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What is the Connection between Soil Carbon Dioxide Emission, Global Warming and Food Security?

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Abstract
In the heart of the western civilization, mainly in the European Union, we are more interested in the quality of the food than in its quantity. Due to our ever-changing world we have to pay more attention to the future of the latter, namely to food security. As food security depends on global warming as well, one of its triggering actors was selected for analysis, the emission of carbon dioxide from the soil. The experiments were set up in the Látókép experimental site, which is situated in the eastern part of Hungary. I have examined the effect of less soil disturbance regarding the CO_2 emission, in the case of winter ploughing, strip tillage and subsoiling methods. Measurements were performed with five differently placed and unique cylinders and with the help of the TESTO 535 measuring device. The results confirmed the hypothesis: less emission can help in the fight against global warming, thus it has a direct link to and impact on food security.

Keywords: food security, global warming, CO_2 emission, tillage methods

1. Introduction

Under current circumstances, the agricultural sector faces challenges, since a large part of available arable land is disappearing due to inadequate farming, urbanization and expanding industry. The issue of the lack and necessity of biodiversity is a great problem for existing production areas. IPBES, the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services was created to address the above; it was established in April 2012 to strengthen the link between science and political decision-making. FAO also deals with the issue of biodiversity separately: in 2019 FAO published its study (The state of World's Biodiversity for Food and Agriculture 2019), stressing the importance of maintaining biodiversity in relation to sustainable food supply and agriculture. (Personal interview, FAO, 2019).Harmony between production and nature is essential, as this is the core significance of agro-ecology. The extent of the role played by agro-ecology in making a decision might affect yield, income, and even future sustainability. Food security is also largely influenced by sustainability and global climate change. In the scope of present research, a smaller proportion of the influencing factors are addressed – different tillage methods that influence carbon dioxide emission of soil – which highlights how a more sustainable future is created by causing less soil disturbance and by applying tillage methods that require less energy.
Regarding the Food and Agriculture Organisation of the United Nations (FAO): *"Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life".* (World Food Summit 1996). This concept has spread since the 1996 World Food Summit, and

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includes the four main pillars of food security: access, availability, utilization and stability. This is a subsidence-type approach, which is preferably used by international organizations and the authors of impact studies (Stamoulis − Zezza 2003; Clay 2002).
The convergence of practical, political and institutional approaches to food security is not necessarily new, but important. Certainly, technology, policy and investment conditions need to be developed in order to solve these interconnected challenges for sustainably increasing food production, reaching the targets of food security and development.
The convergence of practical, political and institutional approaches to food security is not necessarily new, but important. Obviously, technology, policy and investment conditions need to be improved in order to solve these interconnected challenges for sustainably increasing food production, achieving food security and development targets, while addressing the challenges of climate change. The 3 major dimensions of climate change are 1) Sustainably increasing agricultural productivity and income (especially of smallholders); 2) Adapting and building resilience to climate change; and 3) Reducing and/or removing greenhouse gas emissions, where possible. Principles that are more specific to CSA include: The need to identify site-specific solutions to achieve food security under climate change; and Increasing resilience in social as well as production systems and broad-based strategies to manage risk ex-ante and ex-post" (FAO 2014).

1.1 Sustainable development

The issue and concept of sustainability, sustainable development has long been formed and is closely linked to food security. Among the first John Stuart Mill addressed it in his work Principles of Political Economy (1848). However, development of the concept is linked to the Rome Club (1972), and it is included in a report aimed to them. Here, five different parameters were used to study Earth's material flow, which are population, raw material stocks, food stocks, industrial production and environmental pollution (Meadows et al. 1972). Based on the findings, it is clear that not only development is unsustainable in its current form, but ultimately we are approaching a global natural disaster. The World Commission on Environment and Development (WCED) of the UN was founded in 1984 with 22 members, including a Hungarian academic István Láng, while the chairman of the committee was Norwegian Prime Minister Gro Harlem Brundtland. The Committee published its report "Our Common Future" in 1987, which contains the most widely accepted concept of sustainable development (Brundtland et al. 1987): "Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Brundtland et al. 1987). With this report, sustainable development could have risen to a higher political level, and it had a positive message, which, unlike the Rome Club, considered sustainable development feasible (Láng 2003). The three pillar structure of sustainable development was developed here as well, which are: protection of the environment; economic development and social equality. However, the concept is not interpreted identically by everyone or it is not clear to everyone (Daly 1996). Therefore, the practical approach of László Csete and István Láng gives a correct answer to the problem (2009, p. 10): "The slow spread of sustainable development can be explained by the dilemma between the short-term profit-orientation of individuals or

groups and the long-term interest of the survival of society and mankind."
Examining the European Union, it is clear that the issue of sustainable development has been emphasized since the Maastricht Treaty, as environment, economy and society are mentioned together (Bándi et al. 2011). The Treaty lists the promotion of balanced and sustainable economic and social development among the objectives of the Union (EU 1992) and the concept became institutionalized as part of the Amsterdam Treaty (EU 1997).

1.2 Sustainable agriculture

Application of the basic principle is the most important in the case of agriculture, because the natural resources it uses are limited or non-renewable. Of the three pillars, each of them is prominent here (economic, environmental, and social) (OECD 2001, Boody et al. 2005, Rossing et al. 2007, Huang et al. 2015). Examination of existing schemes shows that current population might reach a 4 billion growth by 2050 (a total population of 9.73 billion), which requires a significant increase in agricultural production, 50% more than it was in 2013, provided that the current consumption structure does not change (FAO 2013). However, recently, quality of food has become more important rather than its quantity for people with higher incomes and health considerations in developing countries (Kovács 2016). According to the FAO, due to the different climatic and natural conditions and the asymmetric distribution of Earth's population, by the year 2050 the number of people who consume food produced at a greater distance will increase by about 4 billion (FAO 2013).
In 2010, the share of agricultural land used in agriculture in the EU was 42% (Eurostat 2014a), yet the added value produced in agriculture is relatively small and has a decreasing weight in national economies, but its role in maintaining rural population is of paramount importance (Csete - Láng 2009). Agriculture has the greatest impact on sustainability; as this sector utilizes the largest area in general, the responsibility of preserving biodiversity is also faced by agriculture. However, it is also the largest user of natural resources and its pollution is significant (carbon dioxide emissions, use of fertilizers, methane, dinitrogen oxide) (Valkó 2008).
The concept of sustainable agriculture is widely debated, István Láng defines it as follows: sustainable agricultural development is such economic growth that "harmonizes with the regeneration of natural resources and the assimilation ability of environmental pressure. This will bring about sustained, quantitatively limited, but qualitatively unrestricted economic growth – that is the basis of the protection of interests, aspirations – conservation of natural resources and a broadly interpreted environment, and ultimately a healthier human environment and nutrition, quality of life "(Láng et al. 1995, p. 17)

2. Material and Method

The aim of present study was to analyse the carbon dioxide emission of the soil by examining the effects of different tillage methods. The amount of carbon in the soil is also heavily influenced by human activity, which is mainly due to deforestation and soil disturbance, where the degradation of organic matter is significantly accelerated (Broken

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et al, 2002). The climate changing effect of soil has not been the subject of research for long, but it has become a more and more researched topic as of the 1980s, depending on the increasing rate of global climate change (Robock et al. 1998, Wank & Eltahir 2000). Agriculture is a major contributor to the growth of carbon dioxide in the atmosphere, accounting for 20% of growth (Birkás-Gyuricza 2004). Gases, mainly carbon dioxide released during decomposition of organic matter in the soil and soil respiration are emitted in an increasing rate with rising soil temperature (Schleisinger 1977). Global climate change, therefore, has an impact on the carbon cycle of the biosphere as soil temperature increases. Increasing soil respiration may increase global warming (Kaye & amp; Hart 1998).

Three types of tillage were investigated in the experimental field and a part of the area was irrigated while the other part was non-irrigated. One part of the plot was winter ploughed, while the second part was cultivated with strip tillage and the third part was cultivated with deep subsoiling. The experiment was carried out in the Látókép experimental site, calciferous chernozem soil. The study was completed in June 2018.

Our measurements were carried out with a Testo 535 measuring device, which is an infrared absorption-based CO_2 concentration measuring unit. The individual measuring cylinders with internal ventilation that were placed on the ground had the same diameter (118 × 250 mm). In the 5 cylinders placed next to each other, the initial carbon dioxide value and the emission value of the increased carbon dioxide after the incubation time of 5 minutes were measured. The cylinders were lowered to the ground at a depth of 5 cm, making sure that the soil was the least disturbed at their locations, so that emissions can be measured in the most natural microclimate. At the end of the measurements, the sampling cylinders were cleaned and ventilated to get them ready for another measurements.

In connection with the experiment, the research objective was to examine the carbon dioxide emissions of the soil within one day (24 hours), so measurements were performed in the early hours of the morning, then in the afternoon and in the evening.

In the picture below (*Picture 1*) *a; b; c;* points indicate the irrigated area, while *d; e; f* points are the non-irrigated parts. Points *a; d* are ploughed, *b; e* are strip tillage plots, *c; f* are subsoiled.

Picture 1: The experiment site (Látókép, 2018)

The statistical analysis was carried out in RStudio statistical system. Analytical values were measured in ppm, which was converted to $g/m^2/h$ using the following formula (Zsembeli et al. 2009):
$F = d*(V/A) * (C_2-C_1)/t*273/(273+T)$

3. Results

In the course of the study, the influencing role of temperature on carbon dioxide emissions at different times of the day were analysed, as well as the combined effects of soil tillage and irrigation. Comparison of mean value was performed by means of the LSD test (Huzsvai and Balogh 2015). The post hoc body showed a significant difference ($P < 0.01$) compared to the parts of the day and tillage methods.
By examining different parts days of the day, the highest values were obtained during the morning measurement when the soil began to warm up. Here the value was 1.64 $g/m^2/day$. The afternoon measurement showed lower values, these were the hottest hours in the day, but there was no significant difference between the morning and afternoon measurements. The lowest values were obtained for the evening measurements when the sun was already setting (0.94 $g/m^2/day$). This value is significantly different from the previous results. The least Significant Difference was 0.285885.

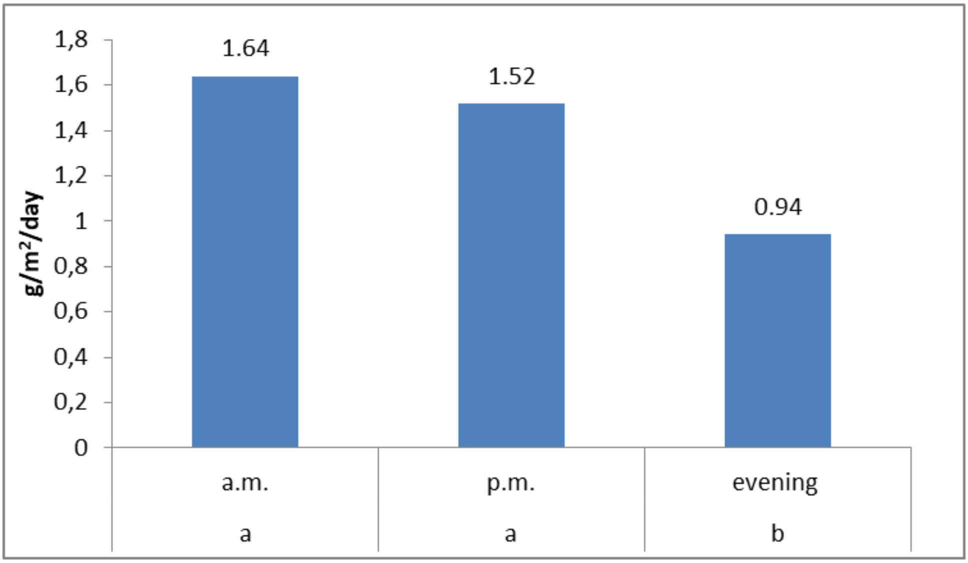

Figure 1: The effect of the daily flux on the CO_2 emission of the soil (Látókép, 2018)

Comparison of tillage methods also provided significant results. The highest values were obtained in the case of the subsoiling tillage variant in terms of the total mean of the day (1.54 $g/m^2/day$), winter ploughing resulted in a slightly lower value (1.48 $g/m^2/day$), but did not significantly differ from it, while the value of strip tillage was significantly lower (1.08 $g/m^2/day$). The least Significant Difference was 0.2862562.

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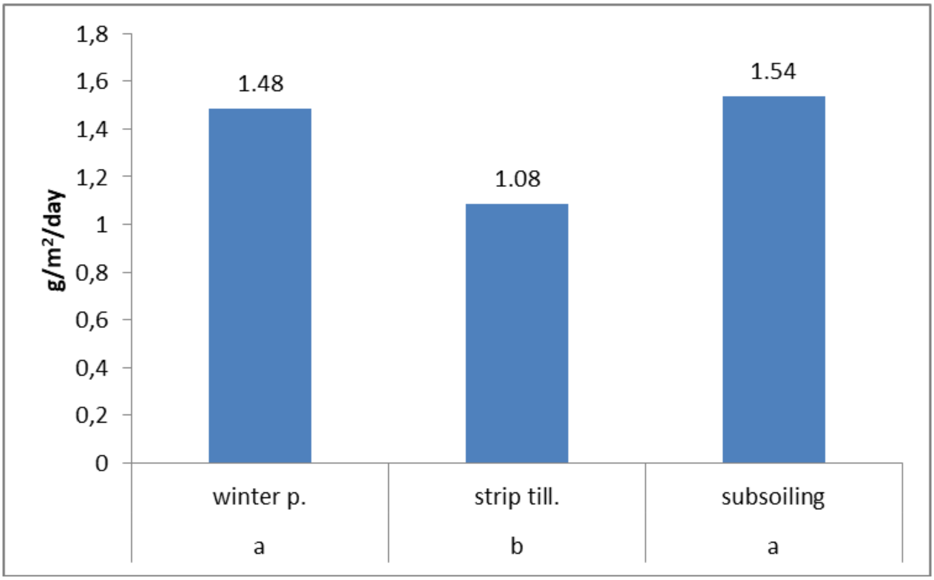

Figure 2: The effect of interaction between the cultivation method and on the CO_2 emission of soil

The effect of tillage was analysed broken down to the different periods of the day, which provided significant results. The highest emission was detected in the winter ploughed area during the afternoon hours (2.07 g/m²/day) and in the subsoiled area during the same period (1.98 g/m²/day). All in all, the strip tillage area provided the lowest values, but at the time of the evening measurement, the amount of emissions was almost the same in the winter ploughed area (0.79 g/m²/day) as in the strip tillage area (0.80 g/m²/day). The least Significant Difference was 0.4951673.

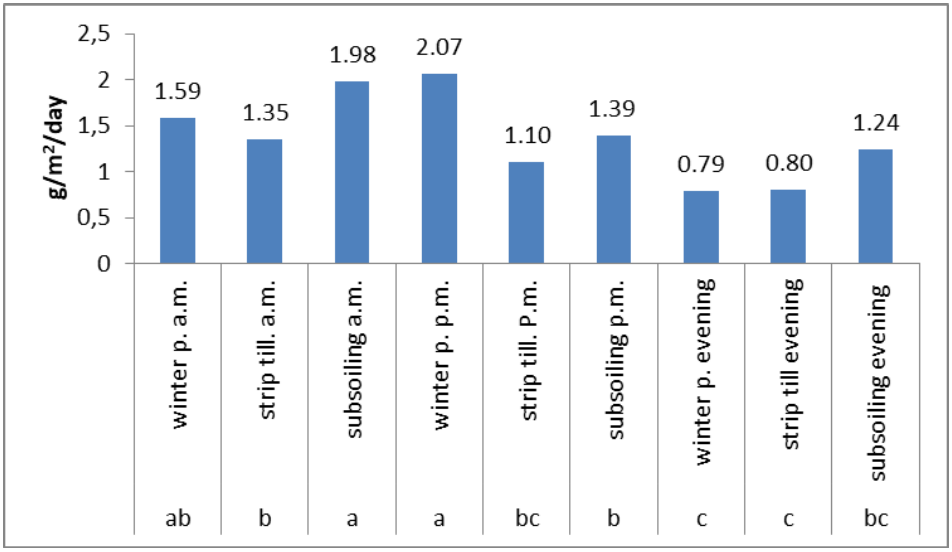

Figure 3: The effect of interaction between the cultivation method and the daily flux

4. Conclusion

The findings confirmed the hypothesis that less carbon dioxide is released into the atmosphere from a less disturbed soil, which contributes to the greater organic matter retention capacity of the soil.

As for the findings, the lowest emission occurs in the evening, while the highest emission takes place at the beginning of the day when the soil warms up. The lowest values were obtained in strip tillage, while the highest values were measured in the case of subsoiling. Comparing the periods of the day and the tillage methods, higher values were obtained during the afternoon hours in the autumn ploughed and subsoiled tillage methods, while lowest values were measured during the evening hours in the ploughed and strip tillage methods. In terms of the experiment, it can be stated that strip tillage, which is a less soil disturbing, conserving tillage method emits less carbon dioxide and is more able to retain the organic matter content of the soil.

Tillage with less soil disturbance is not widespread for the time being, but more and more studies deal with its positive effects. Certainly, the use of new solutions in agriculture is necessary for sustainable food security. It is imperative that the current problems are solved in a complex system, because the regulation of the sectors alone cannot be as successful for food security and sustainable development as the decisions made based on the overall approach.

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References

Bándi, Gy. et al. (2011): A fenntartható fejlődés koncepciójának megjelenése a nemzetközi és európai jogban, valamint az EU-tagállamok gyakorlatában. Nemzeti Fenntartható Fejlődés Tanács, Műhelytanulmányok – No. 6, Budapest, 2011. július, 306 p.

Birkás M. – Gyuricza Cs. (2004): A talajhasználat és a klimatikus hatások kapcsolata. In: Talajhasználat, műveléshatás, talajnedvesség. (Szerk.: Birkás M. – Gyuricza Cs.). Quality – Press Nyomda & Kiadó Kft. pp.10-47.

Boody, G. – Vondracek, V. – Andow, D. A. – Krinke, M. – Westra, J. – Zimmerman, J. – Welle, P. (2005): Multifunctional agriculture in the United States. BioScience. Vol. 55. Issue 1. pp. 27–38. http://dx.doi.org/10.1641/0006-3568(2005)055%5B0027:MAITUS%5D2.0.CO;2 Accessed 25/07/2017

Boody, G. et al. (2005): Multifunctional agriculture in the United States. BioScience, 55 (1) pp.27–38.

Borken, W., Muhs, A. & Beese, F. (2002): Changes in microbial and soil properties following compost treatment of degraded temperate forest soils. Soil Biol. Biochem. 34: pp.403-412

Brundtland, G. H. et al. (1987): Our Common Future. Oxford University Press, Oxford – New York, 400 p

Building a common vision for sustainable food and agriculture Principles And Approaches. Food And Agriculture Organization Of The United Nations Rome, 2014. 40 p

Clay, E. (2002): Food Security: Concepts and Measurement, Paper for FAO Expert Consultation on Trade and Food Security: Conceptualising the Linkages Rome, 11-12 July 2002. Published as Chapter 2 of Trade Reforms and Food Security: conceptualising the linkages. Rome: FAO

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Csete, L. – Láng, I. (2009): A vidék fenntartható fejlődése: a vidék fejlődésének fenntarthatósága – hétköznapi megközelítésben. MTA Történettudományi Intézet, MTA Társadalomkutató Központ, Budapest, 171 p.

Daly, H. E. (1996): Beyond Growth: The Economics of Sustainable Development. Beacon Press, Boston, 253 p.

EU (1992): Treaty on European Union (92/C 191/01). https://eur-lex.europa.eu/legal-content/HU/TXT/?uri=OJ:C:1992:191:TOC, 112 p. Accessed 12/02/2018

EU (1997): Amszterdami szerződés az Európai Unióról Szóló Szerződések és egyes kapcsolódó okmányok módosításáról. 97/C, 340/01. http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:11997D/TXT&rid=1., Accessed 12/02/2018

EUROSTAT [2014]: Eurostat database. http://ec.europa.eu/eurostat/data/database Accessed 12/02/2018

FAO (Food And Agriculture Organization of the United Nations) (2013): Statistical Yearbook, Rome. http://www.fao.org/docrep/018/i3107e/i3107e00.htm Accessed 10/05/2018

FAO [2014]: FAOSTAT database. http://faostat.fao.org/ Accessed 12/04/2019

Huang, J. et al. (2015): Comparative review of multifunctionality and ecosystem services in sustainable agriculture. Journal of Environmental Management, 149 (1) pp 138–147

Huzsvai L., Balogh P., 2015: Lineéris modellek az R-ben, Seneca Books http://seneca-books.hu/doc/Linearis_modellek.pdf

Kaye, J. P. and Hart, S. C. (1998): Restoration and canopy-type effects soil respiration in a Ponderosa Pine Bunchgass ecosystem. Soil Science Economy. Am. J. 62: pp. 1062-1072

Kovács, I. [2016]: The effects of corporate social responsibility on consumer decisions in Hungary. Management. Vol. 29. Issue 2. pp. 27–34.

Láng, I. (2003): A fenntartható fejlődés Johannesburg után. Agroinform Kiadóház, Budapest, 147 p.

Láng, I. et al. (1995): Az agrárgazdaság fenntartható fejlődésének tudományos megalapozása. pp. 5–124. In: „AGRO-21" Füzetek – Az agrárgazdaság jövőképe, 1995/12. szám, Budapest, Akaprint Kft., 125 p.

Meadows, D. H. Et Al. (1972): The Limits To Growth. Universe Books, New York, 295 p.

OECD (2001): Environmental Indicators for Agriculture – Volume 3 – Methods and Results. OECD Publications, Paris, 409 p.

Personal interview with Zoltán Kálmán in the FAO, Rome, 2019).

Robock, A.(1998): Evaluation of the AMIP soil moisture simulations. Global Planet Change. 19: pp. 181-208.

Rossing, W. A. H. et al. (2007): Integrative modelling approaches for analysis of impact of multifunctional agriculture: A review for France, Germany and The Netherlands. Agriculture, Ecosystems and Environment, 120 (1) 41–57.

Schlesinger, W. H. (1977): Carbon balance in terrestrial detritus. Annual Review of Ecology and Systematics, 8: pp 51-81.

Stamoulis, K. − Zezza, A. (2003): A Conceptual Framework for National Agricultural, Rural Development, and Food Security Strategies and Policies. ESA Working Paper No. 03.

Szöllősi, Nikolett- Kovács, Gyöngyi – Zsembeli József (2009): A talaj szén-dioxid emissziója árpa tarlón. Agrártudományi Közlemények, 2009/35: pp 95-102

The state of World's Biodiversity for Food and Agriculture, 2019 http://www.fao.org/3/CA3129EN/ca3129en.pdf Accessed 01/06/2019

Valkó, G. – Fekete-Farkas, M. – Szűcs, I. – Mohamed, Zs. (2008): The Measurement of Sustainability in Agriculture. pp. 295–316. In: SZŰCS, I. et al. (Szerk.): Economics of Sustainable Agriculture I-II. Szent István University, Scientific Book Series, Gödöllő, 316 p.

Wang, G & Elthair, L. A.B. (2000): Ecosystem dynamics and the Sahel drought. Geophys . Res. Lett. 27: pp 795-798

World Food Summit (1996): Declaration on World Food Security, Rome