CARBON SEQUESTRATION POTENTIALS UNDER CONSERVATION AGRICULTURE IN DRY AREAS

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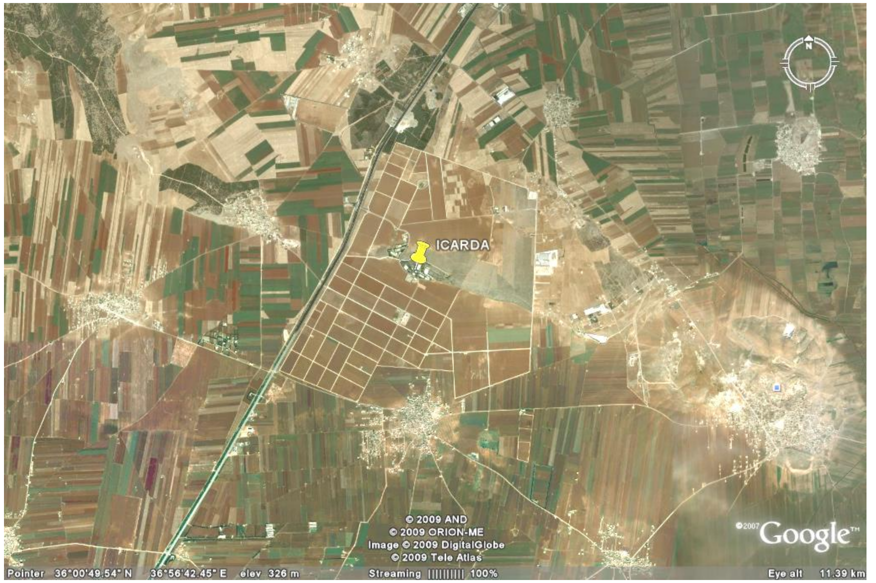
- North-Syria, 30 km south of Aleppo
- semi-arid, continental Mediterranean climate
- Average annual precipitation is around 345 mm
- Average annual temperature is 17.6 °C
- Soils
  - are either
    Typic Chromoxerert or
    Calcixerollic Xerochrept
  - 60-70 % clay
  - pH ~7.7
  - SOM in the topsoil is ~1.0 %



Cropping system in northern Syria

- mostly rainfed cropping of wheat, barley, chickpea, lentil and some other legume (fodder) crops during the winter and spring rainy season
- if access to water:
  - supplemental irrigation of winter crops
  - fully irrigated summer cropping
    - cotton, maize, sorghum, alfalfa, sugar beet, potato

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Conservation Agriculture (CA)

Four central principles of conservation agriculture

1. Minimal soil disturbance over the long term
2. Maintaining permanent organic soil cover by leaving the previous year's residue on the field
3. Crop rotation and/or 'intercropping' to improve soil fertility and control pests and diseases
4. Conservation agriculture requires specially built or adapted seeding machines but it does not require new crop varieties

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CA research at ICARDA

- Dryland cropping with:
  - minimal soil disturbance
  - residue (stubble) retention
  - crop diversification
- (Expected) benefits
  - early sowing
  - savings in time, machinery, fuel
  - improved trafficability, less erosion
  - increase in soil fertility
  - higher yields
  - C sequestration

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CA impact on the soil

- Better soil structure by
  - better stability of (larger) soil aggregates
  - less disturbance of soil macro-fauna (earthworms)
    - bio-incorporation of surface residues
    - formation of macro-pores
- Improved soil moisture availability for plant-growth, through better infiltration (less runoff), and reduced evaporation
- If residue retention is significant:
  - increase in soil fertility via increase in SOM
  - better nutrient (re-)cycling
  - soil organic carbon sequestration

→ better crop growth and yield

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Soil carbon sequestration

Certain expectations are raised:

- *"There is a **vast potential** for C sequestration in dryland ecosystems"*
- *"Soil C sequestration is extremely **cost-effective**"*
- *"Soil C sequestration is a **bridge to the future** until alternative energy options take effect“*
- *“C sequestration has the potential to **offset** fossil fuel emissions by 0.4 to 1.2 billion tons of carbon per year, or **5 to 15 % of the global fossil-fuel emissions.**”*

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Soil organic matter in soils of the dry areas in the Mediterranean region

- Soils in the Mediterranean region are often poor in Soil Organic Matter (SOM)
- Depletion of SOM in response to thousand of years of (unsustainable?) land use
- Carbon sequestration in soils is discussed as a potential for mitigating climate change

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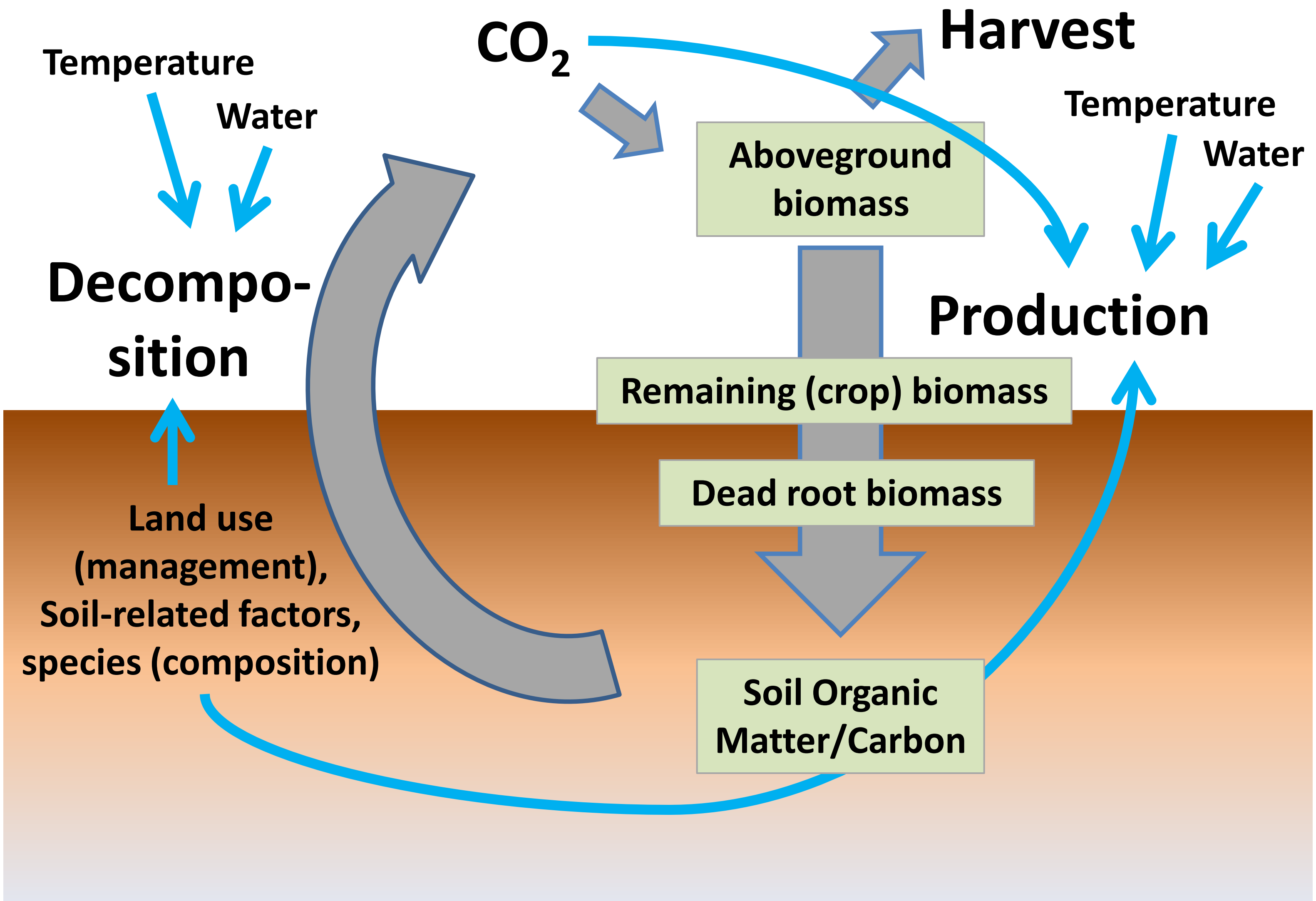
Organic carbon cycling



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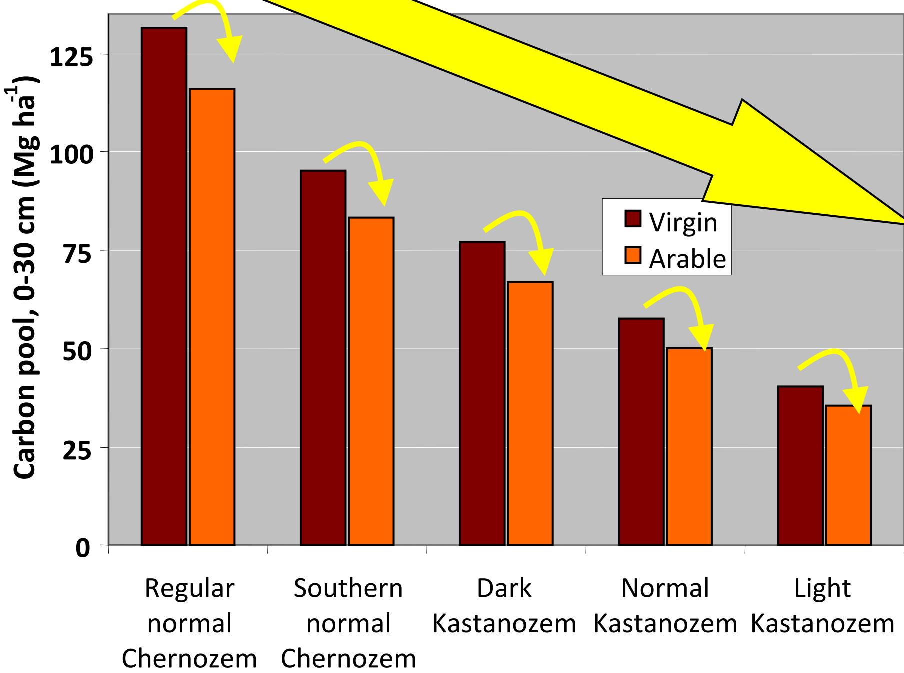
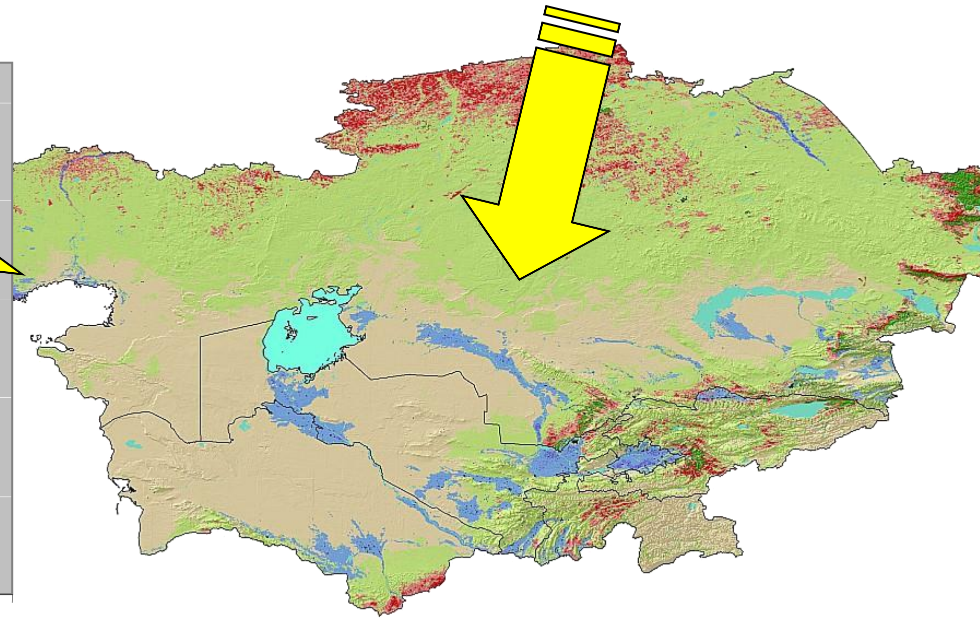
Effect of climate and land use on SOC

Example: Drylands of Central Asia





North → **South**

Precipitation: 350 mm → **180 mm**

Avg. ann. T: 0.6 ºC → **7 ºC**

Percent loss of C

Absolute loss of C

Based on data from Saparov et al., 2007

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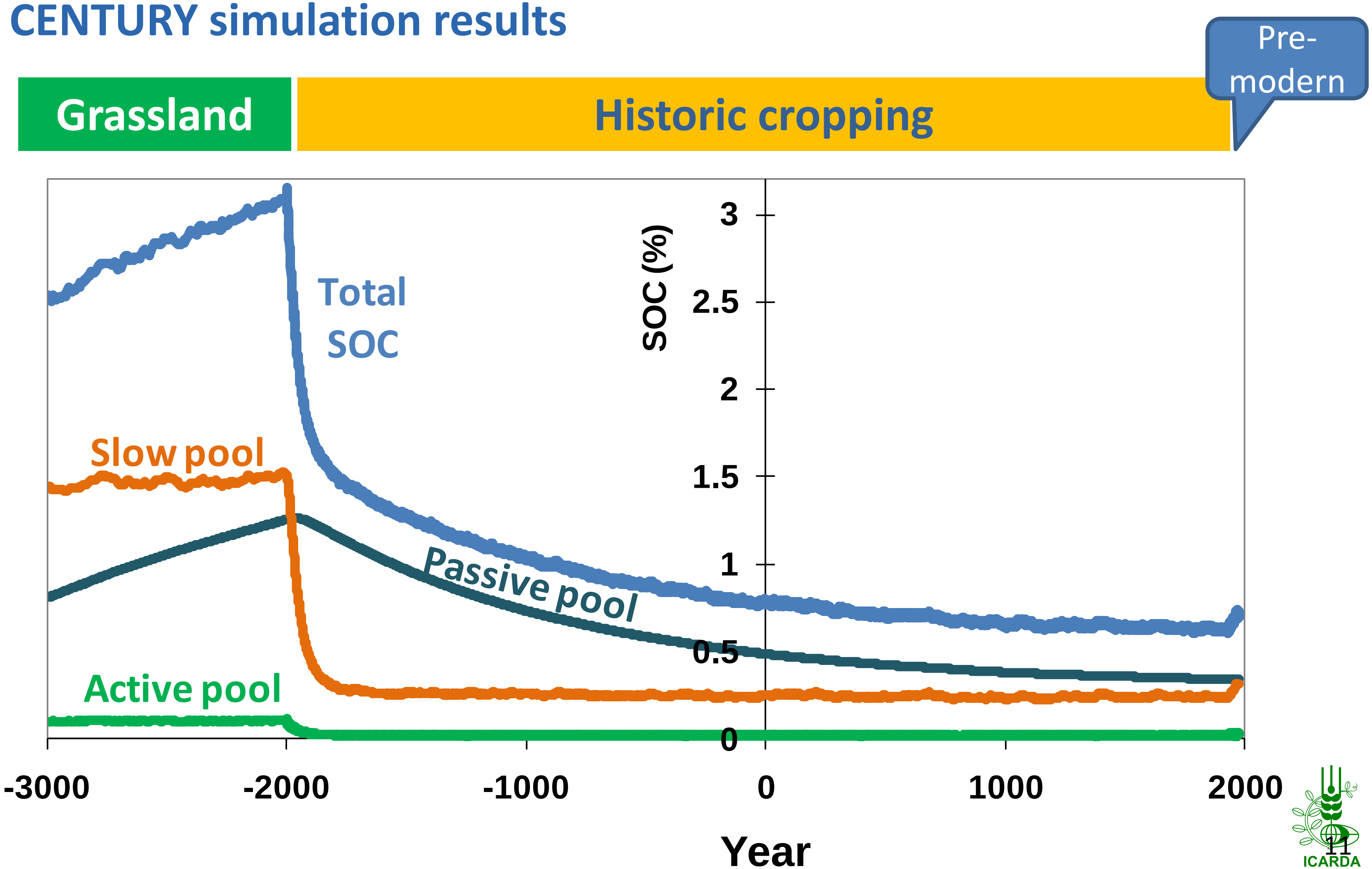
Soil organic matter dynamics in response to historic land use in northern Syria

CENTURY simulation results



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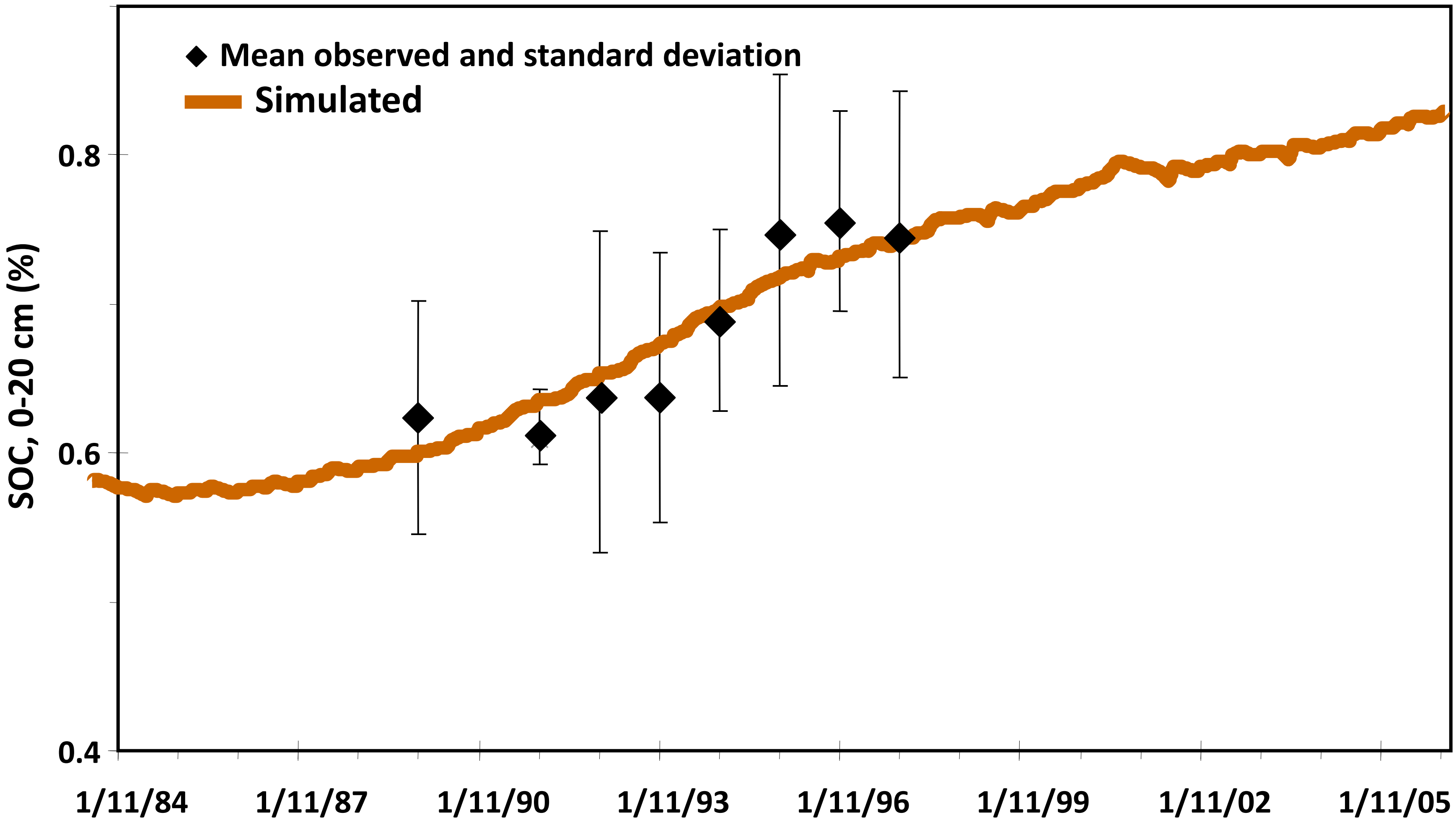
Improved agronomic management, ICARDA headquarter, Syria

- Zero-tillage, with 100 % residue retention (3-6 t/ha straw)



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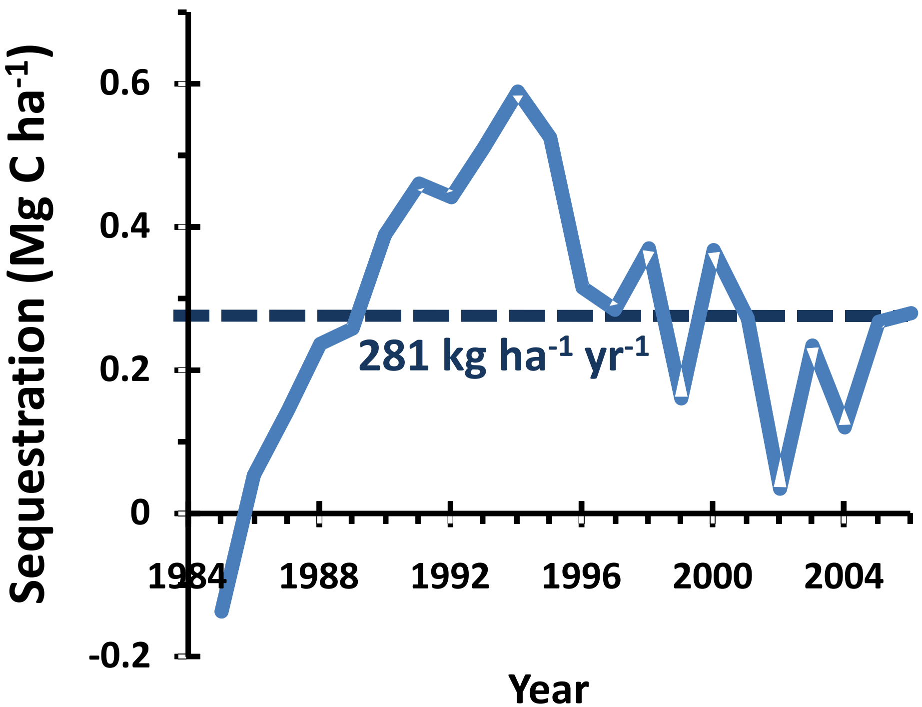
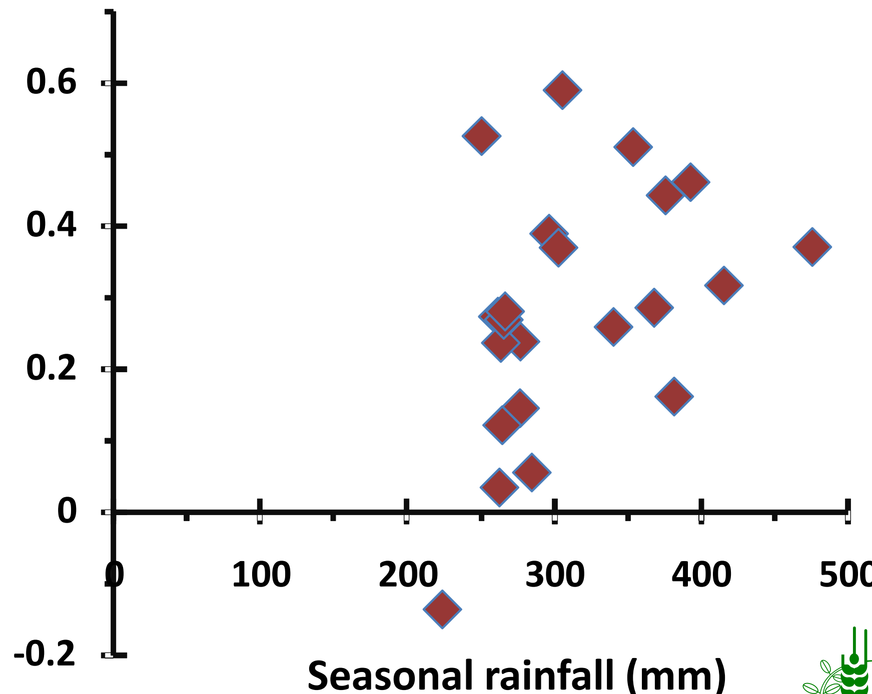
SOC sequestration rate, 0-20 cm

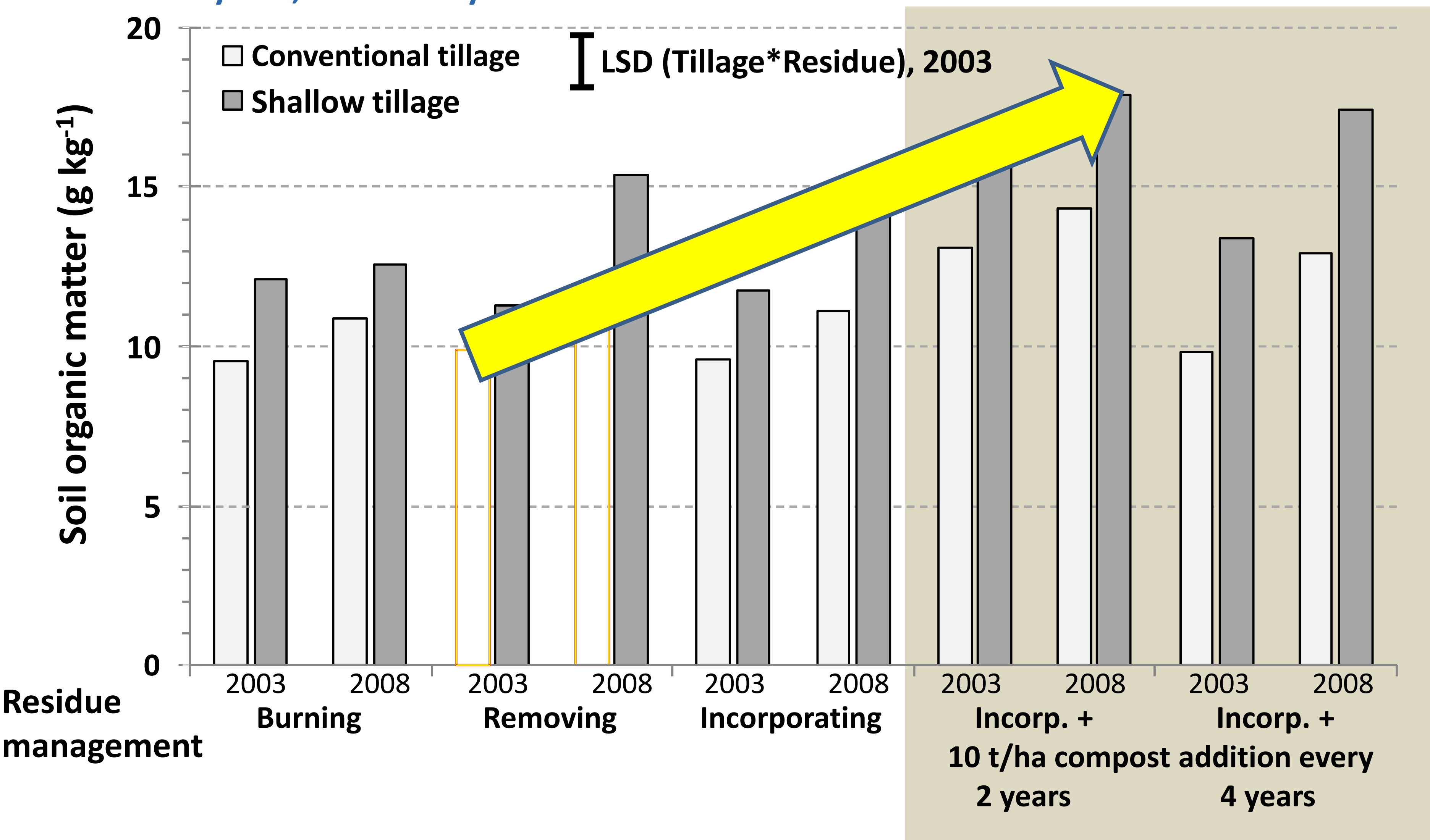
- sharp increase (1987-1994), and
- subsequent leveling off (after ~10 yrs) at lower level
- poor correlation with seasonal rainfall
- average sequestration rate: 281 kg C ha^{-1} yr^{-1} over 22 years





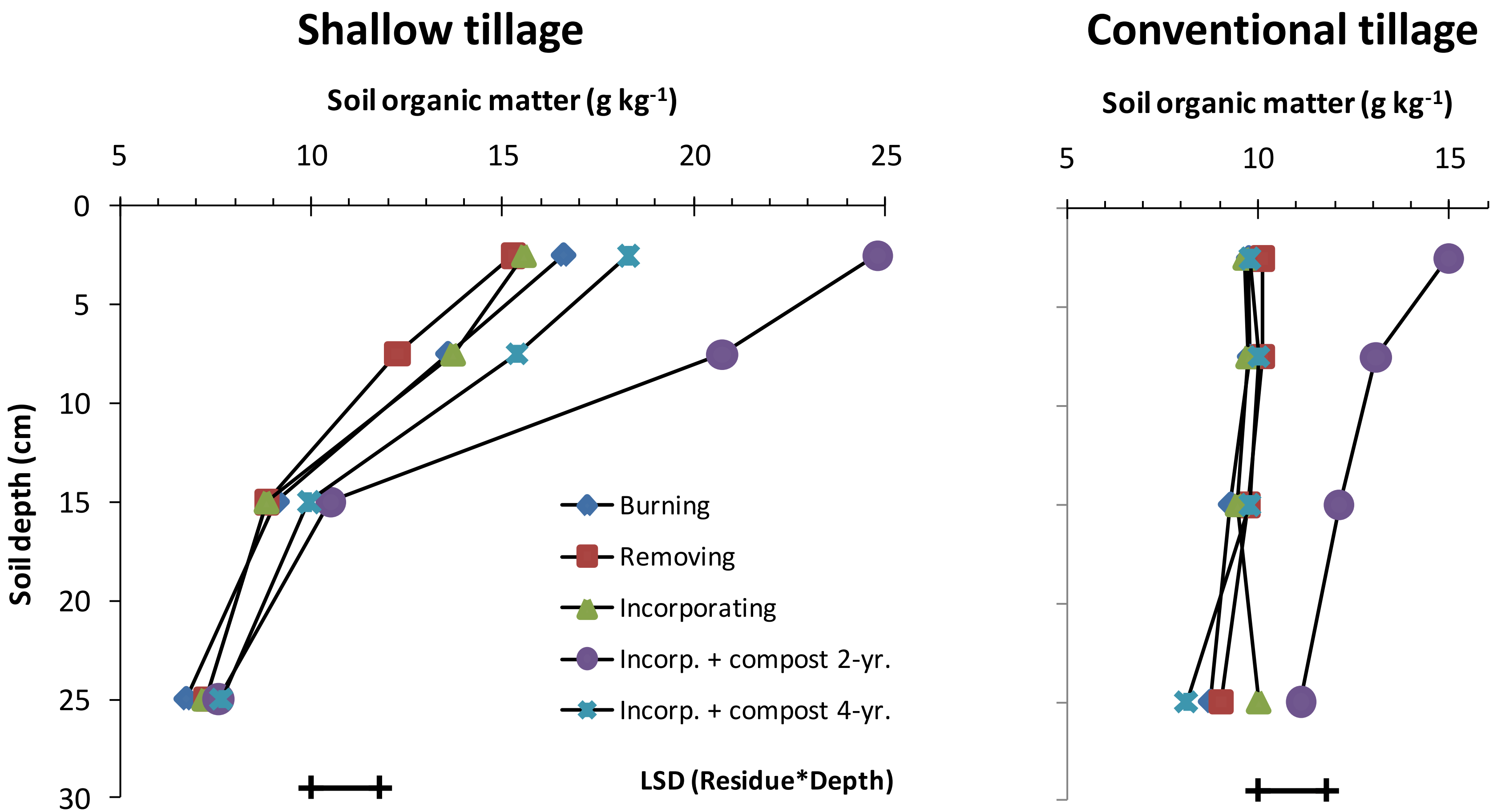
SOM contents in response to shallow tillage and residue management

2003 = 7 years, 2008 = 12 years after onset of trial



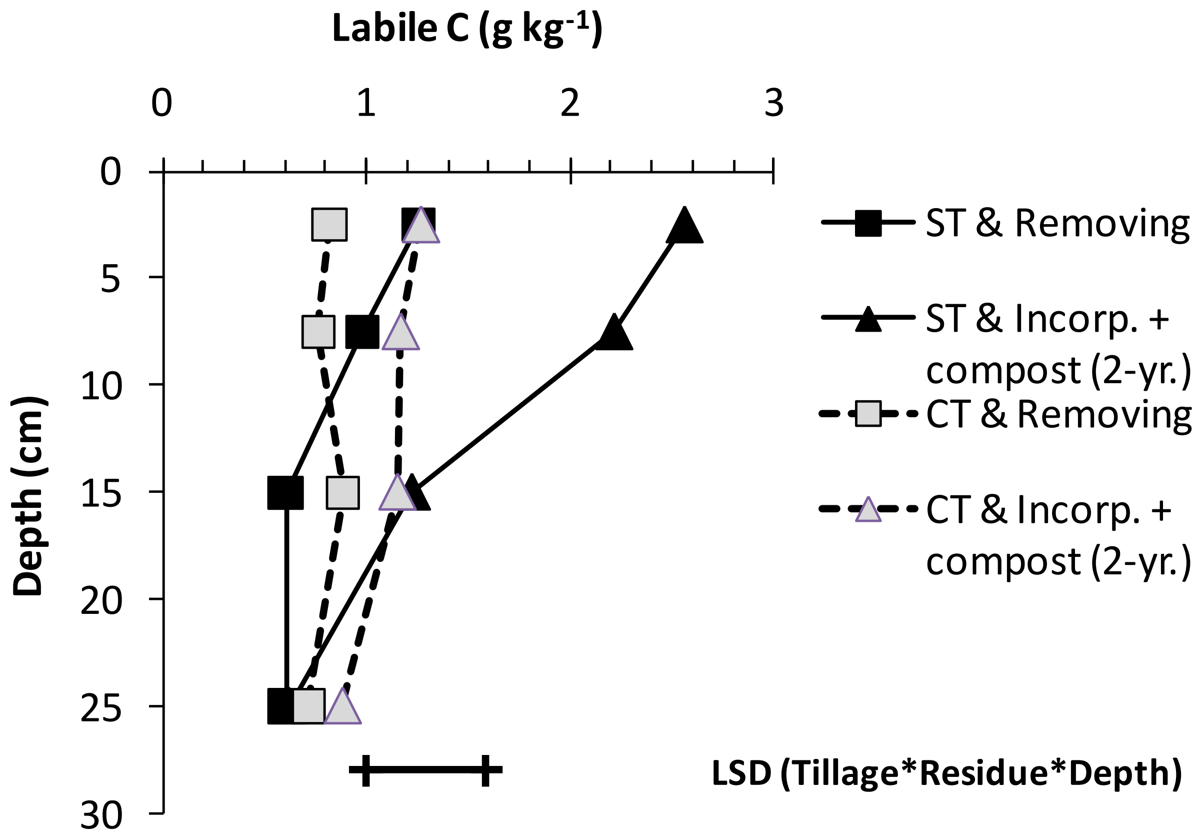
SOM contents in response to shallow tillage and residue management

Distribution of soil organic matter with depth as a function of tillage and residue management in 2003



Rapid accumulation of SOC in the labile pool

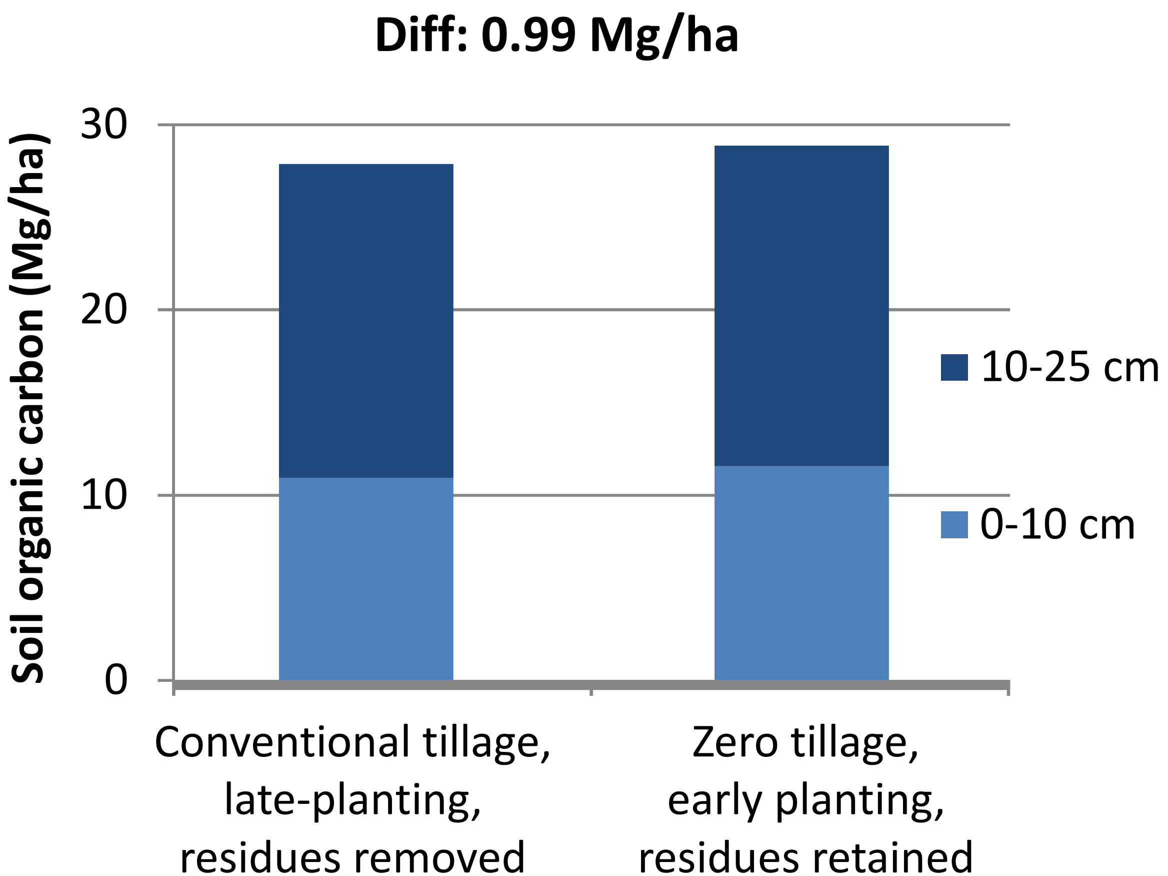
Distribution of labile carbon with soil depth as a function of tillage and residue management



ST= shallow tillage
CT = conventional tillage
'Removing' = removing of straw and incorporating stubble
'Incorp. + compost (2-yr.)' = incorporating straw and stubble and applying compost every two years;

SOC increase in response to CA

- SOC contents in autumn 2011, four years after the adoption of CA at ICARDA headquarters



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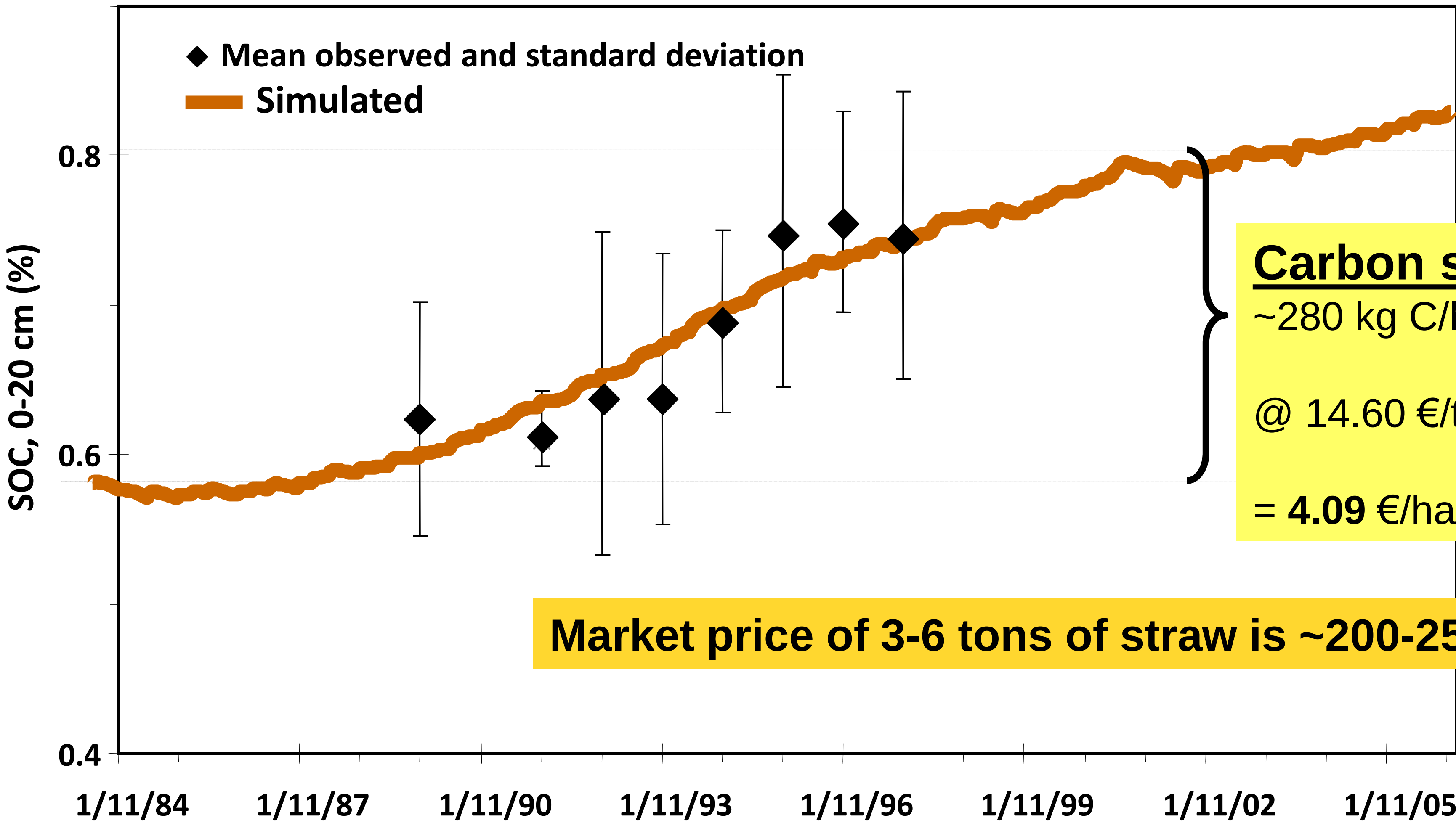
Carbon revenues of improved agronomic practice

- Zero-tillage, with 100 % residue retention (3-6 t/ha straw)



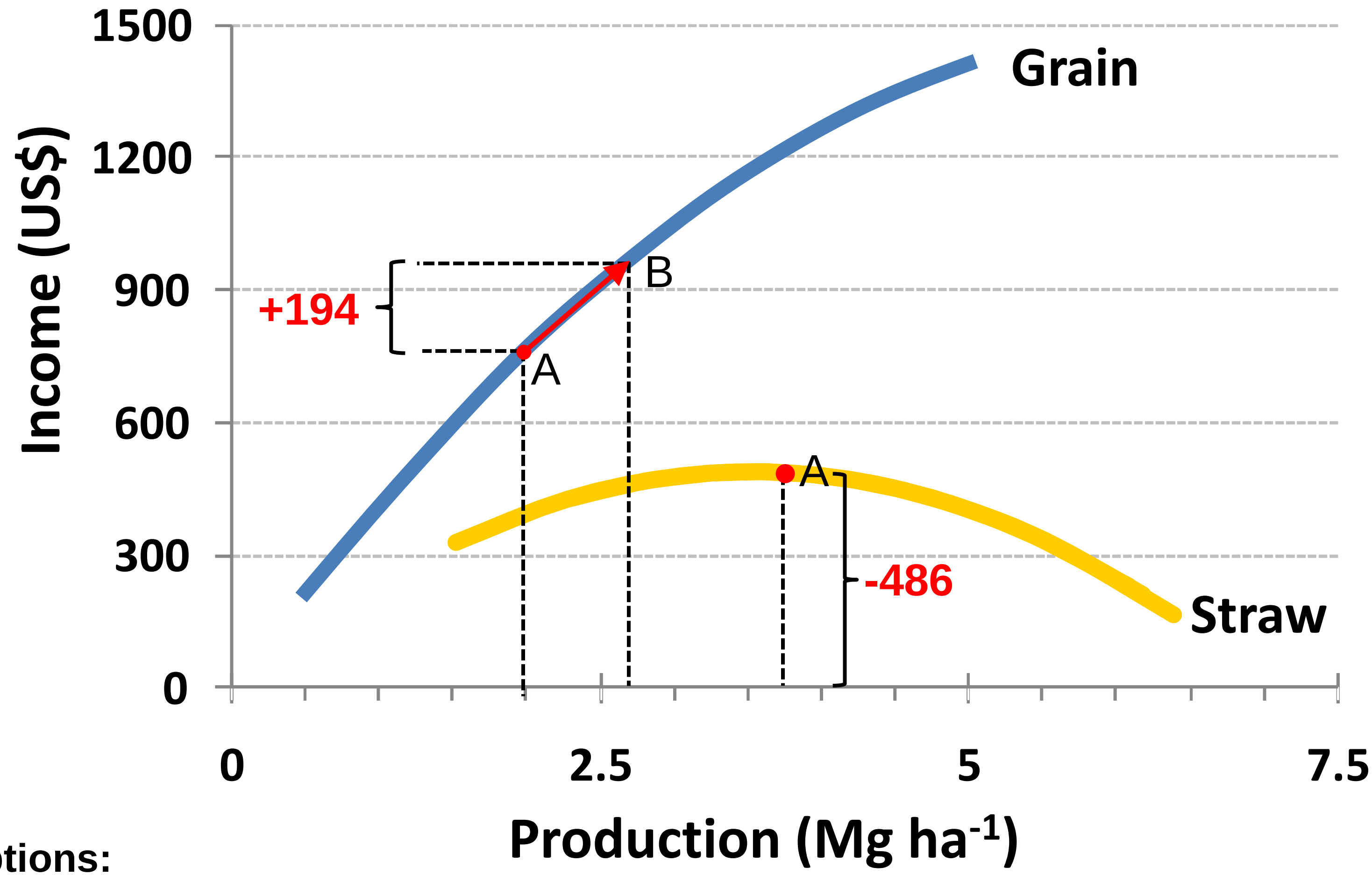
Carbon seq.
~280 kg C/ha/yr

@ 14.60 €/ton

= **4.09** €/ha/yr

Market price of 3-6 tons of straw is ~200-250 €

Cost-benefit of full residue retention and carbon sequestration – example wheat



Assumptions:

- **price of grain decreasing from 0.43 US$/kg @ 0.5 Mg ha^{-1} to 0.28 US$/kg @ 5 Mg ha^{-1},**
- **price of straw decreasing from 0.22 US$/kg @ 1.5 Mg ha^{-1} to 0.02 US$/kg @ 6.5 Mg ha^{-1};**
- **production increase (A → B) due to 100 % residue retention: +33 % grain.**

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Conclusion

- SOC-sequestration in the dry areas
  - is "almost inevitably" a by-product of sustainable land management (Conservation Agriculture)
  - is possible but the impact rather limited; in other words: soil carbon sequestration cannot take the heat of global warming
  - in the intensively used dry areas might come at considerable additional costs
  - is more likely to be put in place (by policies) if it secure the resource basis and adds to the provision of food security.

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Thank you!