Soil organic carbon sequestration and tillage systems in Mediterranean environments

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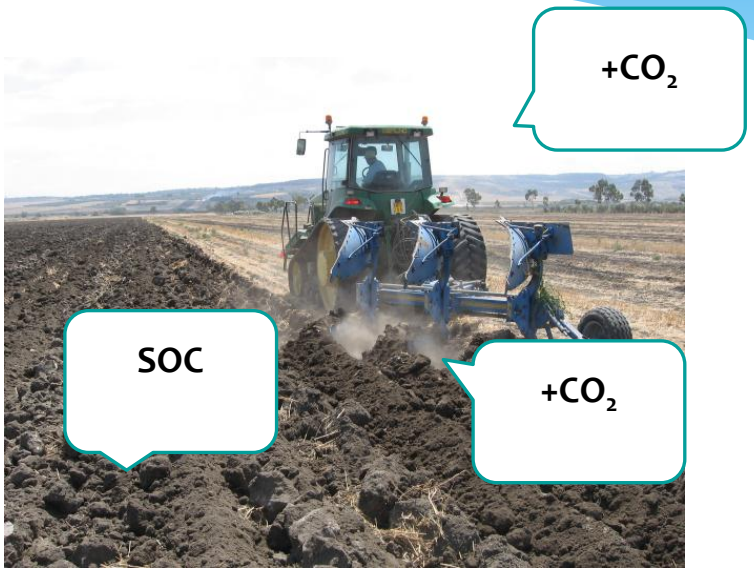
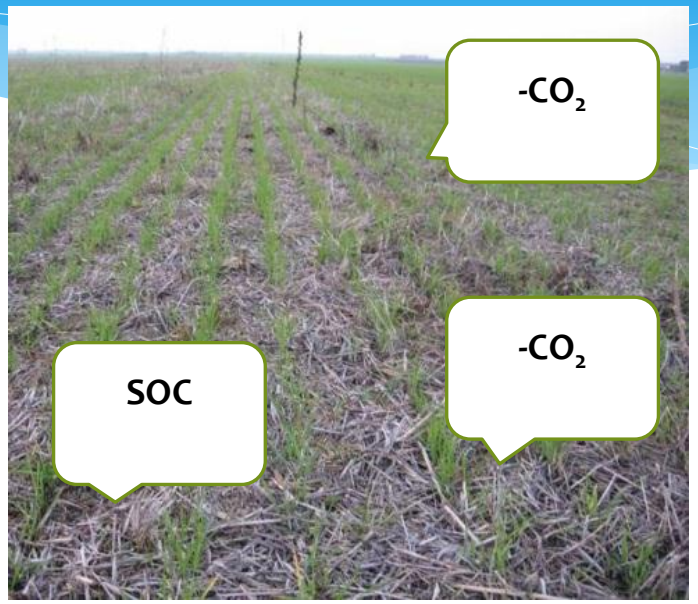
Cropping systems in Mediterranean areas

* rainfed cropping systems are prevalent
* inputs of organic matter are low and mostly rely on crop residues
* SOC losses are high due to climatic factors, and
* anthropic factors such as intensive and non-conservative farming practices
* reduced or no tillage systems are characterized by a lower soil disturbance in comparison with conventional tillage
* are effective on soil organic carbon (SOC) conservation and other physical and chemical processes, parameters or functions, e.g. erosion, compaction, ion retention and exchange, buffering capacity, water retention and aggregate stability



Conventional tillage

Higher CO_2 losses from soil due to higher SOC degradation, and higher emissions from the machinery use.
Higher time requirement and costs per hectare.

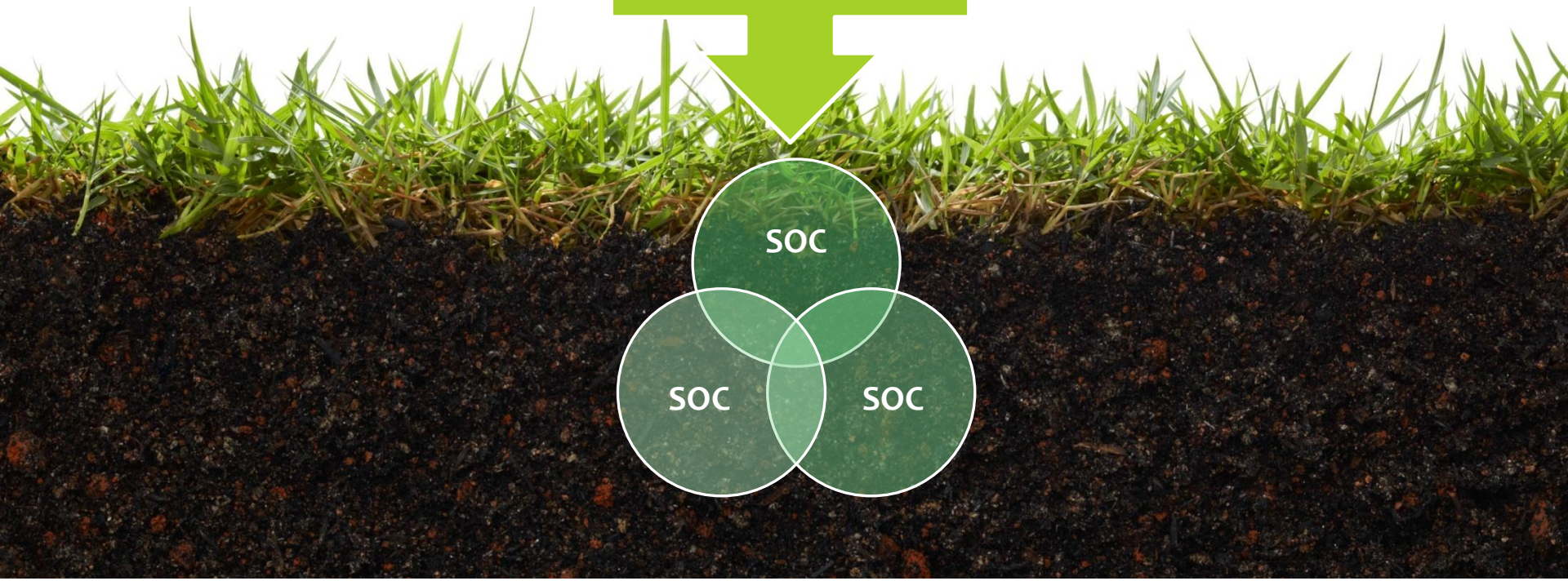


No tillage

Lower CO_2 losses from soil, and lower emissions from the direct seed drilling.
Lower time requirement and costs per hectare

No tillage

Organic carbon is more protected inside the soil aggregates



Methodology

- 66 paired comparisons from 15 studies available in the scientific literature
- field experiments on arable crops in Italy (5), Greece (1), Morocco (1) and Spain (8)
- sampling sites between 33°00’ and 43°32’ latitude N, 2-860 m a.s.l., with 10.9-19.6°C mean annual temperature and 355-900 mm rainfall
- dataset with the main environmental parameters (altitude, temperature, rainfall), soil tillage system information (conventional, minimum and no-tillage), soil parameters (pH, particle size distribution and texture), crop type, rotation, management and length of the experiment in years
- initial SOCi and final SOCf stocks

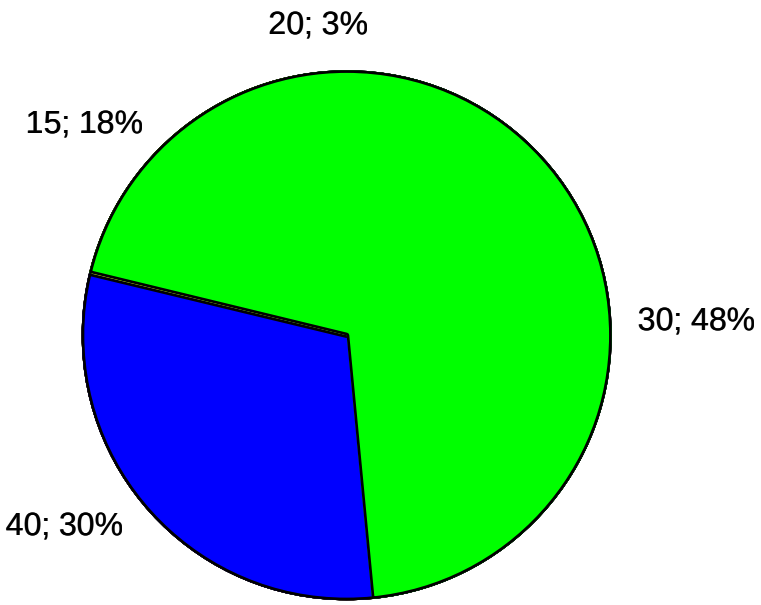
SOC evaluation

Carbon Sequestration Rate
[(SOCf-SOCi)/length in years]

Percentage change in comparison with the initial value
[(SOCf-SOCi)/SOCi*100]

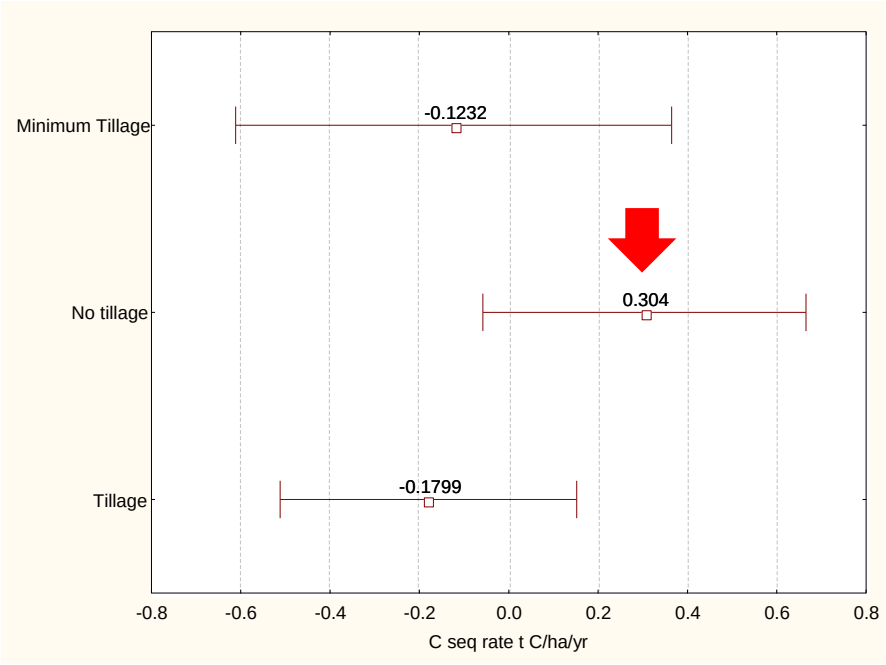
Significance with Kruskal-Wallis test

Sampling depth distribution

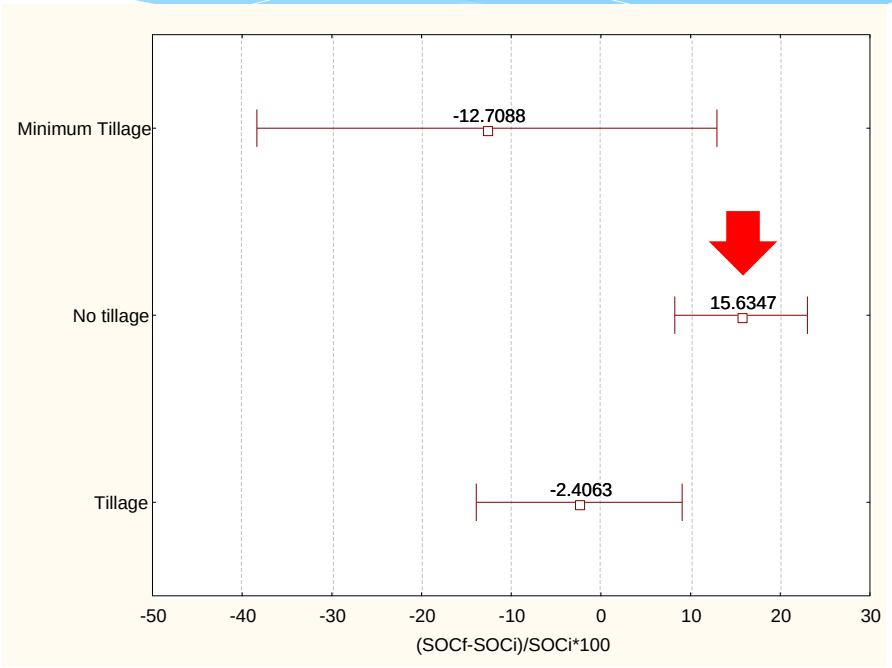


Depth cm and %

Grouping by tillage system

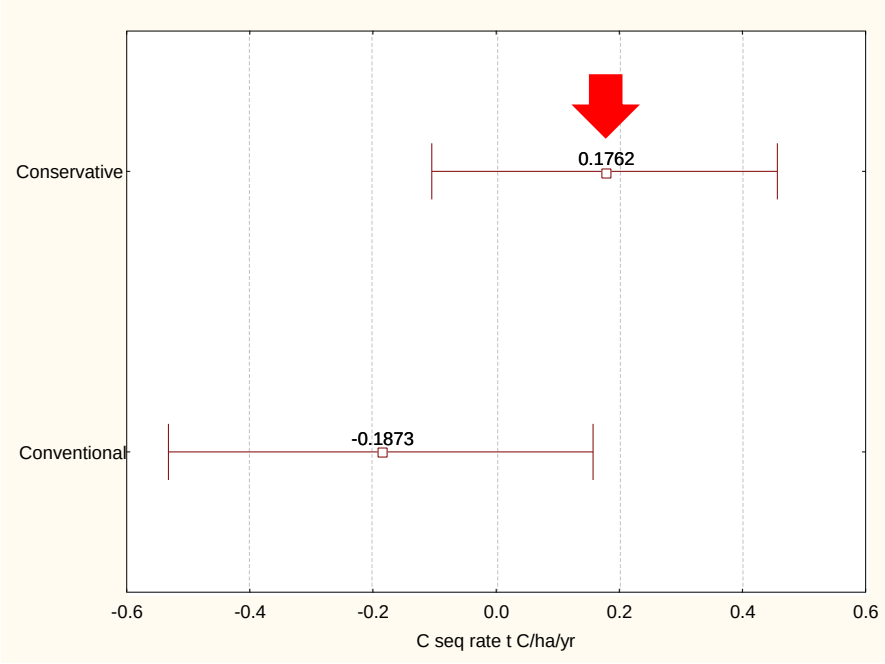


KW test p = 0.0029

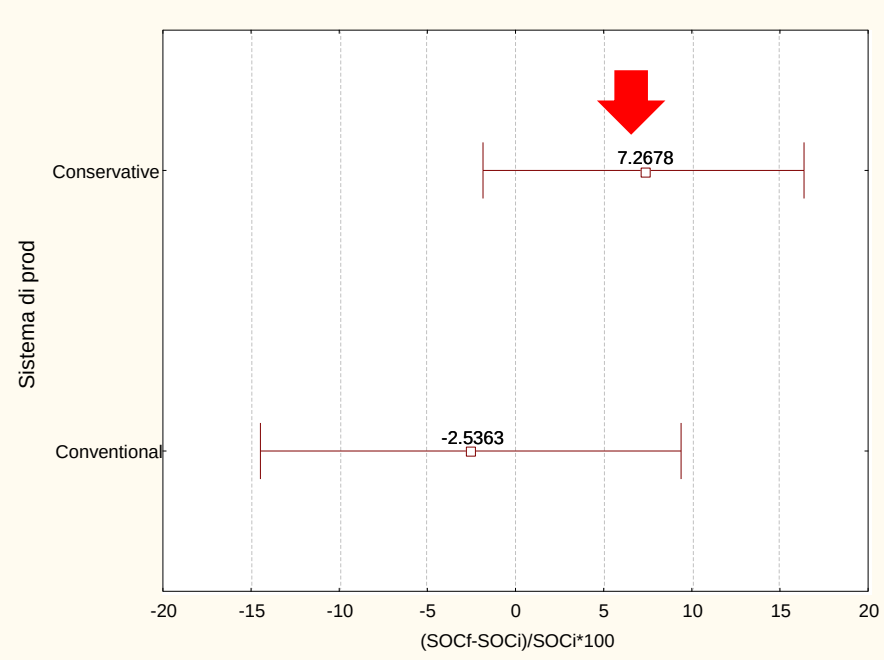


KW test p = 0.0046

Grouping by tillage management

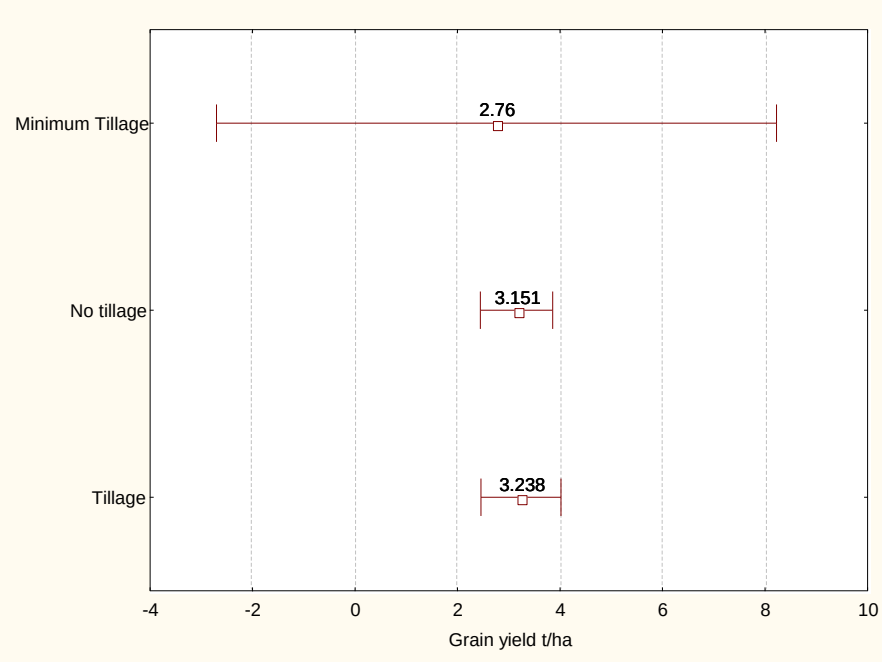


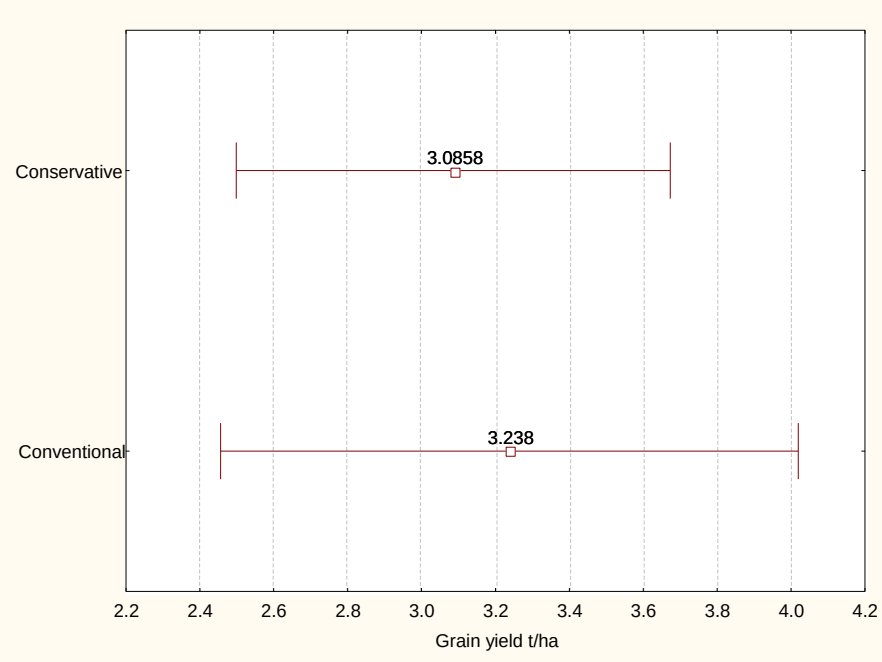
KW test p = 0.0426



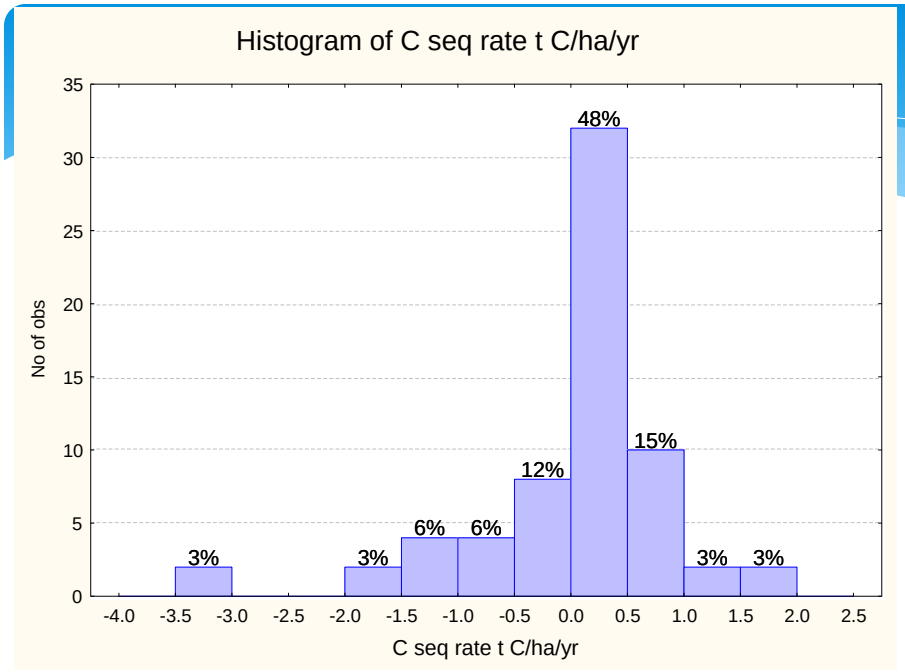
KW test p = 0.1072

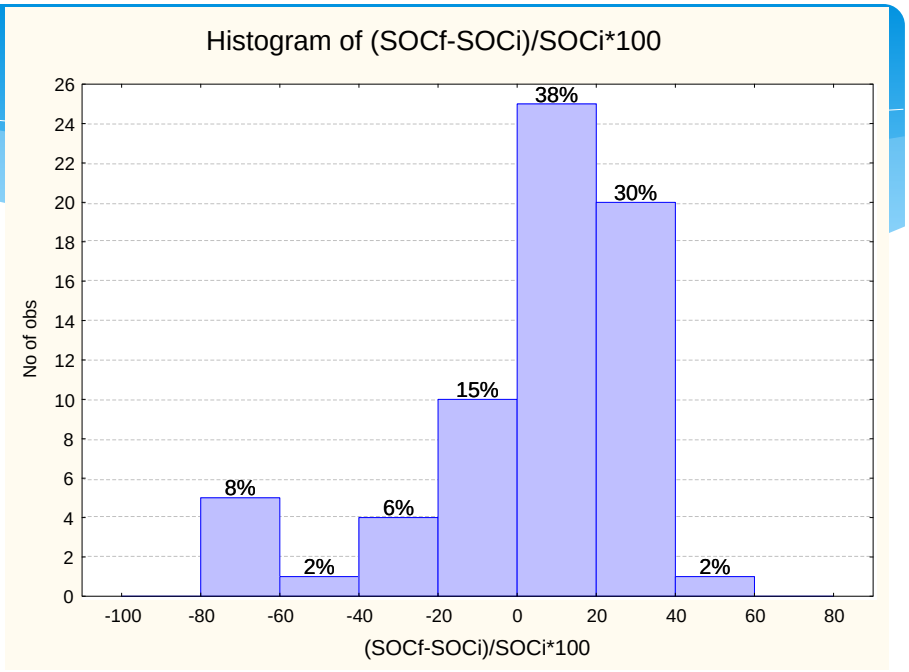
Grain yield by tillage system and management

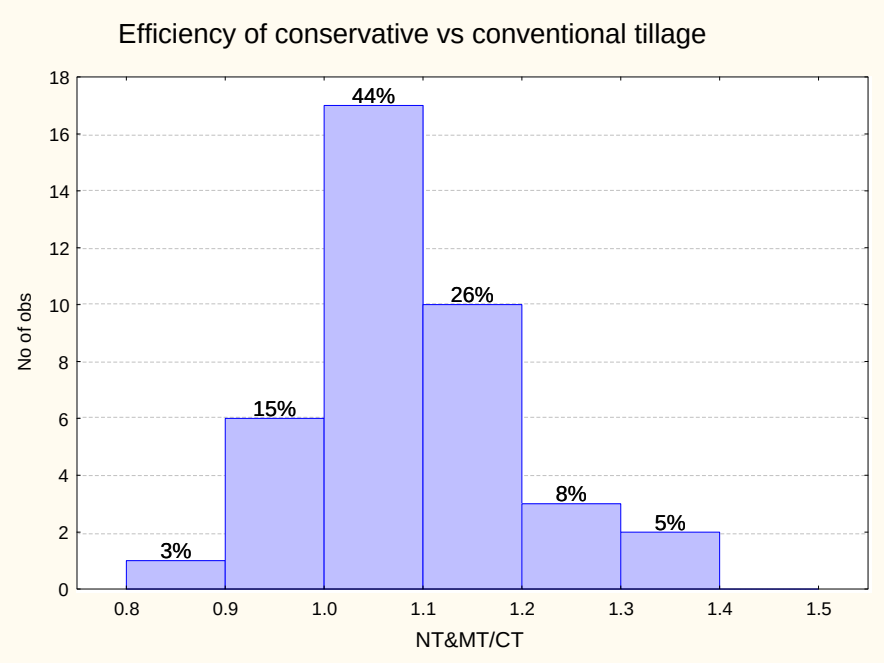




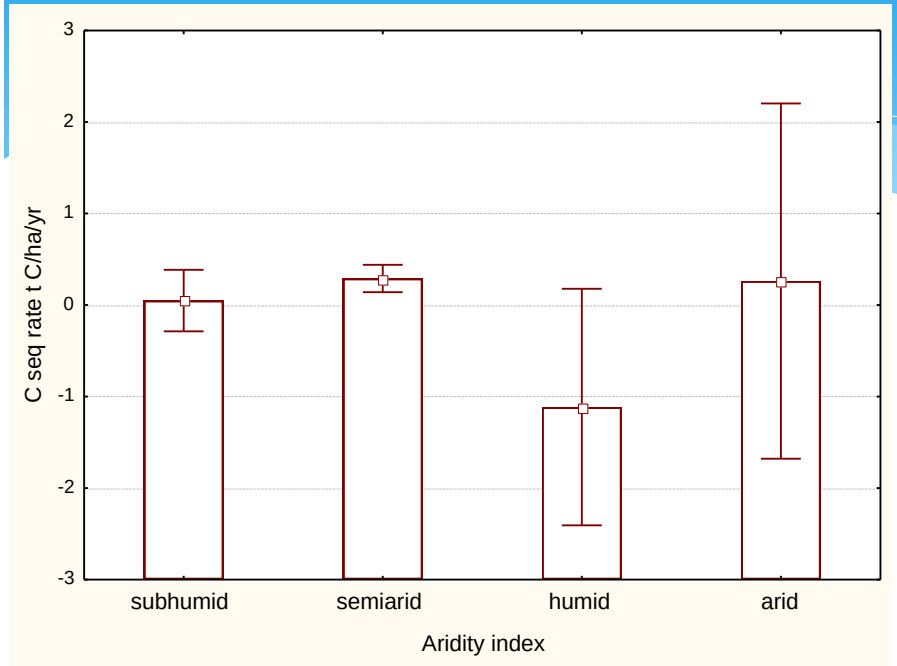
No significant differences

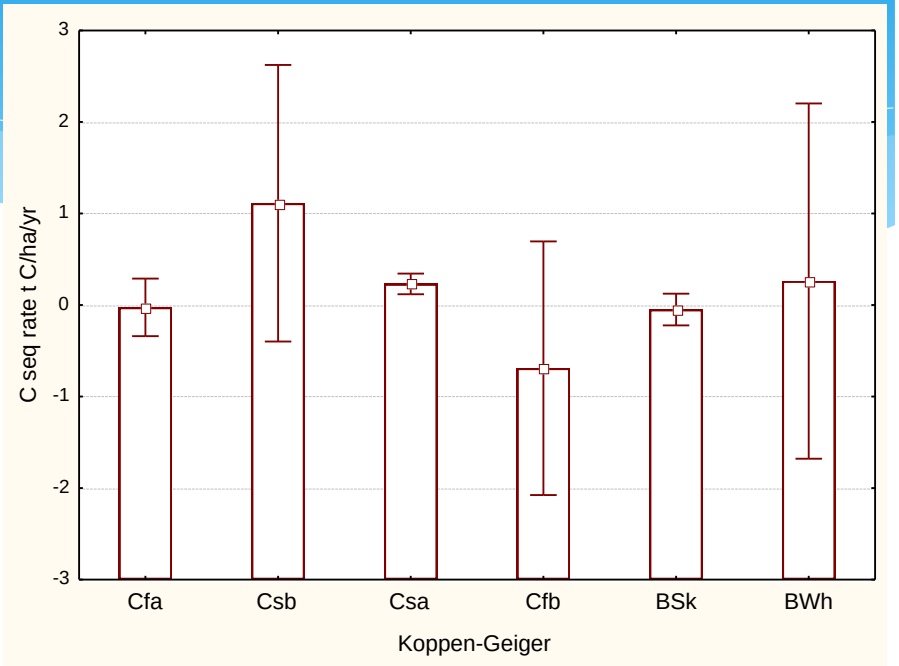

Histogram of C seq rate t C/ha/yr
No of obs
C seq rate t C/ha/yr
3%
3%
6%
6%
12%
48%
15%
3%
3%


Histogram of (SOCf-SOCi)/SOCi*100
No of obs
(SOCf-SOCi)/SOCi*100
8%
2%
6%
15%
38%
30%
2%


Efficiency of conservative vs conventional tillage
No of obs
NT&MT/CT
3%
15%
44%
26%
8%
5%

Grouping by climate (1)





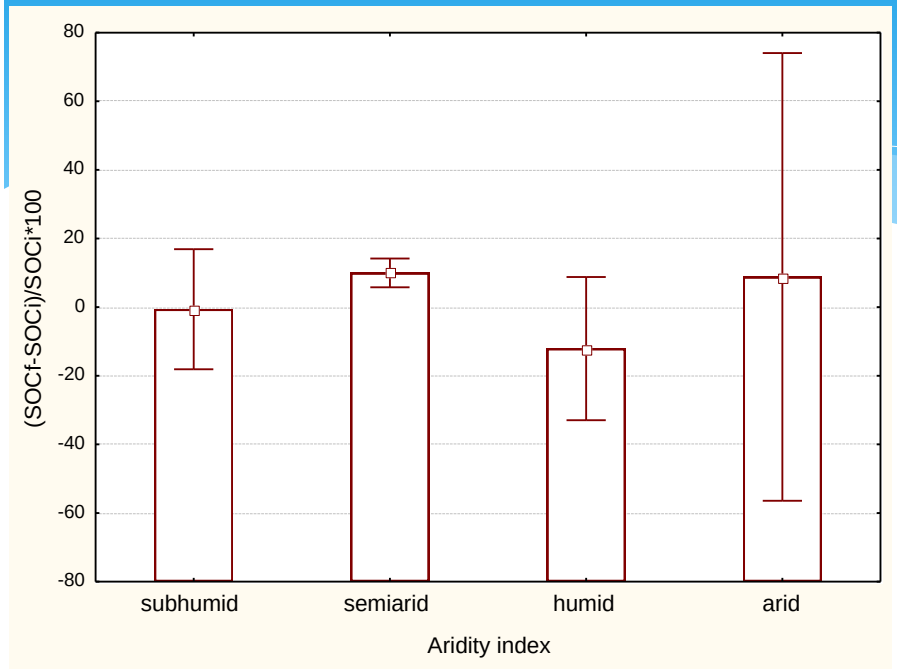
Aridity index (P/T+10)
KW test p = 0.1244

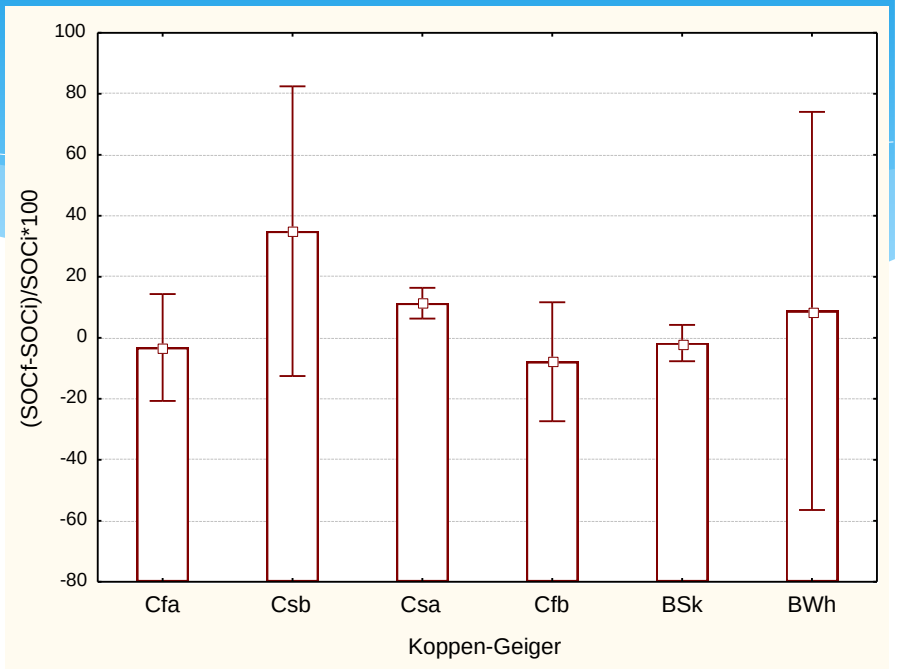
semiarid>arid>subhumid>humid

Ranking (Köppen-Geiger)
KW test p = 0.1199

Csb: warm, summer dry, warm summer
BWh: arid, desert, hot arid
Csa: warm, summer dry, hot summer
Cfa: warm, fully humid, hot summer
BSk: arid, steppe, cold arid
Cfb: warm, fully humid, warm summer

Grouping by climate (2)





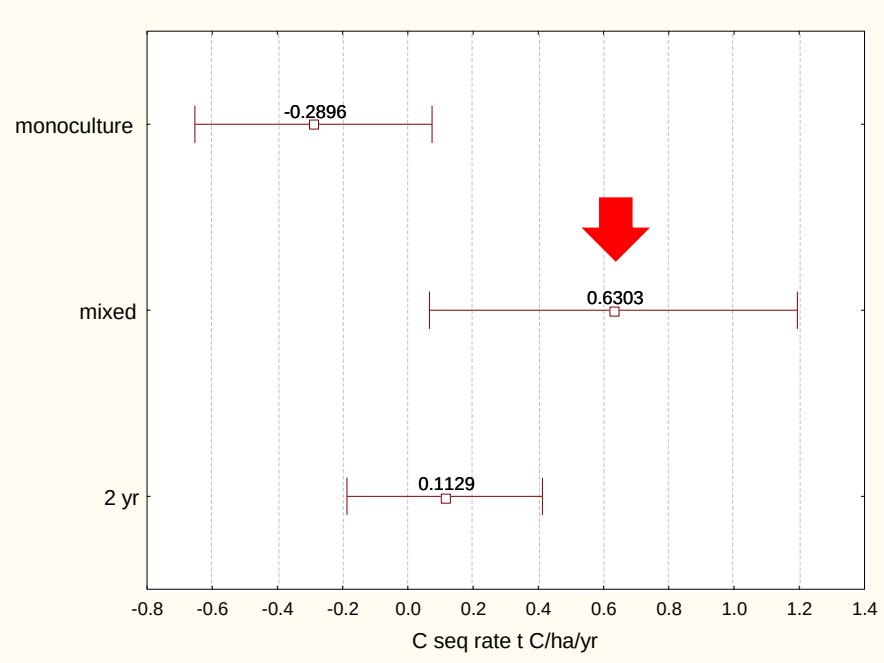
Aridity index (P/T+10)
KW test p = 0.2482

semiarid>arid>subhumid>humid

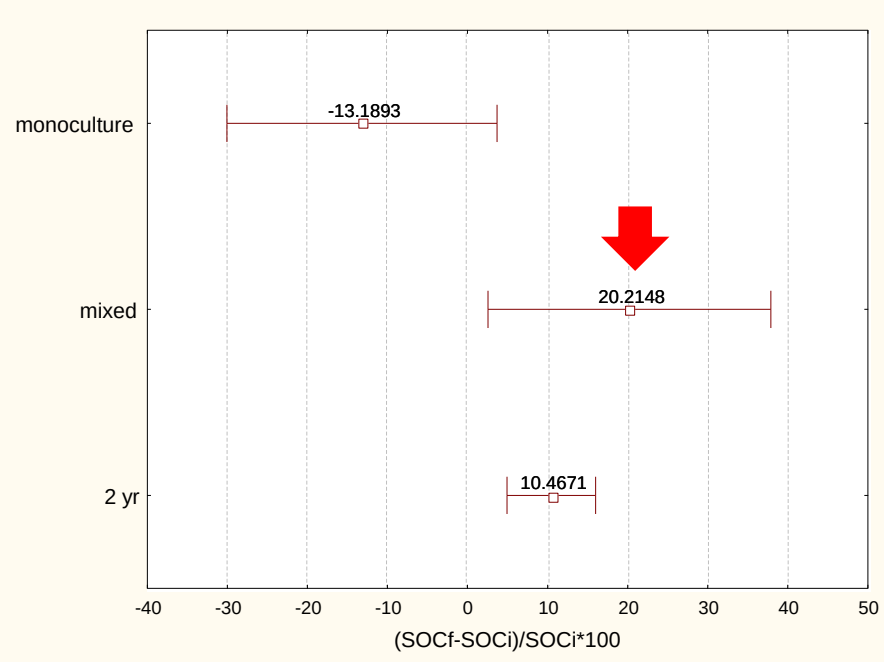
Ranking (Köppen-Geiger)
KW test p = 0.0830

Csb: warm, summer dry, warm summer
BWh: arid, desert, hot arid
Csa: warm, summer dry, hot summer
BSk: arid, steppe, cold arid
Cfa: warm, fully humid, hot summer
Cfb: warm, fully humid, warm summer

Grouping by crop rotation

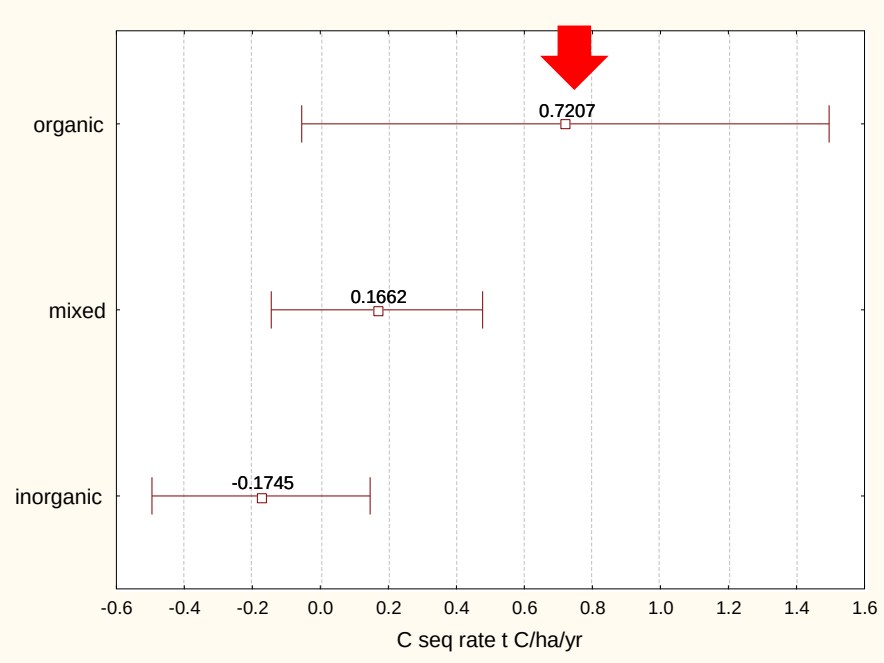


KW test p = 0.0551

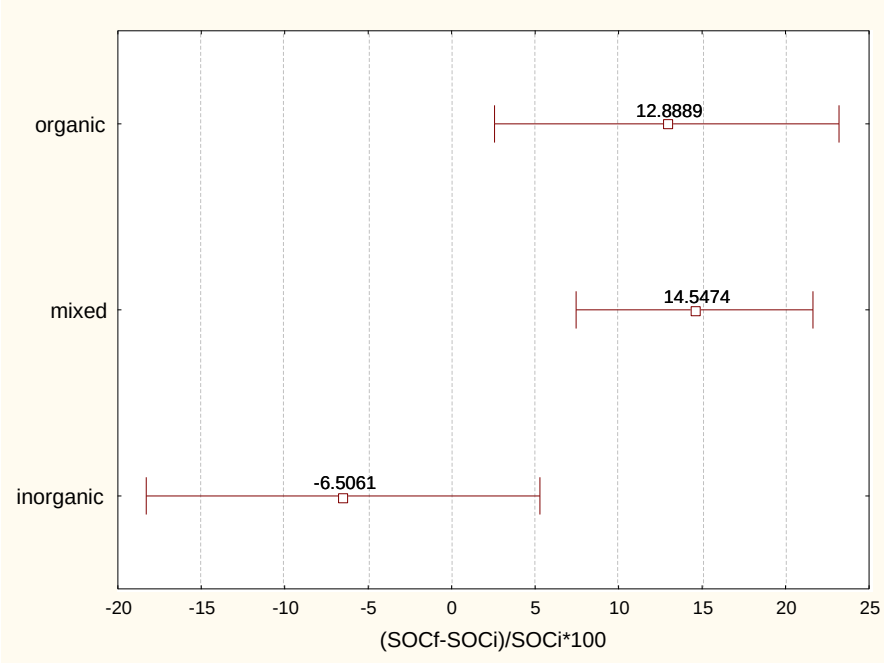


KW test p = 0.0554

Grouping by fertilization

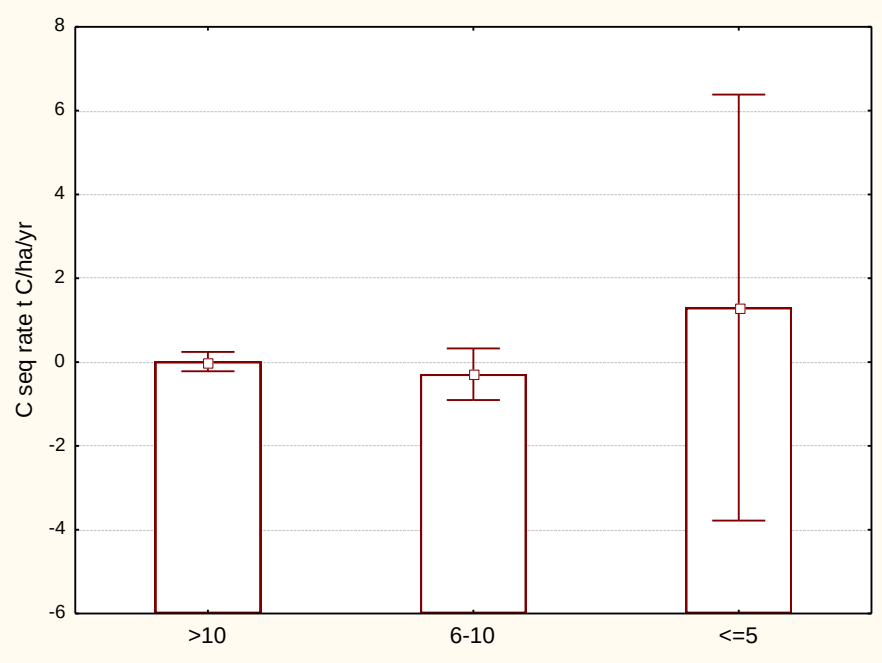


KW test p = 0.0189

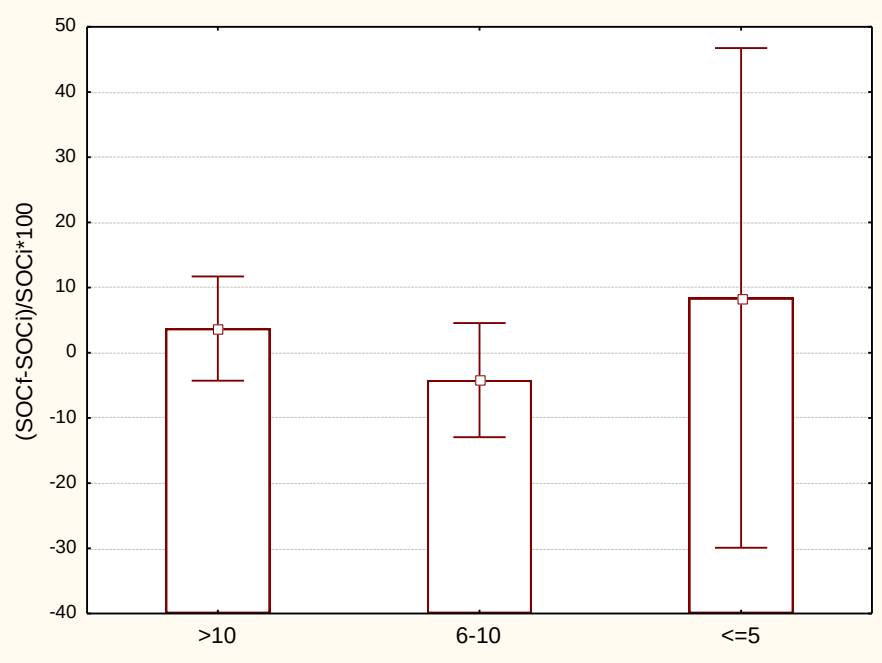


KW test p = 0.0197

Grouping by length

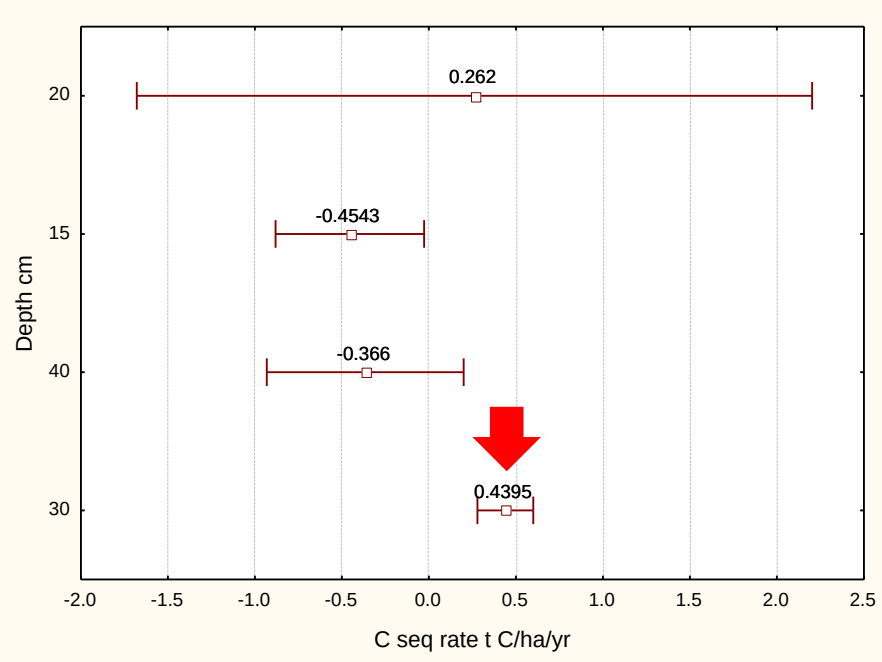


KW test p = 0.0184

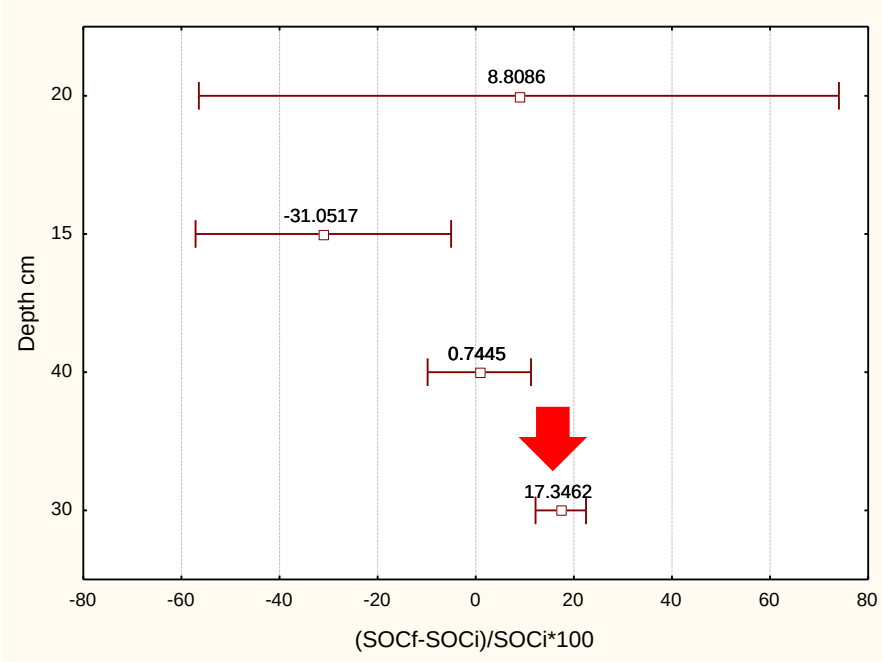


KW test p = 0.1849

Grouping by depth

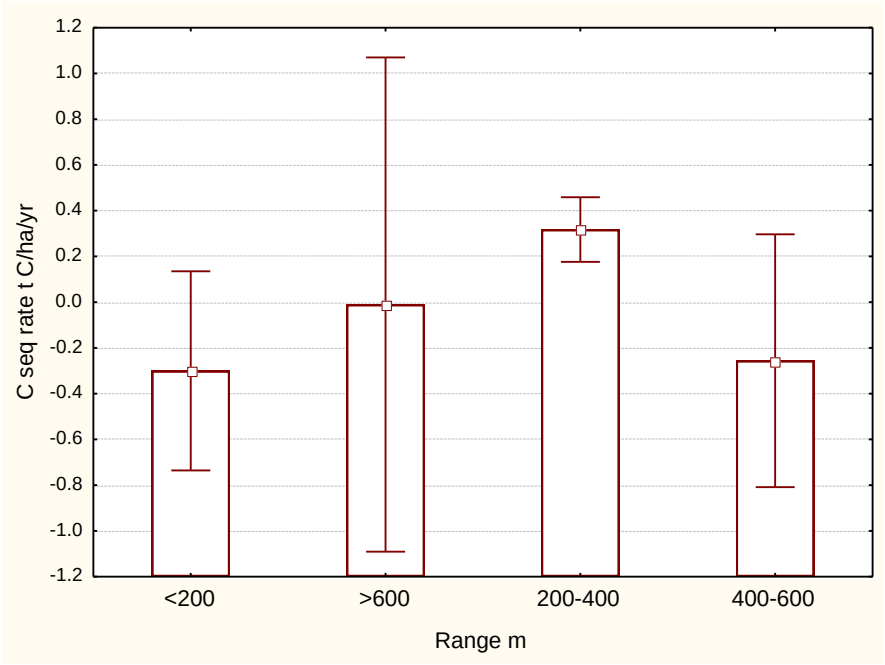


KW test p = 0.0010

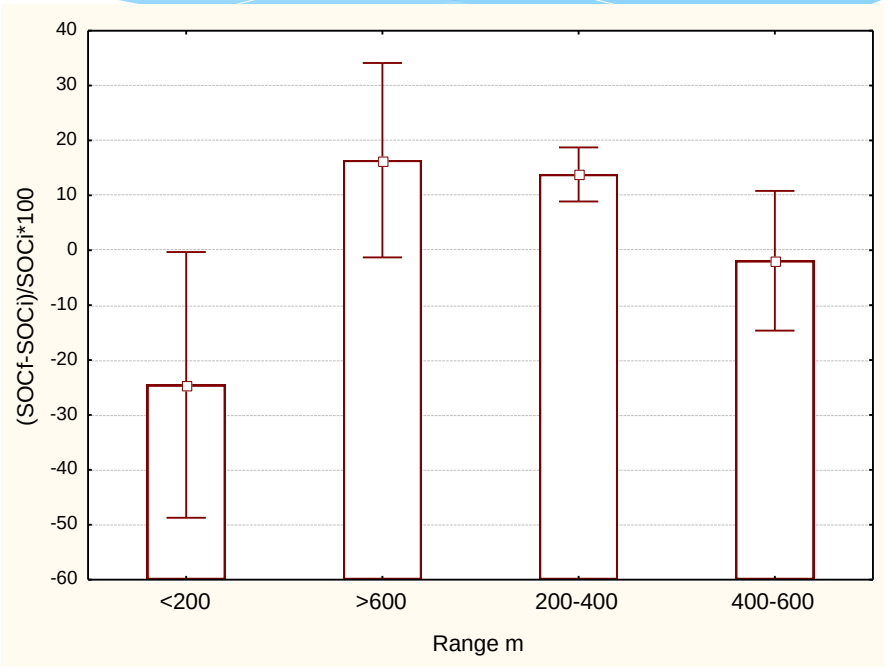


KW test p = 0.0008

Grouping by altitude

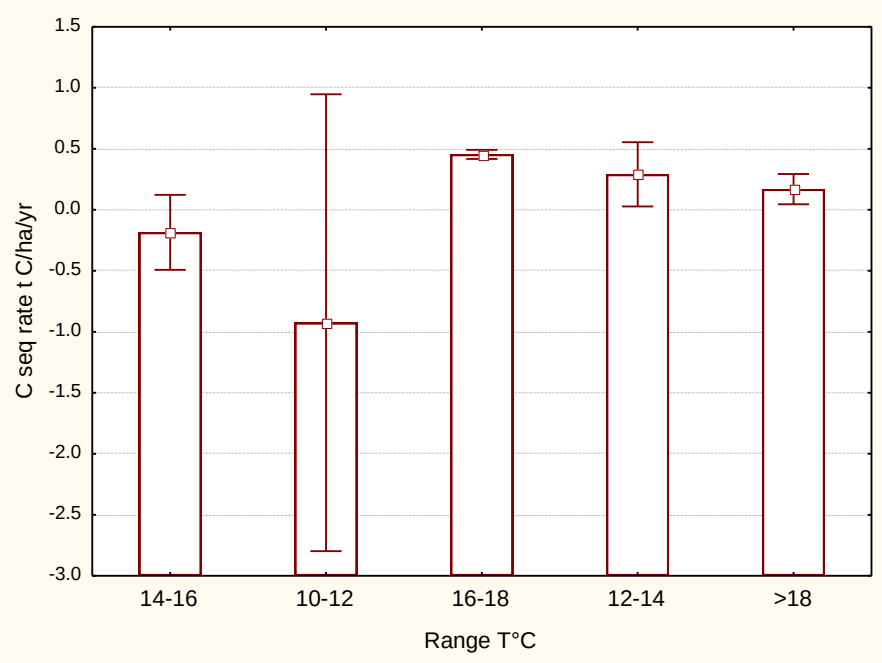


KW test p = 0.0266

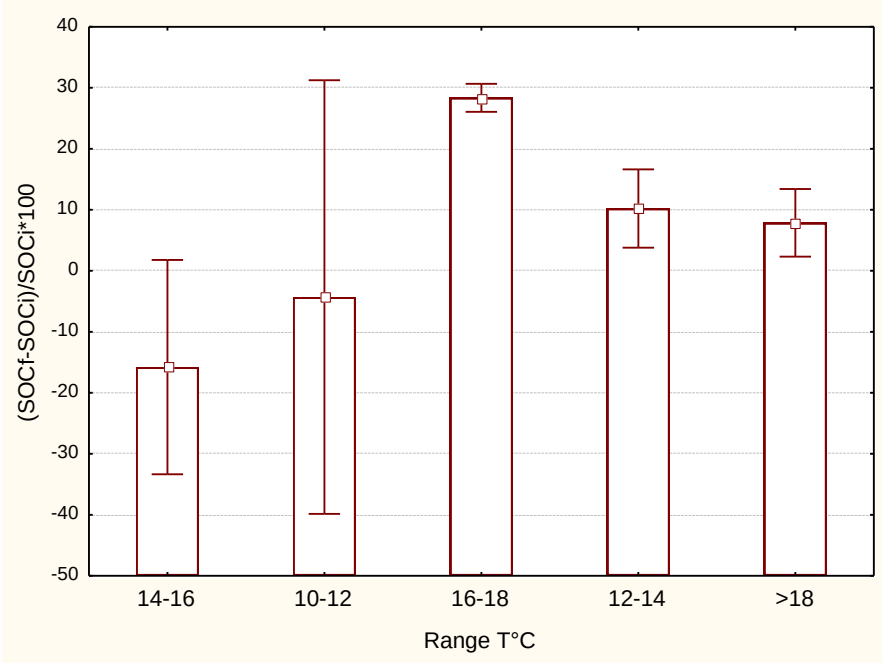


KW test p = 0.0023

Grouping by temperature

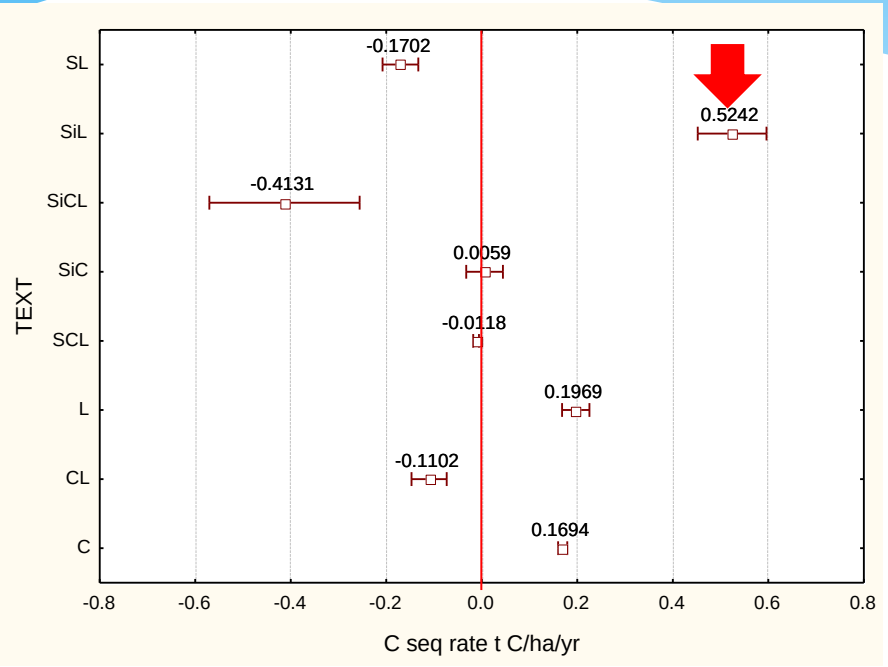


KW test p = 0.0256

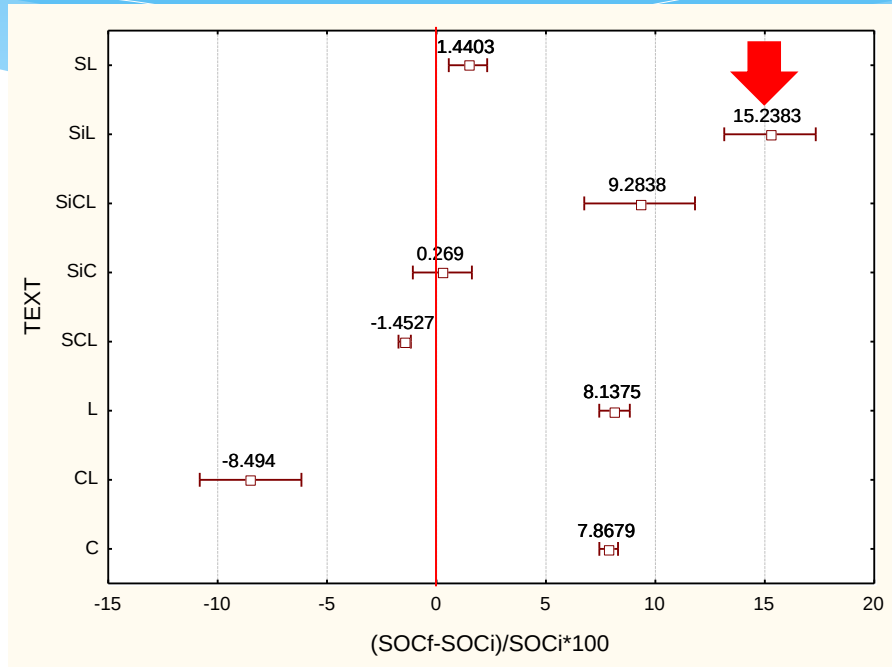


KW test p = 0.0002

Grouping by texture



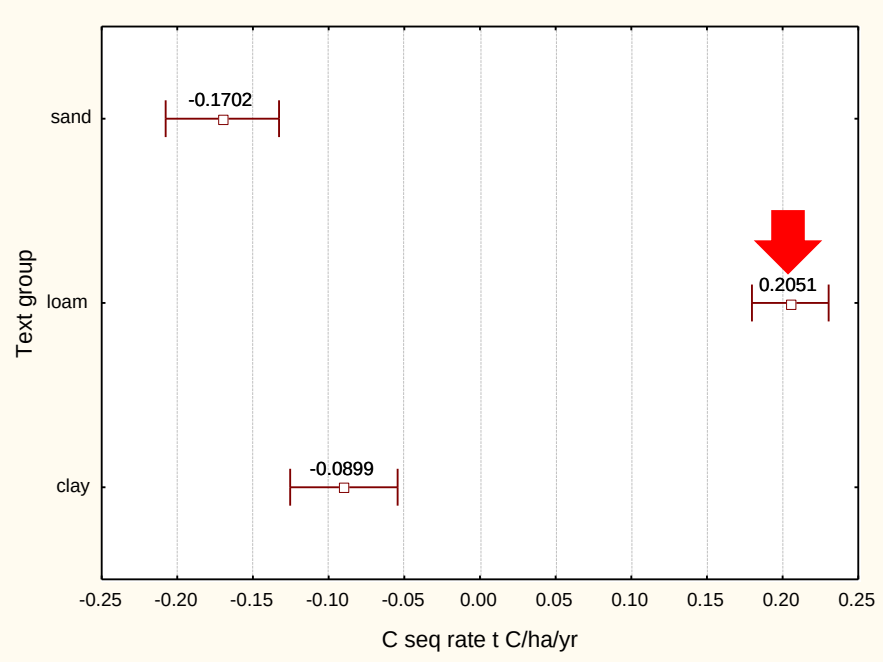
KW test p = 0.0000

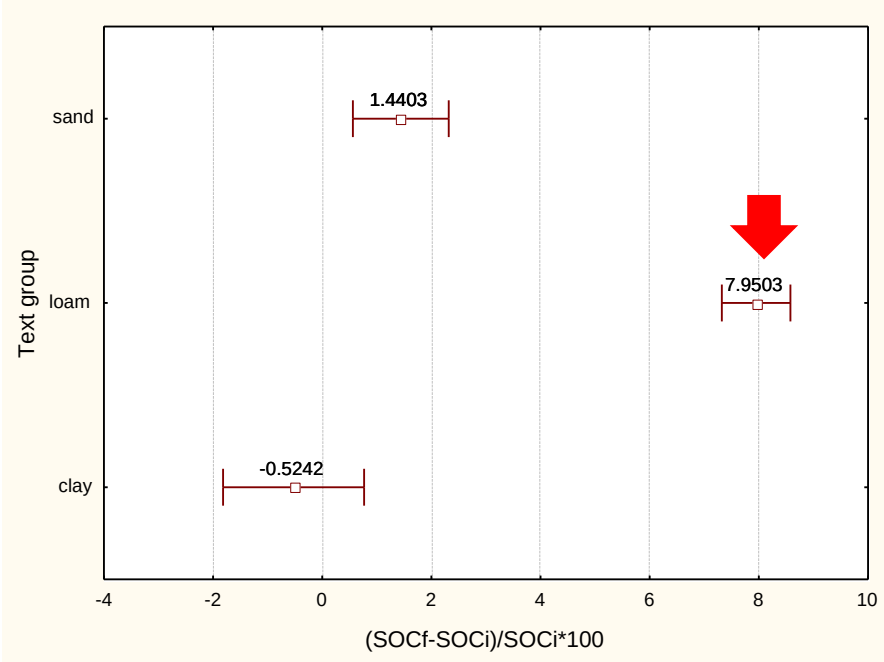


KW test p = 0.0000

Grouping by texture group

Sand >60% S
Loam is about 40%S-40%Si-20C%
Clay > 35%C





KW test p = 0.0000

KW test p = 0.0000

Conclusions

The following conclusions can be derived from the data-set:

- Carbon sequestration rate is significantly more effective under no-tillage in comparison with minimum and conventional tillage
- Grain yields by tillage system are not significantly different
- Mixed crop rotations (more than 3 yrs) and organic fertilizations showed a higher sequestration rate
- SOC sequestration rate is dependent on the duration of the experiment
- Site altitude and temperature influence SOC sequestration rate
- SOC sequestration is significantly dependent on soil texture


Thank you for your attention
We did not inherit the Earth from our parents, we borrow it from our children (Navajo Proverb)
12.10.2006