Interreg CENTRAL EUROPE
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EUFRAS EUROPEAN FORUM FOR AGRICULTURAL AND RURAL ADVISORY SERVICES

Collaborative Online Forum For Exchange & Engagement

Carbon Farming CE

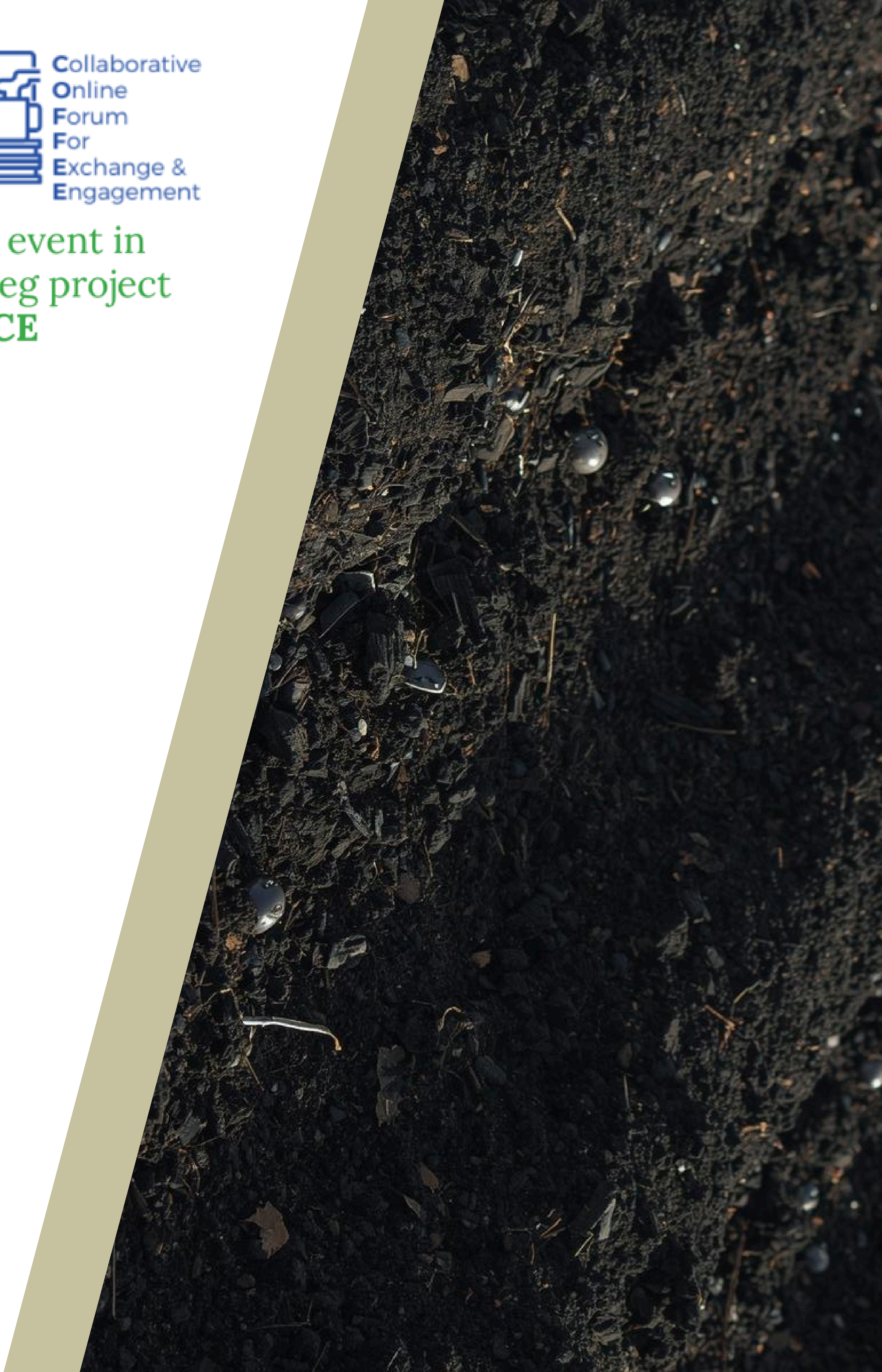
EUFRAS COFFEE Break event in collaboration with Interreg project **Carbon Farming CE**

Fresh insights into carbon farming

HOW IT WORKS AND WHAT'S THE PRICE

Presented by Štěpán Krejčí (Agricultural Research Troubsko)
Moderated by Anita Dzelme (EUFRAS)

ZVT | Agricultural Research, Ltd. Troubsko



About us

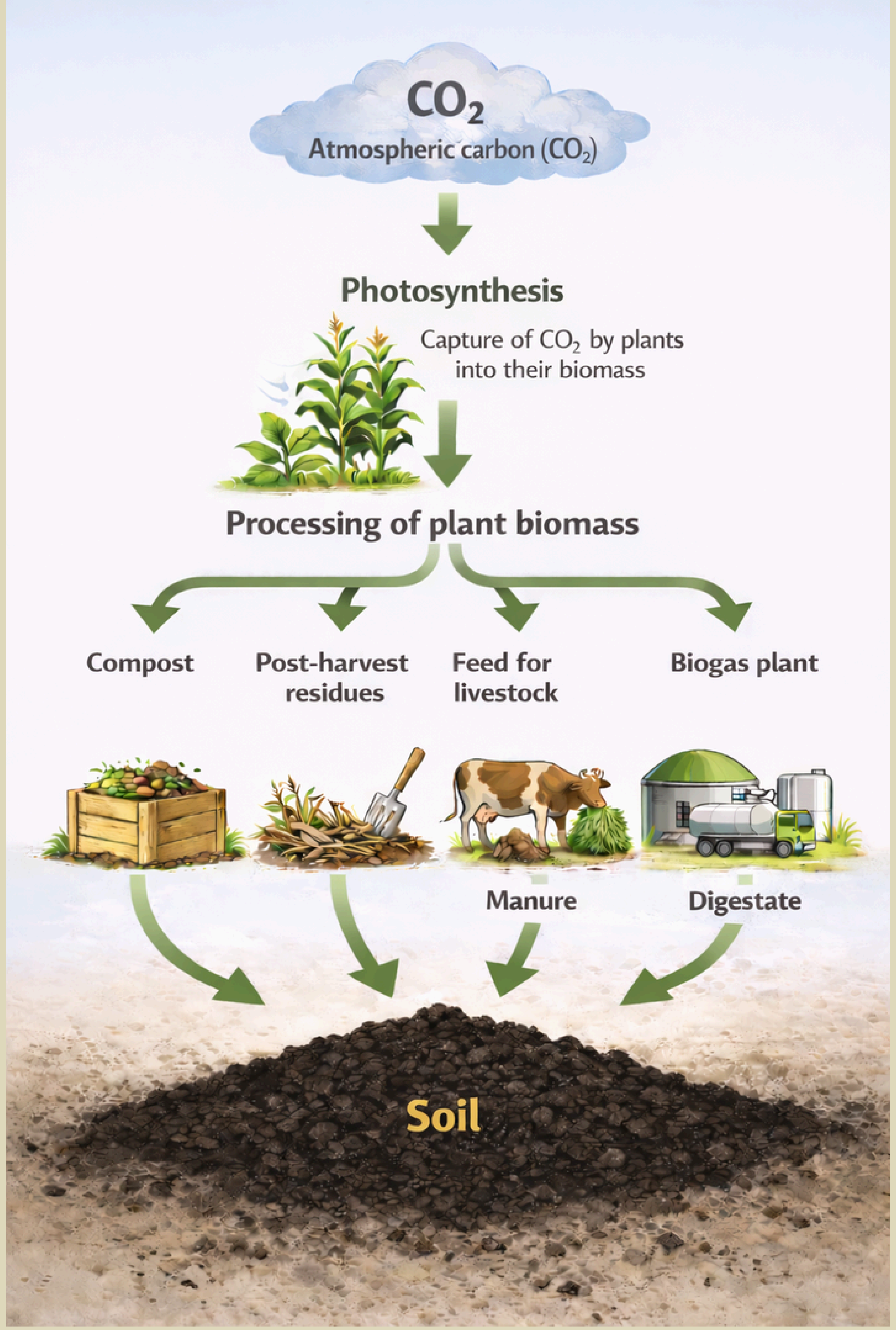
- **Agricultural Research Ltd., Troubsko (ART)**
  - czech private research institute with focus on pedology, anti-erosion measures, fodder species, cover crops, phytopathology, plant protection and much more
  - national and international research projects, seed production, crop breeding, product testing, advisory services in agriculture
- **Mgr. Štěpán Krejčí**
  - researcher at ART, department of agrotechnics
  - currently working on the Carbon Farming CE project

Aerial view of ART facilities in Troubsko, Czech Republic

Carbon farming - general overview

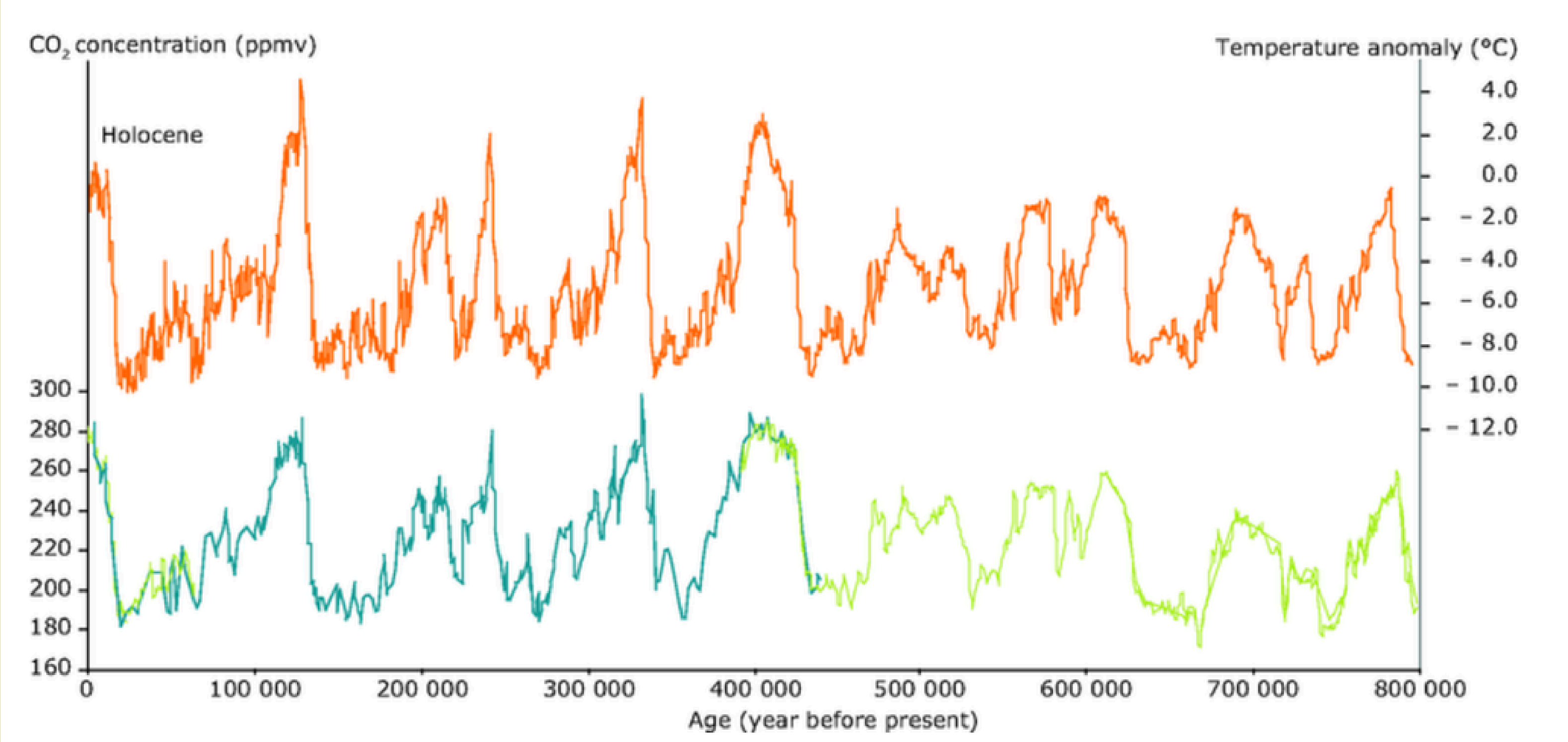
What is carbon farming?

- agricultural approach focused on storing atmoshperical carbon in soil (sequestration) with set of carbon farming techniques
- atmoshperical carbon (CO_2) → photosynthesis in plants → carbon stored in plant biomass → soil
- primary motivation: mitigation of the climatic change
- **“side effects”: improvement of soil quality, lower costs**
- overlap with regenerative agriculture (different motivation, similar outcome)



Carbon dioxide, greenhouse effect and the climatic change

- increased CO_2 concentration in the atmosphere → deflection of heat (infrared) radiation coming from the Earth's surface → trapping of the heat → warming of the surface
- extreme greenhouse effect: Venus (temperature = 460 - 480 °C, pressure = 90 - 93x of Earth's atmospheric pressure)
- effects of the global warming: disturbance of ecosystems and weather cycles → species extinctions, epidemics, pest outbreaks, weather extremes
- current CO_2 level (> 400 ppm) exceeds the variation range of the previous periods



Corelation of CO2 concentration and global mean temperature in the last 800 000 years (European Environment Agency)

Carbon - trouble in the air, blessing in the soil

- carbon content in the soil is positive and desirable
- soil organic carbon → humus
- humus content...
  - improves the physical structure of the soil
  - increases the water holding capacity
  - improves the capability of soil to absorb (hold) nutrients
  - enhances the soil organisms → faster decomposition and nutrient cycle
- partition of soils according to humus content:
  - very low humus soils: < 1 %
  - low humus soils: 1 - 2 %
  - medium humus soils: 2 - 4 %
  - high humus soils: 4 - 8 %
  - very high humus soils: > 8 %

"bad quality"

"good quality"

soil quality

Carbon farming techniques - how to capture carbon into soil <u>and keep it there</u>

- **carbon-capture techniques (promoting sequestrationj:**
    - **organic fertilizing** - application of organic matter on the field increases its content (e. g. compost, manure, biodigestate, biochar)
    - **cover crops*** - input of another organic matter if incorporated, cover of the soil, decreased erosion and desiccation
    - **agroforestry** - stable storage of the atmospheric carbon in tree biomass (wood) for very long periods of time

- **carbon-retaining techniques (limiting desequestration):**
    - **tillage reduction** - lower aeration of the soil → slower mineralization (decay) of the humus
    - **soil covering (mulching)** - prevents evaporation and desiccation, limits aeration and the humus mineralization
    - **cover crops***

Benefits of balanced carbon farming practice

- **increased carbon (humus) content in the soil** - better soil structure and properties - higher water and nutrient holding capacity + microbial nutrient release - **improved water supply, reduction of fertilizer consumption , lower nutrient leaching**
- soil coverage - **erosion limitation, higher water retention**
- tillage reduction - less field operations - **lower fuel consumption, slower machinery aging, less work, less subsoil compaction, limited erosion**
- **enhanced soil organisms** (micro- and macro-) - strenghtening the natural soil-forming process and supporting the ecosystem - **higher resilience of the system towards external factors**
- **SUMMARIZED: inputs and costs reduction, soil health improvement, resilience increase, stabilization (of the system and yields)**

Difficulties and obstacles

- **initial and addtional costs** - new machinery, organic fertilizers, cover crops
- **long time for the positive changes to happen** (humus build-up, yield stabilization) - 5 or more years
- **drop in yield in the first years** of transition to carbon farmingí (especially tillage reduction)
- very delicate and dynamical system of the soil - necessity of careful and thoughtful planning and combination of techniques

Carbon credits - controversy and opportunity

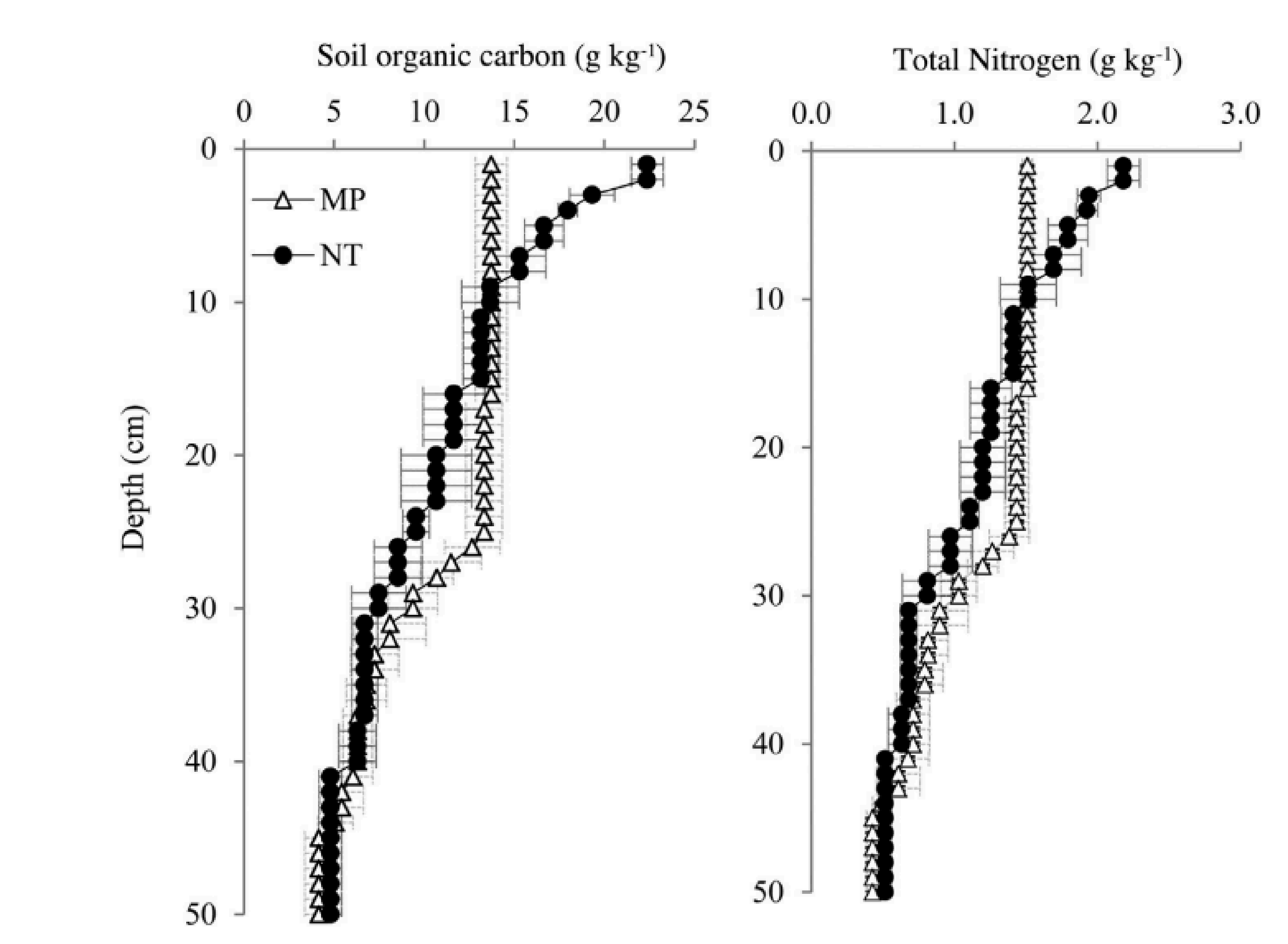
- carbon farming related business
- farmer captures the atmospherical carbon in his field → carbon credit is produced
- carbon credit trader “buys” the credit from the farmer and sells it to companies
- companies improve their PR and declare climatic awareness and responsibility by purchasing carbon credits
- controversy: uncertainity about the certification, trustworthyness, methodologies
- ON THE OTHER HAND... an opportunity how to get started and how to get advisory and recommendations for their shift to carbon farming + extra income

Case study: Martínez et al. 2016

- long-term experiments (up to 20 years) with multiple crop species in no-till system with cover crops
- Oberacker, Switzerland (sandy loam)
- in long-term no-till systems with cover crops, a slight increase or maintenance of yields occured in comparison to conventionally farmed land

Crop	*N*	Yield NT	Yield MP	$100\frac{Yield_{NT}}{Yield_{MP}}$
Winter barley	20	65.9 *a*	62.2 *b*	105.9
Sugar beet	20	11.5	11.9	96.6
Silage maize	20	199.9	198.7	100.6
Winter wheat	19	55.0 *a*	51.9 *b*	105.9
Spring peas	8	42.5 *a*	37.3 *b*	113.7
Spring field beans	6	30.9 *a*	26.3 *b*	117.3
Winter rye	6	59.5	58.6	101.5
Winter peas	5	32.1 *a*	26.6 *b*	120.9
Potatoes	5	341.1 *b*	399.5 *a*	85.4
Ley	2	n/a	n/a	n/a
Soybean	2	26.3	29.4	89.7
Winter field beans	1	23.6	29.0	81.2
Spring wheat	1	60.5	49.7	121.5
Average all crops				102.6

Various crop yields; N = years of cultivation (experiment), NT = no-till system, MP = conventionally farmed land



Soil organic carbon (left) and total nitrogen (right) contents in the depth gradient; NT = no-till system, MP = conventionally farmed land

Case study: Kumar et al. 2012

- long-term experiments (nearly 50 years) focused on comparison of conventional, no-till and reduced-tillage systems in very long term on two sites with different soil types (sandy loam and clay loam)
- Ohio, USA
- robust data with interesting conclusions: minimal differences in yields, soil structure improvemet, water capacity enhancement and organic carbon build-up in no-till and reduced-tillage systems in respect to the conventinally farmed land

Treatment†	Corn yield 2007	2008	2009	2010	2011	Avg.‡
	Mg ha^{-1}					
			Wooster			
Tillage						
PT	10.5 a§	10.6 b	14.1 a	13.0 a	11.9 b	12.0 b
MT	10.7 a	12.3 a	14.4 a	13.5 a	14.1 a	13.0 a
NT	9.1 b	10.4 b	12.9 b	11.1 b	13.3 a	11.4 b
			Hoytville			
Tillage						
PT	9.1 a	6.8 b	9.3 a	9.2 a	11.4 a	9.1 a
MT	8.7 a	6.6 b	9.2 a	9.8 a	11.5 a	9.2 a
NT	8.8 a	7.6 a	9.7 a	8.9 a	11.6 a	9.3 a

Corn yields between 2007 and 2011; for descriptions see the "Soil organic carbon" figure

Treatment†	SOC 0–10 cm	SOC 10–20 cm	SOC 20–30 cm	SOC 30–40 cm	SOC Stock 0–10 cm	SOC Stock 10–20 cm	SOC Stock 20–30 cm	SOC Stock 30–40 cm
	g kg^{-1}				Mg ha^{-1}			
			Wooster					
Tillage								
PT	14.0 c‡	9.52 b	7.01 ab	5.05 b	16.8 c	13.2 b	10.2 ab	7.53 a
MT	15.1 c	12.7 a	7.61 ab	5.21 b	17.3 c	17.2 ab	10.4 ab	7.55 a
NT	18.8 b	14.0 a	5.43 b	3.41 b	20.7 b	18.4 a	7.41 b	4.83 a
WL	26.8 a	16.1 a	11.4 a	6.53 a	28.9 a	21.3 a	15.7 a	9.43 a
			Hoytville					
Tillage								
PT	15.1 c	12.8 c	10.8 b	7.07 b	17.7 c	15.9 c	13.7 b	9.85 b
MT	17.9 b	15.5 bc	10.6 b	8.65 b	20.5 bc	17.9 bc	12.1 b	11.2 ab
NT	19.9 b	17.1 b	9.89 b	8.45 b	22.1 b	19.7 b	12.1 b	10.5 b
WL	56.5 a	38.9 a	22.5 a	16.2 a	62.6 a	33.4 a	27.0 a	19.8 a

Soil organic carbon; PT = conventional system, MT = reduced-tillage system, NT = no-till system, Wooster = sandy loam site, Hoytville = clay loam site

Treatment†	AWC 0–10 cm	AWC 10–20 cm
	m^3 m^{-3}	
	Wooster	
Tillage		
PT	8.30 d‡	6.40 d
MT	10.2 c	8.70 c
NT	13.4 b	10.1 b
WL	14.2 a	13.2 a
	Hoytville	
Tillage		
PT	8.00 c	7.70 d
MT	11.2 b	8.70 c
NT	15.6 a	11.4 b
WL	15.8a	13.5 a

Available water content in two depths, for descriptions see the "Soil organic carbon" figure

Recent research topic, direction of tomorrow?

- ongoing european research projects focused on carbon farming: Carbon 4 Soil Quality, Carbon Farming Centra Europe (elaborated by ART)
- regarded by some as a necessary direction of future development
- significant differences around the world
- sensitivity of the carbon cycle (in soild) to the microclimatic conditions → need for original data for specific local environment (more research needed)
- slow dynamics of the system transition (adaptation) - long-term experiments needed

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CARBON 4 SOIL QUALITY

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Carbon Farming CE

Carbon Farming CE

Project Carbon Farming CE

- international project Interreg
- 2023 - 2026
- carbon farming techniques testing → cooperation models → realization and upscaling of the models
- studied techniques:
  - **organic matter application**
  - **tillage reduction**
  - **cover crops**
  - **post-harvest residues (mulching)**
  - liming
  - agroforestry
  - **diversification of crop rotation**

oficial project website

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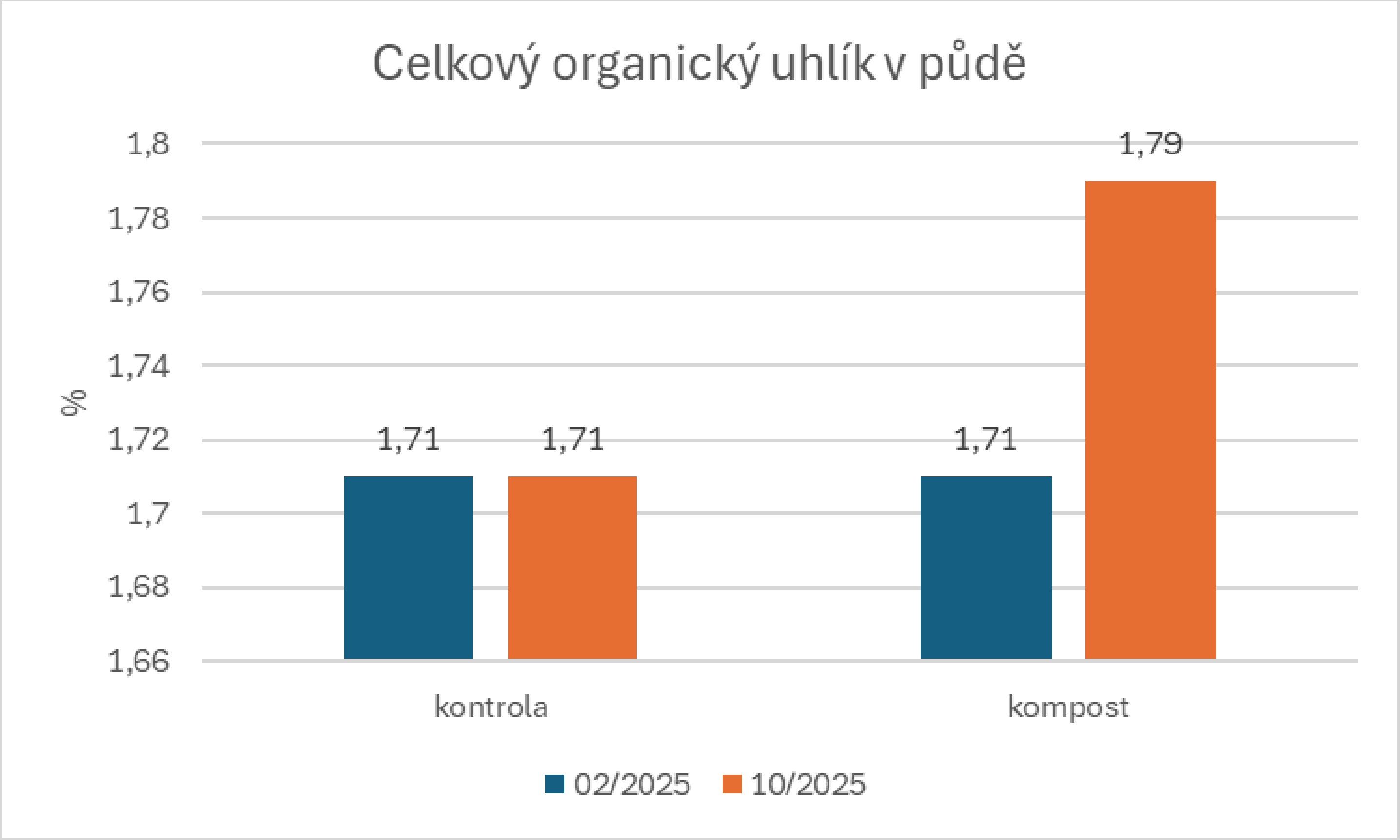
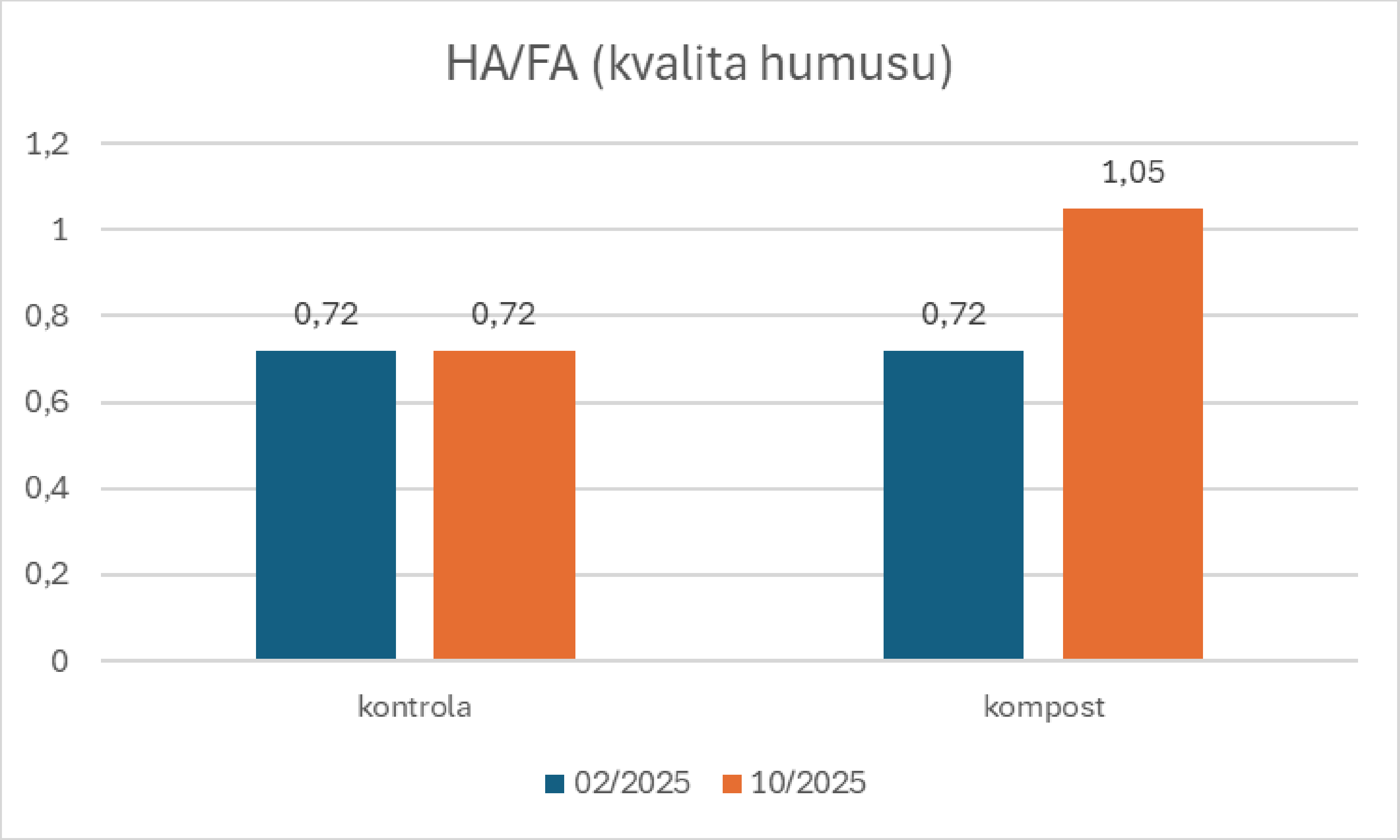
Carbon Farming CE

Carbon Farming CE - selected results: organic matter application (Czech Republic)

- surficial compost application without incorporation (20t/ha)
- season 2023 (Feb -Oct)
- experimental plots: 2 x (100 x 20) m = 4000 m^2

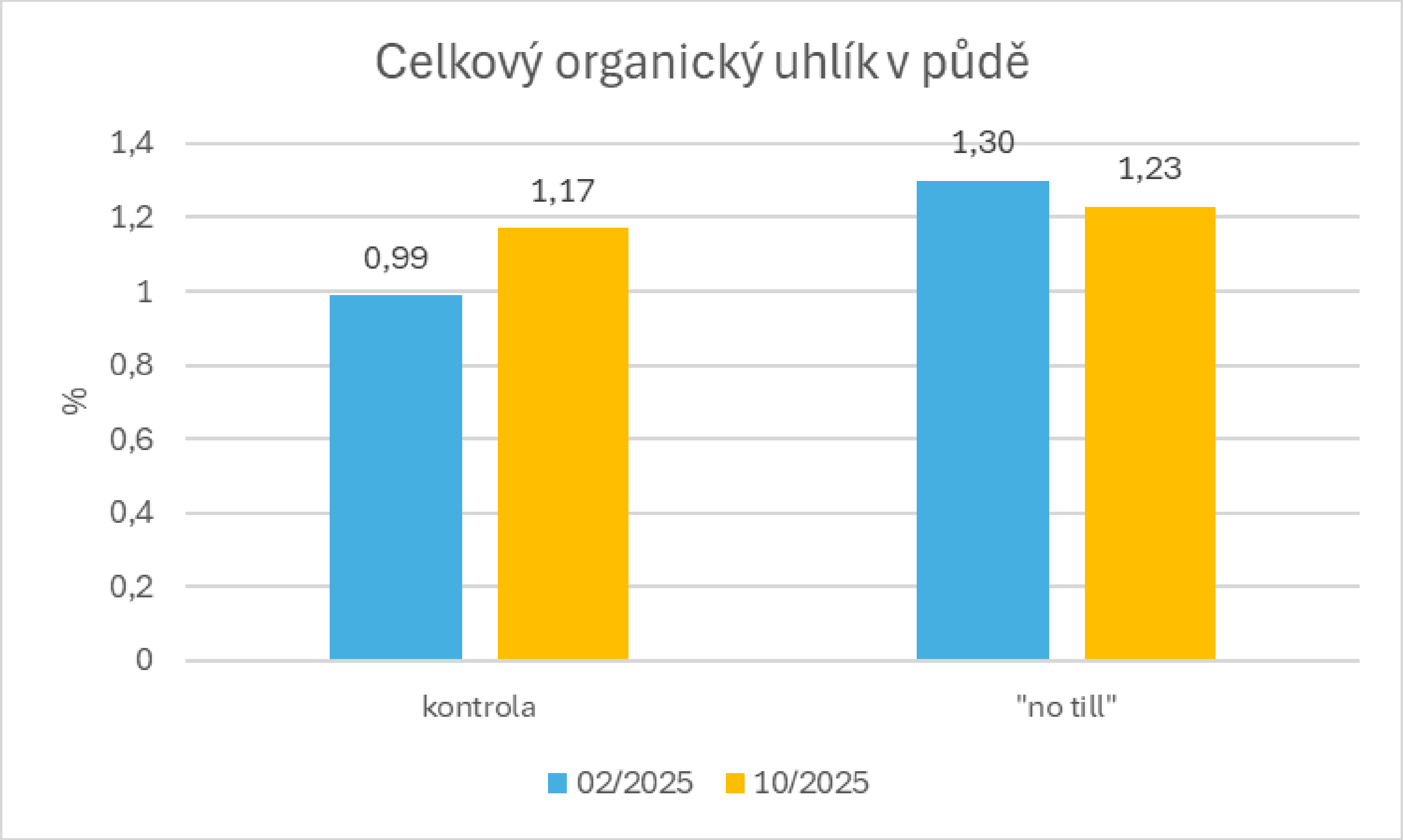




Carbon Farming CE - selected results: tillage reduction (Czech Republic)

- no-till system
- season 2024 (Feb - Oct)
- experimental plots: 2 x (30 x 10) m = 600 m^2

Conventionally farmed (left) and no-till (right) systems

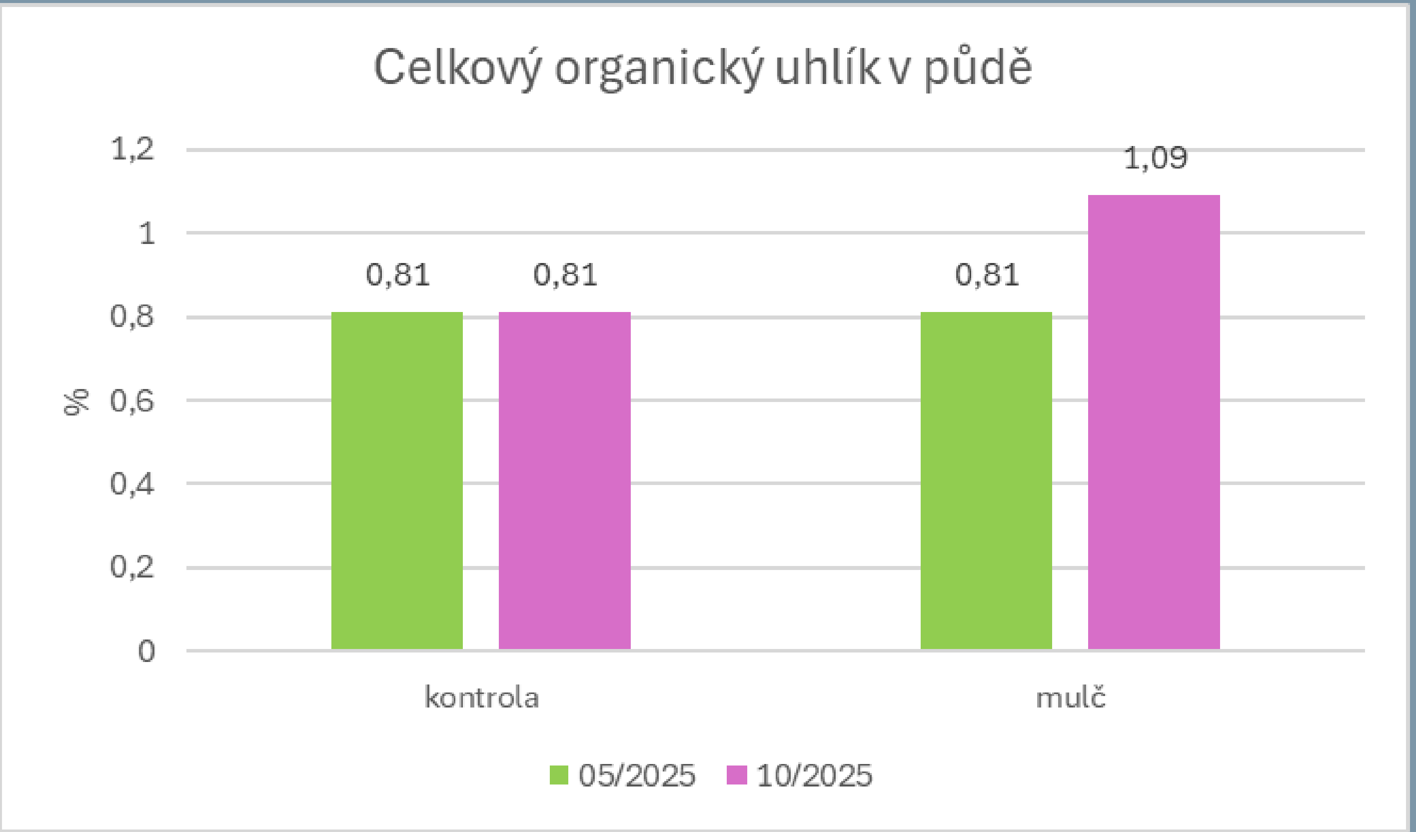


Total soil organic carbon

Carbon Farming CE - selected results: mulching (Czech Republic)

- (post)harvest residues: fresh biomass of fodder Galega (*Galega orientalis)* - mulched in two rounds (21,5 t/ha + 20,8 t/ha)
- season 2024 (May - Jul - Oct), Troubsko
- experimental plot size: 2 x (30 x 10) m = 600 m^2

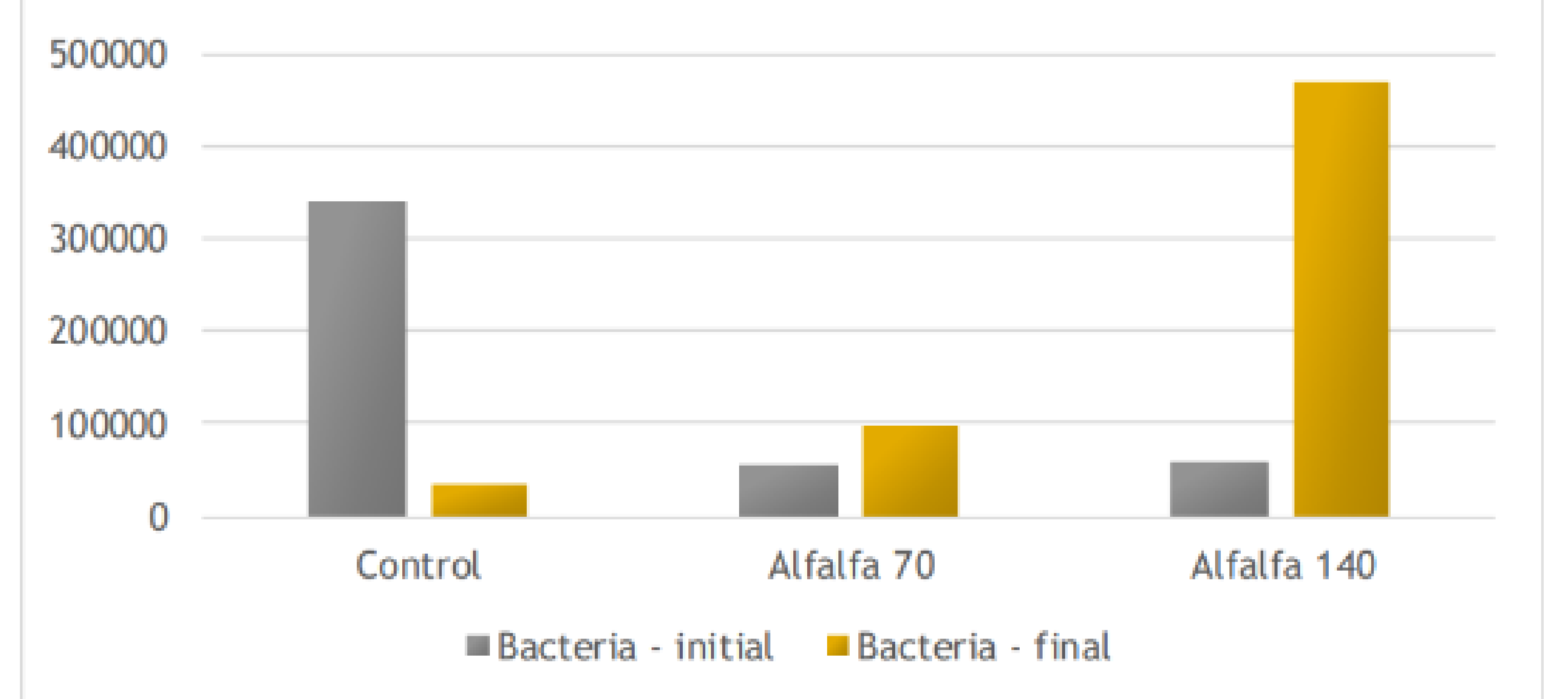
First harvest of *G. orientalis*, May 2024



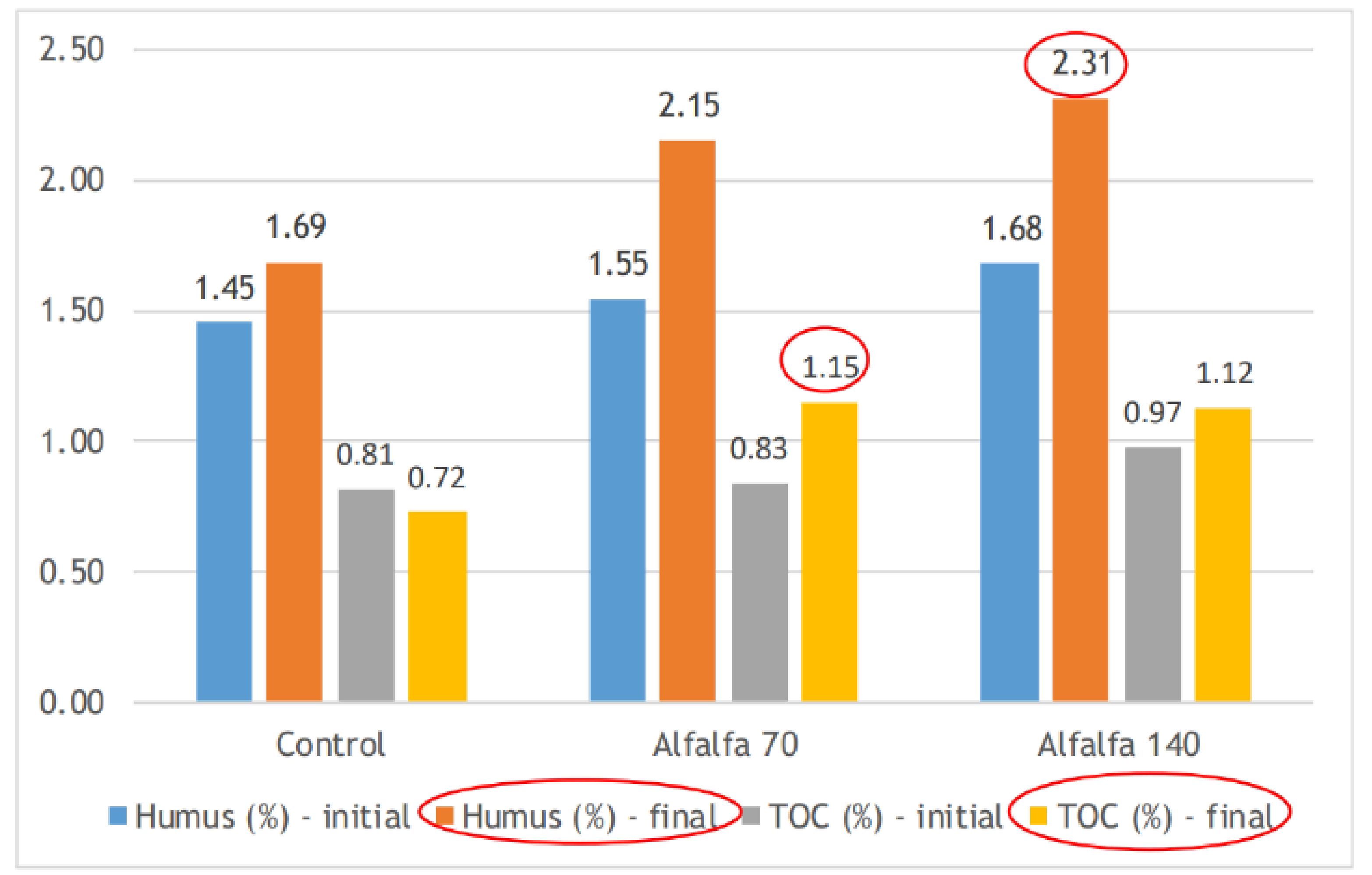
Total soil organic carbon

Carbon Farming CE - selected results: mulching (Croatia)

- (post)harvest residues: fresh Alfalfa biomass - mulched in two different doses - variants (70 m^3/ha X 140 m^3/ha), corn
- season 2024 (Apr - May - Sep), Osijek (CRO)
- experimental plot size: 3 x 216 m^2 = 648 m^2



Bacterial colonization of the soil (CFU/g) before sowing/after harvest

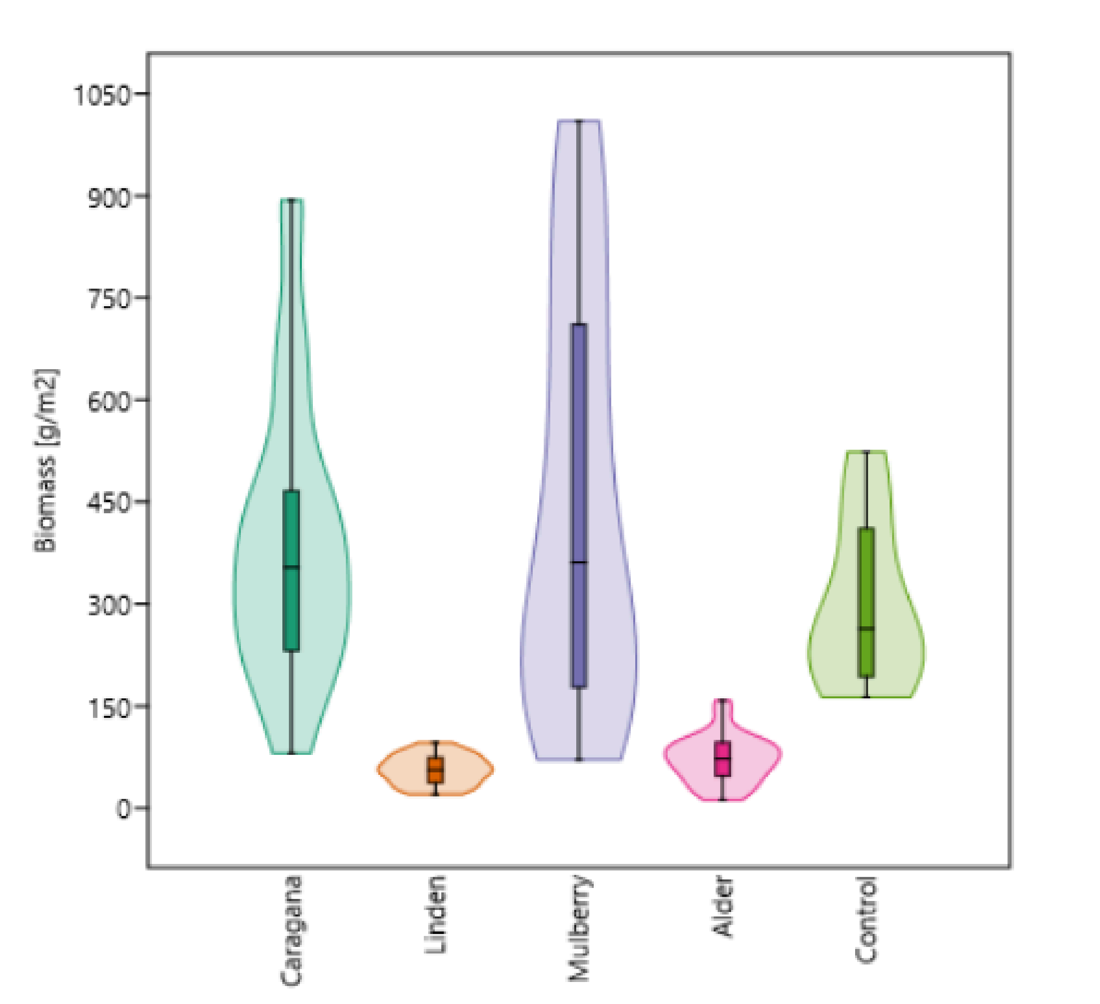


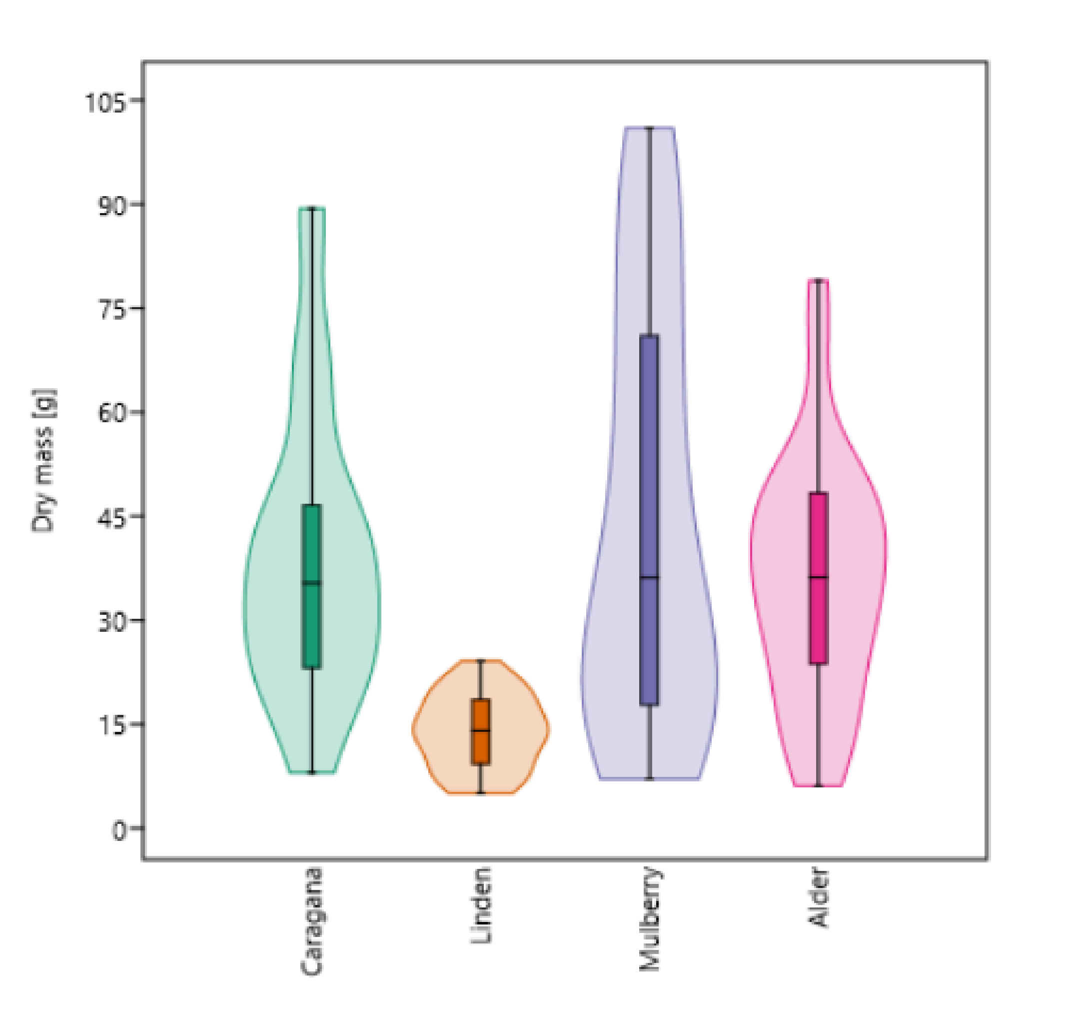
Total organic carbon and humus content in the soil

Carbon Farming CE - selected results: agroforestry (Poland)

- silvopastoral system - 5 tree species: alder, mulberry, caragana, willow, linden
- area of 1,5 ha, cattle grazing
- annual tree sprouts directly for grazing

Caragana aborescens

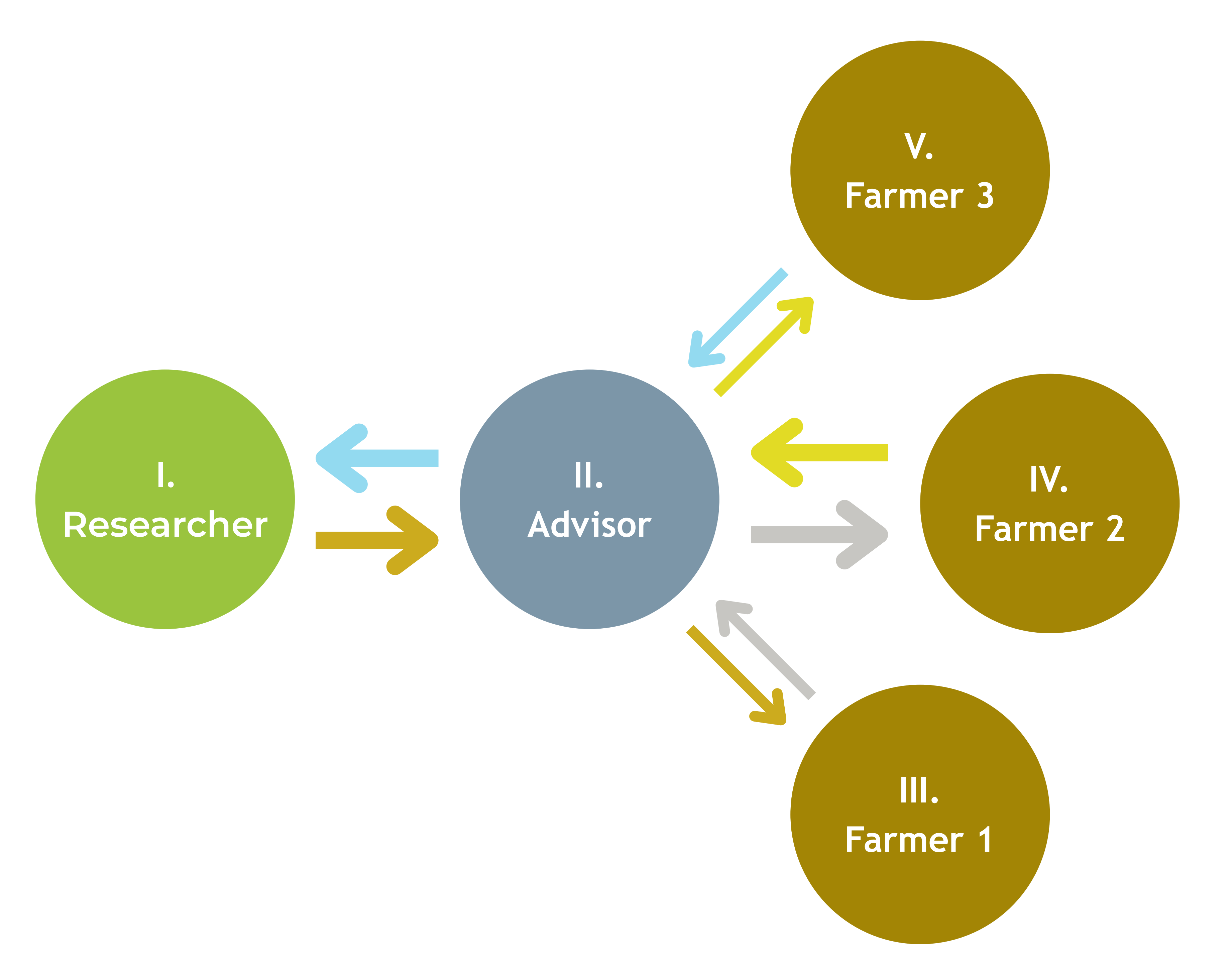




Fresh biomass (left) and dry biomass (right)of various tree species; from the left: caragana, linden, mulberry, alder, (control - ryegrass)

Carbon Farming CE - “Knowledge transfer” type model

- transfer of the knowledge from researchers to the farmers (straight, or through advisors)
- **collaboration of farmers and researchers on further research**
- **advisory and counselling from researchers to the farmers**



Recent carbon farming-relevant studies from Agricultural Research Ltd., Troubsko

- organic matter application
  - compost
  - digestate

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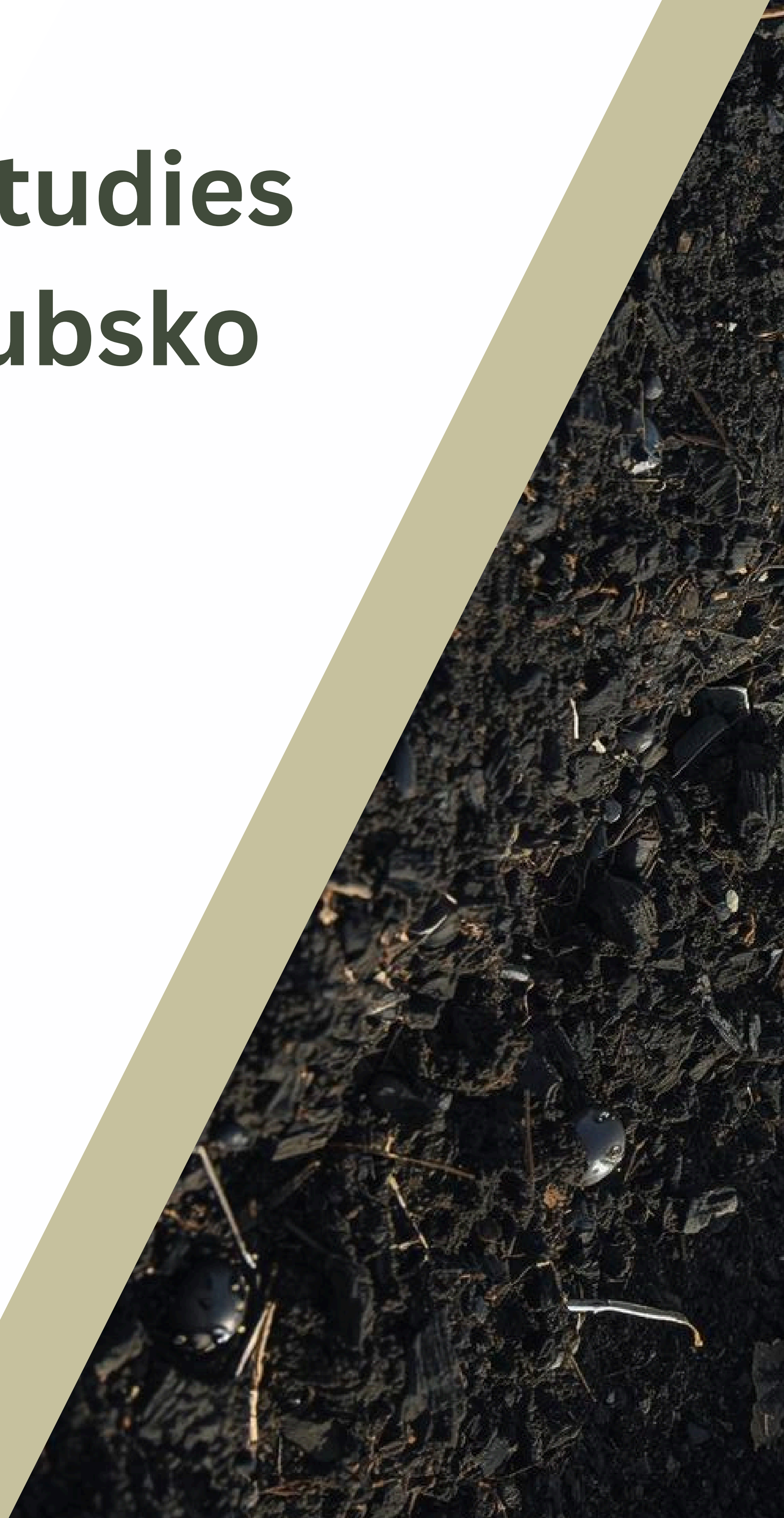


Application of compost without incorporation

- application of compost = organic fertilizing - **addition of organic matter**
- surficial application (without incorporation) = **mulching**
- quality of the compost - crucial aspect
  - C:N = 20 - 30
  - humidity: 40 - 65 %
  - maturing at least 180 days, stable temperature below 40 °C
- experiment duration: **2022 - 2024 (3 years)**
- 3 experimental sites with loamy soils, different application doses and different (locally available) composts:
  - **L1: 30 t/ha** (cambisol, compost C:N = 13, compost N = 500 mg/kg)
  - **L2: 200 t/ha** (cambisol, compost C:N = 6, compost N = 1300 mg/kg)
  - **L3: 30 t/ha** (chernozem, compost C:N = 12, compost N = 2900 mg/kg)

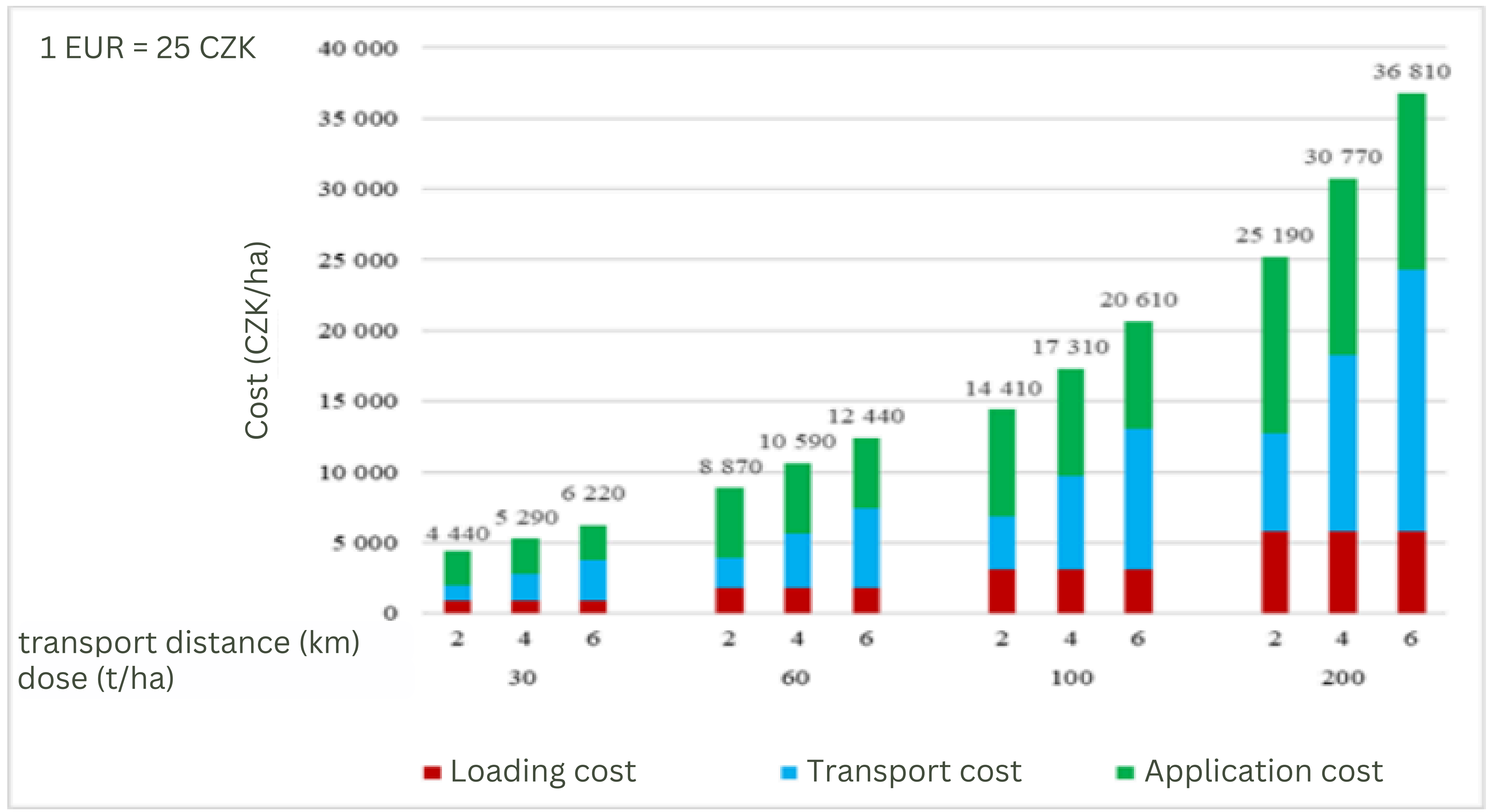
Application of compost without incorporation - results

- soil data:

site	treatment	C_org [%]	HA/FA [%]	N [%]	P [%]	K [%]
L1	control	1.71	1.05	0.18	0.12	0.25
	compost	1.79	0.89	0.18	0.13	0.25
L2	control	1.13	0.69	0.22	0.06	0.25
	compost	1.83	0.51	0.29	0.05	0. 65
L3	control	0.98	0.90	0.15	0.01	0. 11
	compost	1.05	1.22	0.16	0.02	0. 15

Application of compost without incorporation - economy

- most important factors:
  - dosage: **< 100 t/ha**
  - transport range (compost plant - field): **10 - 12 km**
- no incorporation → 20 - 30 % save
- costs analysis:



Digestate application

- digestate = “waste” from biogas plants
- solid + liquid component
  - solid fraction: organic matter
  - liquid fraction: readily available nitrogen (amonia)
- total digestate produced in Europe annually: 130 mil. tons
- pros and cons; needs to be managed carefully
- pros:
  - supports circular economy
  - can bring strong fertilizing effect (higher yields)
  - cheap
- cons:
  - low quality (unstable) organic matter
  - pollution risk (application in the spring)
  - has to be accompanied by fresh organic matter and incorporated immediatelly

Digestate application - experiment

- application of digestate as fertilizer
- **2018 - 2021 (4 years)**
- 3 treatments:
  - **C - control** (no digestate)
  - **T1 - 20 t/ha, applied once in 2 years**
  - **T2 - 20 t/ha, applied every year**

- results:
  - **increased yields**
  - **higher stability of soil aggregates**
  - **increase in C_{org} and humus contents**
  - **increased P and K content**

Year		2018	2019	2020	2021
Crop		winter wheat	winter rye	winter wheat	spring barley
Treatment	C	3,36	4,45	5,78	4,43
	T1	4,52	4,68	6,47	4,79
	T2	5,08 ⟸	4,87 ⟸	6,94 ⟸	4,91 ⟸

Crop yields in the particular years of experiment

Digestate application - economy

- digestate - cheap, but application - expensive
- mineral nitrogen - expensive, application - cheap
- comparison of equivalent N dose for a hectare from digestate and mineral N fertilizer:

DIGESTATE

- 1 ton of digestate: 150 - 200 CZK (6 - 8 EUR)
- transportation (biogas plant - field) in **5 km range** + application: 800 - 1 500 CZK (32 - 60 EUR)
- **total: 3 800 - 5 500 CZK (152 - 220 EUR) per hectare**

MINERAL N

- equivalent N dose to that of 1 t of digestate: 10 500 - 11 500 CZK (420 - 460 EUR)
- application: 500 CZK (20 EUR)
- **total: 11 000 - 12 000 CZK (440 - 480 EUR) per hectare**

ENCOURAGEMENT: CONSIDER TRYING CARBON FARMING

- **for more information, advisory/consultations or possible future collaboration on carbon farming-promoting projects, leave us your contact and mark your interest in this form:**

Reference

- Martínez, I., Chervet, A., Weisskopf, P., Sturny, W. G., Etana, A., Stettler, M., ... & Keller, T. (2016). Two decades of no-till in the Oberacker long-term field experiment: Part I. Crop yield, soil organic carbon and nutrient distribution in the soil profile. *Soil and Tillage Research, 163*, 141-151.

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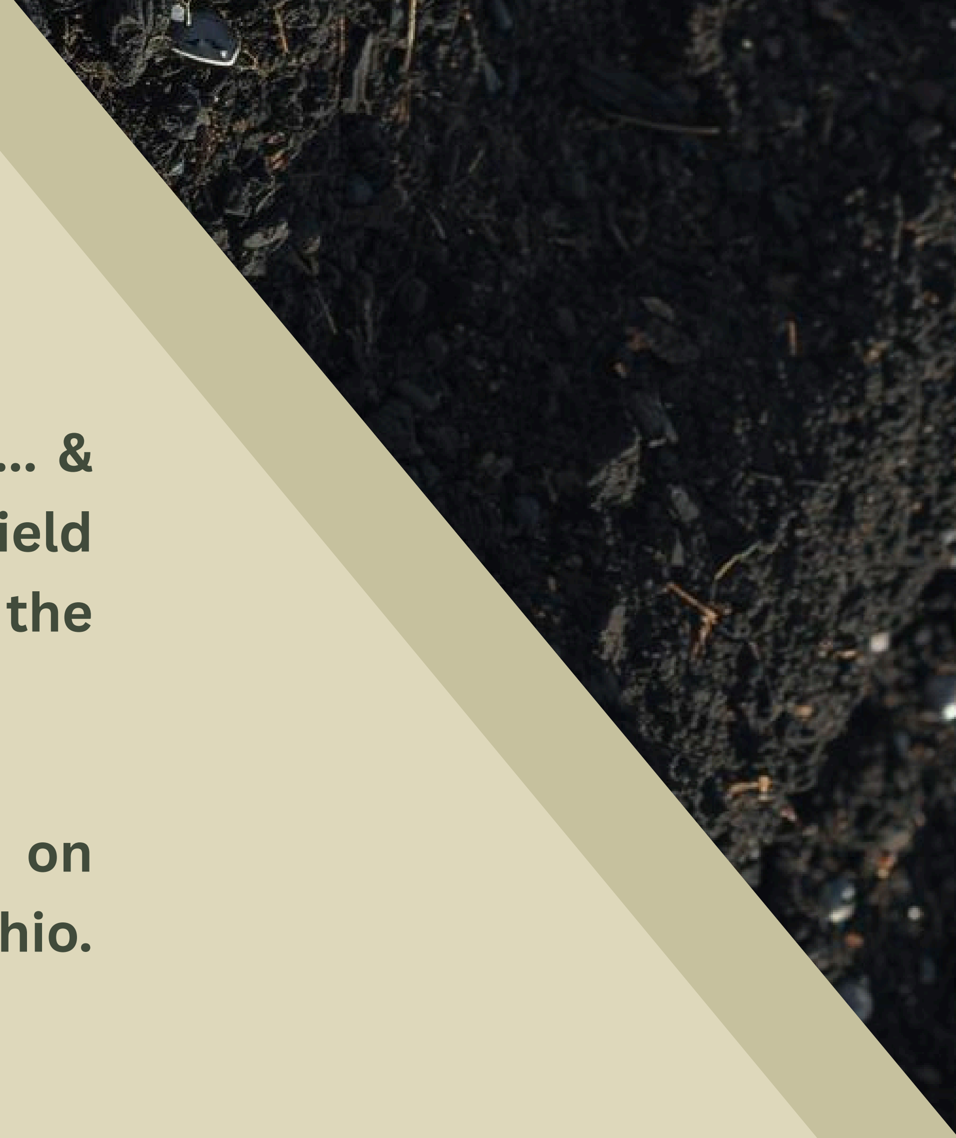

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Thank you for your attention!

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