POSSIBILITIES OF REDUCING CARBON DIOXIDE EMISSIONS IN ARABLE CROP PRODUCTION

Orsolya NAGY[1] – András TAMÁS[1] – Endre HARSÁNYI[2] – András VÁNTUS[2] – Károly KITH[1]

[1]Kálmán Kerpely Doctoral School, University of Debrecen, 4032 Debrecen, 138 Böszörményi Str., Hungary
nagyorsolya@agr.unideb.hu
[2]Institute of Land Utilisation, Technology and Regional Development, Department of Agrotechnology, University of Debrecen, 4032 Debrecen, 138 Böszörményi Str., Hungary
harsanyie@agr.unideb.hu

Abstract: Agriculture is a source of three main greenhouse gases (GHGs), carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). There are other important GHGs which include water vapour and many halocarbon compounds, but their emissions are not considered to be influenced by agriculture. Greenhouse gases change the atmospheric energy balance of Earth. A positive value indicates an increase in the level of energy remaining on the Earth, while a negative value indicates an increase in the level of energy returning to space. Although GHG emission derived from soil has been researched for several decades, there are still geographic regions and agricultural systems that have not been well characterized. Burgeoning global demand for food, fibre and fuel needs ecologically intensive crop management practices that enhance nutrient use efficiency must be involved an appropriate strategy to manage GHG emissions while continuing to achieve gains in yield. Carbon dioxide emission per capita in Hungary was similar to the EU-27 average while in 2009 it reached only two-thirds. To prepare for changing climatic conditions - especially in the agriculture and forestry – the main questions are the development of tillage, water systems and afforestation. We examined and compared the intensity of crop production which could be extensive or intensive. Additionally we summarized the effects of some crop technologies and interventions, depending on the GHGs of CO_2 emission.
Keywords: Greenhouse gases, emission, crop production, crop management

Introduction

Greenhouse gases contribute to global warming, depending on their molecular weight, the radiation qualities and their situation in the atmosphere. Based on researches of the recent years, agricultural activities are responsible for the increasing level of atmospheric carbon dioxide. The large amount of atmospheric processes and the small strength of swallowing of the carbon result a long residence time. The global warming potential (GWP) a generally accepted index shows that during the period of a given mass of greenhouse gas - usually 100 years - how heats the atmosphere - compared to the same mass of carbon dioxide. This index in case of methane (CH_4) is 23, while the nitrogen oxide (N_2O) is 298. By the end of the century the stabilization level of carbon dioxide concentration would be 450 ppm, so the emissions should be reduced by half. The critical level of 500 ppm would likely lead to 2°C increase in average temperature, this impact of climate leads to an ecological crisis (Tamás, 2008). The solution of the "global issues" requires: system approach and new methods of analyzing, planning and decision-making (Moser-Pálmai, 2006).

Materials and methods

In the study we examined the yields of corn and winter wheat in equivalent area of 100 hectare (KSH, 2014), with model calculation in respect of CO_2 and N_2O emissions. The model formed the basis of Hajdu-Bihar county yields and endowments of lands. The 2014 year was positive for the crop. Hajdu-Bihar county's average temperature was

10.9 °C (OMSZ data). The calculations were made by "The Cool Farm Tool" software, Version 2.0, which was created by the University of Aberdeen, in co-operation with the Sustainable Food Lab. The Cool Farm Tool is a farm-level greenhouse gas calculator for estimating net GHG emissions from agriculture. This calculator takes the estimates of technical potential to the farm and uncovers what is practical and pragmatic from a farmer and field perspective.

Results and discussion

The **maize** production was 668.8 tons of the examined area what we were calculated. The fertilization quantities are listed in the Table 1.(59/2008 FVM).

Table 1. Maize Fertiliser Use

Calcium ammonium nitrate 27% N	Super phosphate 21% P_2O_5	Potassium sulphate 50% K_2O; 45% SO_3
562,96 kg/ha	376,38 kg/ha	267,52 kg/ha

The CO_2 and N_2O emission as follows the fertilizer application quantities in the table above. The right column indicates are the basis of the GWP index that corresponds to the particular size of N_2O emissions of CO_2 emissions.

Table 2. Estimated Emissions (Maize)

Estimated emissions	kgs CO_2	kgs N_2O	kg CO_2 eq
Fertiliser production	489 262,6		489 262,6
Background direct and indirect N_2O		88,4	26 173,6
Fertiliser induced field emissions	-	664,1	196 562,4
Agrochemicals	4 100,0		4 100,0
Crop residue management		78,2	23 158,3
Totals	**493 362,6**	**830,7**	**739 256,9**

Agrotechnical means alone are often insufficient and chemical treatment is necessary (Nagy, 2006). The pesticide application was two times. After the harvest, the net yield (cleaning and drying) was 608 tonnes/ha. It means 6,603 tonnes/ha after the cleaning and drying the reduction. Necessary tillage operations are subsoiler, tooth harrow (autumn); disc bedder, pneumatic drill, row crop cultivator, disc harrow after harvest (spring). In addition to tillage four times of fertilizer applications and one time of weed control performed in that area. The harvesting was made one pass by corn combine. The used fuel and its carbon dioxide emissions are summarized in Table 3.

Table 3. Machinery Emissions;

	Energy Use (MJ)	kg CO_2 eq
Diesel	340 407,8	24 071,1
Total (kg CO_2 equiv)	**340 407,8**	**24 071,1**
Total /hectare (kg CO_2 equiv)	**3 404,1**	**240,7**

Table 4. Transport CO_2 Emissions

Units	kg CO_2 eq
Road	2 386,0
Total	**2 386,0**

Furthermore, we have to calculate with the fact that the test area is 15 km far from the site, so the fertilizer and seed have to be transported from the farm site to the field; while the harvested products also have to be transported from the field the farm site by diesel-fuelled (LGV, HGV) vehicles. During the transport the emission of CO_2 is included in Table 4.

In case of **winter wheat** growing in the same area of 524.16 tons gross yields were measured. The agro-ecological conditions are the same as in corn experiment. Difference is mainly observed in the cultivation technology. The amount of the applied fertilizer was as follows. (59/2008 FVM). Technical aspects of fertilizer application are examined by Hagymássy (2003).

Table 5. Winter Wheat Fertiliser Use

Calcium ammonium nitrate 27% N	**Super phosphate 21% P_2O_5**	**Potassium sulphate 50% K_2O; 45% SO_3**
504 kg/ha	264 kg/ha	181,44 kg/ha

As in case of winter wheat, the same soil required lower amounts of fertilizer, therefore, the CO_2 and N_2O emissions were also changed, which is illustrated in Table 6.

Table 6. Estimated Emissions (Winter Wheat)

Estimated emissions	**kgs CO_2**	**kgs N_2O**	**kg CO_2 eq**
Fertiliser production	409 320,4		409 320,4
Background direct and indirect N_2O		88,4	26 173,6
Fertiliser induced field emissions	-	515,3	152 527,3
Agrochemicals	4 100,0		4 100,0
Crop residue management		100,3	29 694,4
Totals	**413 420,4**	**704,0**	**621 815,6**

For winter wheat, the number of pesticide application is the same. After harvesting and drying we calculated with 4% of the amount of a net decrease, so the finished products were 504 tons / 100 hectare. Another variation of the basic operations can be observed, which amended as follows: disc harrow; disc bedder; grain drill; roller packer (autumn); disc harrow after harvest (spring). In addition to the basic operations, it was needed four times of fertilization procession and three times of pesticide spraying. The harvest was made by a combine in the entire area. In the seventh table we calculated with fuel volumes and results of CO2 emissions of the harvest.

Table 7. Machinery Emissions;

	Energy Use (MJ)	kg CO_2 eq
Diesel	347 942,2	24 603,8
Total (kg CO_2 equiv)	**340 407,8**	**24 603,8**
Total /hectare (kg CO_2 equiv)	**3 479,4**	**246,0**

Table 8. Transport CO_2 Emissions

Units	kg CO_2 eq
Road	1 932,6
Total	**1 932,6**

The wheat trial location is at the same distance from the plant site as in the case of maize. The amount of seed is 23 times more compared to the amount of maize seed, so an HGV is necessary to transport the fertilizer, seeds and the harvested crop. The CO_2 emissions calculated by the model were as follows. According to the in the case of two different crops (maize and winter wheat) grown in the same field the following CO_2 emissions have been measured per area unit and yield unit (kg CO_2/ha; kg CO_2/tonne).

Figure 1-2. Kg CO_2 Emissions by Land Area per Hectare: Maize – Winter Wheat

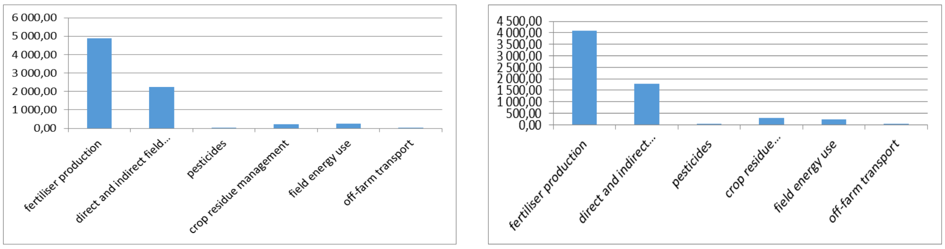
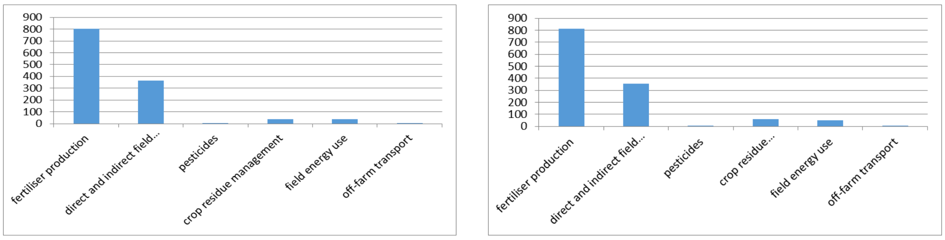


Figure 3-4. Kg CO_2 Emissions by Production per Tonne: Maize – Winter Wheat



Conclusions

We found that there is a linear relationship between the average yield and CO_2 emissions in the examined area. While in the case of maize, 6.08 tonnes/hectare average yield was calculated and the amount of CO_2 in the area 7.657.1 kg, in the case of winter wheat the measured values have been 5.04 tonnes/hectare yield average and 6483.5 kg of CO_2. No significant differences could be observed, when these amounts have been calculated to unit quantity (tonne). Maize: 1259.4 kg CO_2/tonne; winter wheat: 1286.4 kgCO_2/tonne. Furthermore, the quantity of fertilizers also has an impact on CO_2 emissions. Optimum fertilizer technology, purposeful cultivation technology and planned nutrient supply reduce the amount of GHGs into the atmosphere.

References

Bíró Tibor: 2008. Szerk.: Tamás János: Agrárium és környezetgazdálkodás. Mezőgazda Kiadó, Budapest, 117-118.

Hagymássy Zoltán: 2003. Parcella műtrágyaszóró gép fejlesztése és munkaminőségének vizsgálata. Acta Agronomica Hungarica, **12**: 35-38.

Moser Miklós és Pálmai György: 2006. A környezetvédelem alapjai. Nemzeti Tankönyvkiadó, Budapest, 147.

Nagy János: 2006. Maize Production. Akadémiai Kiadó, Budapest,139.

http://www.ksh.hu/docs/hun/xftp/gyor/kal/kal214.pdf (2015 01.04.)

http://www.met.hu/eghajlat/magyarorszag_eghajlata/altalanos_eghajlati_jellemzes/homerseklet/ (2015.01.05.)

59/2008 (IV.29) FVM Rendelet, 4. számú melléklete