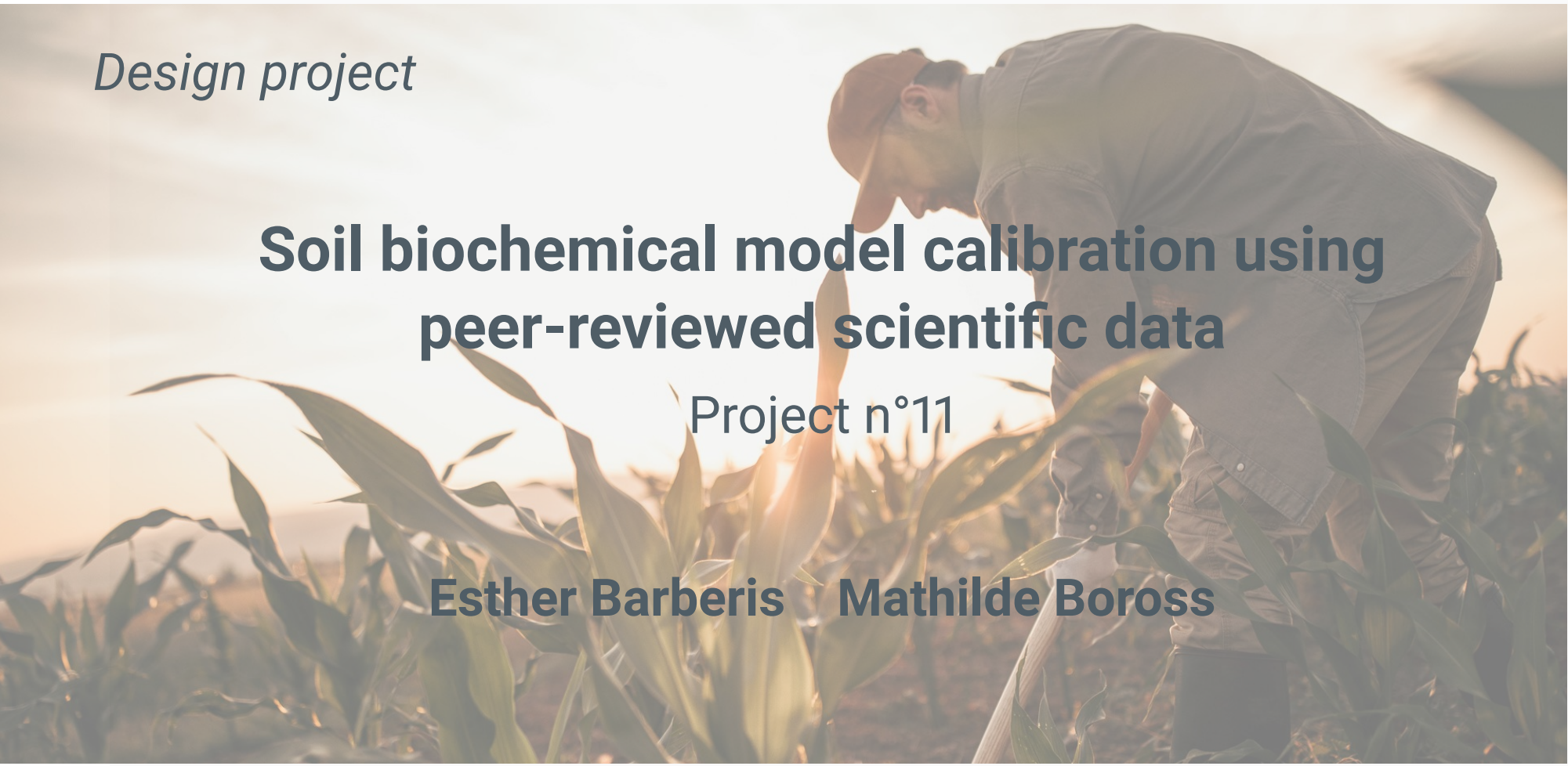

Design project

Soil biochemical model calibration using peer-reviewed scientific data

Project n°11

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EPFL indigo™

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Introduction

- Collaboration with **Indigo Agriculture Ag**
- Impact of agriculture practices on **soil organic carbon (SOC)** sequestration
- Model of soil biochemistry for the quantification of change induced with the management practices
  - Adding **cover crops**
  - Diversifying the **crop rotation**
  - Reducing or eliminating **tillage**
  - Management of **fertilizer** inputs

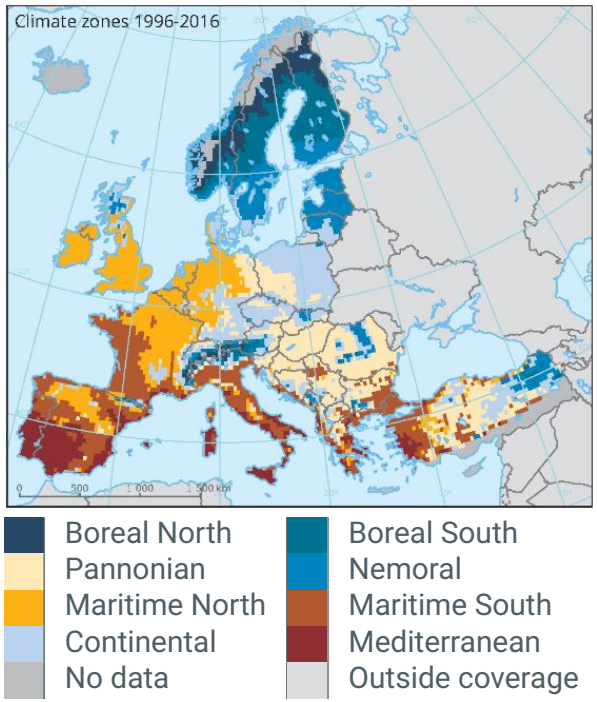



Goal, objectives and methodology

Collection of a database of **SOC content** for different agricultural practices

1. Collection of papers
   - Web Search
   - Databases
2. Selection of papers
   - Peer-reviewed
   - Management, experiment type and duration
   - Measured parameters
   - Practices
3. Definition of the priority order
   - Countries and agro-climatic zones
   - Agricultural practices
   - Crops
4. Extraction of data
   - Paper evaluation
   - Datapoint SOC
5. Analyses of data

Agro-climatic zones according to Ceglar et al.



Description of the Practice categories (PC)	
PC	**PC description**
Fertilization	Inorganic nitrogen fertilizer application
Organic	Organic amendments application (e.g. mulch, compost, manure)
Tillage	Soil disturbance and residue management
Crop	Cropping practices, planting and harvesting
Grazing	Management of grazing and rest/recovery period

Classification of agricultural practices	
Priority	**Practice**
1	No-till/Reduced tillage Cover crop (annual) Cover crop with legume (annual) Multi specie cover crops (annual) Reduced synthetic fertilizer Replace fertilizer with organic amendments
2	Animal integration (grazing) Intercropping Decreased fallow periods Add perennial cover in strips Cover crop (perennial) Cover crop with legume (perennial) Multi species cover crops (perennial)

Hypotheses

Tillage

"Reduction of tillage or no-till leads to the stratification of carbon stocks in soils."

"Measured effects of reduced tillage and no-till results in higher amount of organic carbon in soil surface though less impact is seen at greater depth."

Fertilization

"Application of inorganic fertilizer could increase SOC due to increase crop production and plant residue."

"Application of inorganic fertilizer could lead to soil bulk density increases."

Organic amendment

"Addition of farmyard manure leads to significant increase in soil organic carbon over time."

Results SOC stocks [kg/m^2] all sites

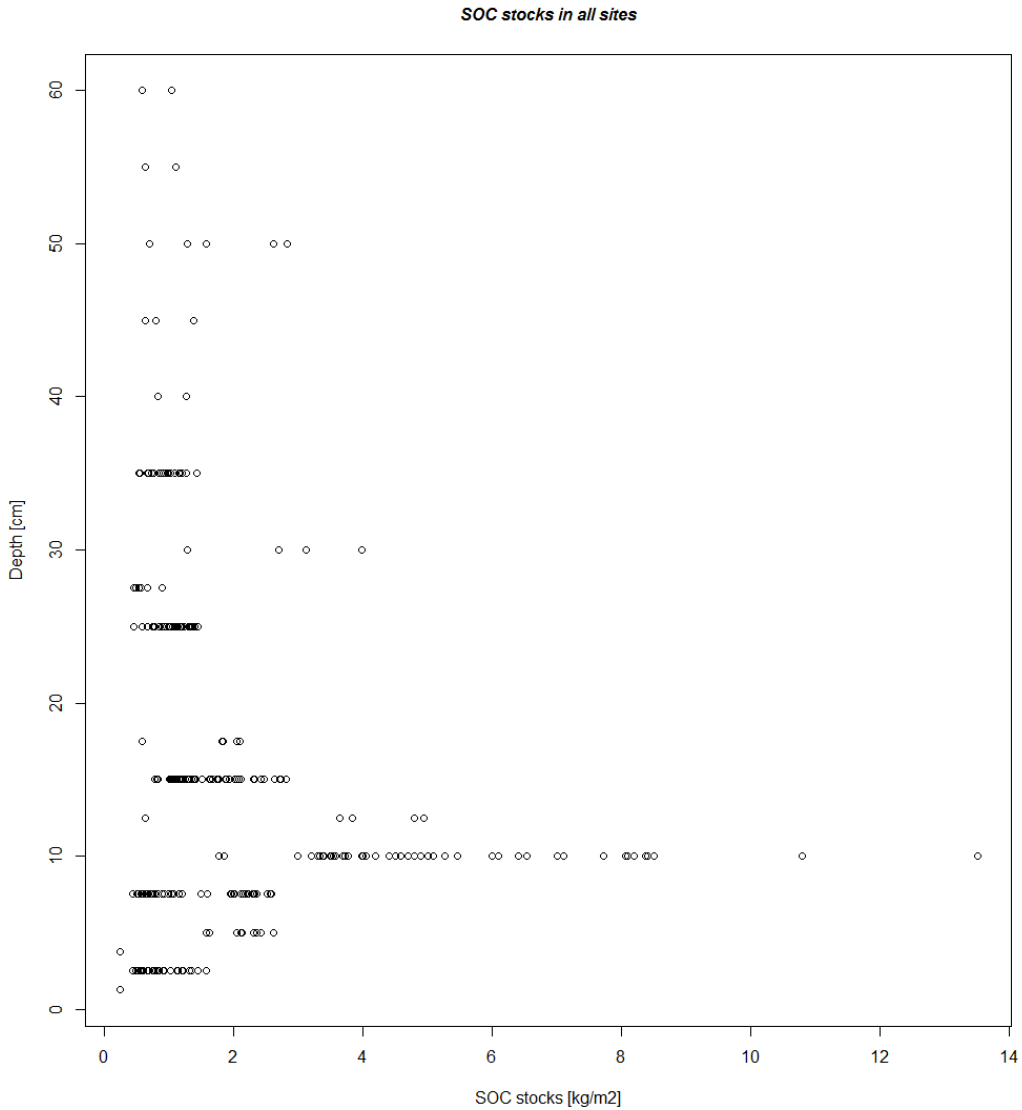


Figure: SOC stocks [kg/m2]

Results Tillage SOC stocks by site

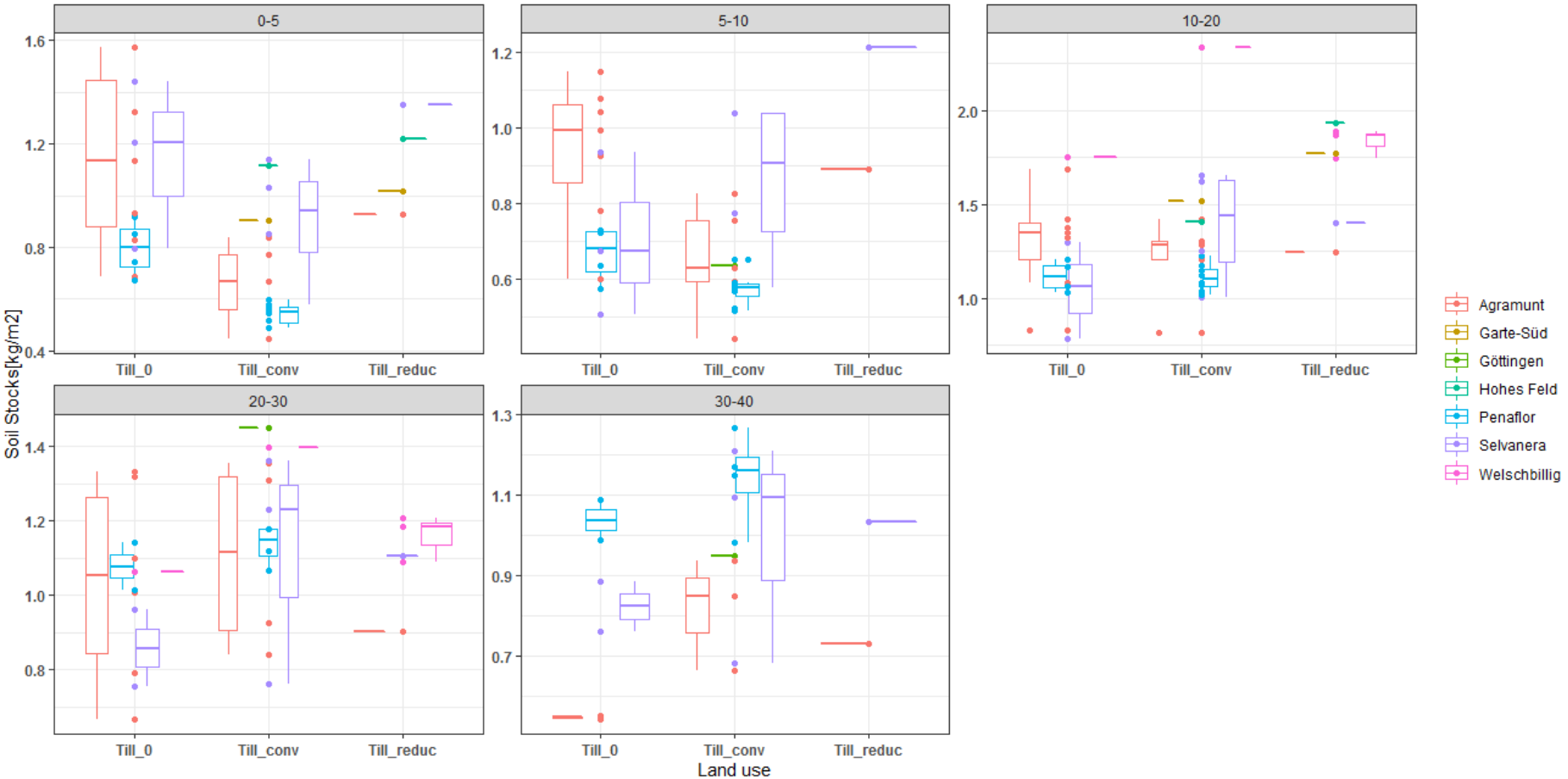
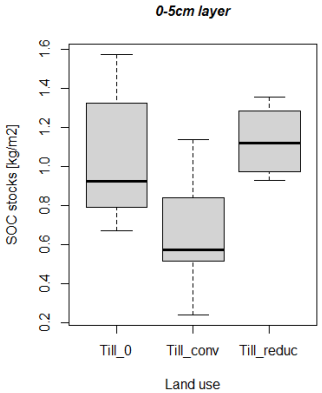
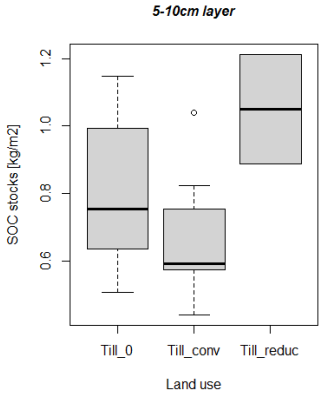


Figure: SOC stocks for tillage

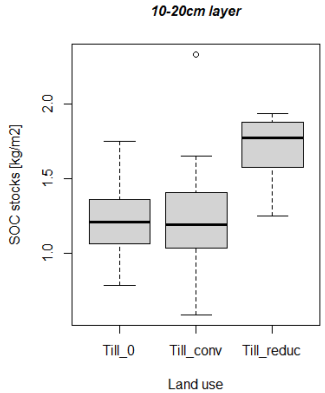
Results SOC stocks in Tillage Summary all sites



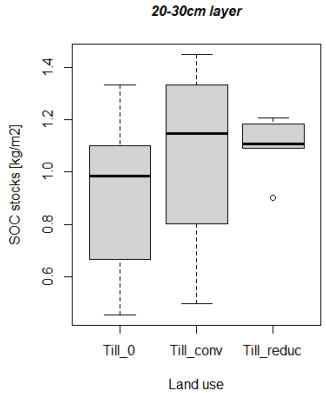
(a) 0-5 cm



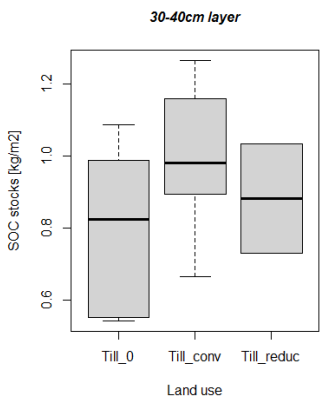
(b) 5-10 cm



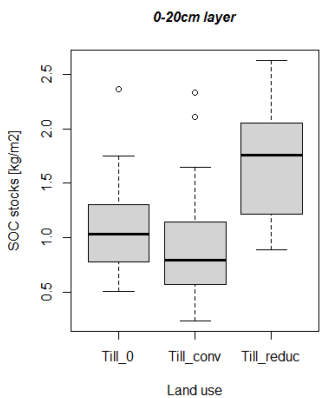
(c) 10-20 cm



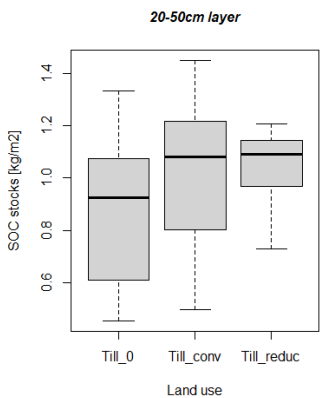
(d) 20-30 cm



(e) 30-40 cm



(f) Topsoil (0-20 cm)



(g) Subsoil (20-50 cm)

Results Fertilization-Organic SOC Stocks by site

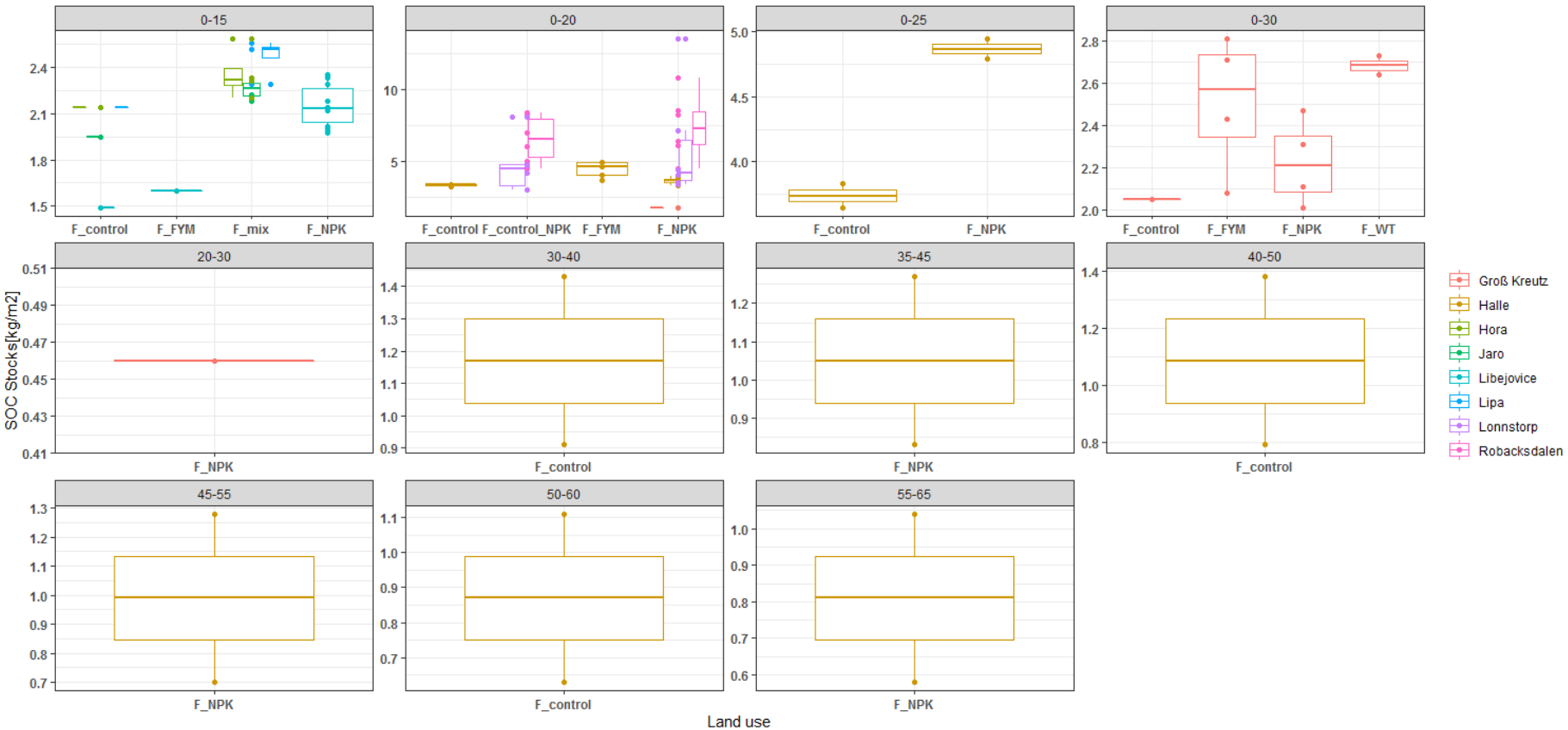
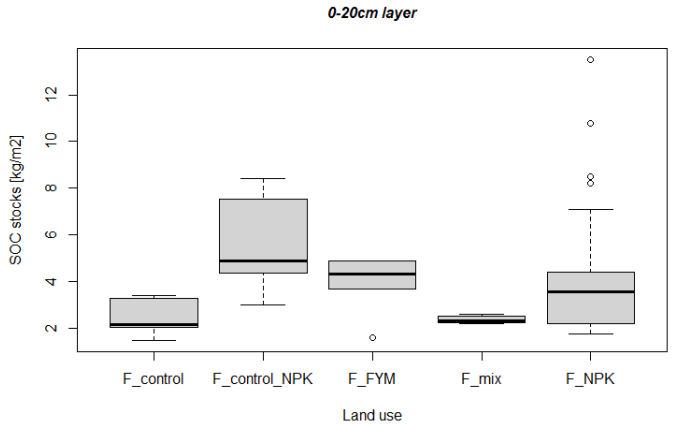
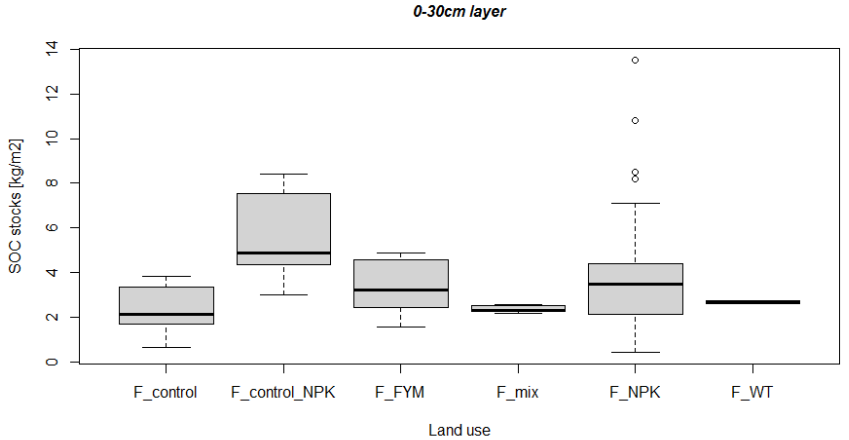


Figure: SOC stocks for Fertilization

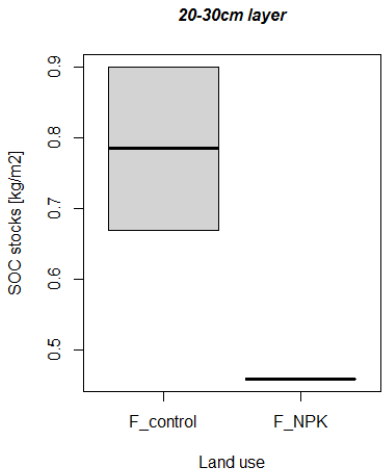
Results Fertilization-Organic SOC stocks Summary all sites



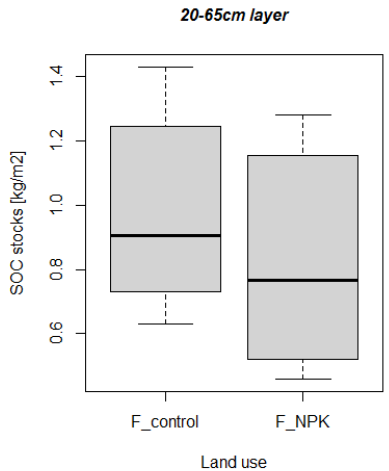
(a) 0-20 cm



(b) 0-30 cm



(c) 20-30 cm



(d) 20-65 cm

Figure: SOC stocks for fertilization treatments

Results p-ANOVA

- At first a linear regression model was applied in combination with a p-anova test to identify the influence of land use on SOC stock at individual depths.
- The confidence used to assess the significance of the results were α **=0.05** and α **= 0.1.**
- The goal was to find if there was any significant statistical difference between each treatment regarding a practice and according to soil depth (regarding SOC content).
- The null hypothesis H_0 for the test is that the means of the group at each level of the independant variables are the same.

Results p-ANOVA - Tillage

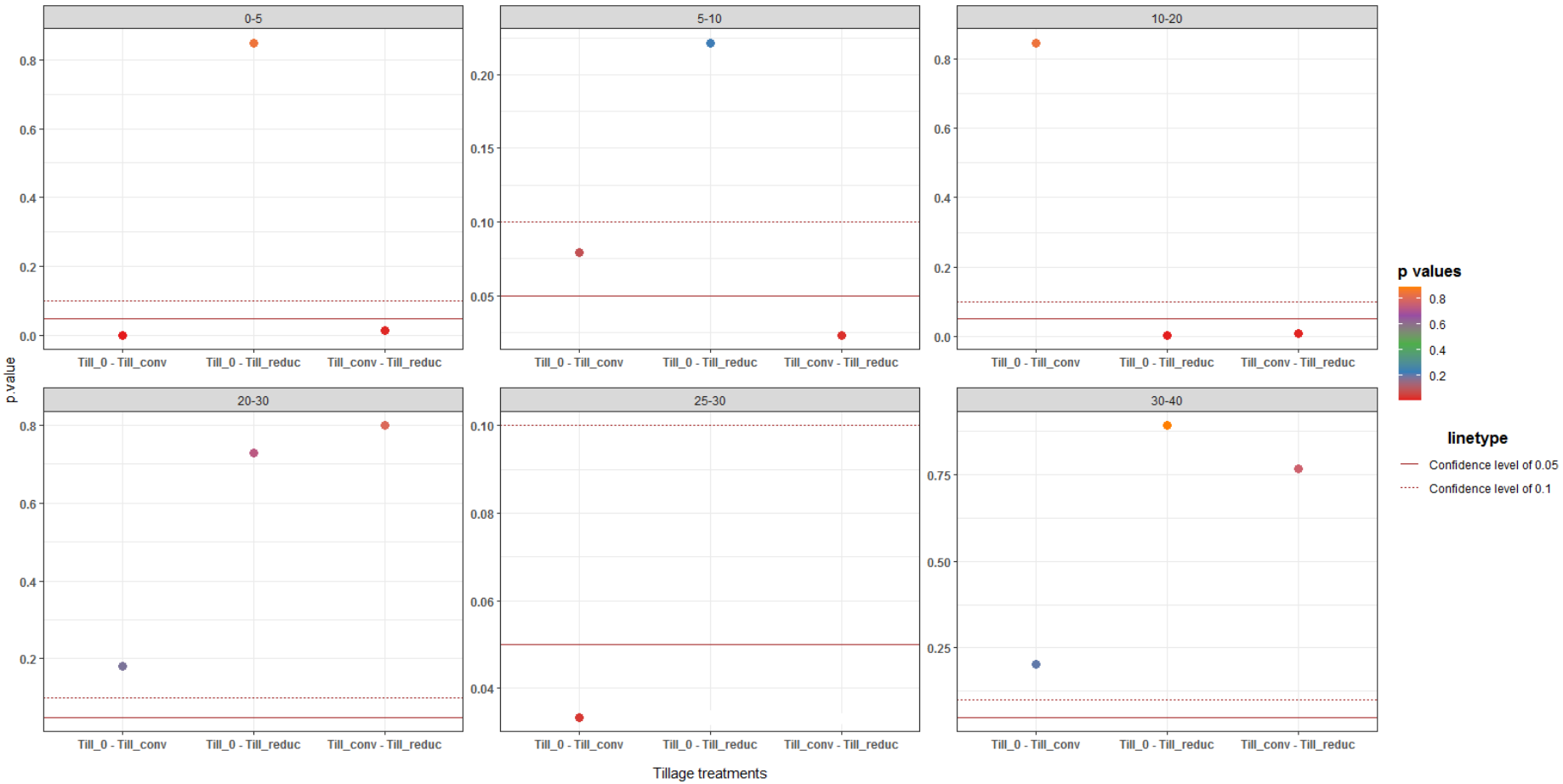


Figure: p-values : Influence of tillage treatments on SOC stock variation

Results p-ANOVA - Tillage

- In the following table are presented other sources of variation on the SOC stock content. The depth range and the type of crop have a significant influence on the SOC content as well (p-value <.0001).
- The variable Land use*Depth and Land use*bulk density are also significant meaning variation in SOC content can be explained by the interaction between land use and the depth range and bulk density.

Model SOC stock with linear regression and p-anova test	
Sources of variation	**p-value**
Land use	0.1533
Land use*time	0.1842
Depth range	<.0001
Crop	<.0001
Bulk density	0.0728
Land use*Depth range	<.0001
Land use*Bulk density	<.0001
Land use*Depth range +Bulk density	0.123
Land use*Depth range*Bulk density	0.5090

Table 15: F and p-values - Linear regression combined with Anova test -Tillage

Figure: p-values : Influence of parameters on SOC stock variation in tillage

Results p-ANOVA - Fertilization-Organic

Figure: p-values : Influence of fertilization and organic treatments on SOC stock variation

Results p-ANOVA - Fertilization-Organic

- In the following table are presented other sources of variation on the SOC stock content. The depth range, the bulk density and the type of crop have a significant influence on the SOC content as well (p-value <.0001).
- The variable Land use*Depth and Land use*bulk density are not significant meaning variation in SOC content cannot be explained by the interaction between land use and the depth range and bulk density contrary to tillage.

Model SOC stock with linear regression and p-anova test	
Sources of variation	**p-value**
Land use	0.0541
Land use*time	0.0472029
Depth range	<.0001
Crop	<.0001
Bulk density	<.0001
Land use*Depth range	0.515
Land use*Bulk density	0.05083
Bulk density*Land use	<0.0001
Land use*Depth range +Bulk density	0.5
Land use*Depth range*Bulk density	0.98

Figure: p-values : Influence of parameters on SOC stock variation in tillage

Discussion of results

- Regarding tillage, we can see a clear significant difference between the effect of no tillage and conventional in the 0-5 cm layer and as well between reduced tillage and conventional tillage.
- Now looking at deeper layers, there were a few significant results including clear significant results between reduced tillage and conventional tillage.
- The goal was to illustrate the SOC stratification occurring under no tillage and reduced tillage meaning higher content is seen in the "top soil" compared to conventional tillage under which SOC content is more homogenized.
- In the case of fertilization, SOC stocks content were usually higher than in the tillage treatment and each treatment was influenced by the input (N,P, K, C).
- We can see fertilization treatments had apparently a significant impact on bulk density but we did not have viable data so it may be biased.

Conclusion

- **Bulk density**: either considered the same in all layers and/or the same across the duration of the experiment or it was usually only measured at the start of the experiment and not at the end.
- **SOC stock content**: not reported on several studies and often only measured at the end of the experiment (no possibility for assessment of its evolution).
- Many studies did not report significant data such as the incertitude linked to measurement of parameters (SOC stocks, SOC concentration, bulk density)
- First step of a project of larger scale: building, adjustment of the database, focus made only on a few priorities
- **Final model**: add value to sustainable practices with smaller impact on soil, useful tool to get more fertile and productive soil