

# INNOVATIVE FIELD TEST METHODS FOR TILLAGE TOOLS

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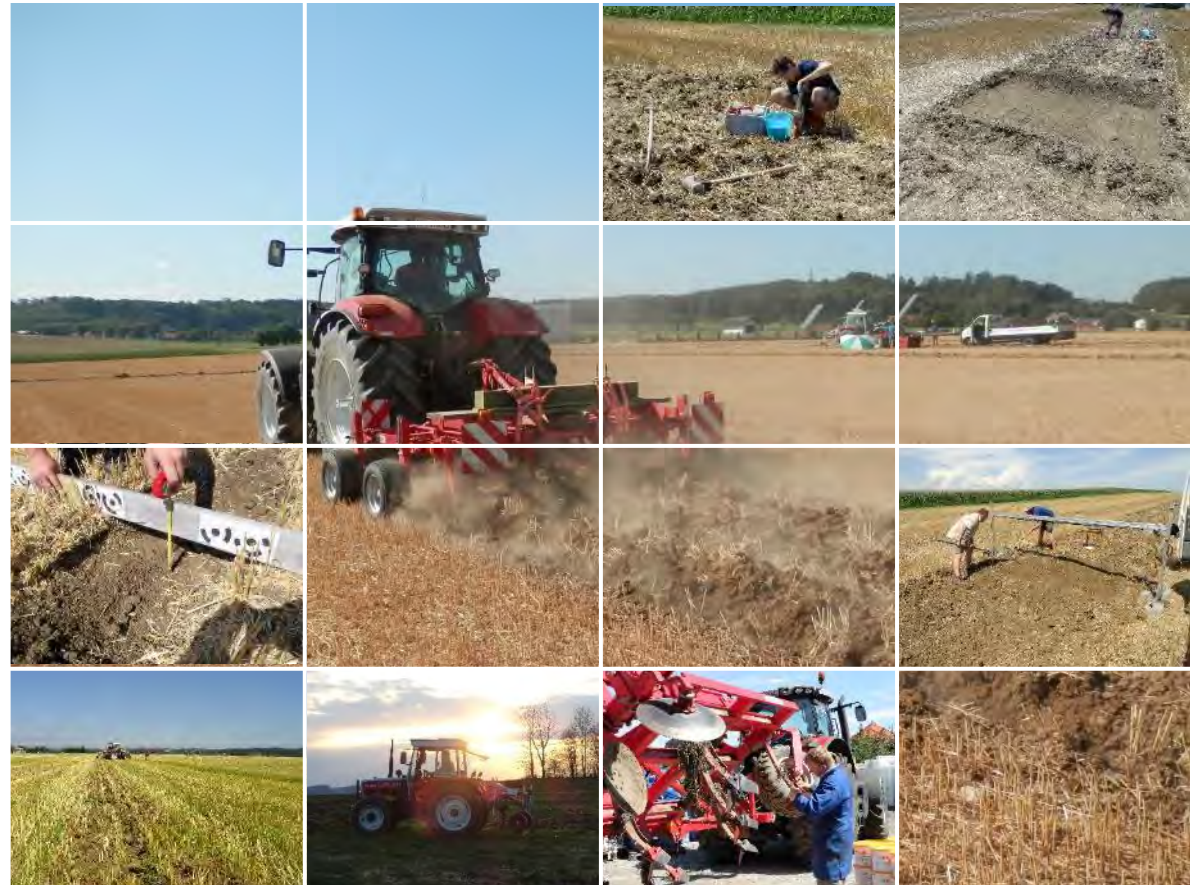
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*JOSEPHINUM RESEARCH WIESELBURG*



## Challenges for in-field testing of tillage tools

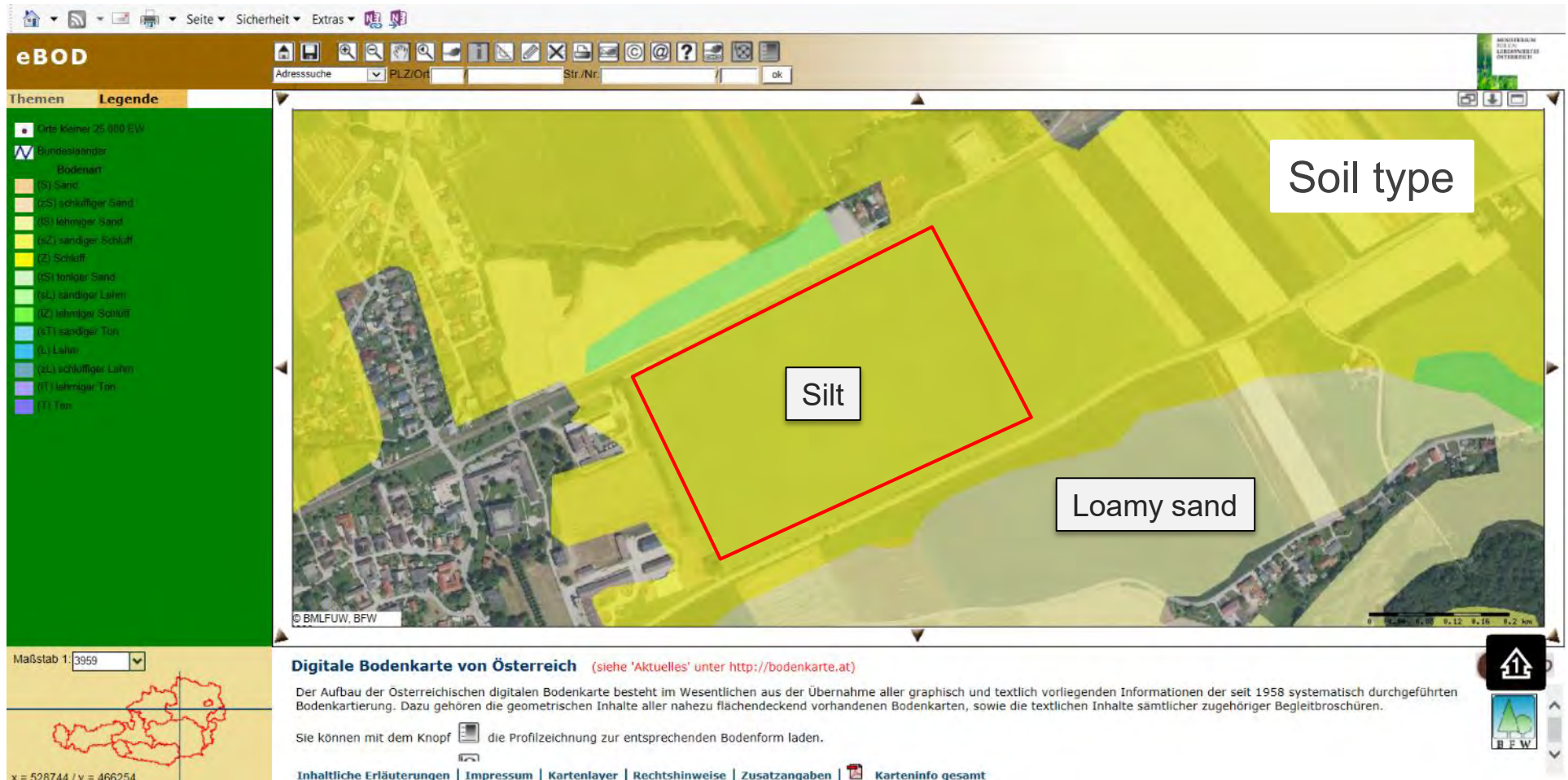
- Spatial variability of soil properties and soil conditions
  - soil type
  - water content
  - bulk density
  - existing tracks
- Test setup / procedure
  - ensuring constant and equal tillage depth
  - constant forward speed
  - assessment of tillage quality



## Spatial variability of soil properties

- Digital soil map of Austria – eBod

<http://gis.lebensministerium.at/ebod>





## Spatial variability of soil properties

- Satellite image



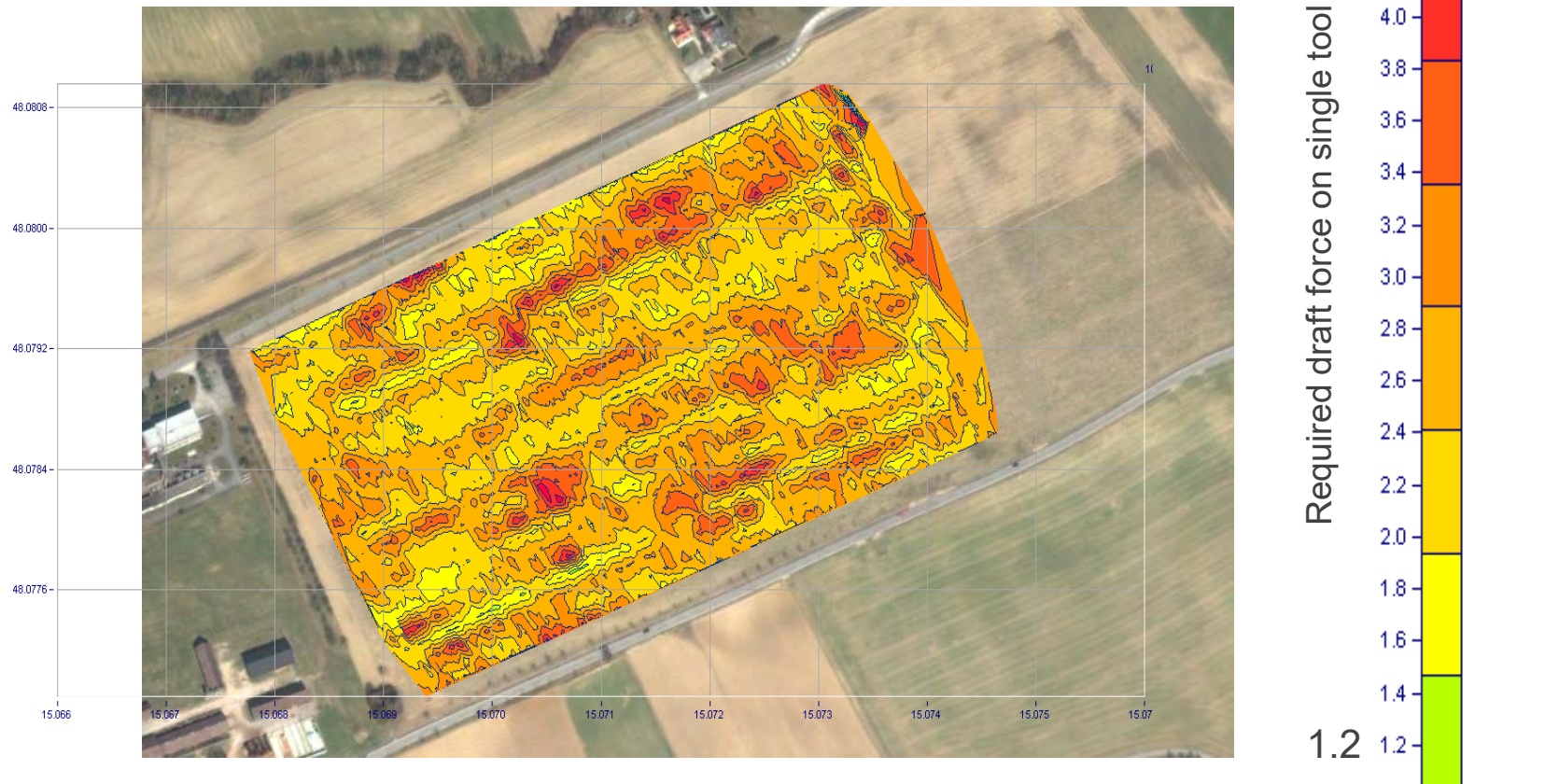
## Spatial variability of soil properties

- Soil water content



## Spatial variability of soil properties

- Draft force requirement on a single tool

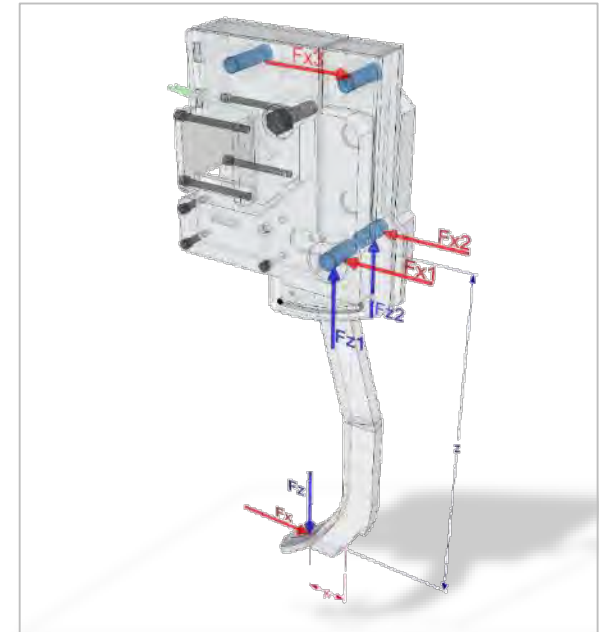
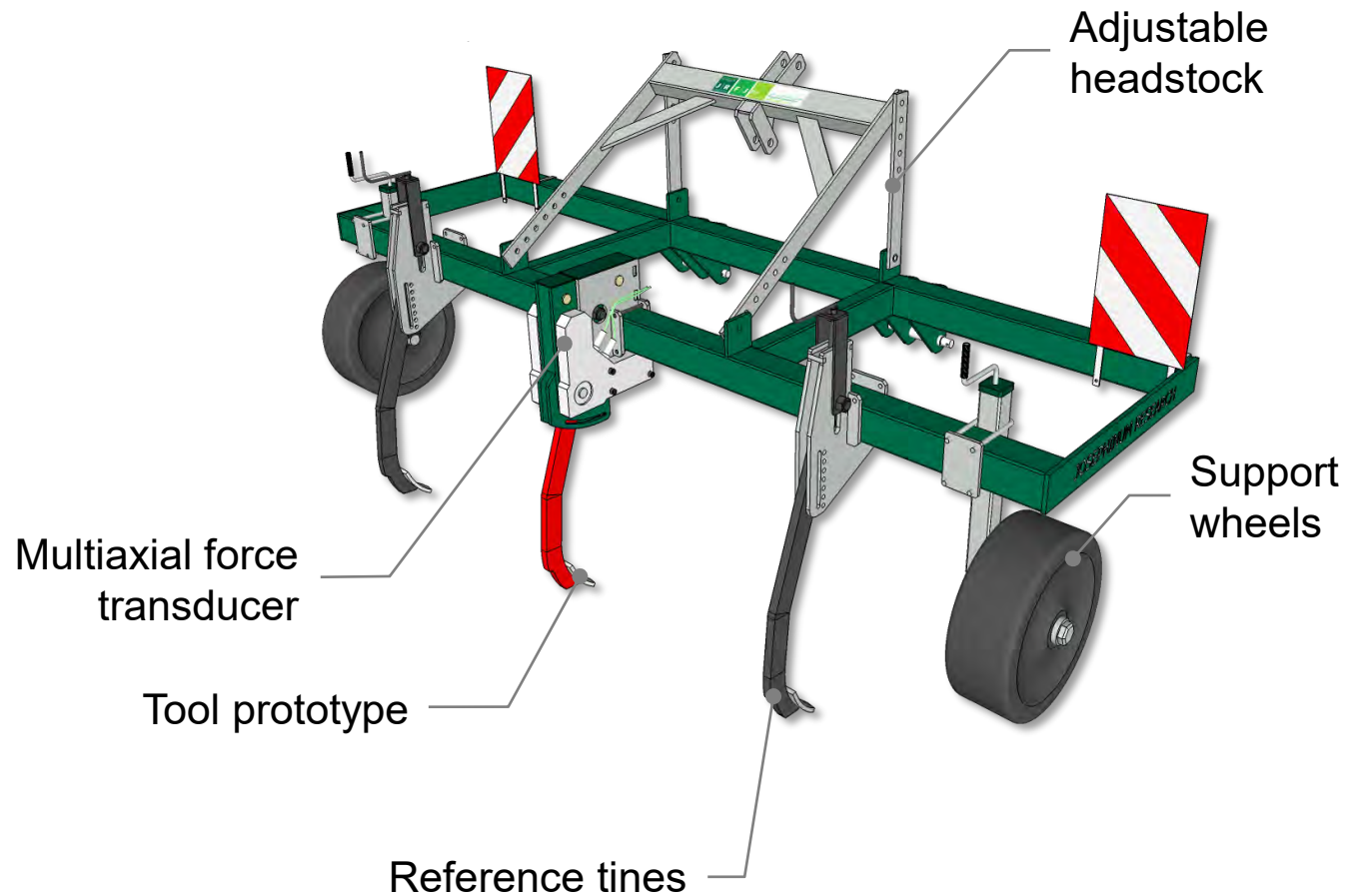


Methods

# FORCE MEASUREMENT DEVICES FOR TILLAGE TOOLS



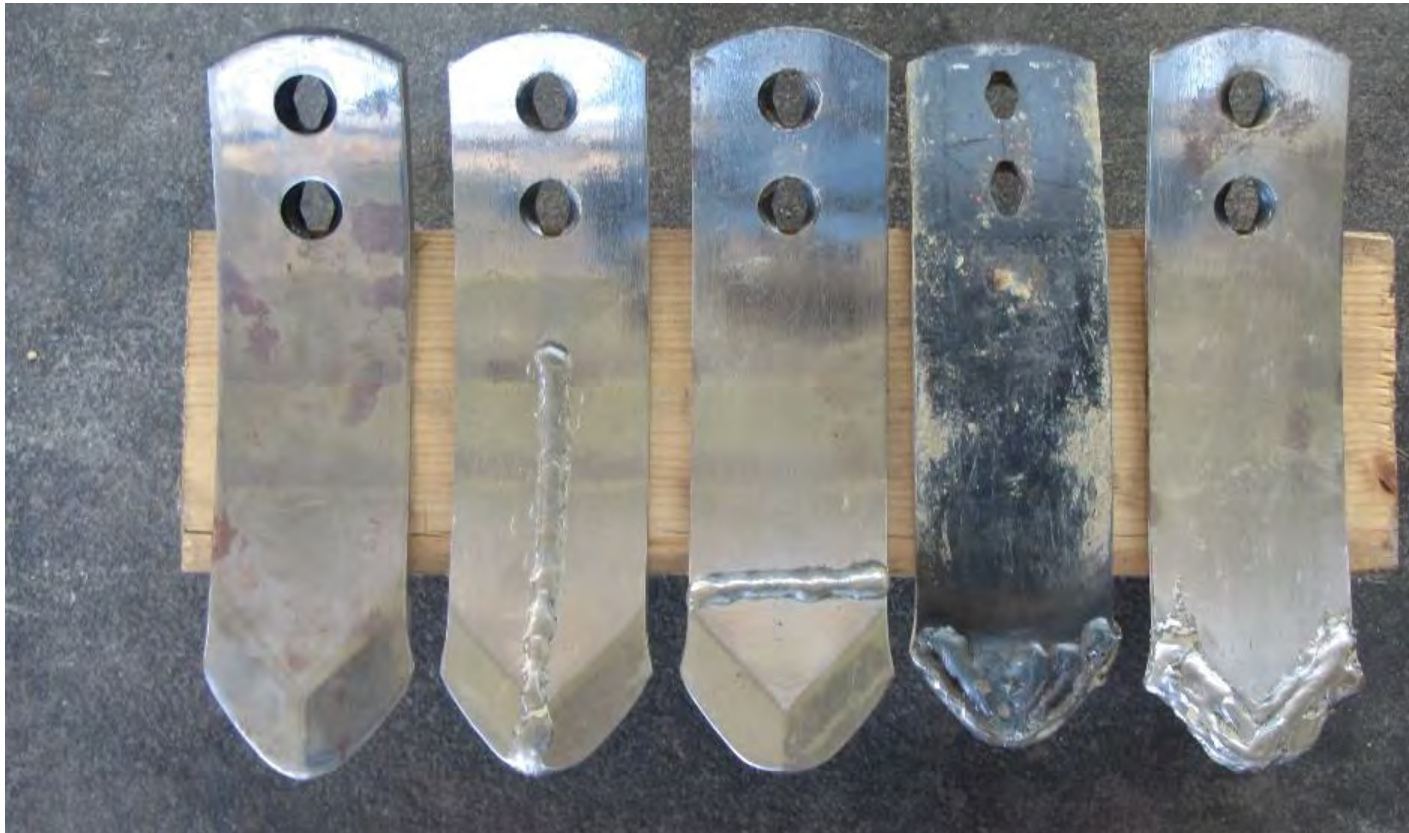
## Force measurements on a single tool





## Force measurements on a single tool

- Increase in draft force requirement through welded hardfacings



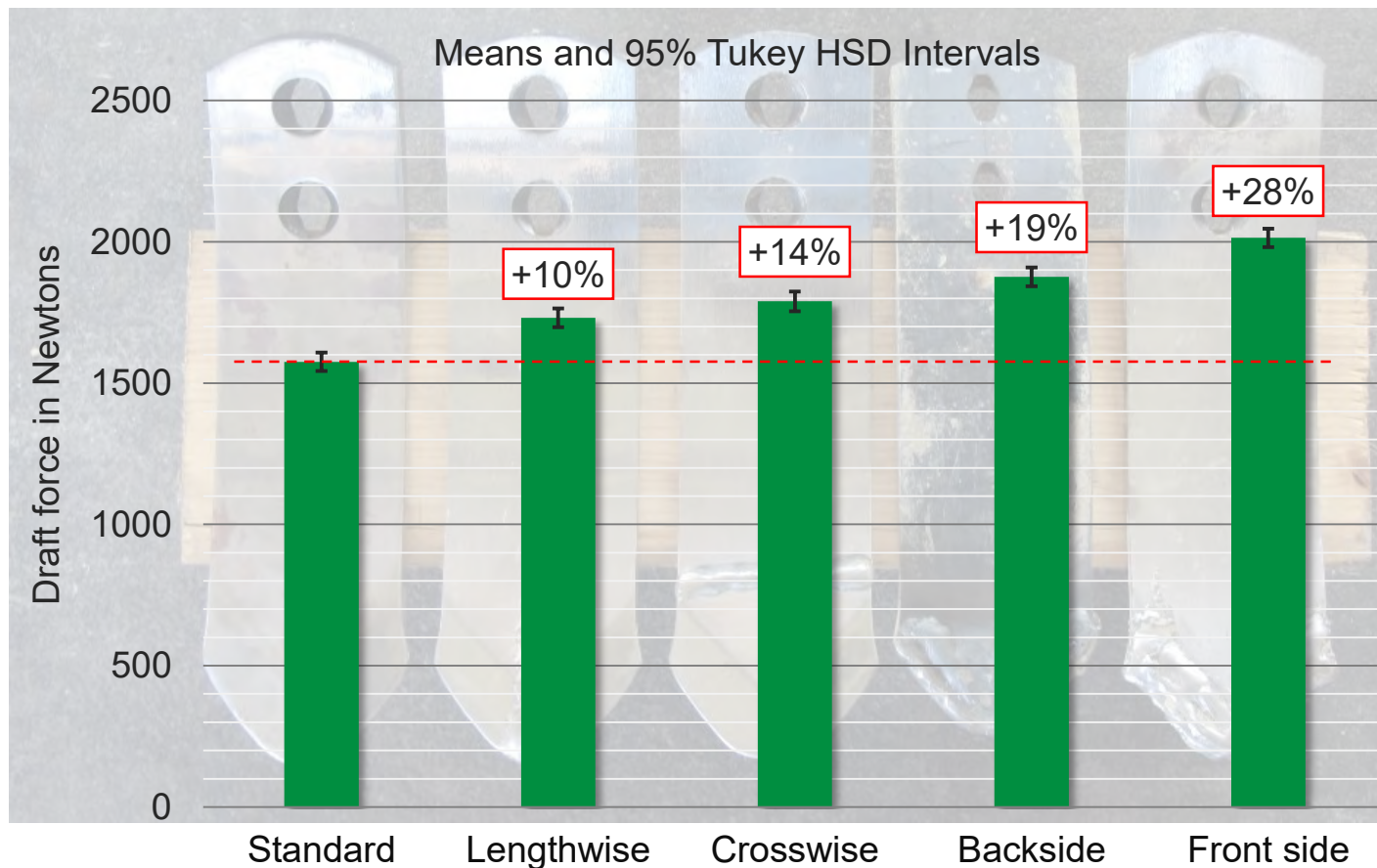
## Increase in draft force requirement through welded hardfacings

- Test tracks angular to main tillage direction
- 10 tracks divided into 4 subsections → 40 repetitions per variant
- Usually no randomisation of track order required



## Increase in draft force requirement through welded hardfacings

- +/- limit of 65 Newtons between variants (Tukey HSD post-hoc test)





## Force measurement on 3-point-linkage

- Force measurement on whole machine in all three dimensions
- Account for interactions between single tools
- Comparison of different tillage systems

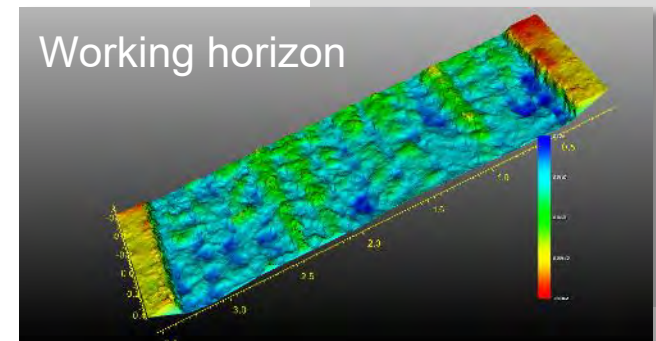
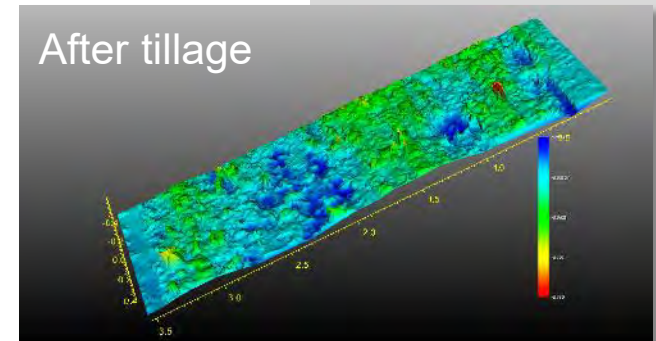
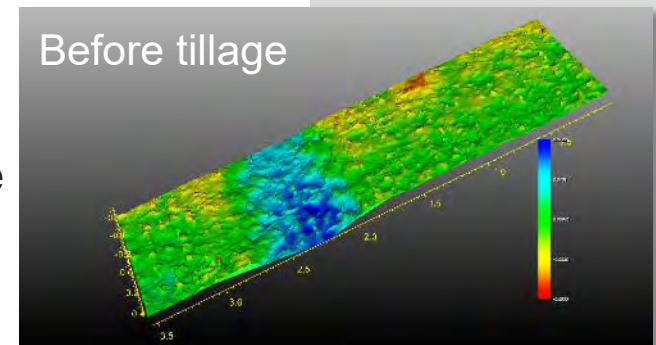


Methods

# 3D SURFACE EVALUATION BY STEREO VISION

## Linear Motion 3D scanner (Stereo Vision)

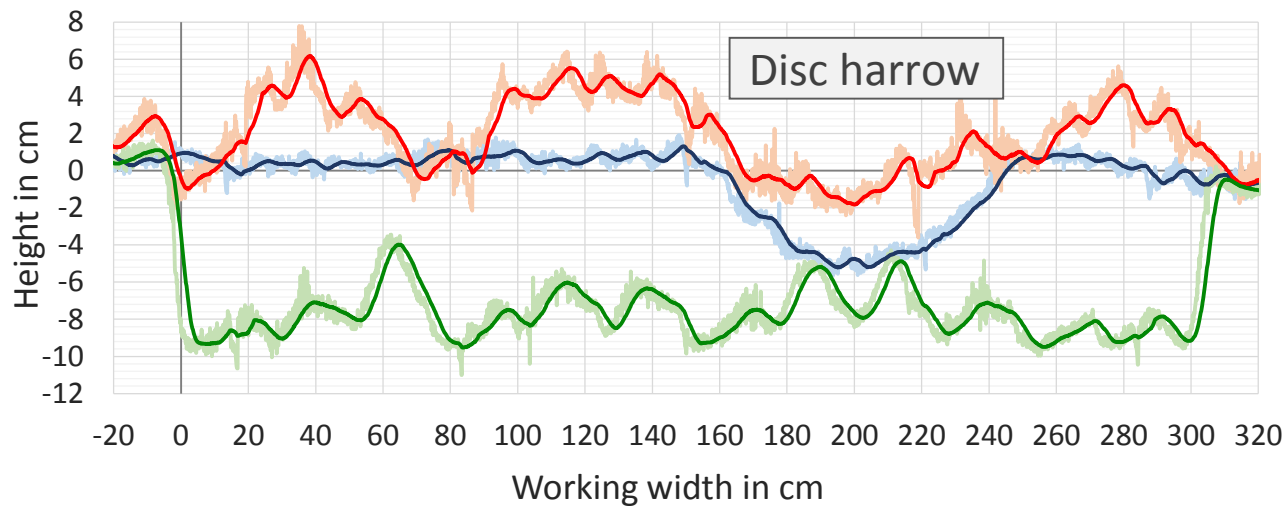
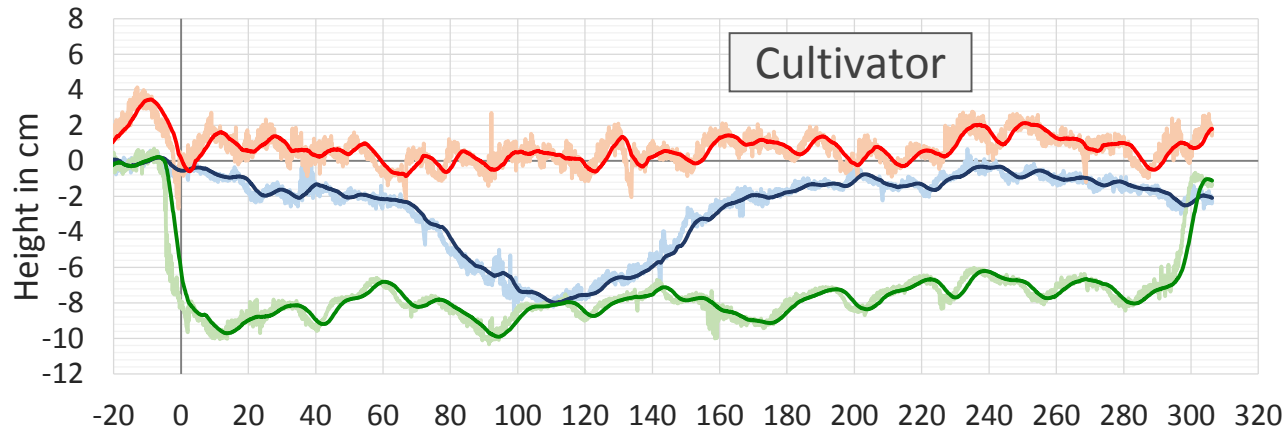
- check-up of the actual working depth
- cross section/volume of soil tilled → specific draft force
- increase of pore volume (loosening effect)
- levelling effect
- soil roughness indices after tillage (crumbling effect)
- profile of working horizon



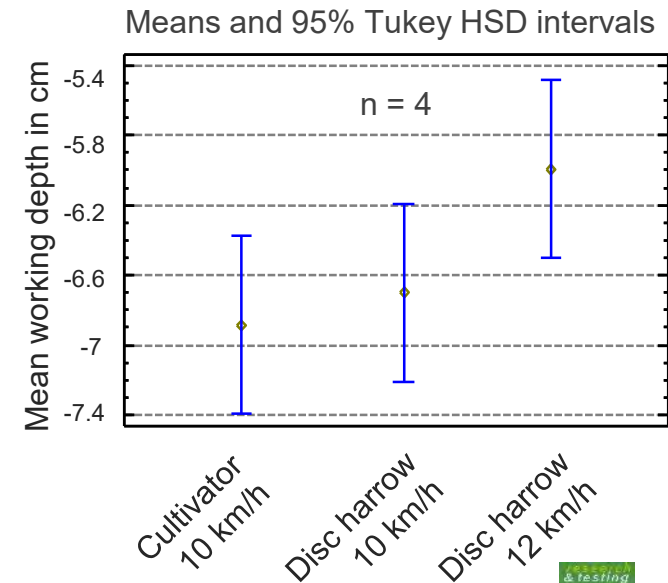
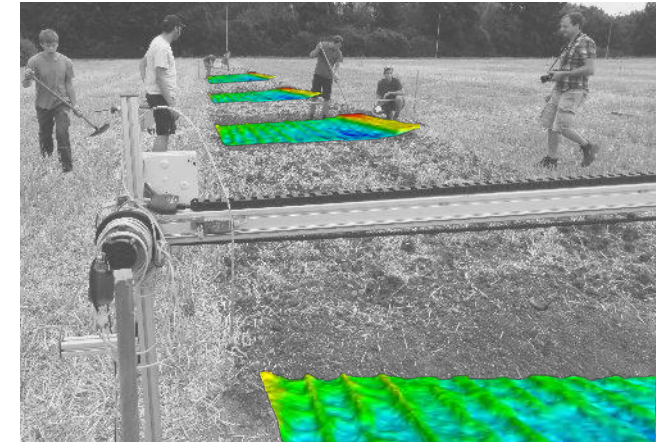


# 3D SURFACE EVALUATION – USE CASE

- Comparison of stubble cultivator with compact disc harrow



— before tillage    — after tillage    — working horizon



Methods

# ESTIMATION OF SOIL COVER BASED ON IMAGE ANALYSIS

- Objective evaluation of protection against soil erosion
- Quality assessment in tillage

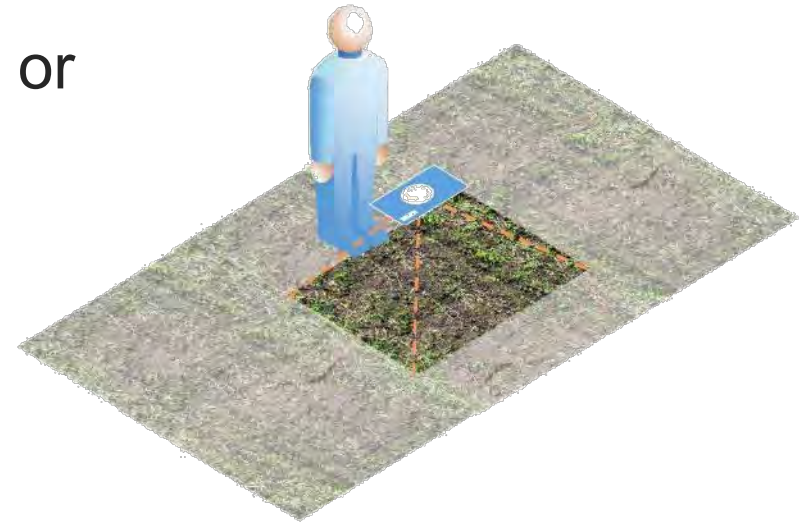


Source: Agricultural Document Library, University of Hertfordshire, 2011

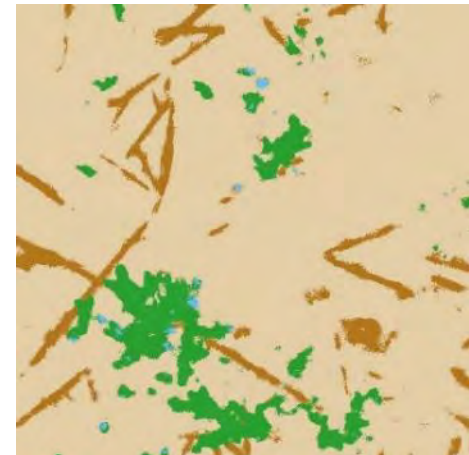
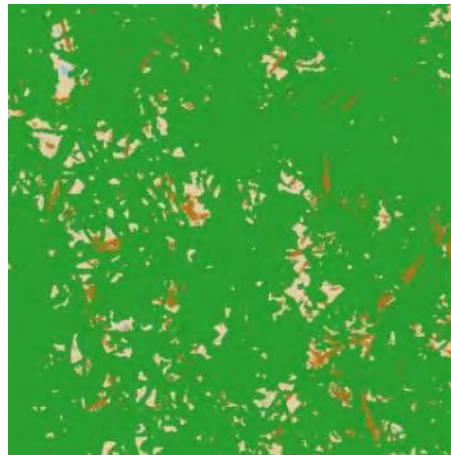
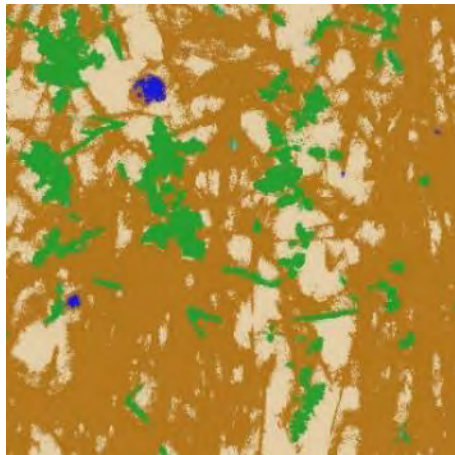




- Image acquisition by any camera or smartphone
- Annotating pixel by pixel
  - Machine learning algorithm based on Entangled Random Forests
  - Client-Server structure
- Categorising in groups
  - Soil
  - Living organic mass
  - Dead organic mass (residues)
  - Stones
  - ...



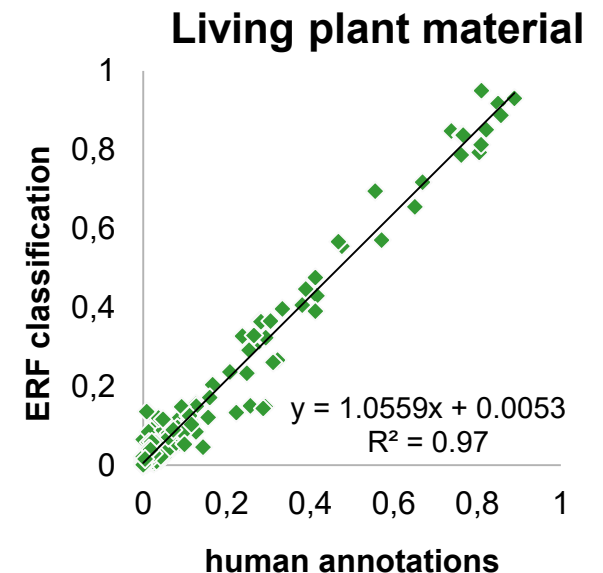
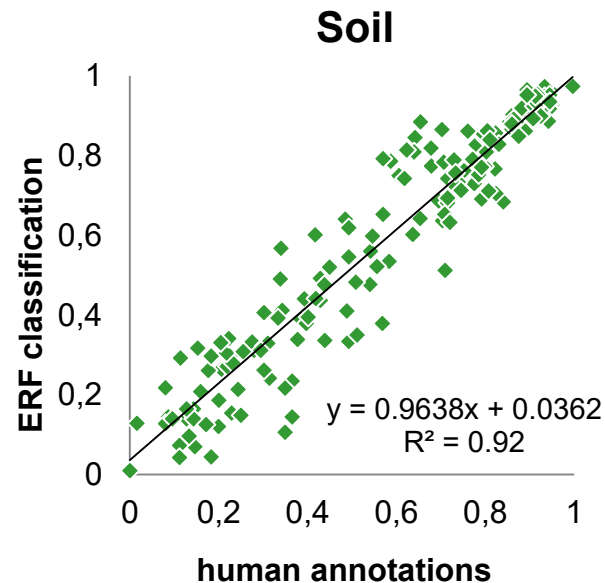
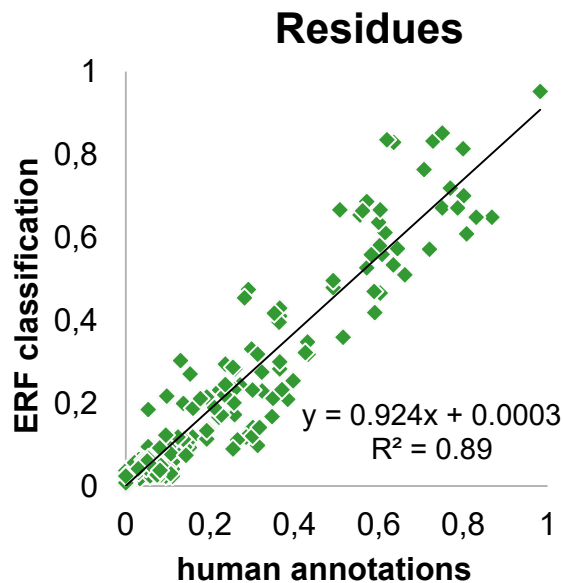
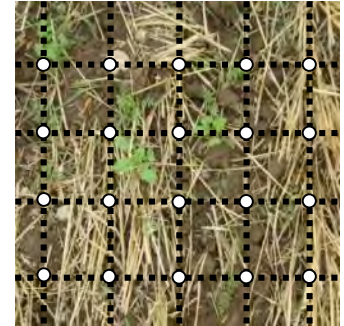
# ESTIMATION OF SOIL COVER



■ living plant ■ residue ■ soil ■ stone ■ biofilm

# ESTIMATION OF SOIL COVER

- Validation: grid method
- The method has a mean deviation of about 6% to manual annotations





# ESTIMATION OF SOIL COVER – USE CASE

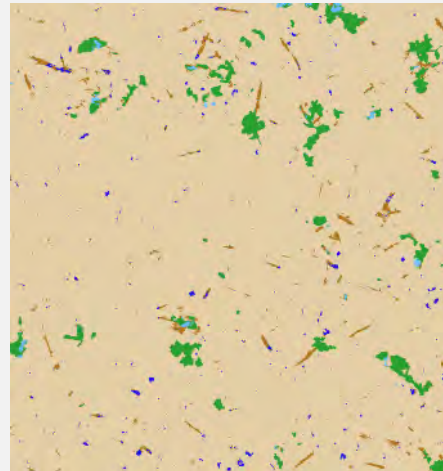
## ■ Tillage of fields with winter greening

Before tillage



soil	46%
living plant	6%
residue	29%
stone	2%
biofilm	18%

After tillage

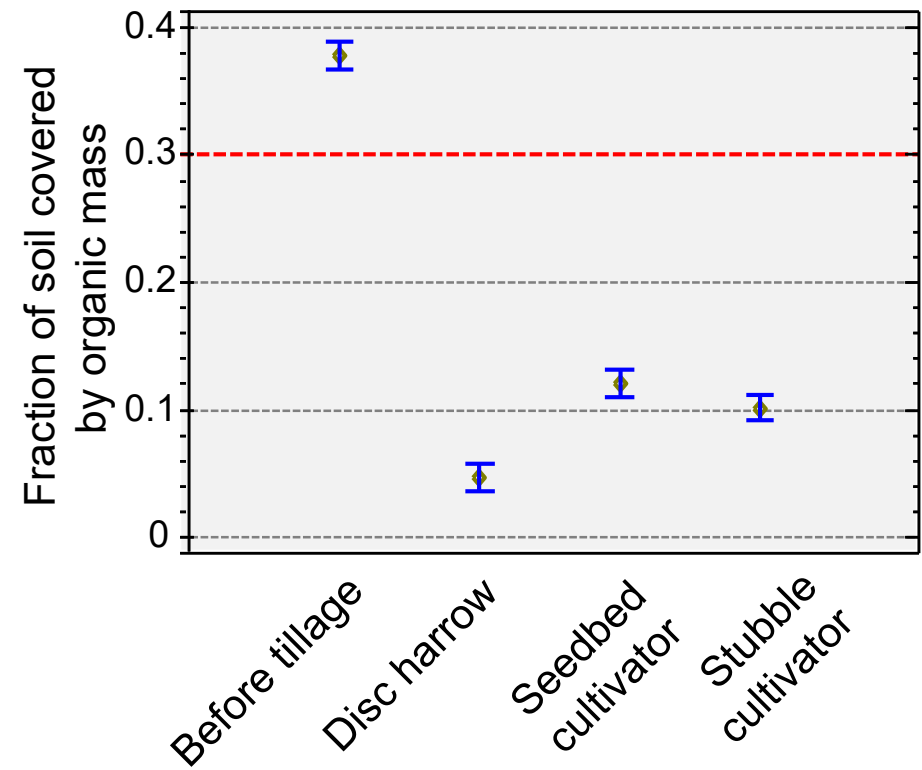


soil	95%
living plant	3%
residue	2%
stone	1%
biofilm	0%

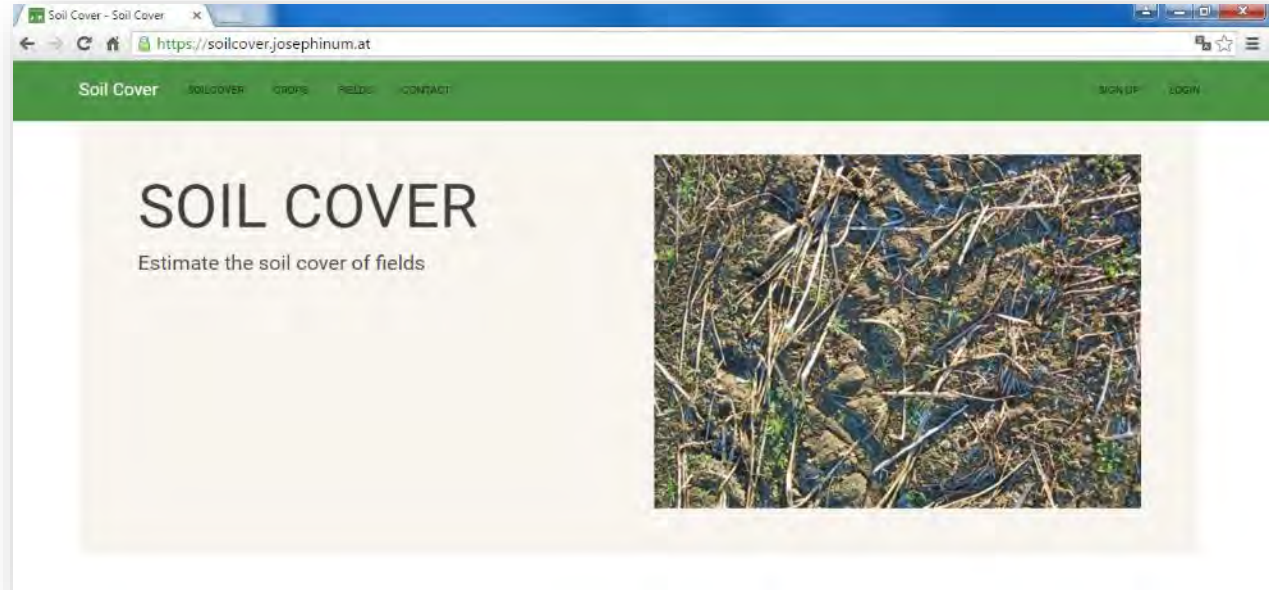
# ESTIMATION OF SOIL COVER – USE CASE

- Tillage of fields with winter greening
- Comparison of three different implements for conservation tillage

Machine	Images	Mean	Homogeneous Groups
Before tillage	96	0.378	X
Disc harrow	96	0.047	X
Seedbed cultivator	96	0.121	X
Stubble cultivator	96	0.102	X
<b>Total</b>	<b>384</b>	<b>0.162</b>	



# ESTIMATION OF SOIL COVER



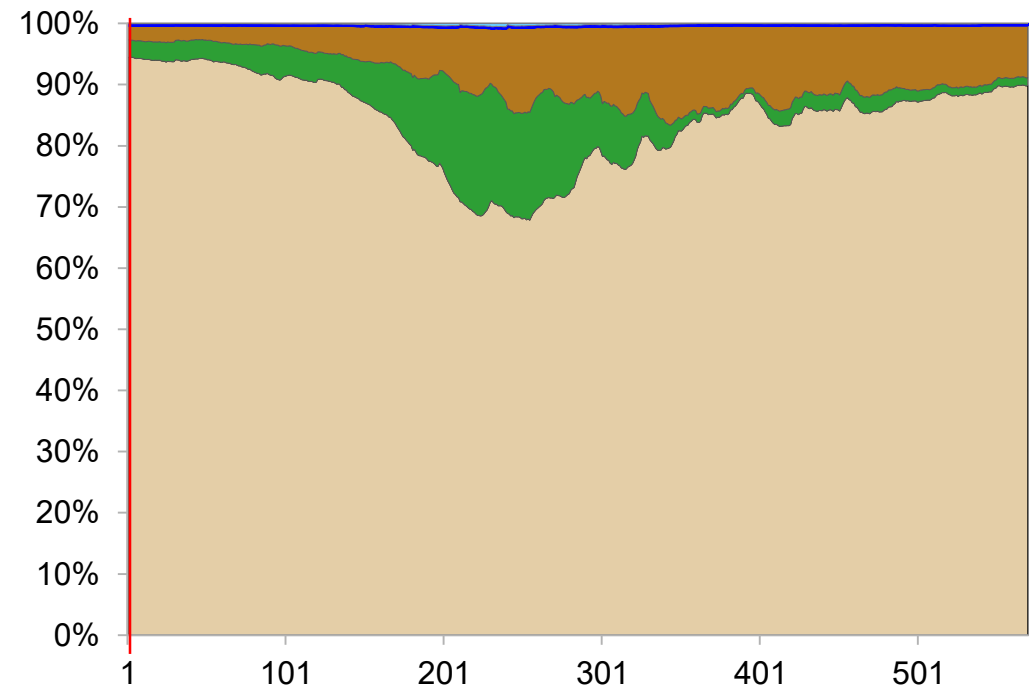
<https://soilcover.josephinum.at/>





## Possible future applications

- Field inspection by UAVs
- Real time evaluation
- Online applications for tillage machine control



■ soil ■ living plant ■ residue ■ stone ■ biofilm

- Force measurements with reference tines enable very precise results even under inhomogeneous soil conditions
- The combination of force measurements with image analysis based methods for quality assessment leads to more comparable and objective results
- Real time applications of image analysis methods may be used for self adjusting tractor-implement combinations in future



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