

COMPARATIVE STUDIES BETWEEN CONVENTIONAL & ORGANIC DEMETER AGRICULTURAL SYSTEMS ON THE MAIN AGRICULTURAL CROPS GROWN ON THE CHERNOZEM OF BAILEȘTI, DOLJ. I. CARBON FOOTPRINT OF WHEAT, BARLEY, CORN AND SUNFLOWER CROPS

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Abstract

Global carbon emissions are mainly due to agricultural production and the machinery used to obtain them, as well as the use of inputs such as fertilizers and pesticides. The global carbon footprint due to this sector is approximately 8%, of which 75% is directly related to the use of fertilizers. For 4 agricultural crops: wheat, barley, corn and sunflower, grown in 2 agricultural farms: Terra Nostra Farm from Băilești - Demeter organic technology and Trăistaru Farm Băilești - conventional technology, the carbon footprint was calculated in the years 2023 and 2024.

The ratio of carbon emitted/carbon sequestered in corn ranged between 176.32 and 349.65 in organic versus conventional technology, in wheat almost identical in both technologies - Demeter organic versus conventional technology (817.45, respectively 818). Close to wheat, barley appears with a ratio value of 777.5 in conventional. In sunflower, the ratio of carbon emitted/carbon sequestered was 523.15 also in conventional technology.

Keywords: agricultural crops, carbon footprint, conventional, organic, production.

1. INTRODUCTION

Carbon dioxide, the most important greenhouse gas, accounts for approximately 60% of the total greenhouse gas effect on global warming (Rastogi et al., 2002).

The term “carbon footprint”, which has become extremely common and is now a global concept (Wiedmann and Minx, 2008), has been defined as “a measurement of the total greenhouse gas emissions caused directly or indirectly by an individual, an organization, even a product and is expressed as carbon dioxide (CO₂) equivalent” by Gao et al., (2013). Global carbon emissions are mainly due to agricultural production and the machinery used to obtain them, as well as the use of inputs such as fertilizers and pesticides. The global carbon footprint due to this sector is approximately 8%. Of these, a significant percentage - 75%, is directly related to the chemical fertilizers used (Choudrie et al., 2008).

One liter of diesel fuel burned results in emissions of 2.7-2.9 kg of CO₂. For classic plowing, a minimum of 70 liters of diesel fuel/ha is consumed, which is equivalent to 203 kg of CO₂/ha. If the conservative system is applied, diesel consumption is reduced to 40 liters/ha, equivalent to 120 kg of CO₂. The "no-tillage" system applied to sowing develops emissions of a maximum of 60 kg of CO₂/ha through a consumption of only 20 l/ha of diesel fuel, practically three times less than in the first case. About 180 kg of CO₂ remained in the soil CO₂ pool (Berca, 2021).

Studies on carbon sequestration in different crops have been carried out by numerous researchers (Jarechi and Lal, 2010; de Oliveira Ferreira et al., 2012; de Freitas Seben Junior et al., 2014; Hypolite, 2021).

A relatively recent study (Ozlu et al., 2022) demonstrated the effect of environmental factors, land use and agricultural practices on carbon footprint management through a detailed analysis. This study highlighted that for a low carbon level, healthy soils have numerous benefits: stability, erosion resistance, easy tillage in cultivated systems, good habitat for soil microorganisms, fertile structure and high carbon absorption. Classic tillage is harmful to soil structure by oxidizing carbon and causing greenhouse gas emissions. If possible, a minimum depth of tillage is recommended. High yields can help soil structure. Minimizing tillage can help avoid soil compaction.

2. MATERIALS AND METHODS

Based on the technological sheets for each crop, from each farm analysed (Terra Nostra Ecoland Băilești, Trăistaru Conventional Farm Băilești), tables were completed with the work performed and diesel consumption according to the model presented by Berca in Table 1 (Berca, 2021).

Table 1. Carbon footprint calculation model

Nr. Crt.	Performed works	Diesel consumption (l/ha)	Emitted carbon (CE) kg/ha	Used inputs	Dose l or kg/ha	Emitted carbon (CE) kg/ha	TOTAL CE Kg/ha
1	Stubble-turning	2.5	1.8	N-fertilizers	140	2.96	114.4
2	Tiger loosening	18	13	P-fertilizers	60	0.2	12
3	Germination bed amendment	5.5	4	K-fertilizers	60	0.15	9
4	Sowing + fertilizing	14	10	Herbicides	2.1	6.3	13.2
5	Fertilizing in vegetation (2)	2.5 x 25	3.6	Insecticides	2	0.36	0.72
6	Herbicides (1)	8	5.7	Fungicides	2,2	3.16	6.95
7	Harvesting	28	20.1	Foliar fertilizers	15	2.96	44.4
8	Transport	5/t	11.2				
	TOTAL	96.5	69.4				500.27

K=0.5

CE works = (69.4+69.4) x 0.2 = 83.28

TOTAL CE (kg/ha) = 83.28 + 500.27 = 583.55

Calculated in CO₂ (kg/ha) = 583.55 x 3.67 = 2141.6 kg equivalent CO₂/ha

Based on the biomass (sample taken from each crop), the harvest index and the defining parameters of stored carbon, the carbon footprint was calculated for the crops studied in 2023 and 2024 for the farms located on the chernozem of Băilești – Terra Nostra and the conventional Trăistaru Farm. On

the first farm, maize and eco-wheat were grown. On the conventional farm, the crops were: wheat, maize, sunflower and barley.

3. RESULTS AND DISCUSSIONS

The comparison between organic and conservative technology regarding the ratio between emitted and sequestered carbon can be made under the conditions in which the common denominator - the soil type and the location, are identical, in our case the town of Băilești (Figure 1).

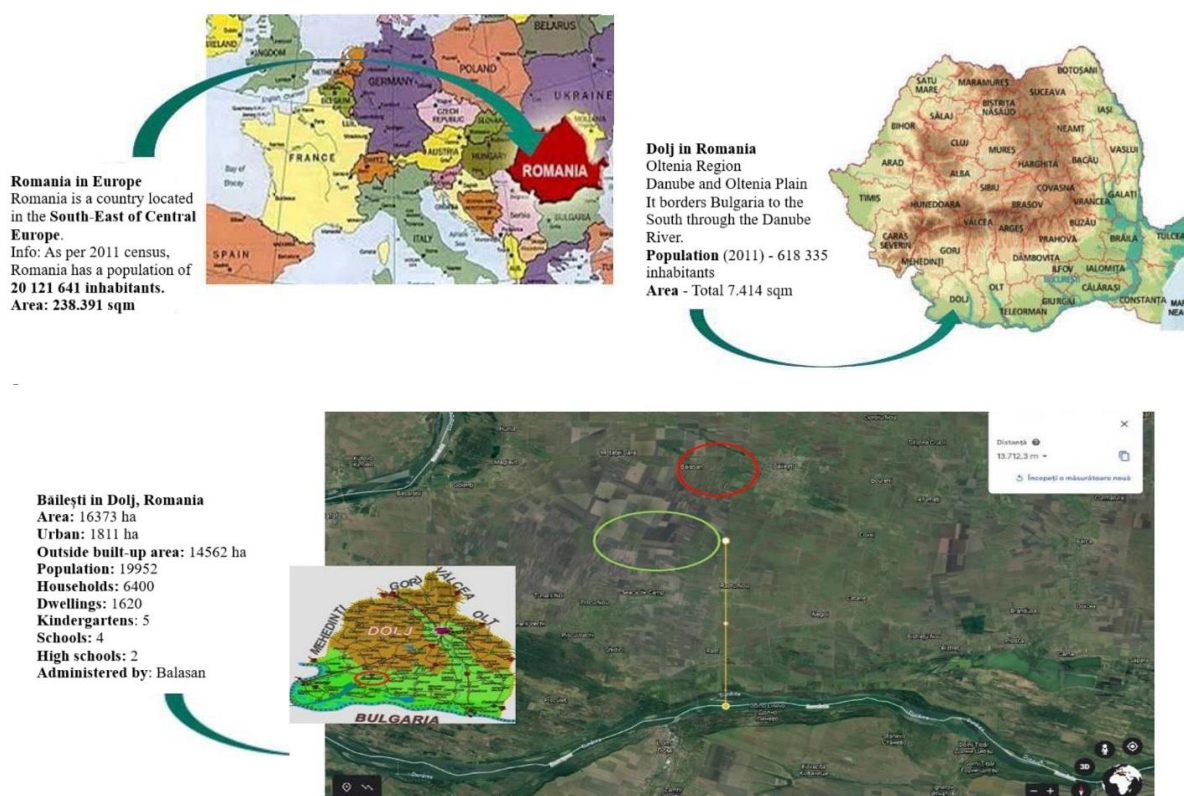


Figure 1. Location of the research area

Băilești is located in the southern half of Dolj County, 57 km southwest of Craiova, 32 km northeast of Calafat and about 16 km from the Danube, in a southeast direction, through the Rast locality. Băilești is a municipality in Dolj County, Oltenia region of Romania, formed by the component towns of Balasan and Băilești (the seat).

The city of Băilești is located in a tectonically stable zone. The typical chernozem of the Băilești Plain has less than 0.8% coarse sand. The fine sand content ranges from 44.1% to 50.2% along the profile (Figure 2). The alteration and leaching process is very weak mainly due to the dust content which is 26% in the surface horizon and which decreases in depth to 20.5%, Clay has values of 30% in the first horizons. (figure 3). This granulometric composition gives the soil a medium to medium coarse texture throughout the profile.

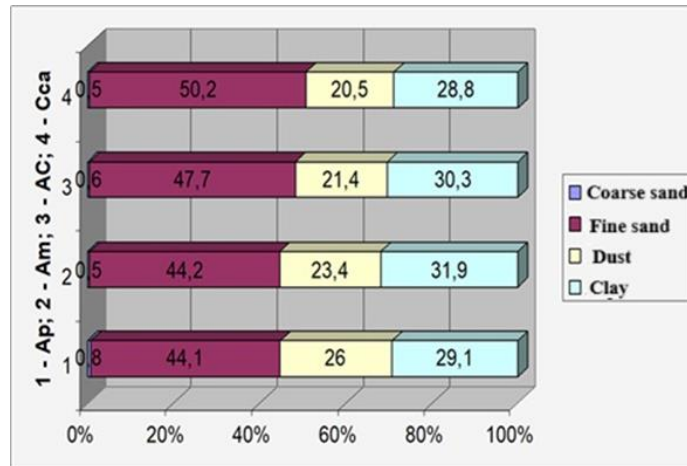


Figure 2. Granulometric composition of typical chernozem

The apparent density has lower values at the surface (1.40 g/cm³). The soil density increases slightly along the profile from 2.64 g/cm³ to 2.70 g/cm³. The total porosity is very good at the surface (54%) and decreases slightly to 48% in depth. These data demonstrate that the typical chernozem in the studied area has good relations with water and air, creating appropriate conditions for plant growth and fruiting.

The Băilești area is characterized by a very fertile soil. Chernozems are spread in the Băilești plain, on flat lands, with the water table at a depth of more than 5 m. They were formed on loessoid materials, under a well-developed grassy vegetation. Currently, the lands are predominantly used for agriculture. The soils are characterized by a profile of the type: Ap - Am - AC - Cca (Figure 3).

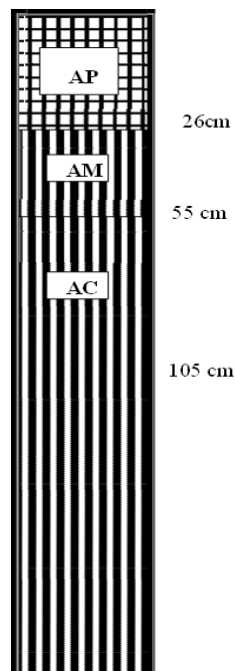


Figure 3. Morphological profile description

Humidity with average values and water capacity with values around 13.5% showed that good conditions were created for plant development and productivity.

From a chemical point of view, it is found that the typical chernozems in the Băilești area are well supplied with organic material, the percentage of humus being over 3% in the first horizons (Figure 4).

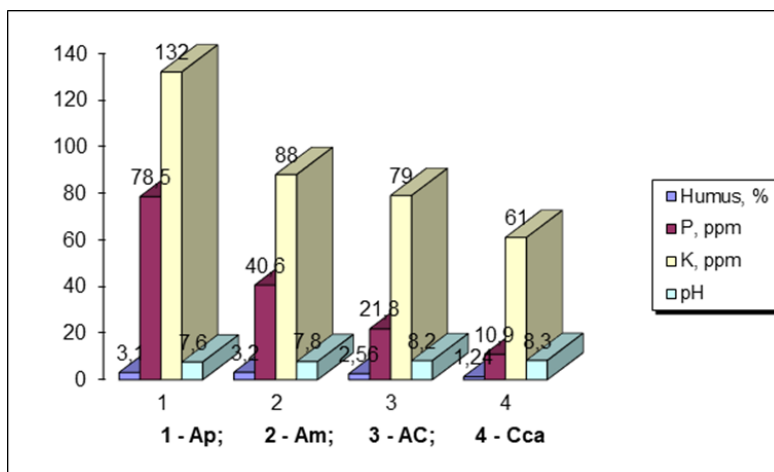


Figure 4. Main chemical properties of typical chernozem

A good percentage of humus is maintained throughout the thickness of the soil profile. The soil is well supplied with macroelements. The total nitrogen content has values in the range of 0.156% - 0.059% depending on the horizon. The phosphorus content values are 70 – 78 ppm and the potassium content 110 - 120 ppm. The pH value increases from 7.6 to 8.3% depending on the soil profile. Typical chernozems in the Băilești area have a high productive potential, which is why reliable yields are obtained.

As shown in Table 2, the lowest ratio is for maize under organic conditions and the highest for wheat under conventional conditions. The small difference between the technologies applied to wheat is explained by the fairly close yields obtained.

Table 2. Carbon emitted/carbon sequestered ratio for crops from organic & conventional farms in Băilești –2023 + 2024 average

Crops	Emitted CO ₂ (kg/ha)	Sequestered C (t/ha)	Ratio of emitted CO ₂ / sequestered C	Ranking
Terra Nostra Ecoland Farms Organic Băilești				
Maize 2023	833.09	4.86		
Maize 2024	796.17	4.37		
average	814.63	4.62	1763.2	1
Organic wheat 2023	597.18	0.54		
Organic wheat 2024	631.99	1.08		
average	614.59	0.81	759.75	4
Claudiu Trăistaru Conventional Farm				
Wheat 2023	1615.13	2.04		
Wheat 2024	1675.65	1.98		
average	1645.39	2.01	818.6	6
Maize 2023	1679.5	4.32		

Maize 2024	1747.07	5.48		
average	1713.29	4.9	349.65	2
Sunflower 2023	811.58	2.14		
Sunflower 2023	716.02	1.4		
average	763.8	1.77	431.53	3
Barley 2024	1733.82	2.23	777.5	5

Based on the analysis of global data on atmospheric carbon sequestration carried out by Mathew et al. (2017), starting from biomass samples and the harvest index calculated for each crop, the carbon sequestered by them was established. For maize, the harvest index was 0.50 and for wheat 0.55. The ratio of carbon emitted and sequestered, comparing organic and conventional technology is shown in Figure 5.

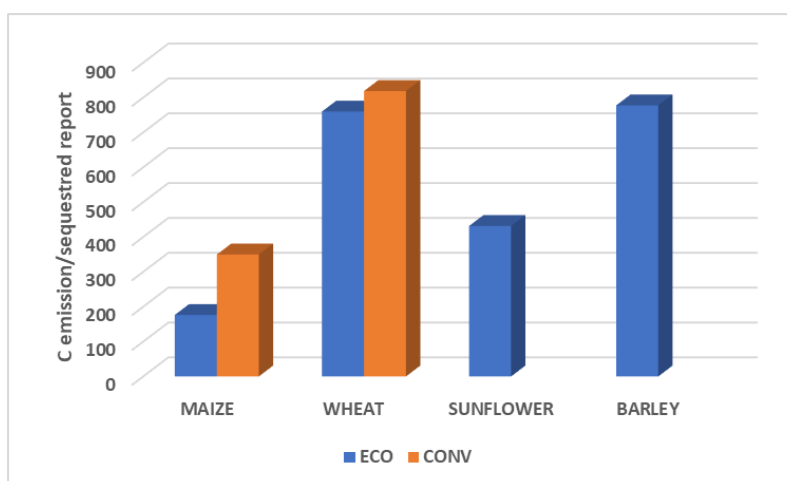


Figure 5. The ratio of carbon emitted and sequestered, comparing organic and conventional technology

At the conventional Trăistaru Farm located in Băilești, the carbon emitted through field operations and inputs had the highest values for maize and wheat compared to that of the organic farm (Figure 6).

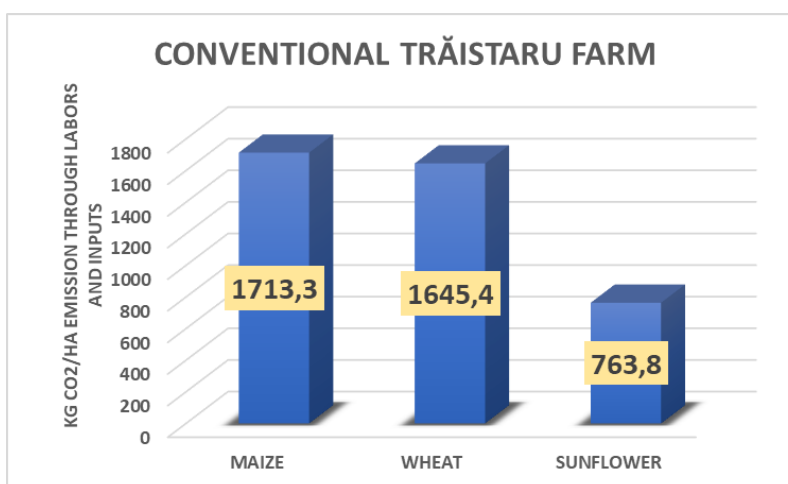


Figure 6. Carbon emitted through works and inputs in 2023 at crops at the Trăistaru Conventional Farm

For sunflower, we did not have a comparison period, but we can mention that this is a more environmentally friendly crop, the amount of carbon emitted being half that of the other two crops. The carbon emitted in large quantities when conventional technology is applied is mainly due to the inputs that are very large and diverse (NP fertilizers, fungicides, herbicides, insecticides, foliar fertilizers). While in conventional the carbon emitted by these has values around 330 kg CO₂/ha, in organic the values are almost identical – 126 kg CO₂/ha.

4. CONCLUSIONS

The evaluated ratio is a numerical value without a unit of measurement that shows how the tons of carbon sequestered relate to the amount of CO₂ emitted by the crop on the surface of 1 ha. Comparatively, the greatest difference between the two technologies is recorded in the maize crop. The difference found in wheat is much smaller given that the higher production from conventional (average over 2 years – 5500 kg/ha) allowed a vegetative development that sequestered a greater amount of carbon and the lower production from organic technology emitted and sequestered less.

5. REFERENCES

- Berca, M. (2021). Sechestrarea carbonului din atmosferă în scopul depoluării, cu ajutorul culturilor agricole și reținerea lui în sol și în producția primară [Sequestering carbon from the atmosphere for the purpose of depollution, using agricultural crops and retaining it in the soil and in primary production]. Retrieved March 5, 2025, from <https://www.probstdorfer.ro/wp-content/uploads/2021/10/SEMINAR-ASAS-25.10.2021-Prof.-Mihai-Berca.pdf>
- Choudrie, S.L., Jackson, J., Watterson, J.D., Murrells, T., Passant, N., Thompson, A., Cardenas, L., Leech, A., Mobbs, D.C., Thistlethwaite, G., Abbott, J., Dore, C., Goodwin, J., Hobson, M., Li, Y., Manning, A., Ruddock, K., Walker, C. (2008). UK Greenhouse Gas Inventory, 1990 to 2006. *Annual Report for sub-mission under the Framework Convention on Climate Change*. Retrieved March 14, 2025, from <http://www.airquality.co.uk/archive/reports/cat07/0804161>.
- de Freitas Seben Junior, G., Corá, J.E., La, R. (2014). Effect of cropping systems in no-till farming on the quality of a Brazilian Oxisol. *Rev. Bras. Cienc. Solo*, 38(4), 1268-1280.
- de Oliveira Ferreira, A., de Moraes Sá, J.C., Harms, M.G., Miara, S., Briedis, C., Netto, C.Q., dos Santos, J.B., Canalli, L.B. (2012). Carbon balance and crop residue management in dynamic equilibrium under a no-till system in Campos Gerais. *Rev. Bras. Cienc. Solo*, 36(5), 1583-1590.
- Gao, T., Liu, Q., Wang, J. (2013). A comparative study of carbon footprint and assessment standards. *Int. J. Low-Carbon Technol.*, 9, 237–243.
- Hypolite, S. (2021). Carbone et energie en agriculture: quels enjeux. Deuxieme partie [Carbon and Energy in Agriculture: What Are the Issues. Part Two]. *Agronomie, ecologie et innovation. TCS*, 114, 10.
- Jarecki, M.K., Lal, R. (2010). Crop management for soil carbon sequestration. *Critical Reviews in Plant Sciences*, 22(6), 471-502.
- Mathew, I., Shimelis, H., Mutema, M., Chaplot, V. (2017). What crop type for atmospheric carbon sequestration: Results from a global data analysis. *Agriculture, Ecosystems & Environment*, 243, 34-46.
- Ozlu, E., Arriaga, F.J., Bilen, S., Gozukara, G., Babur, E. (2022). Carbon Footprint Management by Agricultural Practices. *Biology*, 11(10), 1453.
- Rastogi, M., Singh, S., Pathak, H. (2002). Emission of carbon dioxide from soil. *Current Science*, 82, 510-517.
- Wiedmann, T., Minx, J. (2008). A definition of 'carbon footprint'. *Ecol. Econ. Res. Trends*, 1, 1–11.