The effect of selected soil properties and field management on cereal yields

- Tapio Salo, Riikka Keskinen, Helena Soinne, Mari Räty, Janne Kaseva, Visa Nuutinen, Eila Turtola

Luke
LUONNONVARAKESKUS

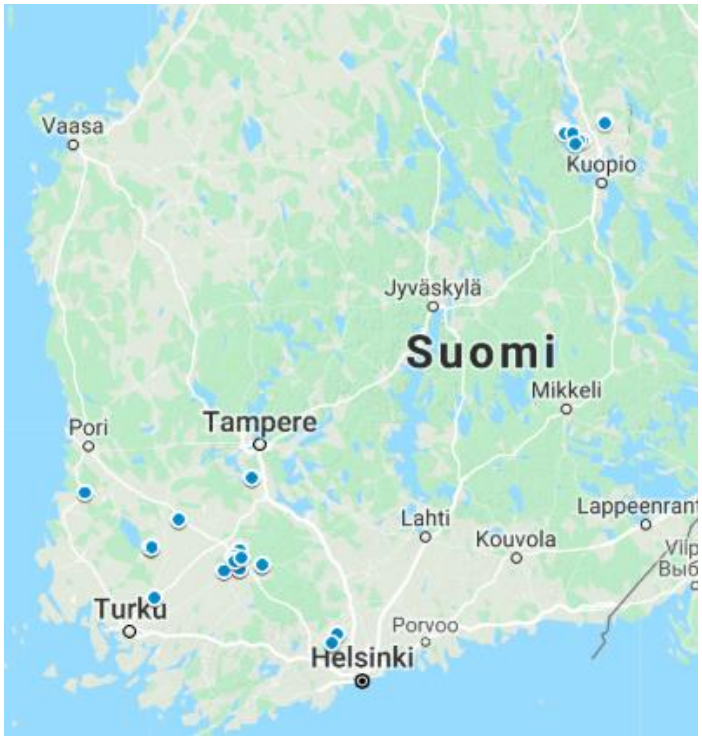
Agricultural soil quality

- Soil quality is often evaluated through **measurable biological, chemical and physical key indicators** selection of which depends on the type of ecosystem in question and overall objectives of the assessment scheme (e.g. Andrews et al., 2002)
- The most frequently used indicators include
  - pH, organic matter or carbon content, total or available nutrient and harmful metal concentrations, cation exchange capacity, electrical conductivity, soil depth, texture, bulk density, porosity, aggregation, structural stability, penetration resistance, water storage and infiltration properties, earthworm density, microbial biomass, soil respiration and nitrogen mineralization (Bünemann et al., 2018).
-

Selection of field plots

- The study comprised in total of 47 sampling sites located in two clusters in southwestern and central-eastern Finland
- The plots were selected among fields of mineral soil (<10% organic carbon) on which a cereal crop was designated to be sown.
- The selection was based on yield records over the previous years and on the practical experience of the station managers and field staff, so that both fields regarded of high and low productivity were included.
- Farm managers of experimental farms and farmers were interviewed in order to get information from management of the selected fields.

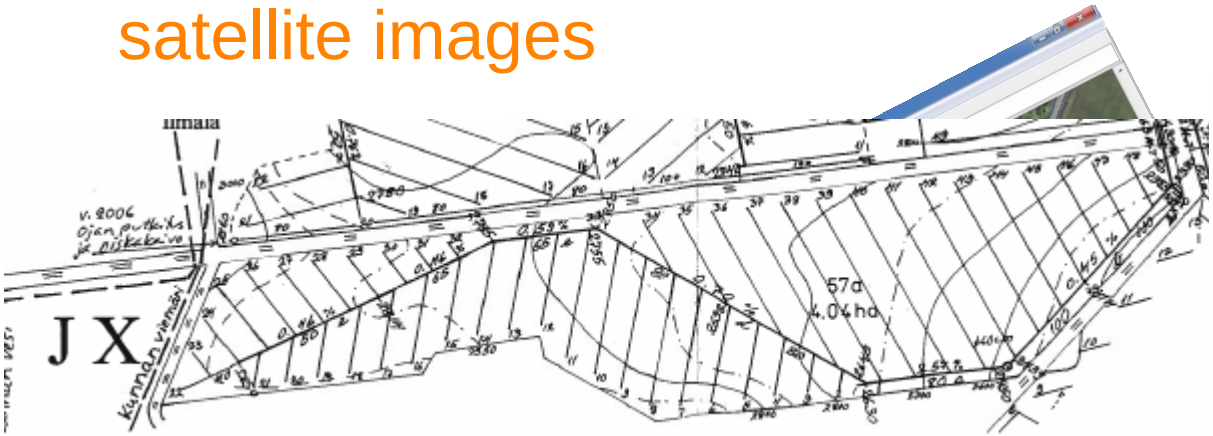
Location of fields

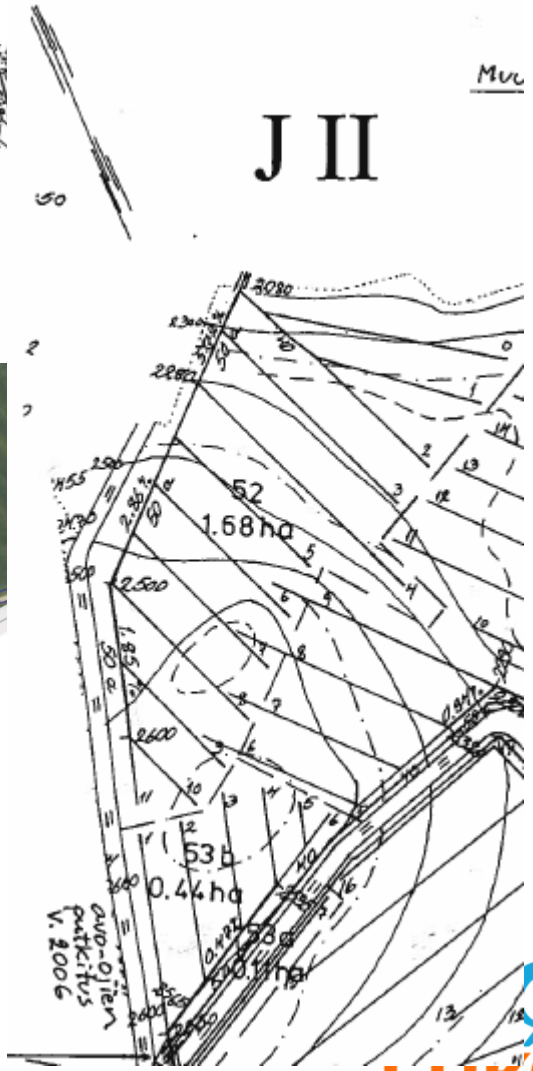


- Luke farms:
  - Jokioinen, 2016-2017, n=14
  - Maaninka 2016-2017, n=4
- Farms, 2017
  - Uusimaa, n=4
  - Varsinais-Suomi, n=5
  - Satakunta, n=4
  - Häme, n=4
  - Maaninka, n=9

Luke
LUONNONVARAKESKUS

Background data, drainage maps, aerial photos, satellite images





LUKE
LUONNONVARAKESKUS

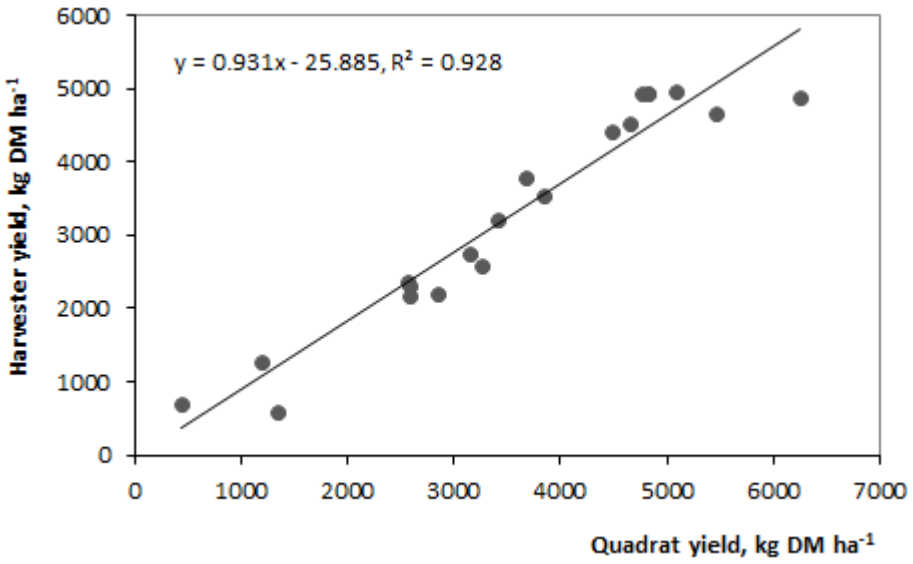
Methods

Sampling and analysis

- Representative central sampling point and three surrounding sampling points that were placed on a circle to around 5 m distance from the central point were located.
- From all of these four sub-sampling sites, yield, soil profile and soil aggregate samples were collected.
- In addition, a soil fertility sample was taken from each central sampling point.
- Yield samples were collected after ripening by cutting down the entire plant stand within a 75 × 75 cm frame
- In addition, two different sampling techniques were compared by harvesting crop from selected fields with a 75 cm × 75 cm quadrat frame method and trial plot harvester during 2016−2017.

Yield samples

- 4 75cm x 75 cm quadrat plots per field and year
- Compared to field harvester yields



Luke
LUONNONVARAKESKUS

Sampling of soil profile

- Soil profile samples were taken from the plant row by an auger with c. 4.5 cm diameter to a maximum depth of 60 cm.
- Soil cores were cut within the auger to 10-cm-length segments.
- Roots appearing at the opposite fresh broken faces were counted.
- Thereafter the soil core segments were dried at 40 ˚C and weight to determine bulk density of the soil layers.
- Finally, the samples were ground to pass a 2-mm sieve and analyzed for total C and N via dry combustion (Dumas method, Leco TruMac CN).
- Soil aggregates were sampled from 0-5 cm
- Soil fertility samples were taken from 0-20 and 20-40 cm

The effects tested in the statistical analysis

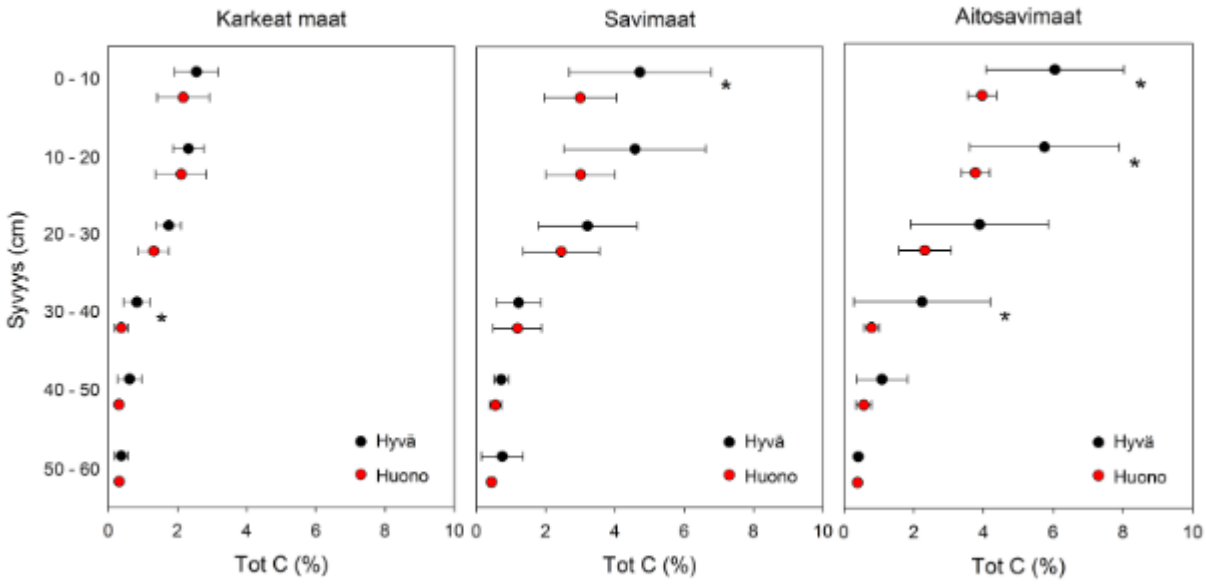
Categorical variables	Classes	Values
Cultivation zone	3	South-west, Häme region, East
Crop	4	Barley, Oats, Spring rye, Wheat
Soil type	3	< 30% clay, 30-60% clay, > 60% clay
Sampling year	2	2016, 2017
Crop rotation	2	Cereal monoculture, other crops included
Soil management	2	Ploughing, Other
Use of lime	3	< 10 years, 10-20 years, > 20 year
Use of organic fertilisers	2	No, Yes in last 10 years
Hydrological quality	2	Poor, Good
Field quality	2	Poor, Good

The effects tested in the statistical analysis

Soil measurements Continuous	**N**	**Range**
Carbon %	60	1.3-9.1
Clay % / Carbon %	60	0-22
Soluble P (mg l^{-1})	60	0.7-27.3
Soluble Ca mg l^{-1}	60	265-4205
Soluble Mg mg l^{-1}	60	48-1336
Soluble K mg l^{-1}	60	60-464
EC 10xmS cm^{-1}	60	0.54-1.86
pH	60	5.1-7.0
CEC (meq $100g^{-1}$)	60	1.7-34.0
Ca CEC (meq $100g^{-1}$)	60	1.2-22.8

Field management		
N rate kg ha^{-1}	60	54-180

Carbon and soil types (classification based on clay content)



Luke
LUONNONVARAKESKUS

Table X. Correlation of clay and carbon with other measured soil properties.

Variable	Clay %	Carbon %
Carbon %	0.51	
Nitrogen %	0.62	0.97
Clay/Carbon	0.80	-0.04
Soluble P (mg l^{-1})	-0.46	-0.36
Soluble Ca (mg l^{-1})	0.81	0.27
Soluble K (mg l^{-1})	0.84	0.15
Soluble Mg (mg l^{-1})	0.78	0.34
EC	0.00	0.13
pH	0.11	-0.38
CEC (meq 100g^{-1})	0.93	0.39
Ca CEC (meq 100g^{-1})	0.87	0.45
Mg CEC (meq 100 g^{-1})	0.86	0.21
K CEC (meq 100 g^{-1})	0.83	0.43
WSA %	0.51	0.38
Turbidity	0.70	-0.01
Bulk density (kg dm^{-3})	-0.22	-0.50
Root number cm^{-2}	0.44	0.29

Table X. Correlations of soil properties and fertiliser applications (p<0.05) with yield. (N=45)

	Yield (kg ha^{-1})	
	Corr	p
Clay %	-0.38	0.011
Silt %	0.48	0.001
Soluble Mg (mg l^{-1})	-0.41	0.005
Soluble K (mg l^{-1})	-0.46	0.001
CEC (meq 100 g^{-1})	-0.34	0.022
Mg CEC (meq 100 g^{-1})	-0.43	0.004
K CEC (meq 100 g^{-1})	-0.46	0.002
WSA	-0.51	0.000
N rate (kg ha^{-1})	0.70	<0.001
N rate split (kg ha^{-1})	0.65	<0.001
Org. N (kg ha^{-1})	-0.29	0.050
Yield history (kg ha^{-1})	0.45	0.002

Table x. The estimates and probabilities of selected variables in Model 1(Carbon content) and Model 2 (Clay to carbon ratio). Pr > 0 shows the probability that estimate would be 0. P shows the probability that effect would not be significant.

	Model 1 (Carbon)					Model 2 (Clay/Carbon)		
Effect	Value	Estimate	Pr > 0	P		Estimate	Pr > 0	P
Intercept		-2996	0.0143			-829	ns.	
Cultivation zone	South-west	**2335**	0.0003	<0.001		**2192**	0.0024	0.009
	Häme	**2410**	0.0002			**1795**	0.0099	
	Eastern	0	.			0	.	
Crop	Oats	-315	ns.	<0.001		-391	ns.	0.011
	Barley	**1327**	0.0009			**1037**	0.0155	
	Spring rye	**2193**	0.0152			1429	ns.	
	Wheat	0	.			0	.	

	Carbon model					Clay/carbon model		
Soil type	Clay >60%	-1614	ns.	0.003		1330	ns.	0.447
	Clay 30-60%	**-2770**	0.0008			1143	0.263	
	Clay <30%	0	.			0	.	
Liming	< 10 years	**1952**	0.002	0.001		**1157**	0.1313	0.102
	10-20 years	493	ns.			220	ns.	
	> 20 years	0	.			0	.	
Hydrology	Poor	-**2397**	<.0001	<0.001		-**1787**	0.0032	0.003
	Good	0	.			0	.	
Soluble Ca		***-1.82***	<.0001	<0.001		***-1.34***	0.0024	0.002
Soluble Mg		***3.06***	0.0111	0.011		***3.42***	0.0319	0.032
Soluble P		-26.38	ns.	0.031		-63.4	0.1023	0.060

	Carbon model					Clay/carbon model		
Carbon		**638**	<.0001	<0.001		.	.	.
Clay/Carbon		.	.	.		**-11.07**	ns.	0.007
N rate		**61.4**	<.0001	<0.001		**60.0**	<.0001	<.0001
Soluble P in clay > 60%		29.83	ns.	0.001		184	0.1067	0.008
Soluble P in clay 30-60%		***343***	0.0002			***284***	0.0035	
Soluble P in clay < 30%		0	.			0	.	
Clay/Carbon in clay > 60%		.	.	.		**-207**	0.0759	0.029
Clay/Carbon in clay 30-60%		.	.			-**227**	0.0089	
Clay/Carbon in clay < 30%		.	.			0	.	
Coefficient of determination between observed and predicted values				0.85				0.82

Kiitos!

Luke: Tapio Salo, Riikka Keskinen, Visa Nuutinen, Mari Räty, Eila Turtola, Janne Kaseva, Helena Soinne

Syke: Katri Rankinen, José Cano Bernal. Pirkko Kortelainen,

HY: Matti Sihvonen, Sampo Pihlainen, Kari Hyytiäinen, Sanna Kanerva

SYKE

HELSINGIN YLIOPISTO

Luke
LUONNONVARAKESKUS