

GREENHOUSE GAS EMISSIONS WITHIN THE PRODUCTION OF POTATOES IN CENTRAL EUROPE

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Abstract

Potatoes are cultivated in conventional as well as in organic farming systems and although the production area itself is not large as compared to other crops (e.g. 1.17 % of arable land in the Czech Republic, 2.14 % in Germany, but also 14.89 % in the Netherlands), in terms of production and subsequent food usage they belong to the most important crops not only in Europe. Farming system, which is used for their cultivation, can be one of the main factors affecting the production of greenhouse gases. The work is focused on monitoring and calculating the value of emissions expressed in CO₂ equivalent ($\text{CO}_2\text{-eqv} = 1x \text{CO}_2 + 23x \text{CH}_4 + 298x \text{N}_2\text{O}$) which is produced within the cultivation of potatoes in conventional and organic farming system. The results show that when comparing emission load within the agricultural production of potatoes there is an evident difference between conventional and organic farming systems, while different values can be observed in all parameters (field emission, planting, fertilizing, agrotechnical operations, pesticides). Although agrotechnical procedures themselves, including fertilization, are very similar in conventional and organic farming, the emission load produced per one kilogram of conventional potatoes is 0.145 kg CO₂e while the load produced per one kilogram of ecological potatoes is for the amount of 0.126 kg CO₂e by around 13 % lower.

Key words: greenhouse gases emissions, potatoes, farming systems

Climate changes have a significant impact on agricultural systems all over the world and can be a crucial factor in ensuring sustainable food production. The rate of human influence on these fluctuations has still been discussed. However, it is evident that within anthropogenic emissions of greenhouse gases it is possible to achieve certain reductions.

Among other branches of human activity, the production of emissions of greenhouse gases is influenced also by agricultural production which, according to IPCC (2007), produces about 14 % of anthropogenic emissions, while the share varies among particular countries according to the intensity of agricultural production.

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 %. According to EIPRO (2006), 29 % of emissions produced within the EU are related to food production. These emissions produced within food production encroach even beyond their own field cycle, e. g. on the production of fertilizers and agrochemicals, processing or all process transports.

One of the most common food crops, which is considered as the fourth most important crop after maize, rice and wheat (Staubli et al., 2008)

and which is widely grown also in the Czech Republic, are potatoes. Although in recent years according to the FAO, areas where potatoes are grown has reduced significantly in Central Europe, potatoes still belong to the most important crops in terms of their importance for food production.

Similarly to other crops, potatoes show noticeable differences between conventional and organic farming systems. These are apparent especially in the different use of fertilizers and pesticides, when the organic farming with applying organic fertilizers and minimizing or absence of chemicals achieves better results in comparison with conventional farming system. Detailed analysis of particular farming systems enables us to define areas in which it is possible to achieve the reduction of GAG emissions production while maintaining production capabilities of the system.

The monitoring of particular emission loads under different agricultural systems can be based on the LCA analysis. According to Kočí (2009), this analysis uses for the evaluation of the environmental impact the assessment of the material and energy flows that the monitored system shares with its surrounding space (the environment).

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Environmentally friendly farming systems and adjustment of procedures in conventional and intensive farming systems can become an effective tool for the reduction of greenhouse gas emission within cultivation of crops.

MATERIAL AND METHOD

To compare the production of CO₂e 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 was given one kg of the final product (potatoes), data quality geographically corresponds primarily to the Czech Republic, it is supplemented by data from the Ecoinvent database representing data for Central Europe, in terms of time primary data corresponds to the period 2009 - 2011, secondary data 2000 - 2011, 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 potatoes in both farming systems. Agriculture was defined by that of inputs and outputs related to one hectare (fuel consumption, consumption of seeds, pesticides, fertilizers / yield

per hectare). Into the process of agriculture were included N₂O emissions from agricultural land, calculated according to the IPCC methodology (De Klein, 2006). Emissions of involved greenhouse gases are expressed in relation to their effect on climate change by an equivalent CO₂e (CO₂e = 1x CO₂ + 23x CH₄ + 298x N₂O).

RESULTS AND DISCUSSIONS

Growing potatoes in the EU is a traditional cultural activity. Currently it is implemented on about 1.17 % (35,000 hectares) of arable land in the Czech Republic (Žižka, 2011). A similar situation is also in other countries of the EU, according to FAO data for 2009 potatoes are grown in France on 0.90 % (165,576 ha), in Germany on 2.14 % (255,200 ha), in Great Britain on 2.28 % (138,000 ha), in Poland on 3.92 % (490,853 ha) and in the Netherlands even on 14.89 % (156,969 ha) of arable land. In terms of total production according to the FAO data the largest global producer remains China (74,799,084 t), within the EU it is Germany (10,201,900 t), Poland (8,765,960 t), the Netherlands (6,843,530 t), France (6,582,190 t) and Great Britain (6,045,000 t).

Acreage under potatoes with data on their share on the arable land and the annual production in selected countries of Central and Eastern Europe are shown in Table 1.

Table 1

Growing potatoes in selected countries of Central and Eastern Europe (based on FAO 2010)

	CZ	PL	A	SK	HU	BG	RO
Acreage (ha)	35,000	490,853	21,973	11,000	20,242	13,800	246,982
Share on arable land (%)	1.17	3.92	1.60	0.80	0.44	0.44	2.81
Production (t)	682,511	8,765,960	671,722	125,900	439,897	251,100	3,283,870

Production of potatoes is in terms of production of emissions differently demanding depending on habitat conditions, used agronomical processes and chosen agricultural system. Environmentally friendly farming systems, that use measures against erosion and advanced methods of nitrogen management, have the potential to sequester carbon and reduce GHG (Lal, 2004; Lal et al., 2003; West, Marland, 2002; Follett, 2001; Paustian et al., 1997). This is confirmed by our results, where from comparison of emission load of agricultural production of potatoes in conventional and organic farming systems, which is shown in Figure 1, arises that one kg of conventional potatoes produces 0.145 kg CO₂e, while one kg of organic potatoes 0.126 kg CO₂e,

i. e. about 13 % less. To even more significant differences came Dorniger and Freyer (2008) who calculated that the emission load is 0.081 kg CO₂e/kg of tubers with conventionally and 0.035 kg CO₂e/kg of tubers i. e. 42.92 % with organically grown potatoes. Lackner (2008) calculated that the emission load within conventional growing of potatoes is 0.124 CO₂e/kg of tubers while within organic production it is 0.044 kg CO₂e/kg (data from the GEMIS database) which is a difference of 31 %. Fritesche and Erbele (2007) give that the emission load is 0.199 kg CO₂e/kg with conventional and 0.138 kg CO₂e/kg with organic potatoes, i.e. 69 % of emissions. However, calculation frames usually vary e. g. depending on inclusion of emission from transport and storage.

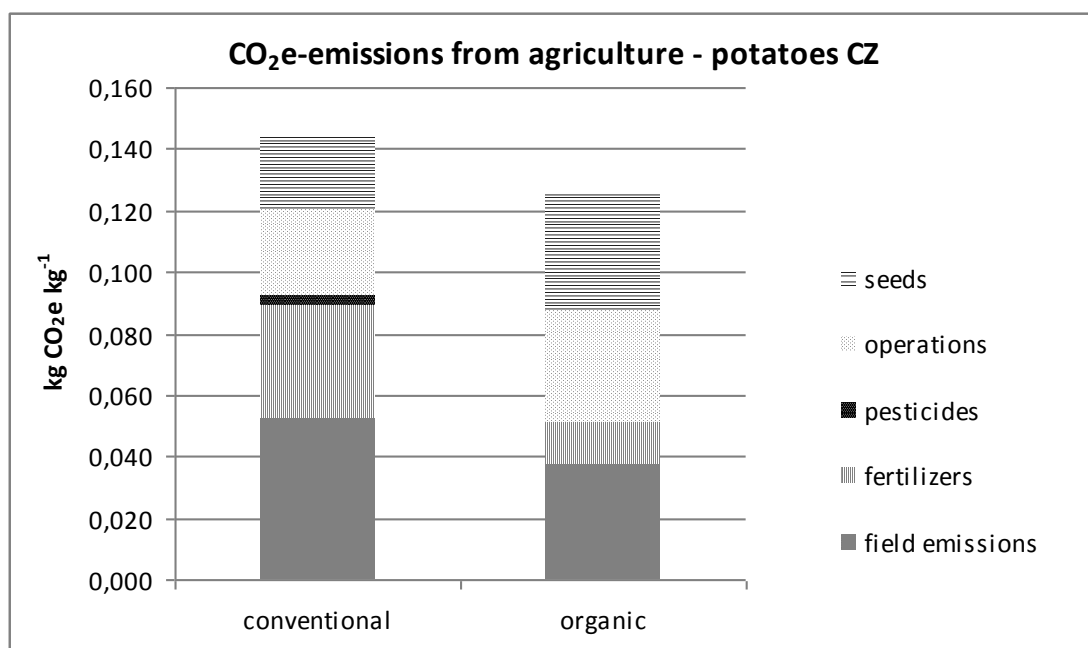


Figure 1 Emission from agricultural production of potatoes

Figure 1 shows also the partial composition of emissions from conventional and organic production of potatoes. While in conventional agriculture field emissions make up the largest share (0.053 kg CO₂e - 36 %), in organic farming system this value is lower (0.037 kg CO₂e - 30 %). Significantly higher is also the share of emission associated with fertilization which is in the conventional farming system 0.037 kg CO₂e (26 %), while in the organic one only 0.014 kg CO₂e (10 %). Conversely, for seed and agrotechnical operations the situation is reversed and more emissions are in the organic farming system (conventional system - agrotechnical operations - 0.028 kg CO₂e (19 %), seed - 0.024 kg CO₂e (17 %), organic system - agrotechnical operations 0.037 kg CO₂e (30 %), seed 0.037 kg CO₂e (30 %)). The value of emissions produced per one kg of potatoes in the conventional farming is increased by pesticide use (0.003 kg CO₂e - 2 %), which is completely missing in the organic farming system.

CONCLUSIONS

This study is a partial output of the Project EUS- M00080 – SUKI – The possibilities for dining facilities within reduction of the emission of carbon dioxide using the outputs of the VZ: MSM 6007665806 – The sustainable farming methods in submontane and mountain areas focused on the compliance between their production and non-production utilization.

From the results it can be stated that the cultivation of potatoes in organic farming is less

loading than conventional farming in terms of production of greenhouse gas emissions. Organic farming produces in general within the crop production less emission expressed in kg of CO₂e/kg than conventional farming where the main factor causing this environmental load is production of synthetic nitrogen fertilizers.

Under conditions of Central Europe and with the use of technologies and methods common in this region there is a saving of about 13 % of emissions CO₂e/kg in the organic farming system as compared to the conventional one.

Primary agricultural production is not the only air polluter. In the extended framework an important role in food production play also transport, processing of primary production to finished products, their long-term storage and preparation of food. Therefore, sustainable economic system must promote environmentally friendly organic production as well as regional production and consumption of fresh natural food.

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