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Conservation agriculture
For living soil and economic survival of the farmer

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Lecture
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(Postojna, SI)
Online 19th Summer Academy
“Regenerative Agriculture. A bold step towards sustainability”
Sept 8, 2021

Four levels of regenerative agriculture, organized as successive stages

(Soloviev E.R. and Landua G. “Levels of Regenerative Agriculture,” Terra Genesis International, 2016; Soloviev, “Lineages of Regenerative Agriculture, 2018)

1. a **“functional”** level focused on best practices that regenerate soil health and sequester carbon;

2. an **“integrative”** level focused on more holistically designing farms to improve the health and vitality of the wider ecosystem, not just soil;

3. a **“systemic”** level that views the farm within wider ecosystems of enterprises building multiple forms of capital; and

4. an **“evolutionary”** level involving “pattern understanding of the place and context” within which agriculture takes place.

Conservation/regenerative agriculture

Mandatory targets – functional level

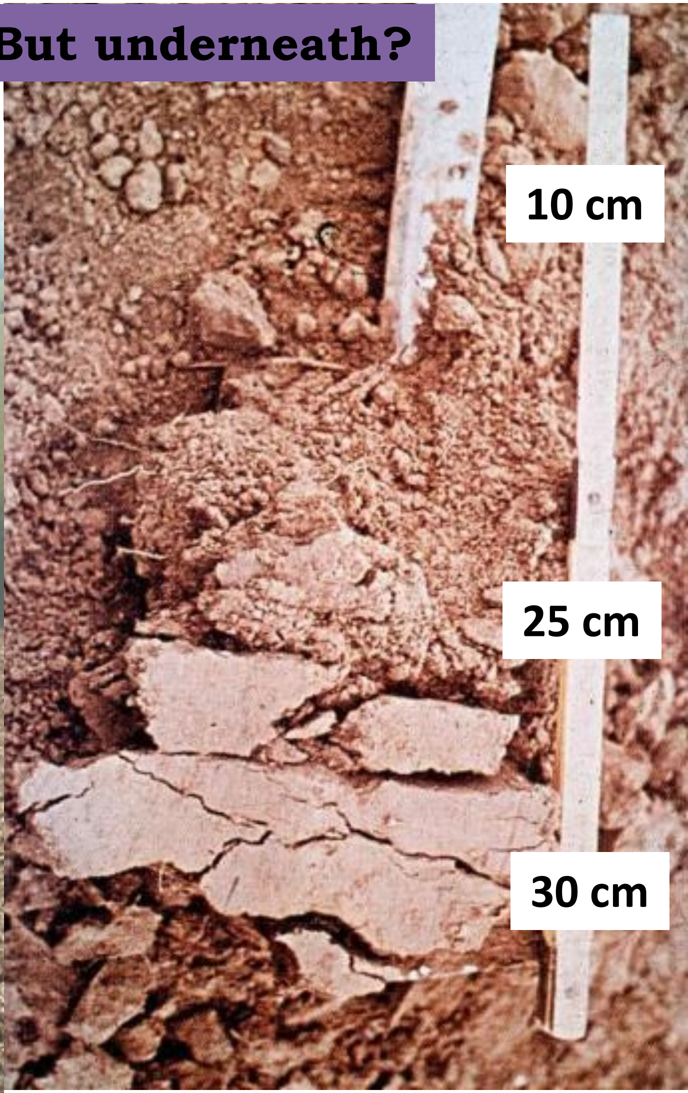
1. reducing the intensity of tillage
2. increasing the content of organic substance in top-soil (carbon sequestration) measurable after 5 years
3. at least 30% of soil surface permanently covered (by crops or crop residue)
4. increasing biodiversity of agroecosystem

Draw backs of conventional agriculture

(ploughing, soil turning, exposing bare soil to drought, compaction, and erosion)

Modern conventional tillage agriculture – high mechanical disturbance, bare soil, poor diversification, high agro-chemical, energy & capital, high cost …….

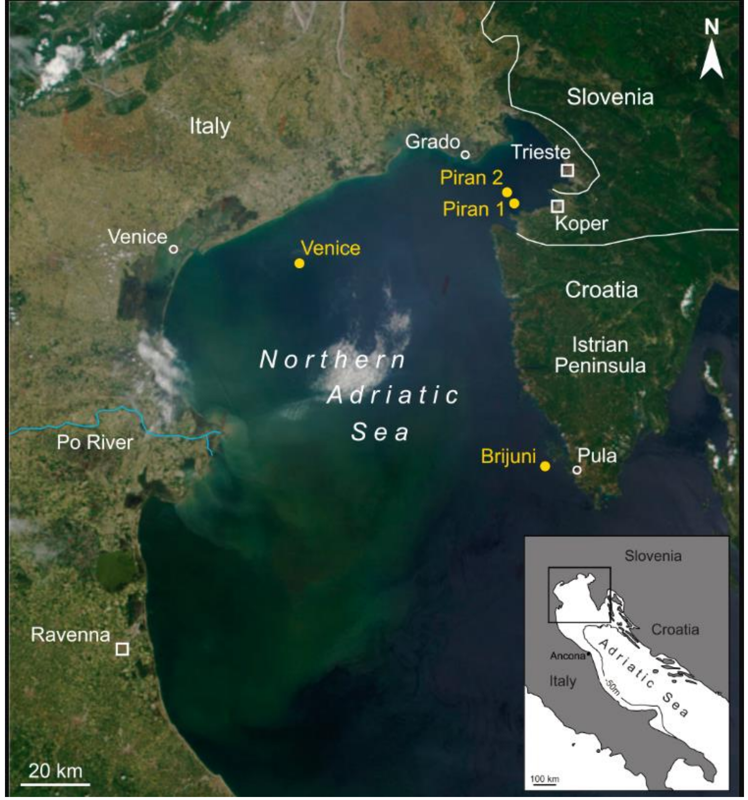
But underneath?

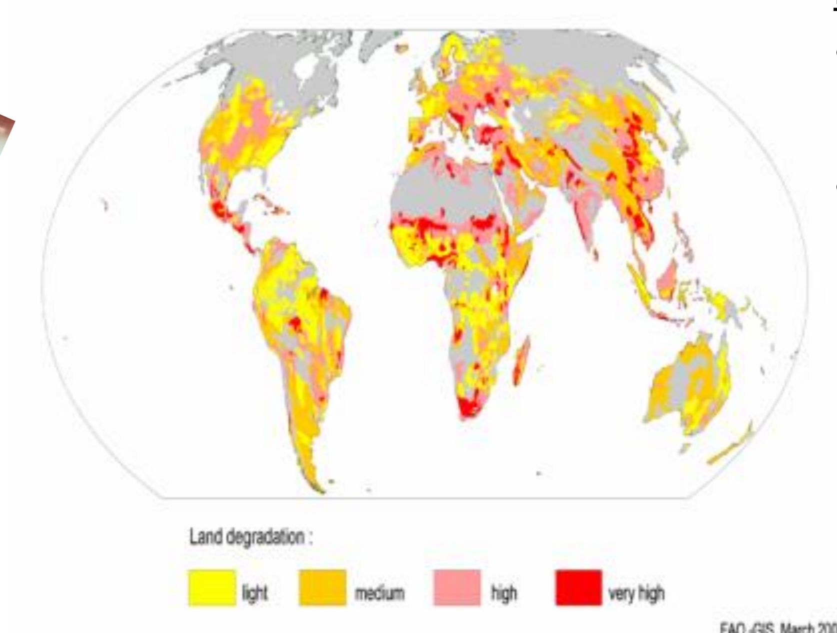


Agricultural degradation

Leading to global change

PALAIOS (2019) 34 (3): 121-145.
https://doi.org/10.2110/palo.2018.068





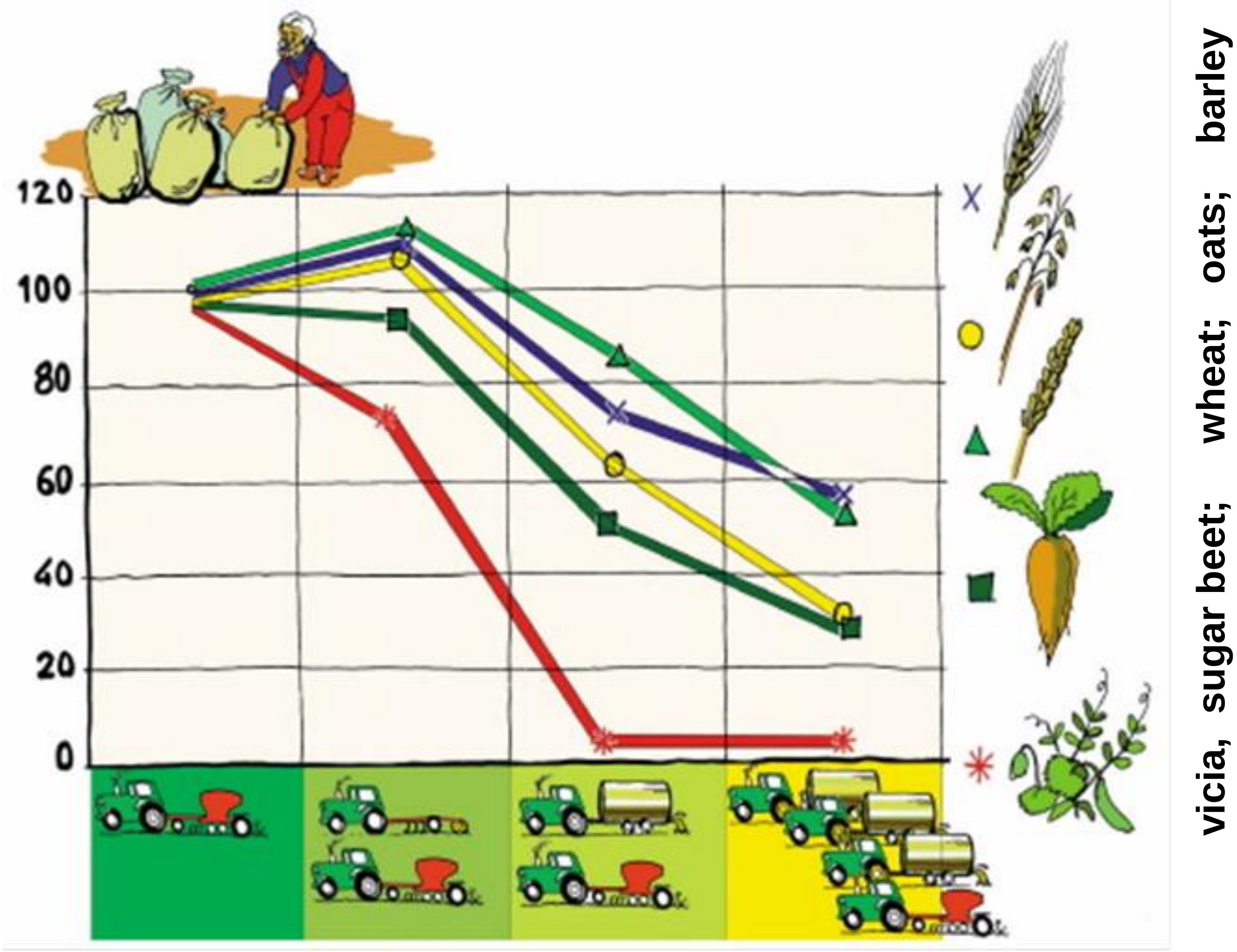
FOR AGRICULTURE, FARMER & SOCIETY

- Higher production costs, lower farm productivity and profit, sub-optimal
- yield ceilings, poor efficiency and resilience, poor adaption & mitigation
- climate change

FOR LANDSCAPE, ENVIRONMENT & SOCIETY

- Dysfunctional ecosystems, loss of biodiversity,
- degraded ecosystem services - water, carbon, nutrient cycles, suboptimal water provisioning & regulatory water services etc.

Compaction effect on crop yield due to intensive tillage, and traffic over field



Heavy machinery compacts the plowed soil

Conservation tillage enables better traffic-ability

Erosion of the conventionally tilled (plowed) soil is better visible from a bird perspective

Soil plowing and intensive driving over such soil causes high erosion risk

surface water is turbid, and muddy due to poor soil structure stability

Center for Soil and Environmental Sciences

Conservation Agriculture as a basics for sustainable development



http://www.fertilcrop.net

Four basic principles for maintaining and improving **soil health**

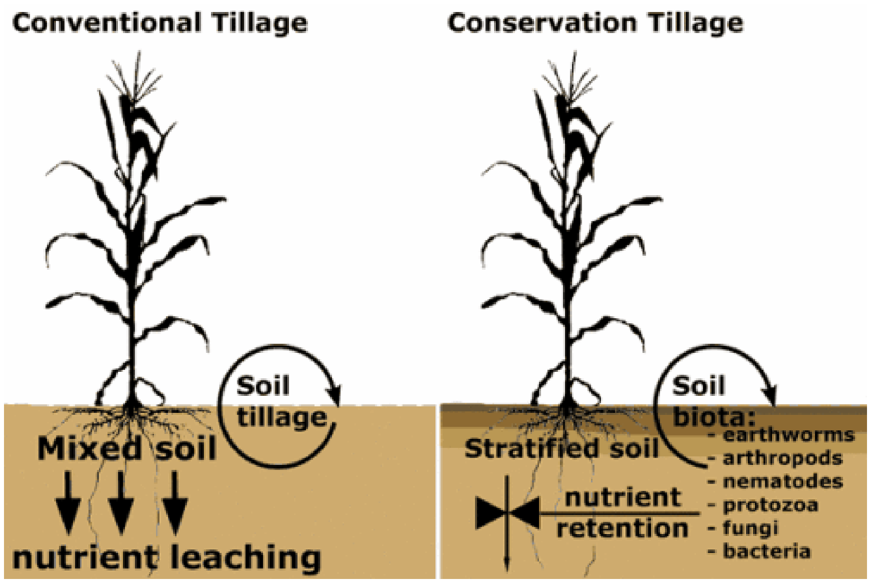
(The USDA Natural Resources Conservation Service; NRCS)

1. **Disturb the soil as little as possible**

2. **Keep the soil covered as much as possible**

3. **Keep plants growing throughout the year to feed the soil**

4. **Diversify crop rotations as much as possible, including cover crops**



less operations, but not simple

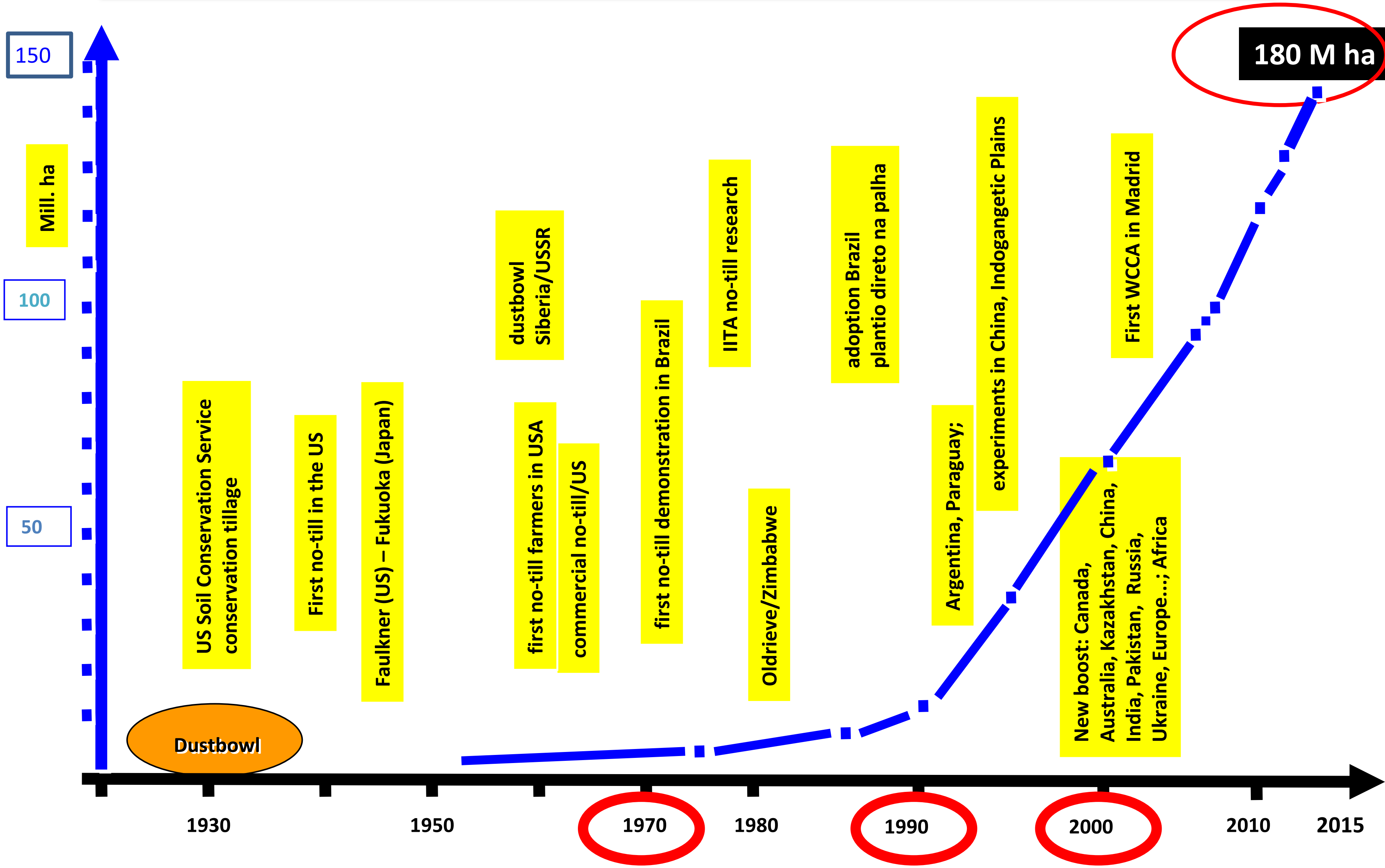
special knowledge, experience and machinery is needed

Minimum soil disturbance

Cover crops

Worldwide History and Adoption of CA (2015/16)

Since 2008/09 increasing at 10.5 M ha annually

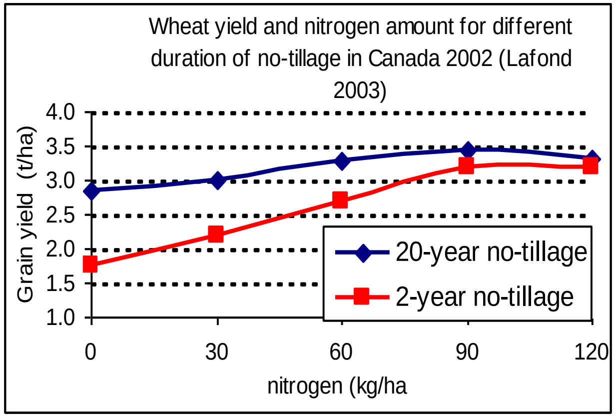


Patterns of deliverable benefits with CA

for small or big farms (A. Kassam, 2019)

AGRICULTURE, FARMER & SOCIETY

- Increased & stable yields, higher productivity & profit (depending on level and degradation)
- Less agrochemicals: less fertilizer (up to 50%) & pesticides
- (up to 20-50%)
- Less machinery, energy & labour cost (50-70%)
- Less water needs (30-40%)



LAND, ENVIRONMENT & SOCIETY

- Can feed more people & animals (carrying capacity)
- Lower impact of climate change – adaptation & resilience to drought, floods, heat, cold
- Climate change mitigation – carbon sequestration & lower GHG emissions
- Environmental services and lower environmental cost (water, infrastructure)
- Rehabilitation of degraded lands & ecosystem services







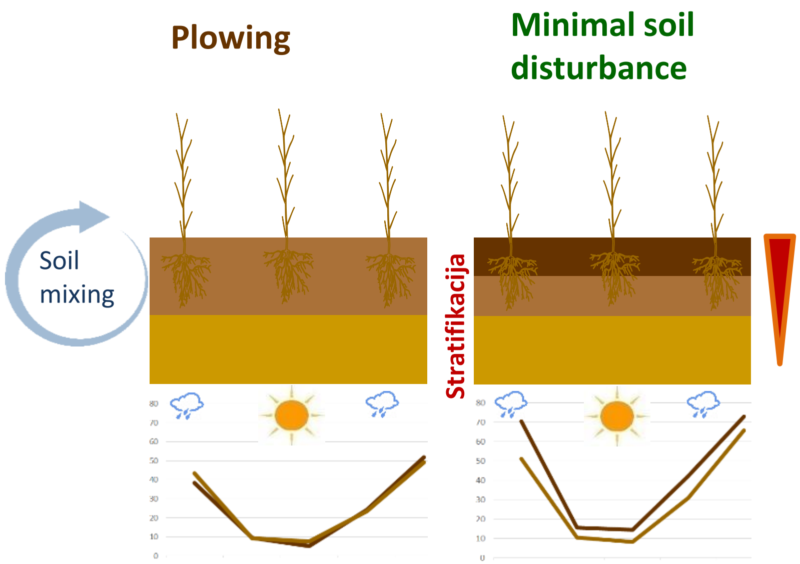






Our Long Term Field Experiments

Conservation Agriculture improves soil



Longterm field experiments

Mihelič, Suhadolc et al.:

- Biology and fertility of soils, **2015**, 51: 923-933.
- Soil Biology & Biochemistry, **2018**, 120: 233-245.

- Soil organic matter
- Structure stability
- Water infiltration
- Water retention
- Nutrient retention
- Microbial biomass
- Abundance of bacteria and fungi
- Functioning of soil organisms
- Earthworm abundance and biomass

less

- ❑ Soil erosion
- ❑ Pollution of water, and air

- ❑ *??Emissions of GHG (CO_2, CH_4, N_2O)??*

LTE Moškanjci

Plowed field in the autumn and seeded by winter wheat

Field with the same crop- No-till wheat drilled after maize for grain

Plants do deep tillage

Soil is vertically opened by frozen and decaying roots in spring

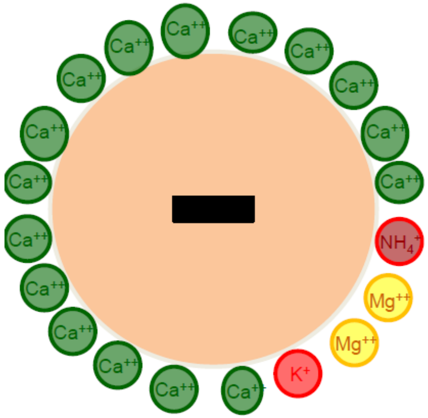
Mixed cover crops for better soil

A key for good soil structure is a **crop rotation** wich provides **soils covered permanently** by living plants or plant residue

Soil structural stability

Influence of soil sorption complex saturation with **Calcium**

Good soil structure with **high Ca**



pH 7

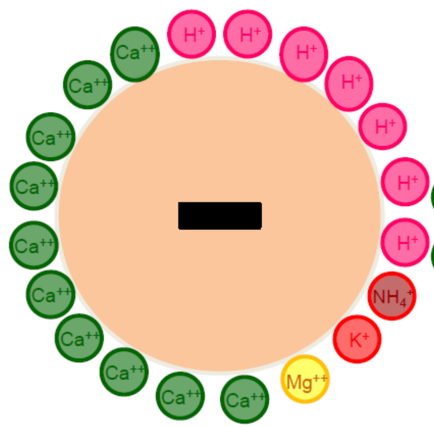
80 % Ca^{++}

10 % Mg^{++}

5 % K^+

5 % NH_4^+

Bad soil structure due to soil **acidification**



pH 5,5

50 % Ca^{++}

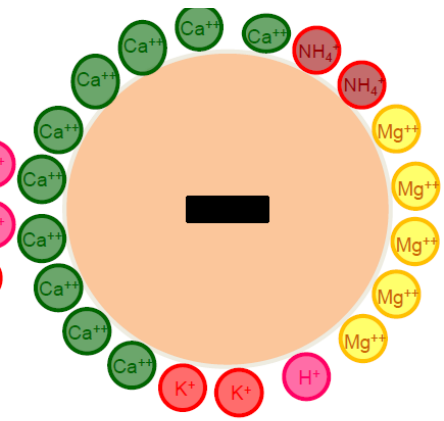
5 % Mg^{++}

5 % K^+

5 % NH_4^+

35 % H^+

Bad soil structure due to poor cation balance (**lack of Ca**)



pH 6,5

50 % Ca^{++}

25 % Mg^{++}

10 % K^+

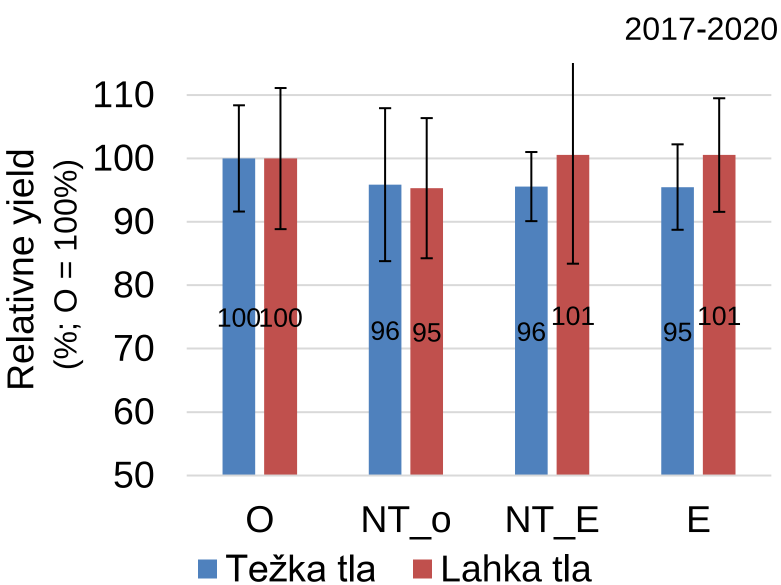
10 % NH_4^+

5 % H^+

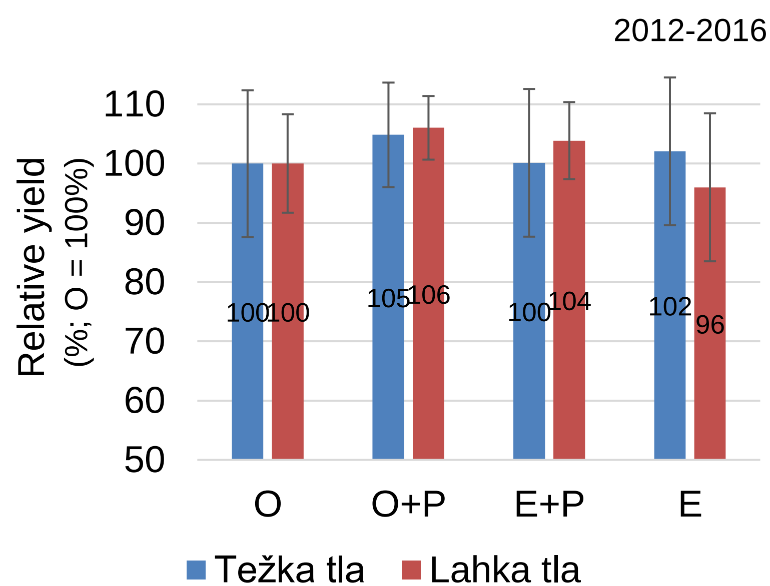
Fababean was directly planted (no-till) into rolled-down winter rye on June, 3

Fababean on July 30
(2 months after planting)

Crop yields (maize, ry, wheat, oil rape – canola, soy, barley) are on the **same level** in conservation (**E**) vs. plough (**O**) in light (red) and in heavy (blue) soil types



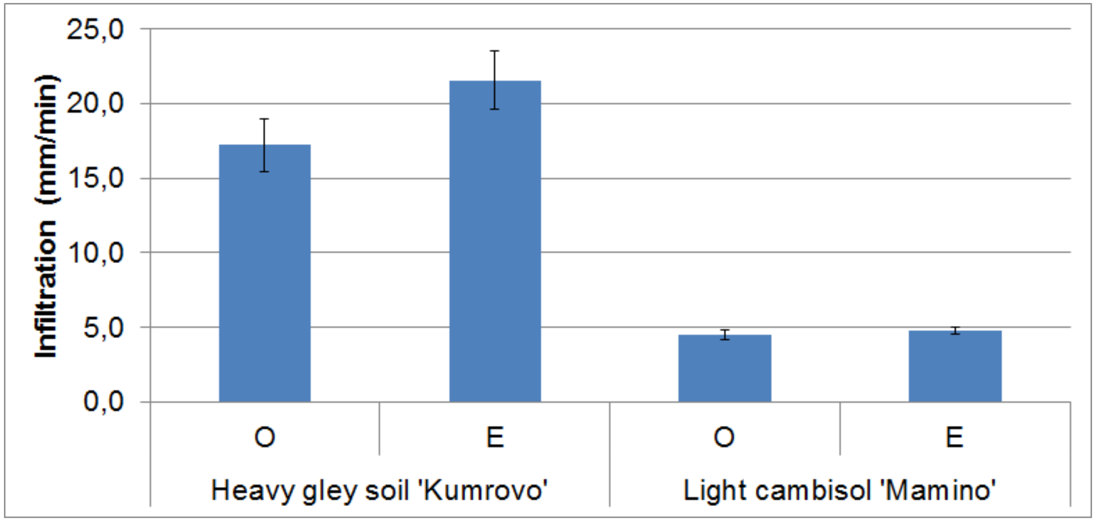
Heavy, deep gley

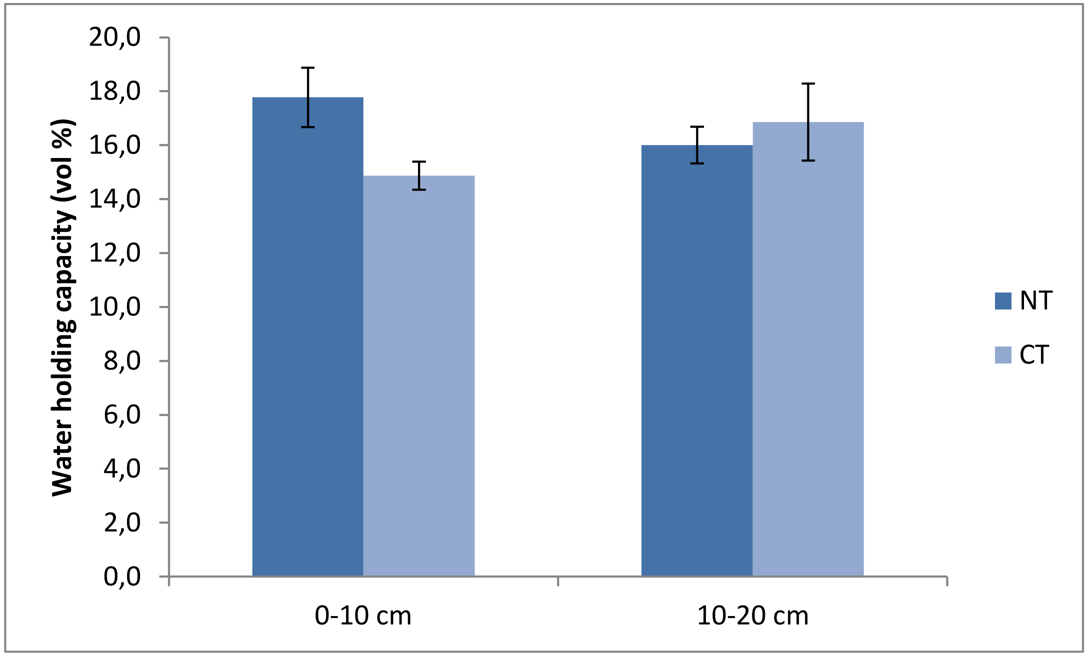


Light shallow cambisol

Physical soil improvements after 5 years with Conservation ag - CA (E) *vs.* Conventional (O).

Soil depth (cm)	Volume weight (g/cm^3)			
	CA (E)		Plough (O)	
0-10	**1.31**	a	**1.51**	b
10-20	1.45	b	1.50	b
20-30	1.60	bc	1.60	bc

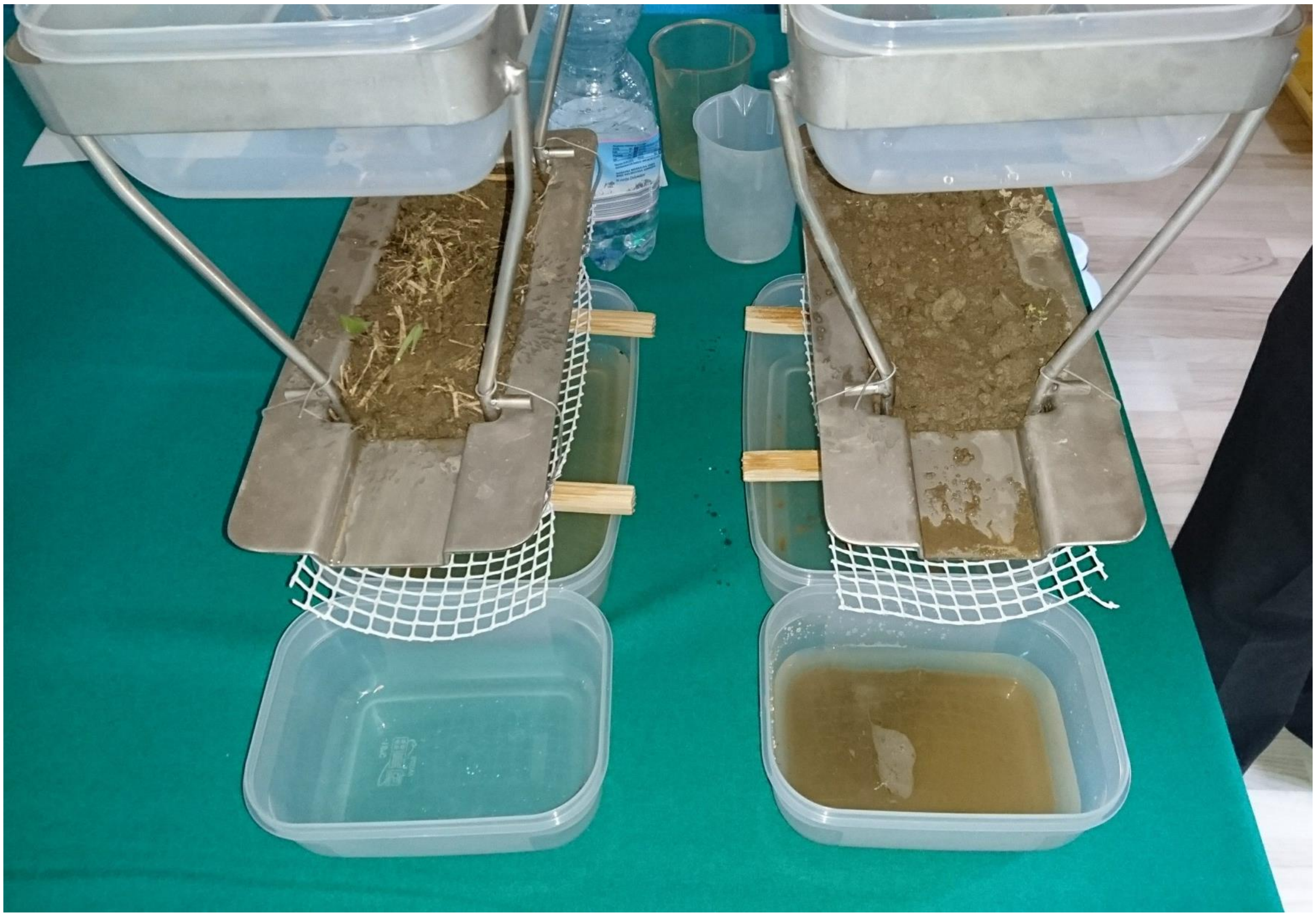




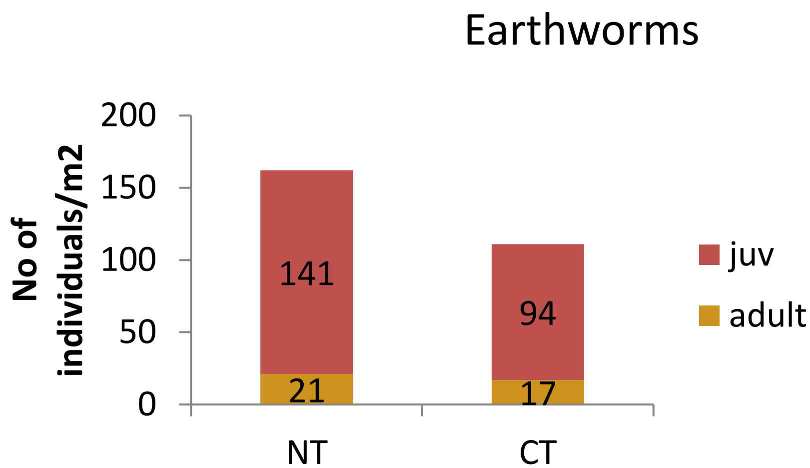
Rain test: infiltration and run-off dependent on soil tillage intensity (difference after 17 years of continuous field experiment)

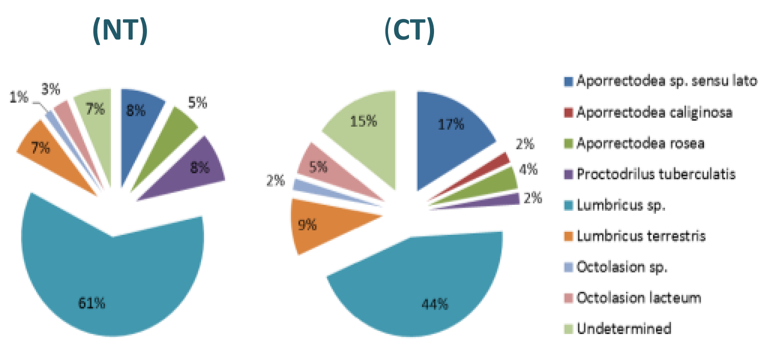
Raintest_SI_Engsubs.mp4 - Shortcut.lnk

Composting tillage **Plowing**

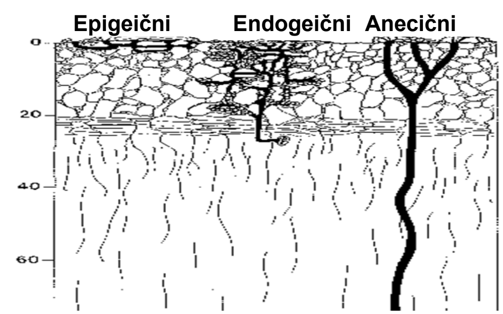


Long term field experiment





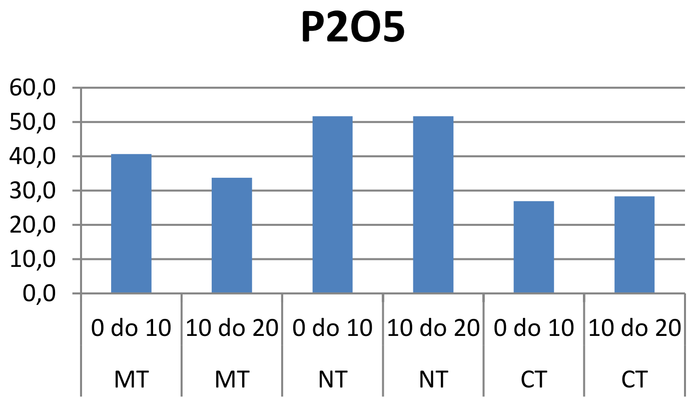
Ecological groups

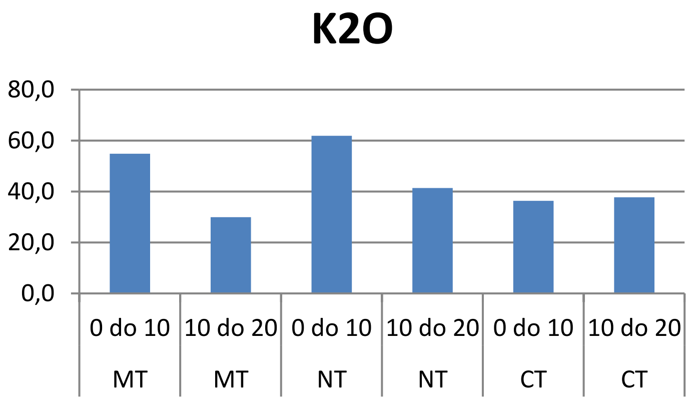


What is happening with available plant nutreints?

LTE „Rašica“ after 20 years (vzorčenje tal: 9.7.2020)

(shallow cambiosol; **fertilization equal on all treatments**)





MT = composting tillage(10 cm deep) continuously from 1999;
NT = no-till from 2016, earlier MT;
CT = conventional tillage with plough (25 cm deep) continuously from 1999

Increase of humus with conservation agriculture

The process is slow - a long-term insistence is needed

Minimum tillage (MT) *vs.* Conventional plowing (CT)

Treatment/soil depth (cm)	Corg (%) 2017	TN (%) 2017
MT 0-10	1,83a	0,168a
MT 10-20	1,40b	0,128b
MT 30-60	0,74c	0,073c
CT 0-10	1,40b	0,125b
CT 10-20	1,45b	0,130b
CT 30-60	0,72c	0,063c

After 17 years:

5 t/ha more humus in the upper 10 cm of soil ;

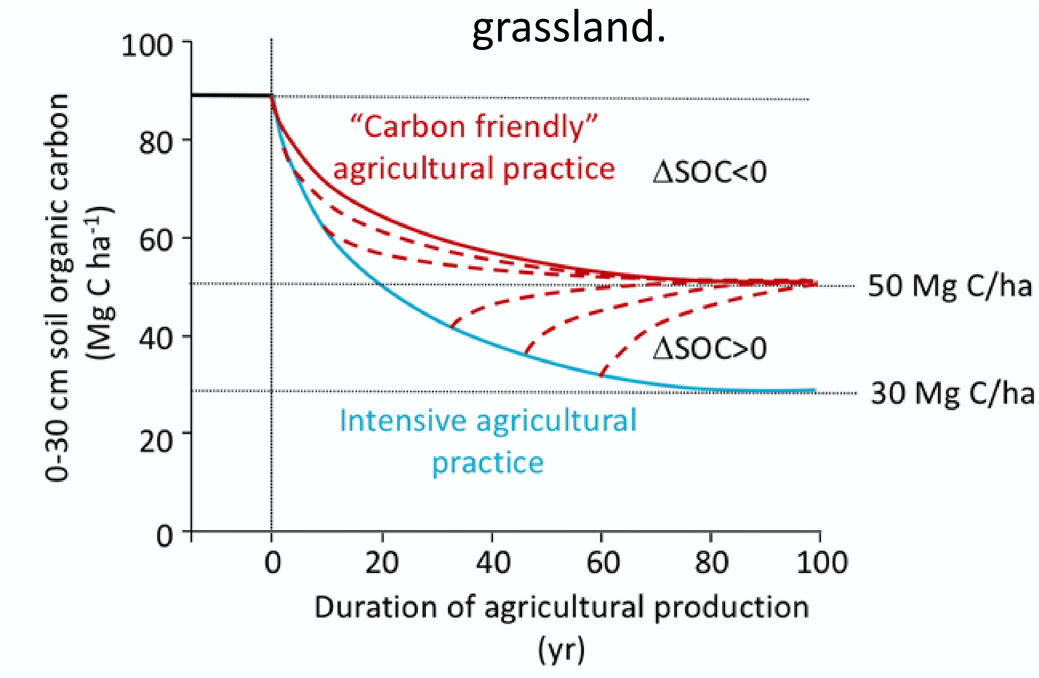
For this amount of humus build-up:

- wheat straw 38 t/ha should be incorporated into soil (straw value ≈ 5700 € or 335 €/a)

➢ energy equivalent of 15 t oil (≈ 15000 €).

Building soil is a time-consuming process.

In tilled fields, the decomposition of soil organic matter is also greater in conservation agriculture than in permanent grassland.



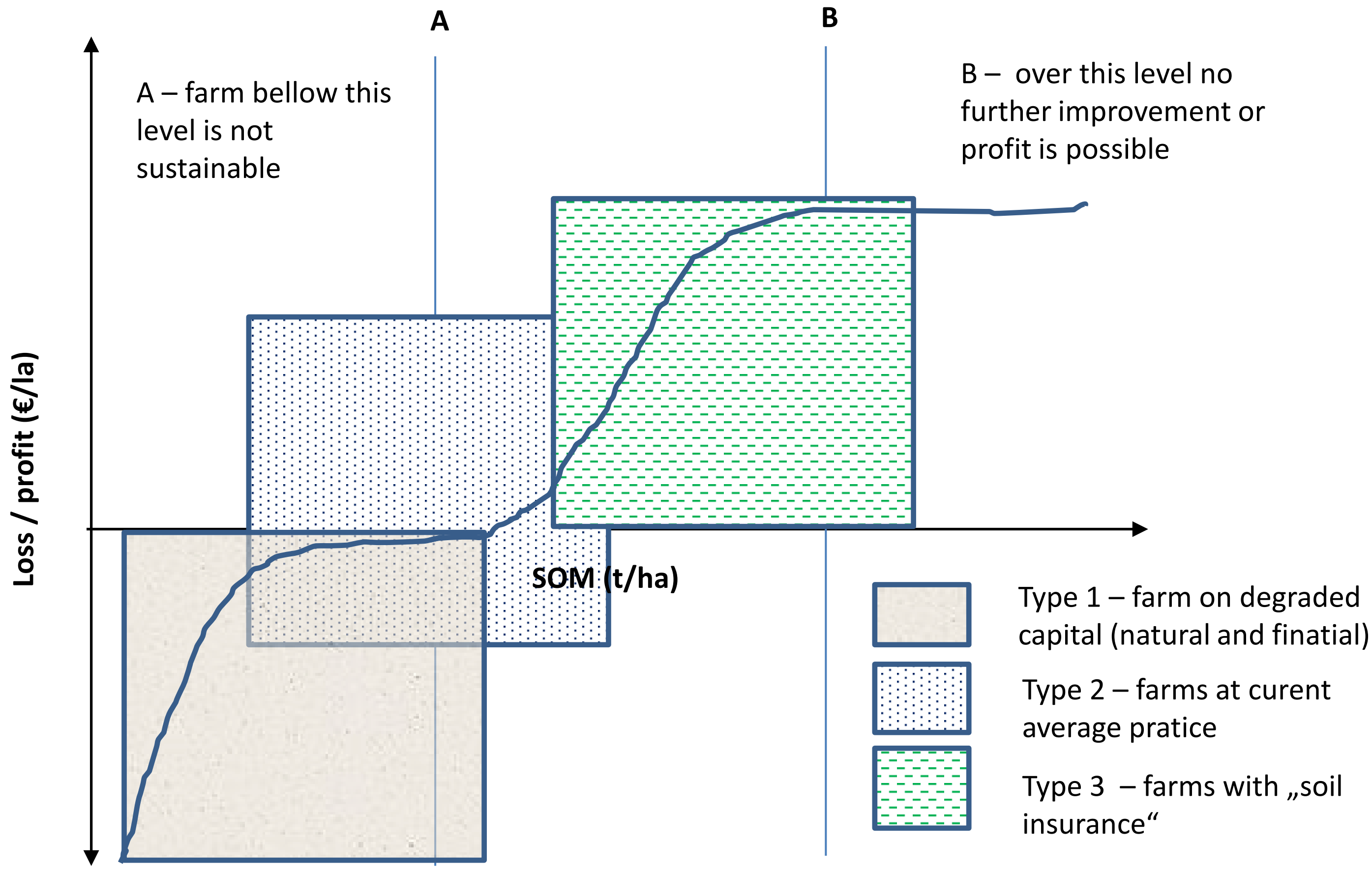
Schematic impact of temporal starting position on SOC[3]. *Note the decline in all cases.*

https://www.futuredirections.org.au/publication/conservation-and-regenerative-versus-intensive-agriculture/

Regenerative agriculture improves soil health, primarily through the practices that increase soil organic matter.

Regenerative Agriculture Initiative, CSU Chico, and the Carbon Underground, “What Is Regenerative Agriculture?” February 2017.

Soil organic matter (SOM) is like a currency; a guarantor of economically safe production



“Conservation agriculture. For living soil and economic survival of the farmer “

Important questions:

1. Which problems can solve conservation/regenerative agriculture?
2. What needs to be regenerated (restored) and maintained (conserved)?
3. What agronomic approach / activity will enable or facilitate this regeneration/conservation?
4. Can this approach be integrated into agronomic practices that will be economically and socially justified in a given environment?
5. Which political, social and economic forces will promote the use of new agronomic practices?

Thank you!