventional farming system, it is less than a half (0.303 kg of $CO_2$e / kg of oats) within the organic one.

## 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 oats, the choice of the organic farming system leads to emission savings, namely 0,347 kg of $CO_2$e / kg of oats.

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, and also within the seed production phase.

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