Roadmap to Regen agriculture

Presentation Estonian Organic Farming Platform ***29.11.2022***

Jussi Knaapi

MAHEPÕLLUMAJANDUSE KOOSTÖÖKOGU

- **<u>It’s all about food!</u>**
  Local
  Seasonal
  Regen
  Nutritious
  Fossil free

- # My background

  - ”Normal” schooling
  - Home farm used to have pigs
  - Then arable, sucarbeet, potatoes, cereals
  - Noted already on early days, how vunerable our soil is, shallow topsoil (25 cm) easily showed up gray colour subsoil
  - On my ”ag-chem” years it was easy to bush on yields, because our soils have very good AWC (available water capacity)
  - However, gradually you tend to notice how narrow margins are, when pushing top yields with chemistry
  - To start a new journey, you need to have some impulse from outside, I got mine about 10 years ago, when first european contacts to regen world game up
  - My teachers (to name a few) have been in some order Neil Fuller, Jan Feersma, Elaine Ingham, Jill Clapperton, Rick Bieber, Bud Davis, Don Reikowsky, Christine Jones, Will Brinton, Fredrik Thomas and now resently the JillClapperton’s peer to peer group.
  - Typically there are very few finnish researchers on area….. Well luckily some domestics also exist!

- # My estonian background

  - Early 1990’s there was a ”New farmers project”, where finnish advising people were involved
  - In Tartu was a co-organisation ”Leadership school” = ”Maatalouden Johtamisen korkeakoulu”
  - Idea was to form a co-operation group of four individual farms
  - Big mistakes happend there, 1st – the farmers were politically chosen 2nd – they didn’t get along too well, 3rd – we tried to copy a finnish model to this group, 4th we didn’t understand, that times are changing and the ”normal” farms are losing viability anyway 5th regen ag didn’t yet excist, 6th economical turbulence was taking over us all in 90’s
  - Later I got involved to real estonian agriculture – a group of finns had started a project ”AS Vahenurme”, which later on made big headlines in estonien press got to the end with lots of headache and we ended losing lots of money among other things…
  - And finally, a conclusion was that a finnish farming & advising model didn’t fit to Estonia and this project ceased away
  - Conclusion was: Each country must rely on their own vision and will, but mutual co-operation is still very important

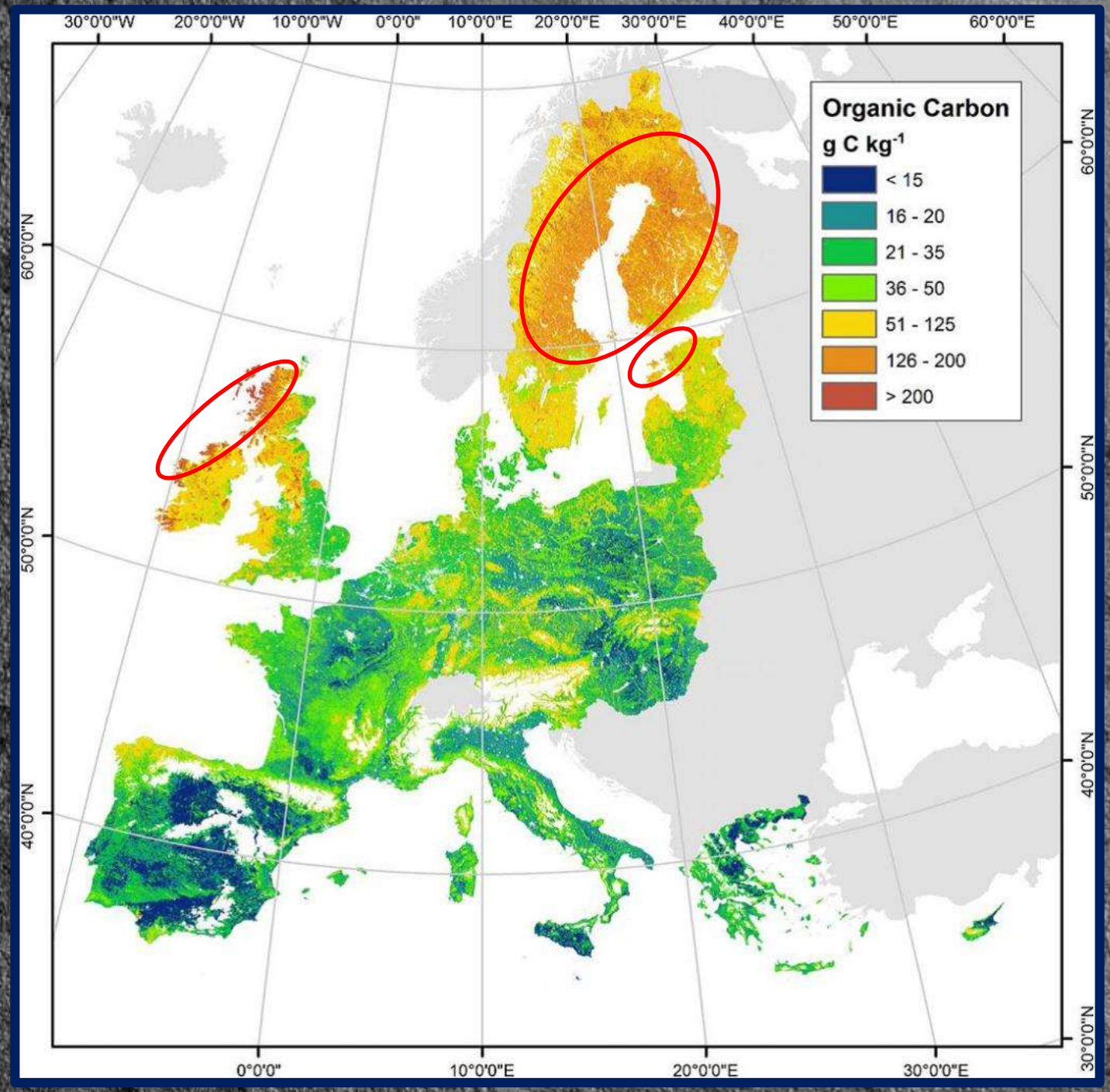
- **How to measure environmental impact right**
  - Yes, we are concerned about climate, but also waterways (Baltic Sea) and ecosystems
  - A big issue (in Finland) is that we have 2 kind of research: 1. Political 2. Real scientific
  - ”Politicals” rely on ”LULUCF”-model, which means that all turf soils must away and to be classified as wetland or forests – mainly wetlands – mostly this is simply put foolish but offer an easy route to (political) Net Zero
  - Nobody hardly tries to tell there are better managements, which can provide win-win-win
  - In other words lessen emissions, keep production going and keep countryside alive – and also ecologically alive
  - The big dilemma is that public thinks veganism is the answer and ruminants the problem
  - Hopefully Regen ag can give answers to this
  - In Fínland we do have two issues, which are kind of disturbing this regen process
  - They are 1. Ca-growers (ECAF=Notillers) and 2. Eco-growers (the official organisation)!
  - Luckly there are people in both of these organisations how do understand that there really is no problem

Soils are different!

- We need differentiate soils down to whole profile
- Huge variation in AWC, chemistry, Redox, microbial status
- Base problem is nearly always just one – man made compaction

Horizons	depht, cm
A	0 – 20
B	20 – 50
C	50 - 90
A	0 – 20
B	20 – 50
C	50 - 90

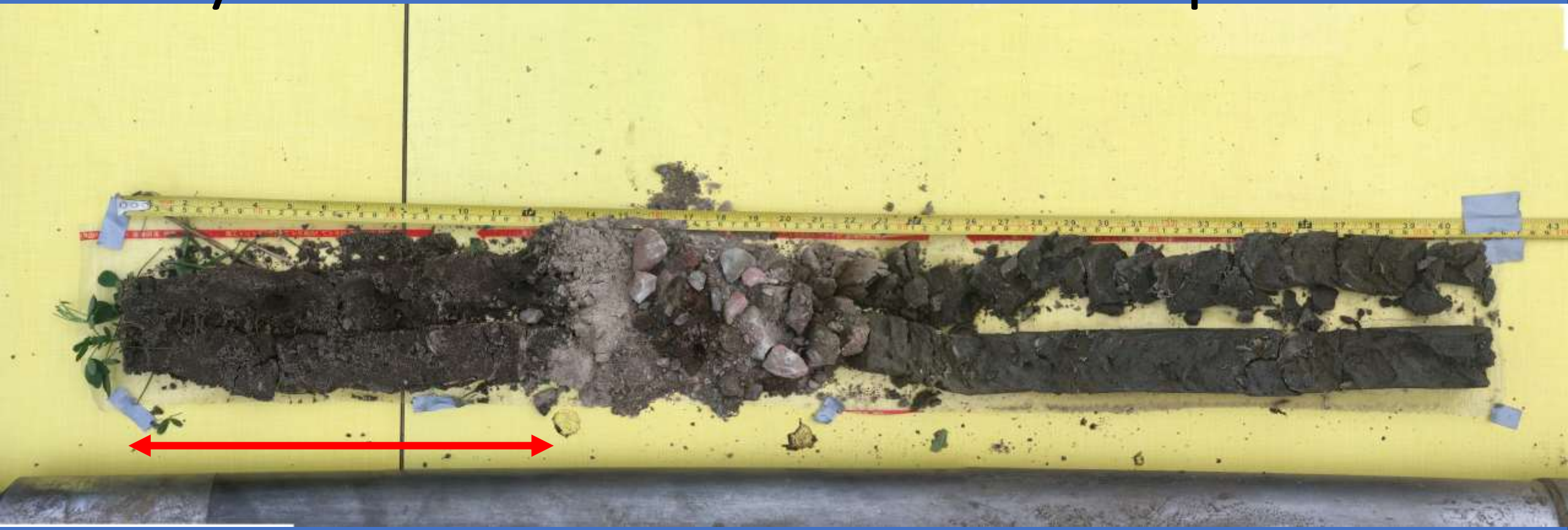
- There still are borealic climate areas which have not lost their SOM!
- Asid soil type, huge AWC, moderate temperatures
- These factors offer good road map to regen ag
- Altough there is a risks also >
- By wrong (present style) management, these soils are high risk areas for negative emissions (CO2)
- On the other hand, they can provide huge green mass production potential and their waterway leaching is well in control



Field vs. forest!

- Examble: Kari Farm in middle Finland
- These two samples are from side to side
- Field (left) was reclamed 1970’s and has been on Eco since then
- Sample on right is forest
- Grass based rotation
- Picture is from 2019

Fotosyntesis is the driver of SOM build up

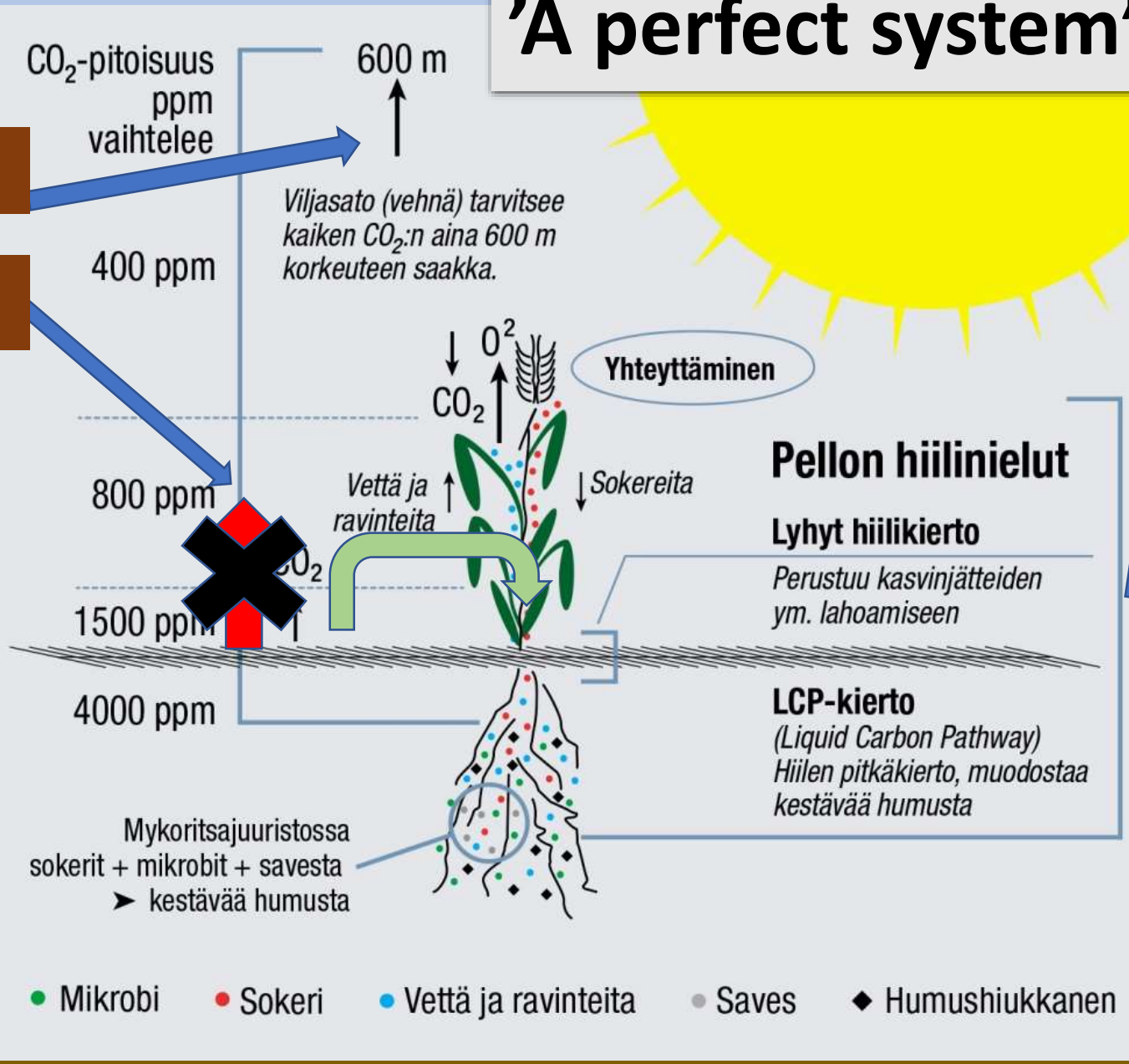


- Two generatons earlier this calserous soil had very shallow topsoil – morain layer was dominant
- Ruminants and resently rotational grazing has build up 20 – 30 cm topspoil
- Resently lusern has been quite dominantly in grass mixes

’A perfect system’

Normal cereal yield needs all CO2 up to height of 600 m

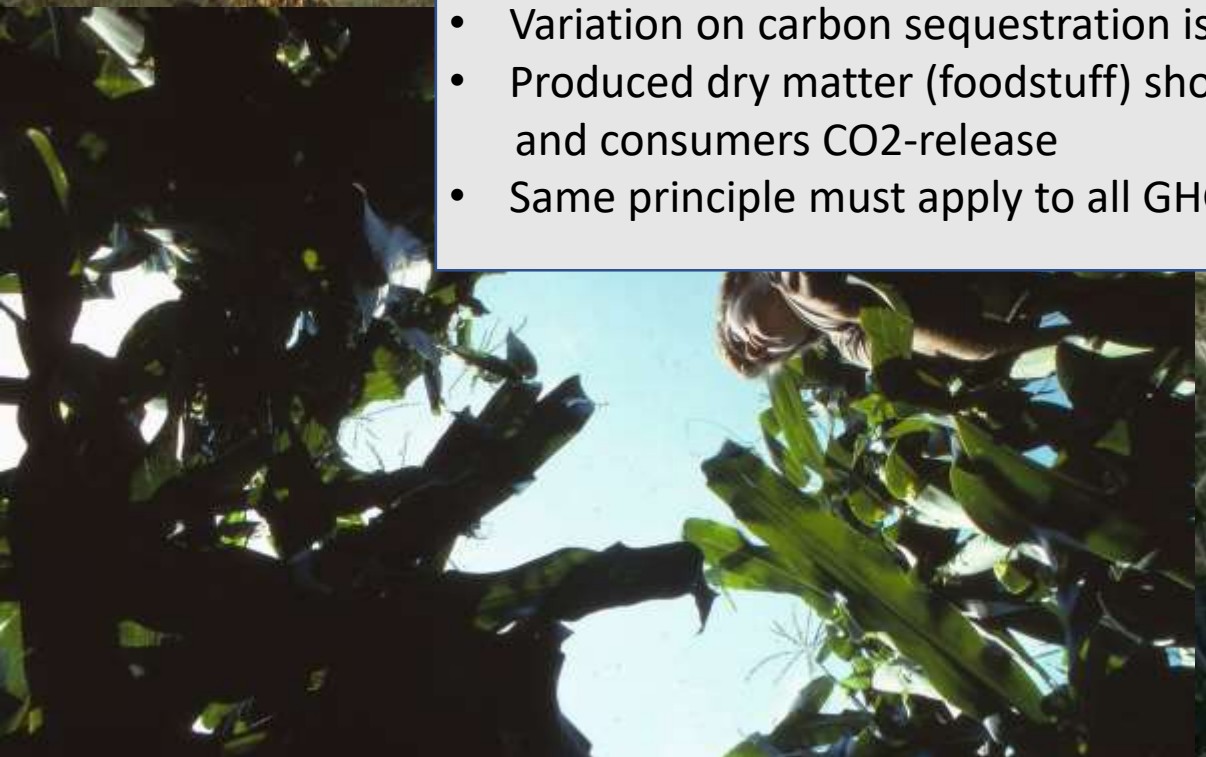
Plant can not produce well without soil emitting CO2!

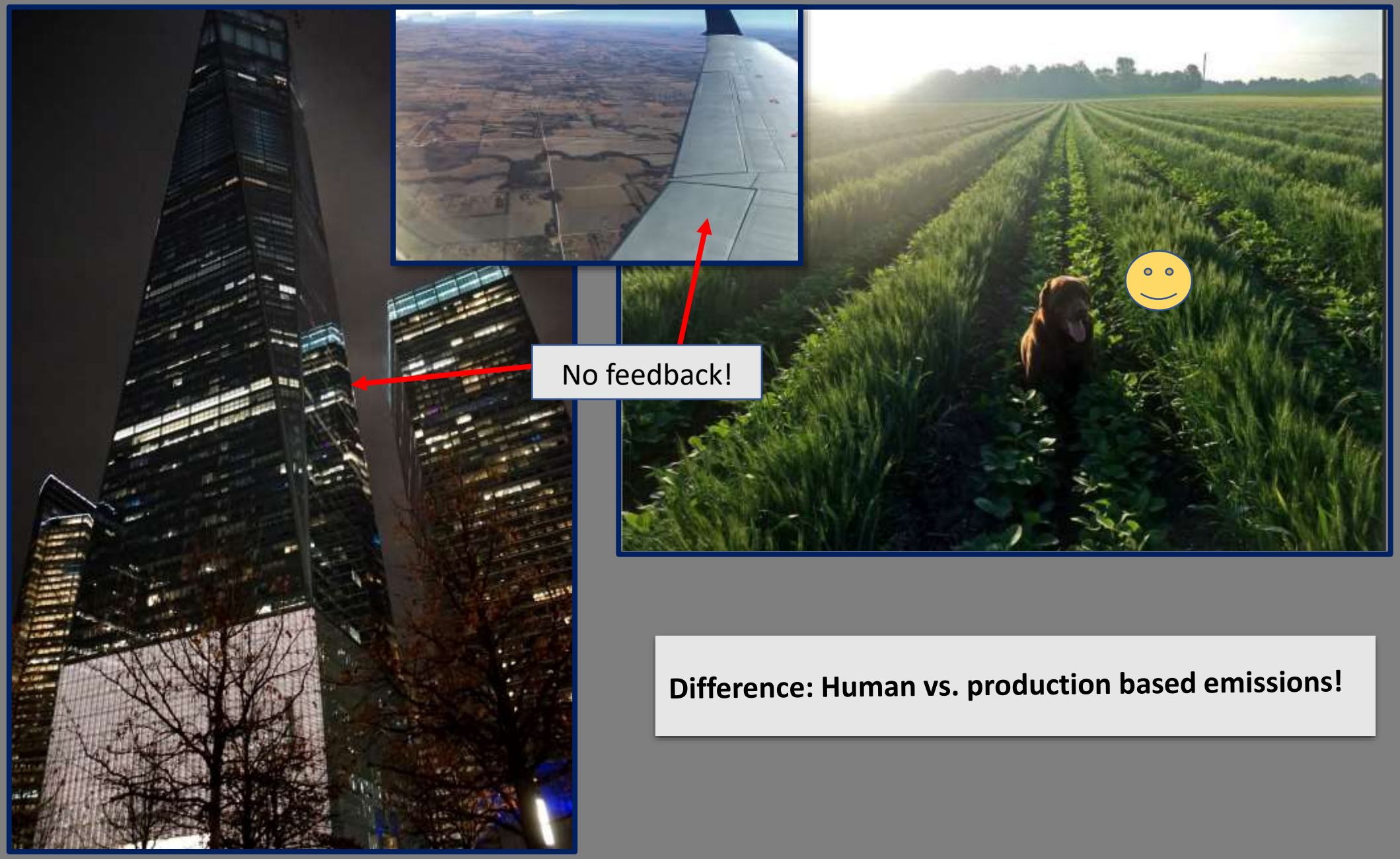


There are two carbon processes in soil:
- Composting aerobically in topsoil
- Humus building process = Liquid carbon bathway (LCP)
- Also called as ”carbon pump”

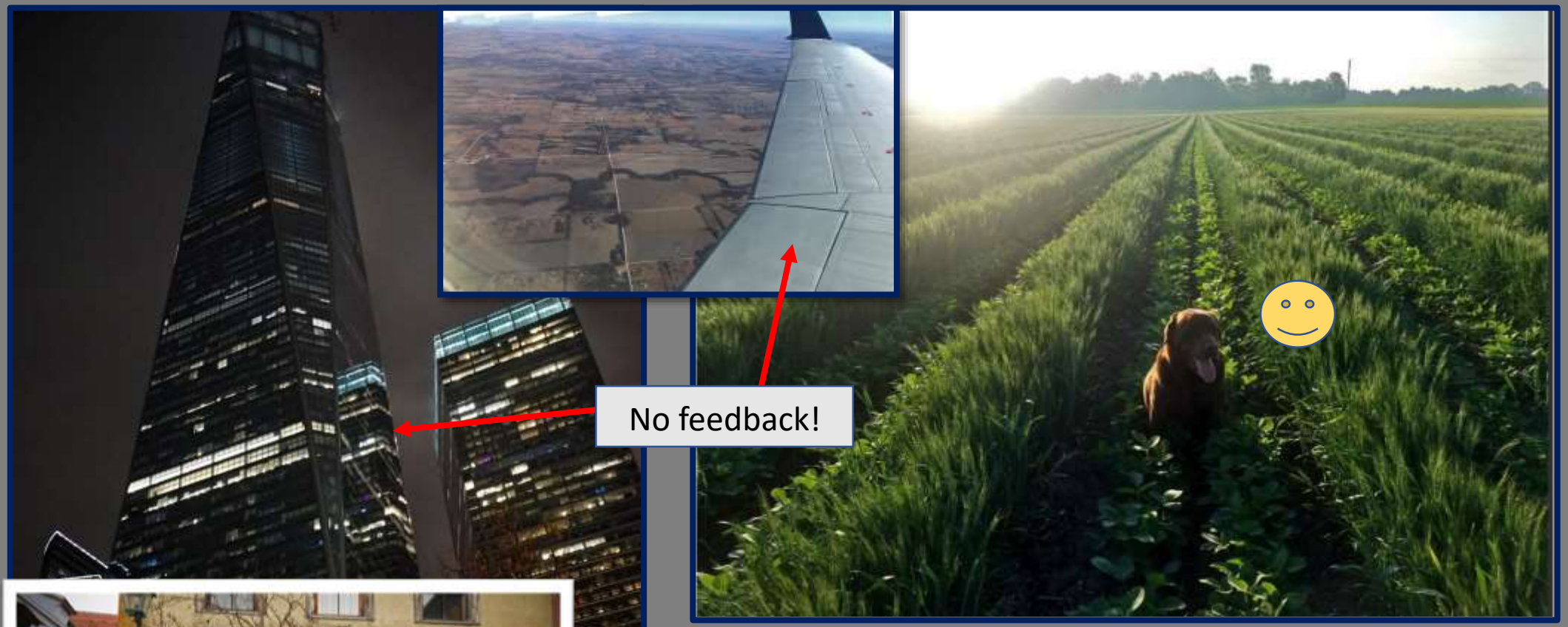
Based on Christine Jones & Will Brinton info

- Variation on carbon sequestration is huge and depends totally on management
- Produced dry matter (foodstuff) should always be counted as agriculture’s CO2-binding and consumers CO2-release
- Same principle must apply to all GHG emissions





Difference: Human vs. production based emissions!

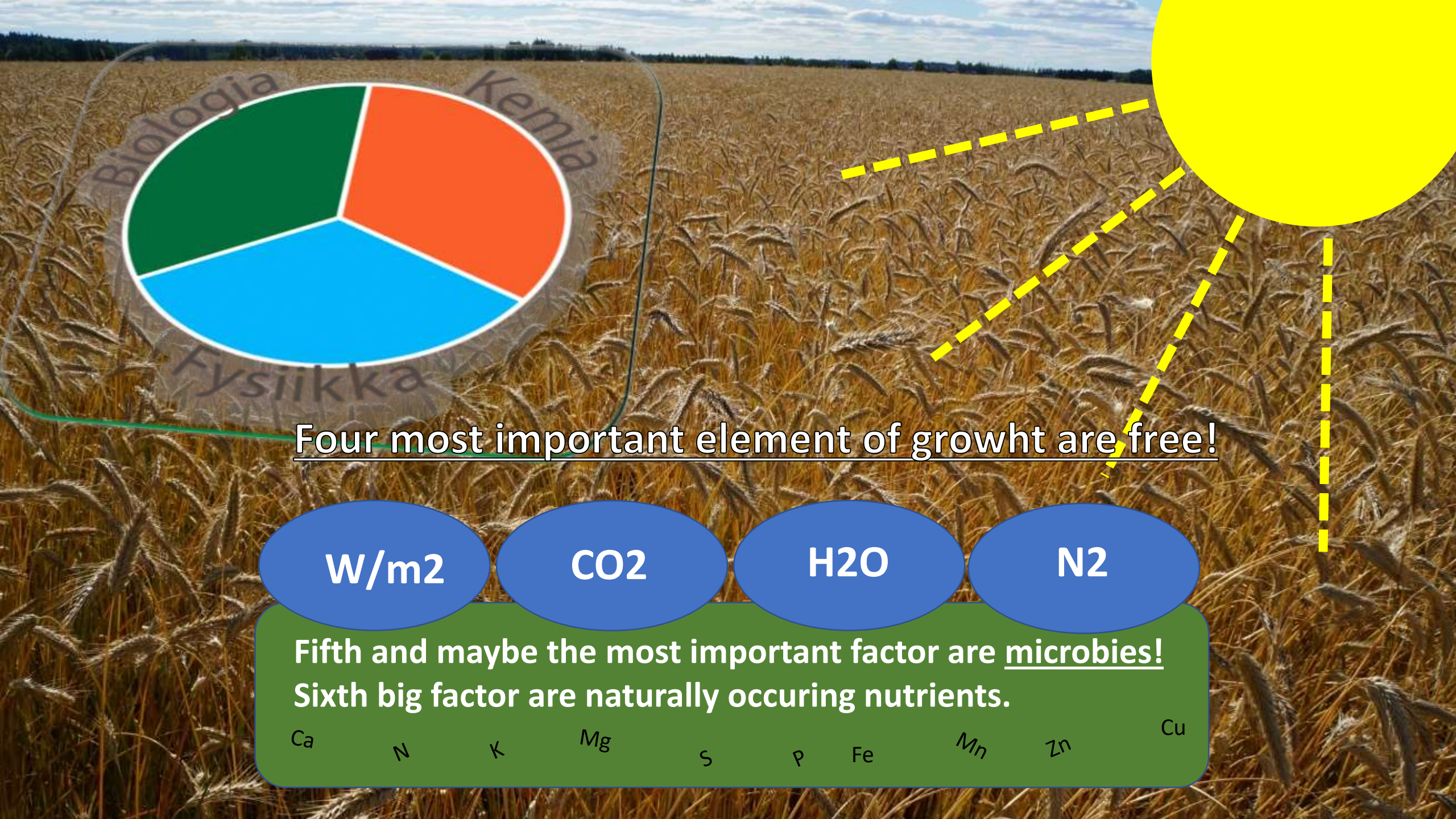


No feedback!

Difference: Human vs. production based emissions!

Old fence line

Distance of plants < 5 meters



Four most important element of growht are free!

W/m2 **CO2** **H2O** **N2**

Fifth and maybe the most important factor are microbies!
Sixth big factor are naturally occuring nutrients.

Ca N K Mg S P Fe Mn Zn Cu

- Situation in many European countries is demanding!

- Situation in borealic climate is totally different, soils tend to accumulate carbon, many factors have effect here

Exambles of carbon negative growht (CO2).

Sucarbeets. 300 ppm

Oats 320 ppm

Grass silage 2nd cut 310 ppm

Turf soil, soil flux 420 ppm

Turf soil , vegetation included, 350 ppm

Turf soil, ploughed, soil flux 660 ppm

Turf soil, no inversion, Soli flux 370 ppm

Mittaukset 2019, Ari Koutonen FICA ja Jussi Knaapi

Problem

- **Anaerobic, tight soil**
  - Reducting environment
  - Measured as Redox value
  - Gaseous emissions
    - Losses of nutrition
    - Denitrification – N2 ja N2O
  - Soil biology suffers
  - Patogenic microbies dominate
  - Weak growht
  - Poor root development
  - Limited gas & water movement
  - Increasing negative spiral
  - Negativ environmental impact

Close up

- **Compacted zones in root layer**
- 0 – >> 100 cm
- Measured with penetrometer.. or
- volymeweight
- Spade test
- Visual assesment

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Typical compaction layer created by disc cultivator

Close up

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- 0 – >> 100 cm
- Measured with penetrometer.. or
- Volyme weight
- Spade test
- Visual assesment

Typical compaction layer created by plough

Close up

- **Compacted zones created in 17 years**

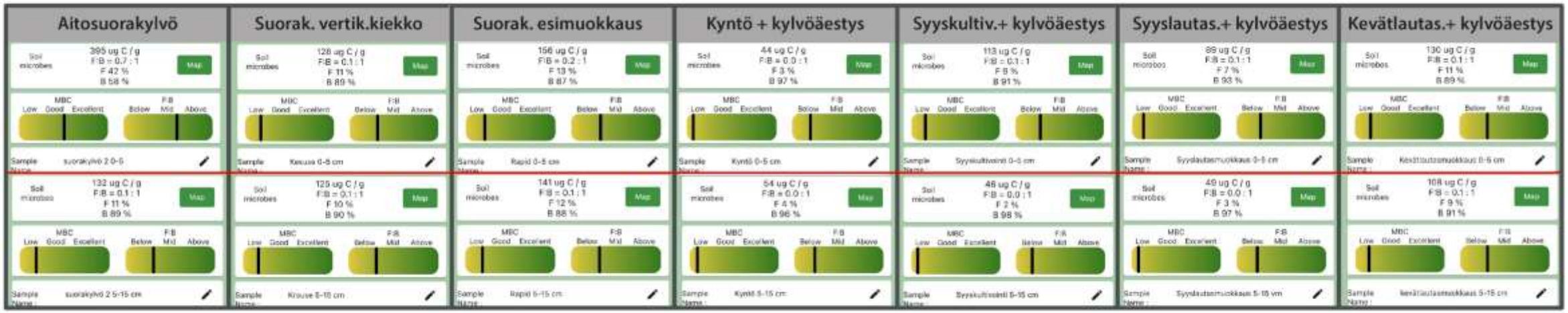
SOM-% 0-5 / 5-15 cm

Multavuus-%	Multavuus-%	Multavuus-%	Multavuus-%	Multavuus-%	Multavuus-%	Multavuus-%
15,8 / 9,7	13,5 / 8,8	13,4 / 9,7	8,4 / 8,4	8,8 / 8,9	10,7 / 9,1	10,4 / 9,7

Microbiometer results

Close up

- **Affects also the microbial balance**



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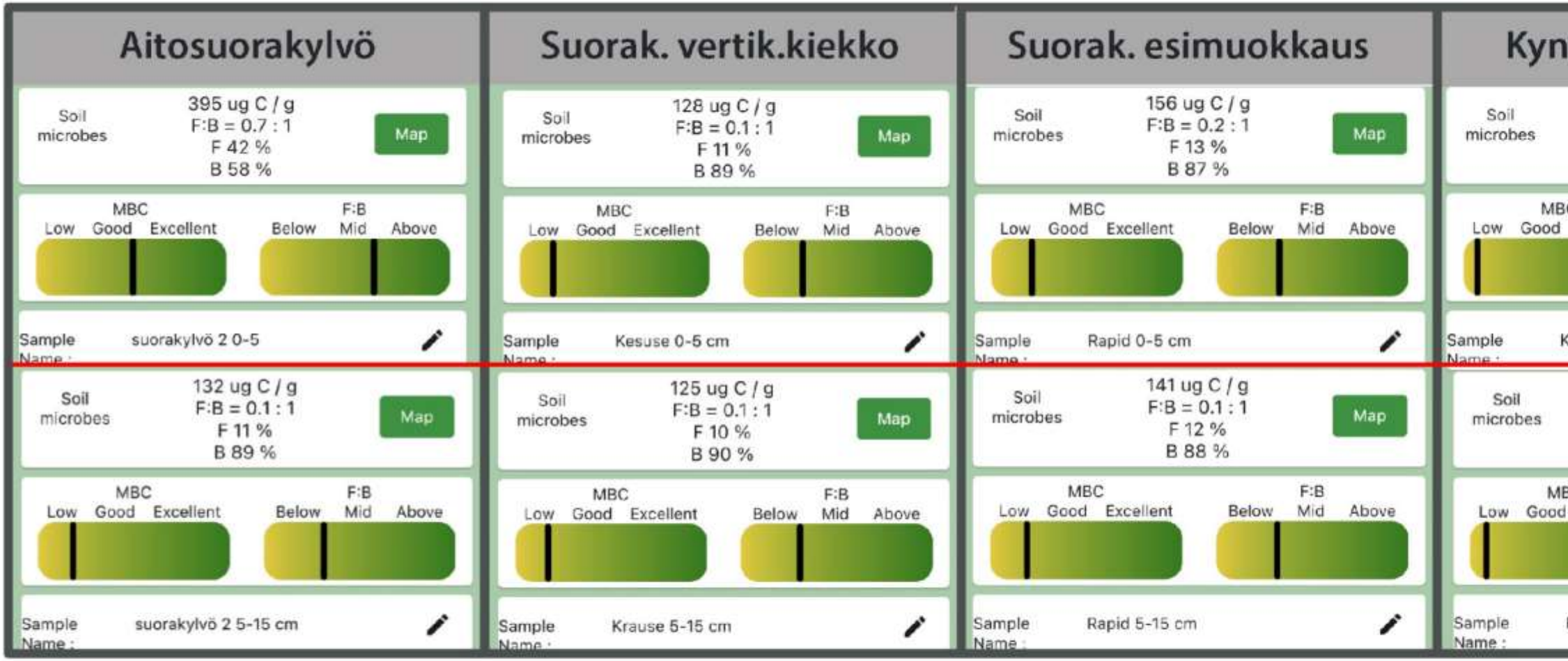

Doc Pohjanheimo's research

Professori Onni Pohjanheimon kokeita Jokioisissa v. 1961

Spring cereals

Taulukko 7. Osoittaa minkälaisia tuloksia kosteussulun avulla on saavutettu.

Lajike	Ei peitetty hiekalla Jyväsato kg/ha	suhdel.	Peitetty hiekalla Jyväsato kg/ha	suhdel.
Paavo	5810	100	10350	178
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drought ideal

Jokioisten hiekkapeltokoe on osoittanut, että ilman kasteluakin voidaan kevätviljoista saada satoja, jotka ovat tuntuvasti runsaampia kuin ne, joita olemme tottuneet saamaan. Maan vesivarat riittävät tällaisiin. Olisi löydettävä keinot niiden hyväksikäyttöön. Koe antaa arvokkaita viitteitä kevätmuokkauksen tavoitteista. Tärkeimpänä näistä näyttäisi olevan maan vesivarojen hukkaan haihtumisen estäminen ja huolehtiminen niistä toimenpiteistä, jotka auttavat juuria tunkeutumaan syvemmälle kuin mitä ne tavallisesti voivat kasvaa.

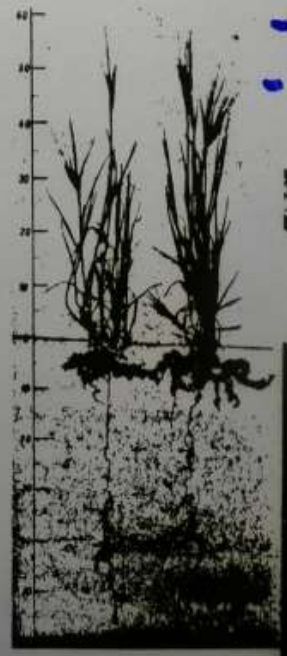
— tasainen, maan pintaosien nopeata kuivumista estävän muokkauskerroksen aikaansaaminen

— kylvö tasaisesti kosteaan kerrokseen, josta juurien kehittyminen voisi esteettömästi jatkua ilman, että kuivuus pysähdyttää tai hidastuu juurien kehittymistä ja toimintaa

— että kevätmuokkaus aloitetaan heti kun savi on kuivunut muokkautuvaksi noin 5 — 7 cm:n syvyydeltä

— että kylvö tehdään muokatun kerroksen alarajalle

Epäonnistuneen muokkauksen tuloksena kehittynyt juuristo.



kuva 1.

points:
- moisture
- rooting

kuva 2.

Näin kehittynyt oraisto tuottaa runsaan sadon. Näyte otettu 6 viikkoa kylvön jälkeen. Näytteenottokehikko on 70 cm korkea. Kuva Jokioisten koekentiltä v. 1960.

Minimium tillage

- Worst impact is done by a tool, which is not adjustable and acts like a plane
- Disc type ”Min till” equipments

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- Depending how it’s used

Spaderoll harrow!

Minimium tillage

- Worst impact is done by a tool, which is not adjustable and acts like a plane
- > disc type ”Min till” equipments
- Some tools are ’acceptable’
- Depending how it’s used
- This tool might be better, it’s adjustable

Vertical disc

Plough

- Worst impact is done by a tool, which is not adjustable and acts like a plane
- Problematic plough culture
- Total disturbance/inversion
- Plough pan

Tillage is here done in poor conditions, also soil is demanding > heavy, tight, moist clay

Plough

- Challenges on clay- & sloping soils
- Challenges on (oxcidation) mulch- & turf soils

Mg-dominant clay soil in april

Notill 1.0

- At least party solvs these problems
- Loss of SOM
- Plough pan
- Uncovered soil over winter period
- Microbial balans (bacterial dominance)
- But it is not perfect!

Classic ”Finnish type” technic

Notill 2.0

- Vertical disc opener loosens tight layers
- Straw cover kept up better

Comparison to inversion technic

Notill 3.0

- New ”Regen Ag” management
- Requires open structure
- Must cope seeding to heavy covers
- With or without crimpler roller

”Newest” technic

Notill in sloping soils

- Done right it is the best technic
- Minimal particle erosion
- Low ’soluble’ (PO4) run off, if done right
  > management, which has no pan layers!
- Minimal disturning of soil structure

Notill is very good on sloping fields

Soil type , special requirements

- On Clay soils, cracking
- On lighter mineral & high organic soils, how to keep SOM constant

Cracking

Both soil types are manageable!

Loss of SOM

Soil type , special requirements

- On Clay soils, cracking
- On lighter mineral & high organic soils, how to keep SOM constant

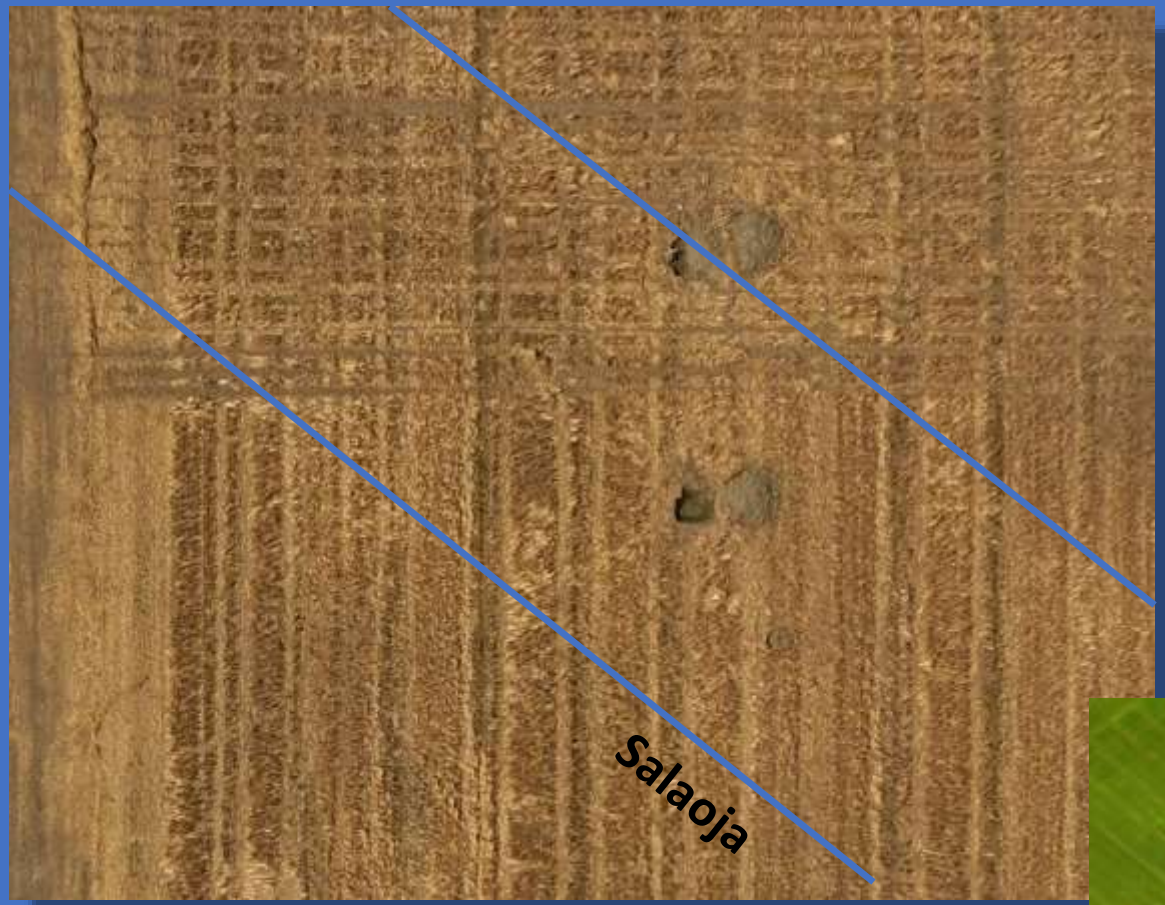
Cracking

Loss of SOM

Managemental choices

- ”Those regular one’s”, tiling, base fertility etc.
- Topography
- Total change of management, Regen Ag
- Continous follow up of the effects of changes
- Non-chemical weed control in Eco growing >
- https://youtu.be/HqtAYEtweiY

The status of tiling



Topografi

The way of management

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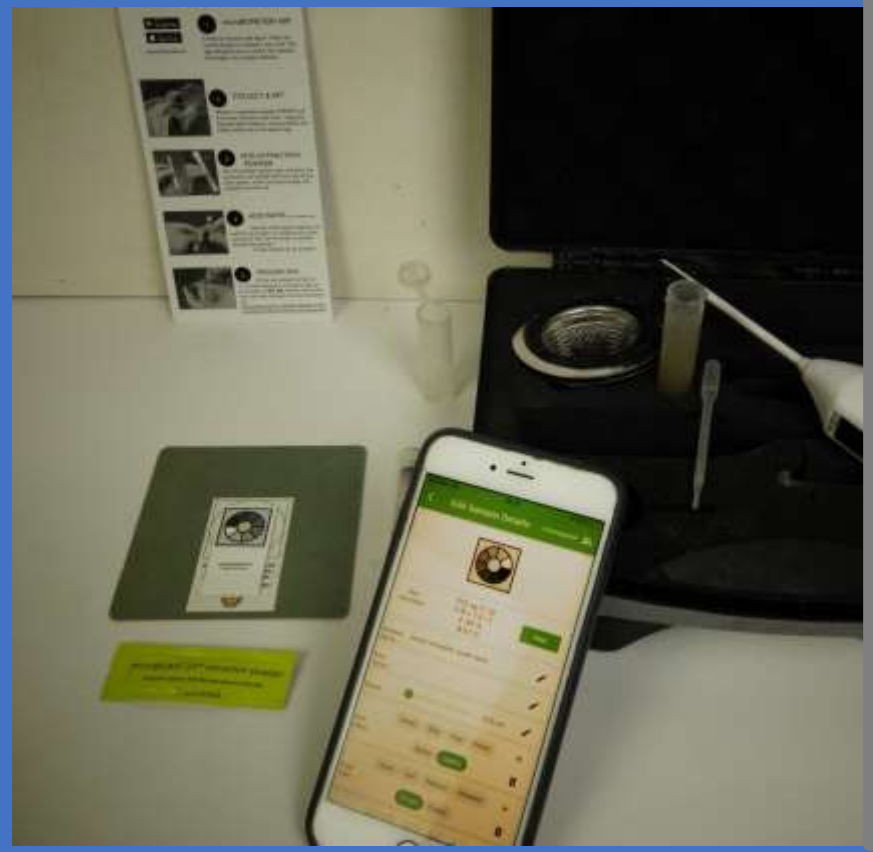
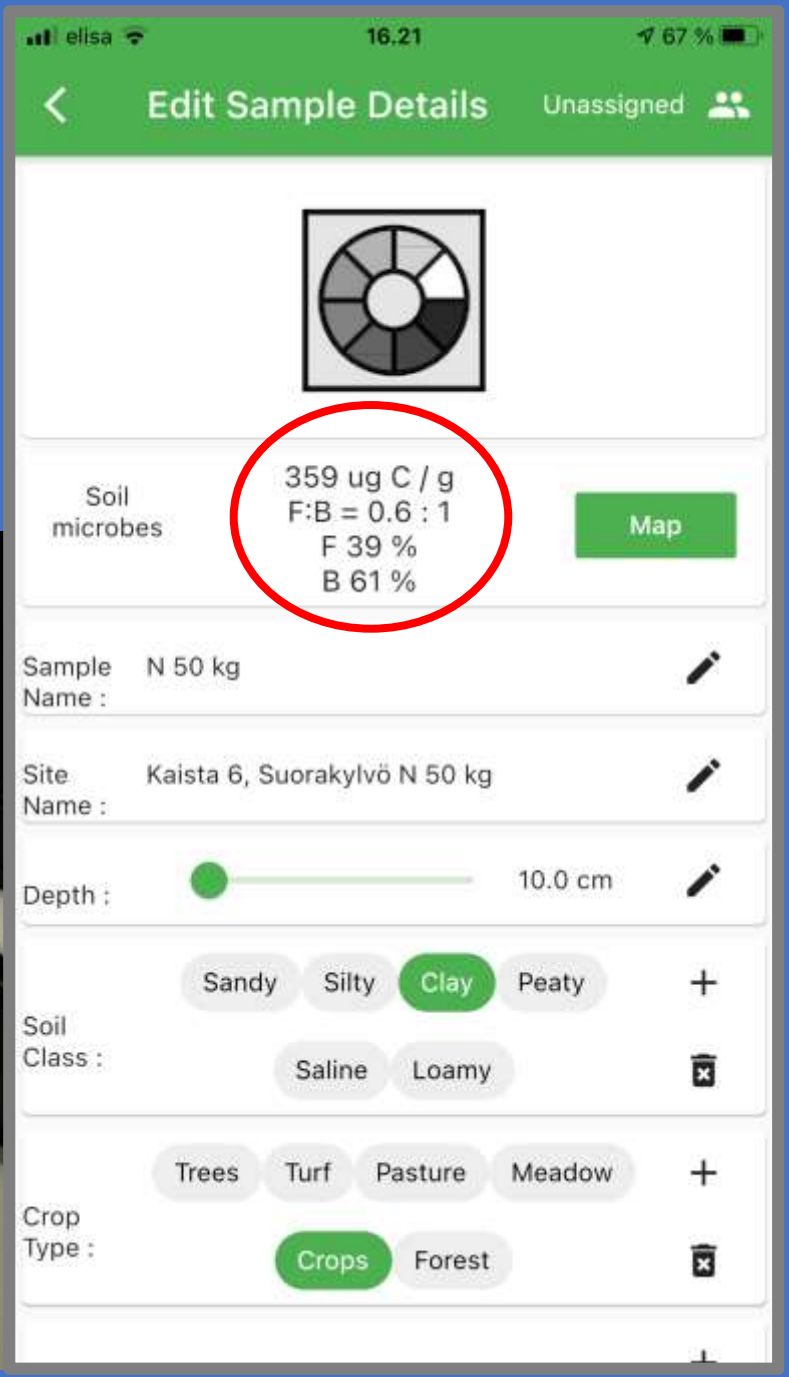
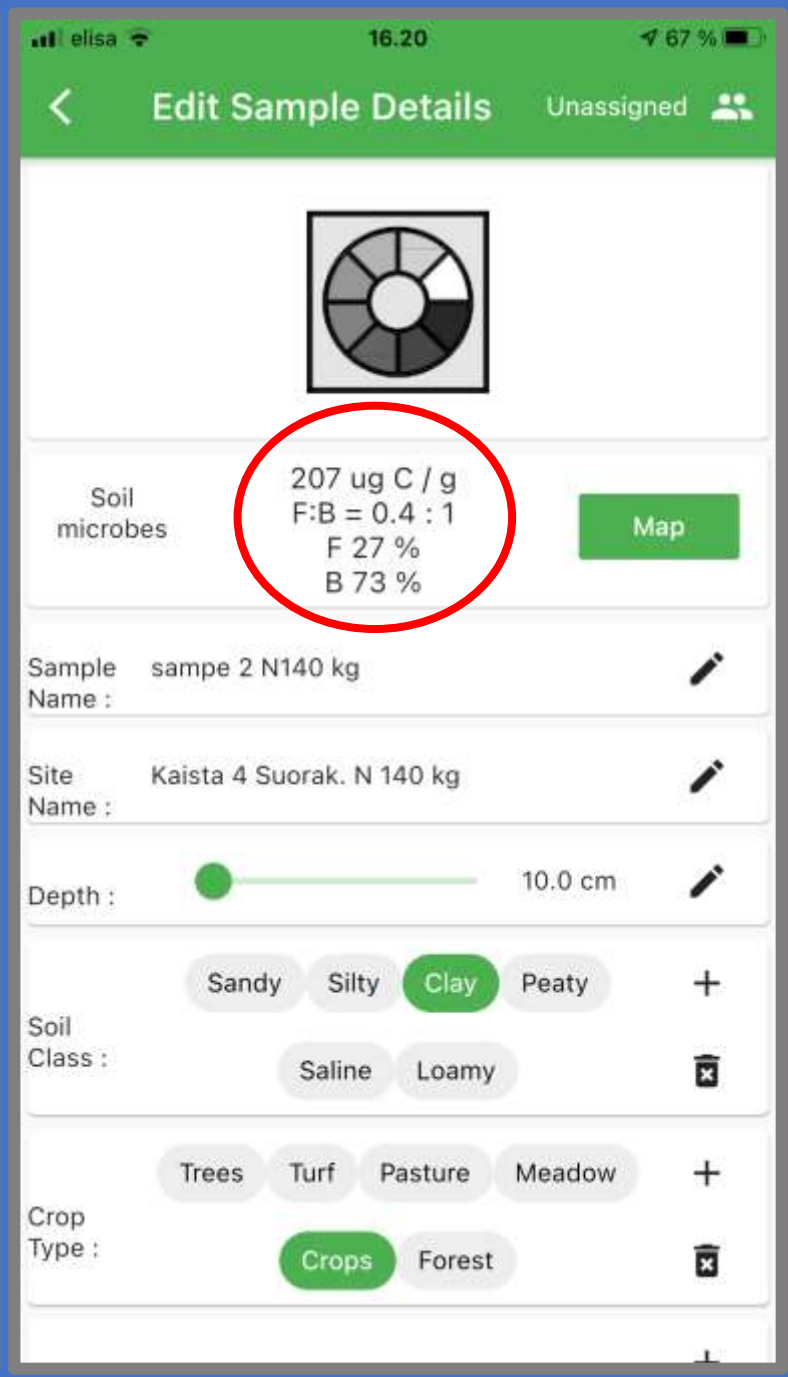






Soil Microbiology Report

Organism Biomass

Analysis	Units	Result	Guideline	Low	Optimal	High
Moisture content	%	25	15 - 55			
Active Bacteria	µg/g	25.0	30 - 150			
Total Bacteria	µg/g	571	300 - 600			
Active Fungi	µg/g	158.9	30 - 150			
Total Fungi	µg/g	326	300 - 600			
Hyphal Diameter	µm	3.00	>2.5			

Organism Ratios

Analysis	Result	Guideline	Low	Optimal	High
Active/Total Bacteria	0.04	0.1 - 0.5			
Active/Total Fungi	0.49	0.1 - 0.5			
Active Fungi/Active Bacteria	6.35	1.0 - 2.0			
Total Fungi/Total Bacteria	0.57	1.0 - 2.0			

Protozoa

Analysis	Units	Result	Guideline	Low	Optimal	High
Flagellates	No/g	7622	5000-100000			
Amoebae	No/g	564	5000-100000			
Ciliates	No/g	609	0 - 100			

Nematodes

Analysis	Units	Result	Guideline	Low	Optimal	High
Total Nematodes	No/g	14	10 - 20			
Nematode types	Fungal feeders: 3%; Bacterial feeders: 84%; Predators: 3%; Plant parasitic: 0%; Juveniles: 10%					

Mycorrhizal Colonisation

Analysis	Units	Result	Guideline	Low	Optimal	High
Ectomycorrhizae	%	0	10 - 50			
Endomycorrhizae	%	7	10 - 50			

Potential Nitrogen in Soil

Nitrogen (N)	kg/ha	31 - 63	Potentially cycled for a period of 3-6 months*

*Please note that this value is related to the microbiological activity and is not a chemical measure of nitrogen.

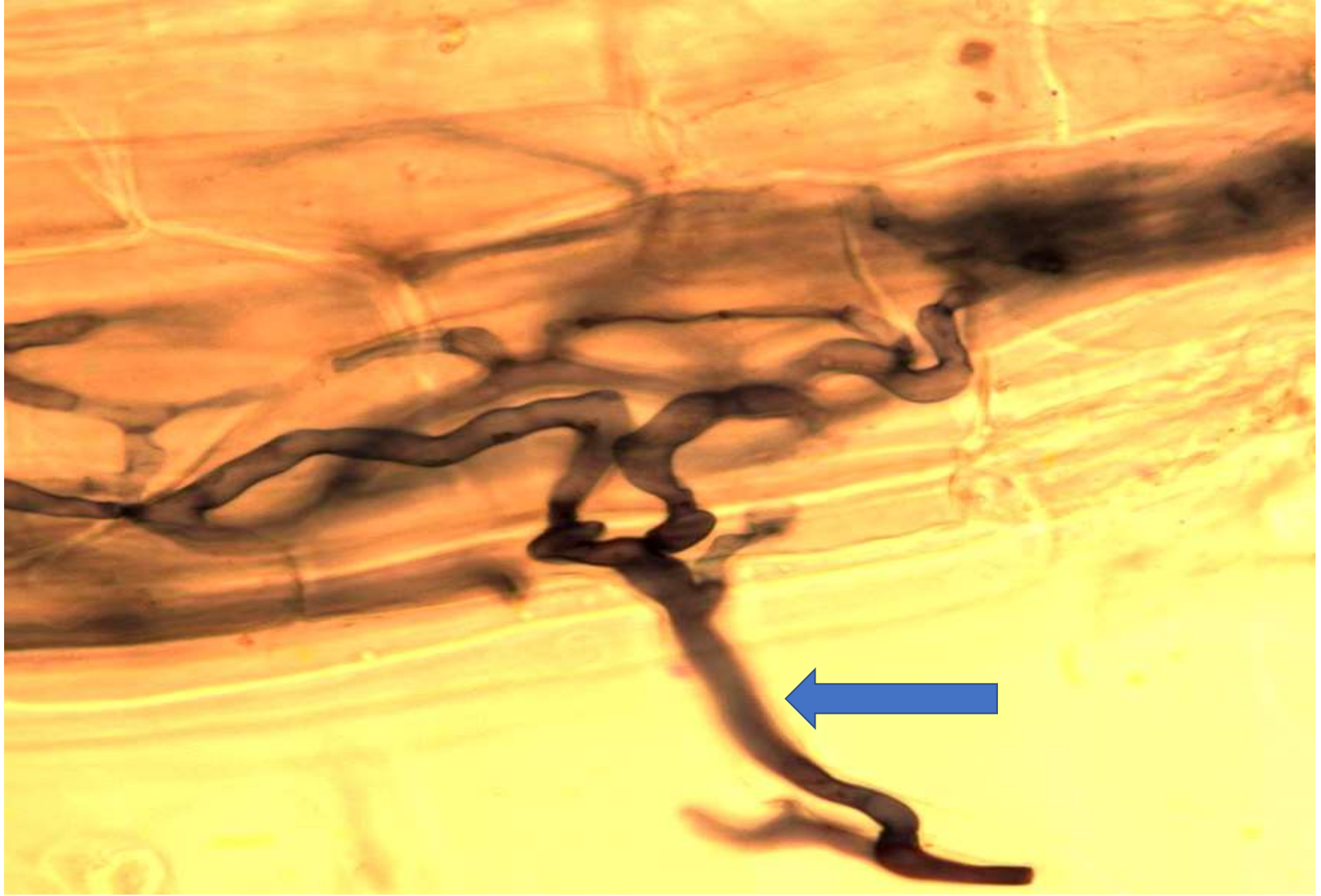


Photo courtesy Jill Clapperton

Solvita CO2 burst test

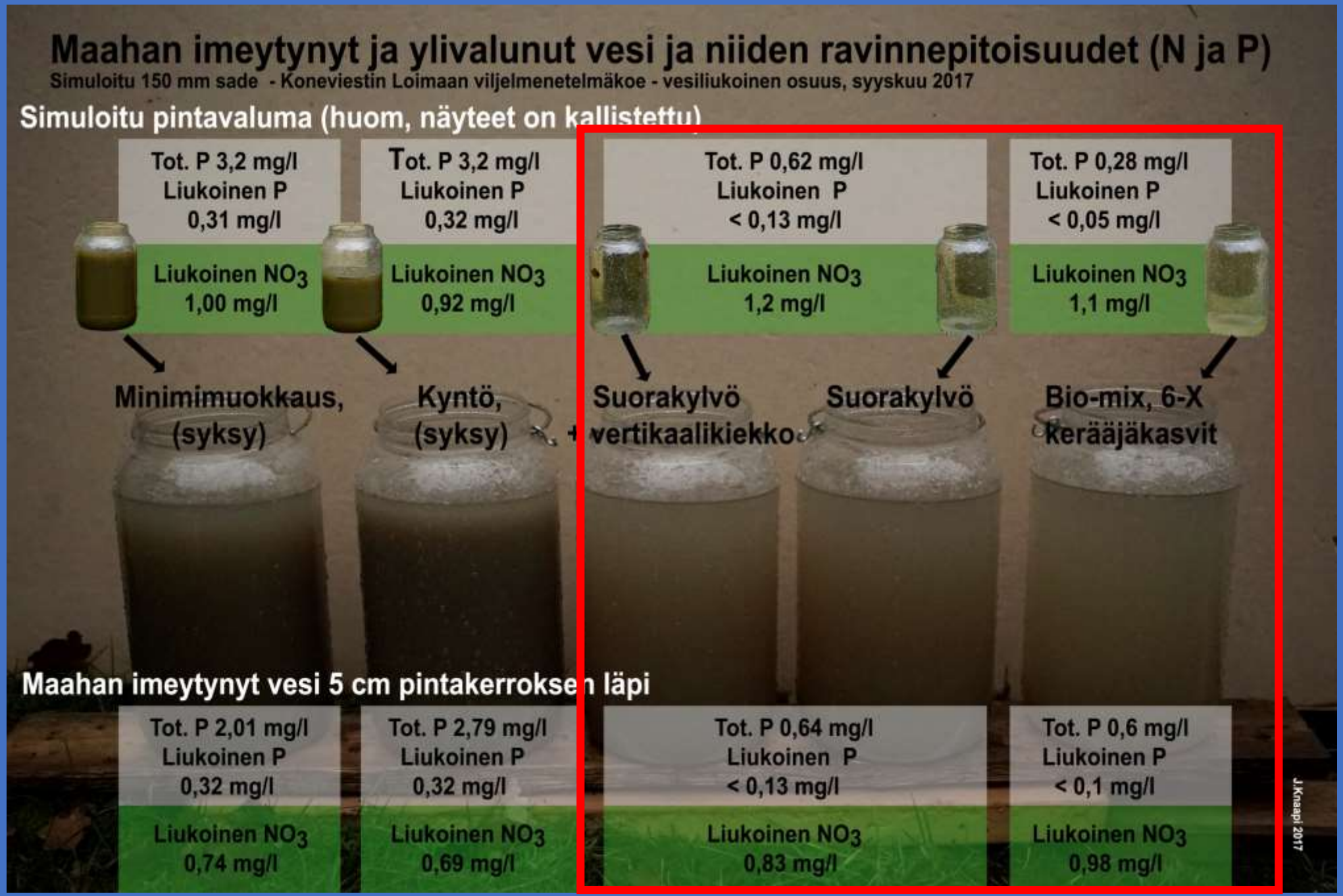
Right after managemental task

After few weeks

The follow up of management changes

Viljelytapamuutos

Foto Johanna Jahkola


Maahan imeytynyt ja ylivalunut vesi ja niiden ravinnepitoisuudet (N ja P)
Simuloitu 150 mm sade - Koneviestin Loimaan viljelmenetelmäkoe - vesiliukoinen osuus, syyskuu 2017
Simuloitu pintavaluma (huom, näyteet on kallistettu)
Tot. P 3,2 mg/l
Liukoinen P
0,31 mg/l
Liukoinen NO3
1,00 mg/l
Tot. P 3,2 mg/l
Liukoinen P
0,32 mg/l
Liukoinen NO3
0,92 mg/l
Tot. P 0,62 mg/l
Liukoinen P
< 0,13 mg/l
Liukoinen NO3
1,2 mg/l
Tot. P 0,28 mg/l
Liukoinen P
< 0,05 mg/l
Liukoinen NO3
1,1 mg/l
Minimimuokkaus, (syksy)
Kyntö, (syksy)
Suorakylvö vertikaalikiekko
Suorakylvö
Bio-mix, 6-X kerääjäkasvit
Maahan imeytynyt vesi 5 cm pintakerroksen läpi
Tot. P 2,01 mg/l
Liukoinen P
0,32 mg/l
Liukoinen NO3
0,74 mg/l
Tot. P 2,79 mg/l
Liukoinen P
0,32 mg/l
Liukoinen NO3
0,69 mg/l
Tot. P 0,64 mg/l
Liukoinen P
< 0,13 mg/l
Liukoinen NO3
0,83 mg/l
Tot. P 0,6 mg/l
Liukoinen P
< 0,1 mg/l
Liukoinen NO3
0,98 mg/l
J.Knaapi 2017

Microbial status – possible to heal!

ski

Kuva: Fanni Heinonen HY, 2014

Kuva: Fanni Heinonen HY, 2014

Professori Onni Pohjanheimon kokeita Jokioisissa v. 1961

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points:
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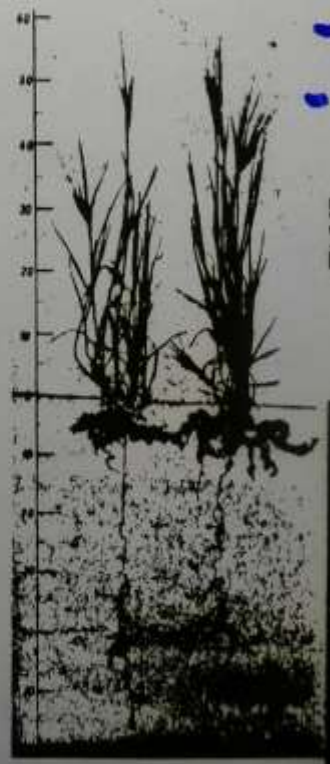

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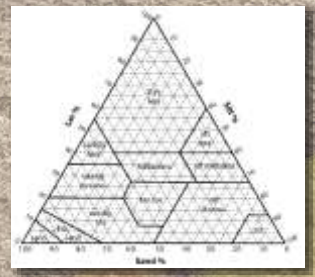
The technic of soil scanning

pH

Topography

EC



SOM

N

Agronomic Zoning & VRA maps

Influencing factors

Management

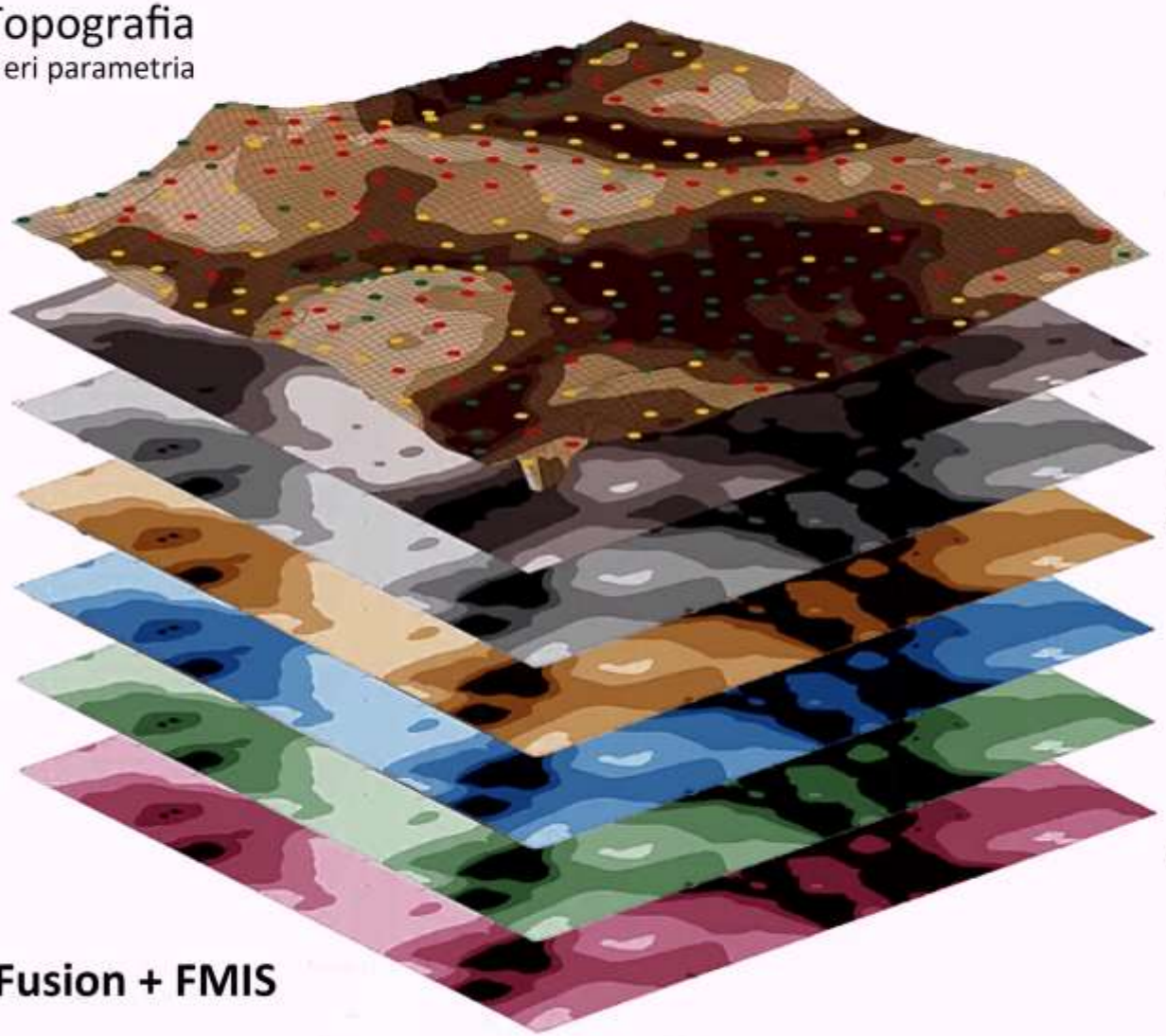
'Management, choices'


IC465
IC464
IC462
IC461
IC179
IC175
IC164
IC186
IC466
Kyttäläntie
Leikkiläntie
Eerenintie
Murronkuja
Vainuantie
Kujanpääntie
Yttiläntie
Jalonojanmäentie
Jonkanmäki
2481

Sensorien fuusio --> 1 + 1 on enemmän kuin 2

Topografia
3 eri parametria

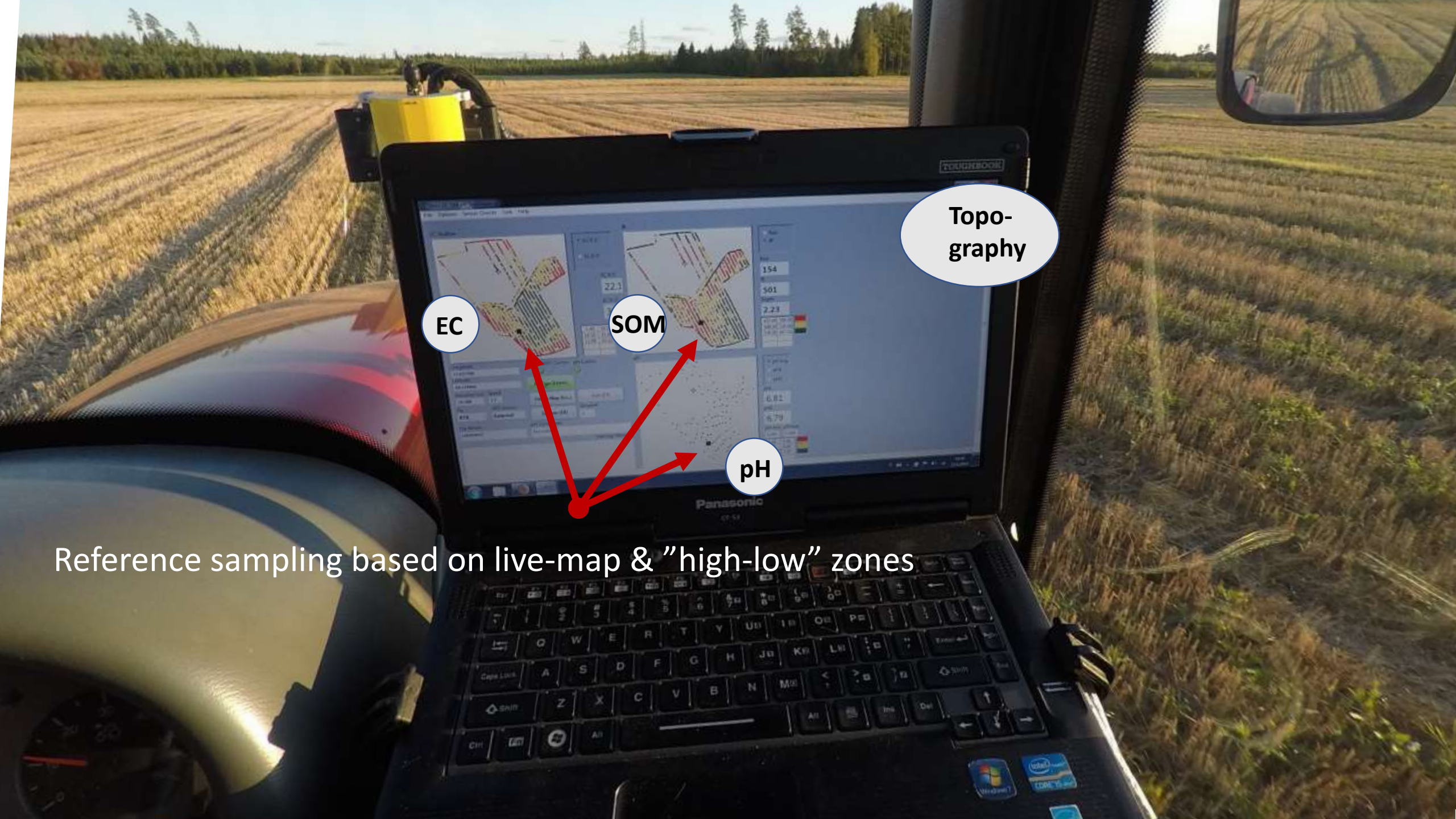
pH 0-15
SOM 0-15
EC 0-30
EC 0-90
C^{o} 7,5
Kost.-% 7,5
CO_2 0-90
Tr. Canväylä + säätilatieto



Perusmittaus

Laajennettu mittaus

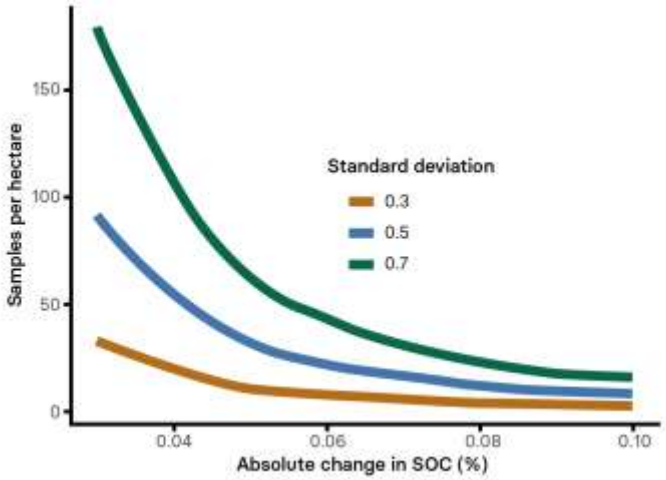
FieldFusion + FMIS



Reference sampling based on live-map & ”high-low” zones

Agronomic and carbon measurement simultaneously

Referensesampling - SOM-%

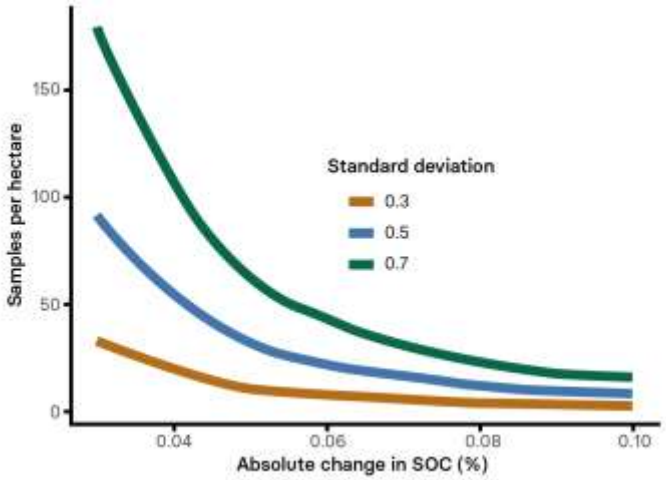


SOM-estimates n 400 pcs/ha
Ref.sampling 4 – 6 kpl/parcel + based on zoning

Soil laboratory > Carbon stock

Agronomic and carbon measurement simultaneously

Referensesampling - SOM-%



SOM-estimates n 400 pcs/ha
Ref.sampling 4 – 6 kpl/parcel + based on zoning

Soil laboratory > Carbon stock

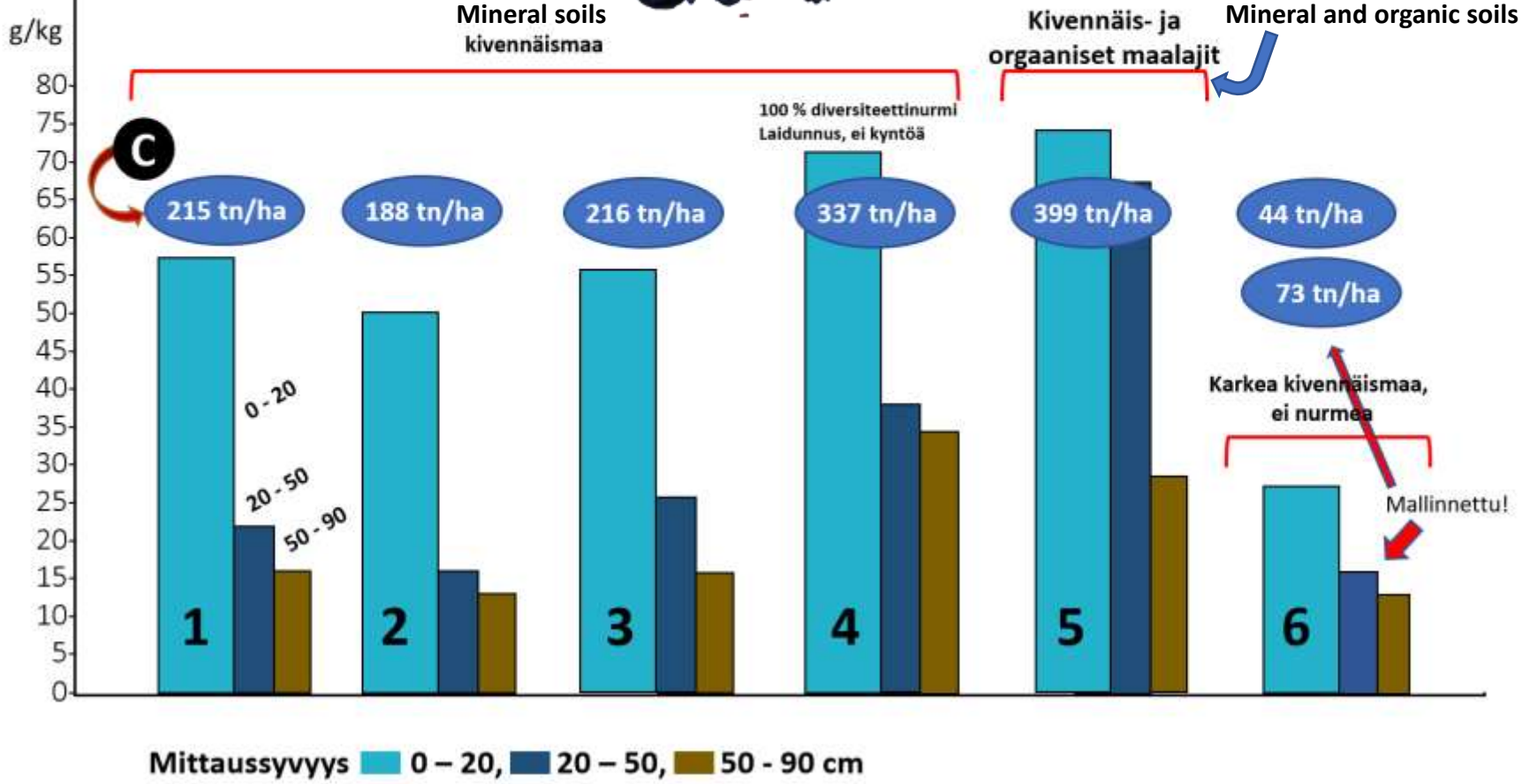
We need to standardize sampling & analysing!!

Carbon stock – g/kg at different dephts

Luken pitkäaikaistutkimus 1974-2018

Knaapi & Knaapi maaperäskannaus 2019
n. 140 koepaikkaa (toistaiseksi)
Jokaiselta koepaikalta useita (n 4) referenssinäytettä
Jokaisesta referenssinäytteestä 12 osanäytettä
Näytteet 0 – n 90 cm

1. Notill , KV Loimaa - 14 years
2. Plough, KV Loimaa - 14 years
3. Grassley, 11 sites - < 5 year
4. Rotational grazing, Eco 24 years, 40 without ag-chemicals, no plough 20 years, 1 site
5. All Knaapi & Knaapi samples 140 sites
6. Coarse sandy soil, mix rotation, 10 sites (sampling only 0-20 cm)



Soil mapping - Results from season 2019 - SOM

SOM-% in profile >>	Notill >>	Plough >>	Grass Ley (silage) 11 parcels >>	Grass Ley & rotational grazing
0 - 20 cm	9,2-10,5 %	8,5-9,0 %	9,7 %	12,3 %
20 - 50 cm	3,5-4,0 %	2,5-3,0 %	4,5 %	6,6 %
50 - 90 cm	2,5-3,0 %	2,0-2,5 %	2,7 %	5,8 %

All samples from same type soil (clay, sand, no organic soiltypes included)

Loimaa site

Samples taken season 2019. Analyse: Seilab, LOI method

Knaapi/Neuvo 2020

Grass ley samples taken 4th Oct 2019. Analyse: Hortilab, LOI method

Kankaanpää Farm

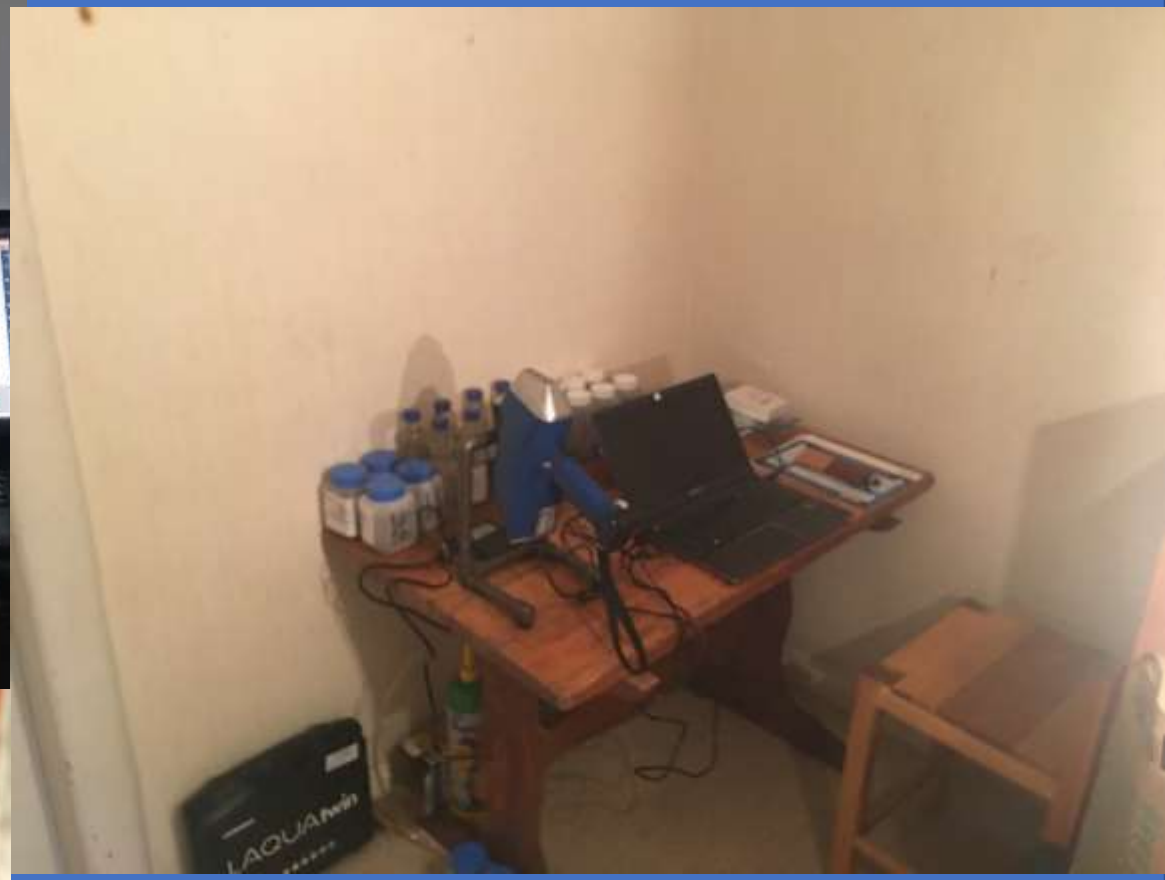
Data from Koneviesti Loimaa site, Knaapi/Neuvo2020 measurements and Kankaanpää Farm

Some key factors affecting the efficacy of carbon sequestration

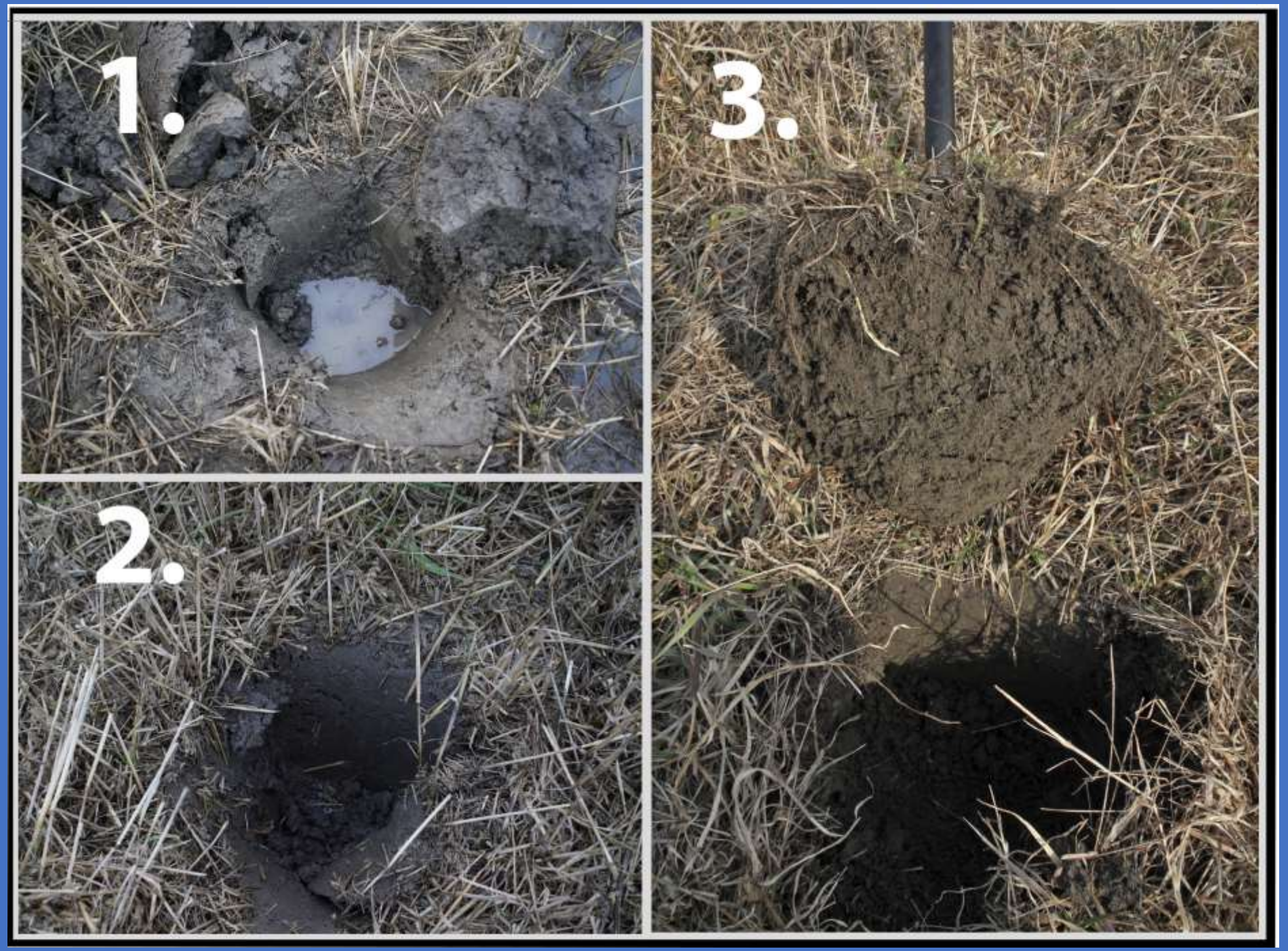
- Balanced C/N relation – target to have 24/1 relation, but….. seldom achieved!
- Fungal/bacteria balance
- Control of evaporation – effective rain vs ’meterological rain’
- Control of water potential (WP) in soil
- Understanding the difference of volumetric and potential water
- Understanding, how soil life (CO2 breathing) and plant canopy interact – feedback & the lenght of effective season important

Challenges in Carbon measurement!

Testing nutritional quality



XRF-gamma ray technic


1.
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Kiitos!