
Food and Agriculture Organization of the United Nations
GLOSOLAN
Soil spectroscopy training workshops
Soil spectroscopy from the Danish perspective
Nicolai Bork, Project Manager, FOSS
Online webinars
GLOBAL SOIL PARTNERSHIP

OUTLINE

- FOSS
- The soil testing market
- The FOSS solution
- Summary and outlook

Nicolai Bork, nbo@foss.dk

A HISTORY OF PIONEERING INVENTIONS

FOSS

In 1956, Nils Foss identified the need for a portable moisture analyser

Fast, easy-to-use and dedicated, the Cera-Tester was the first FOSS innovation

Matching innovative technology to the demands of particular industries has been the foundation of FOSS ever since

1956

Cera Tester monitors moisture content in grain. The instrument is a highly popular world first.

1963

Milk becomes a major business area, and the Pro Milk helps to speed-up the analysis of fat content in milk.

1973

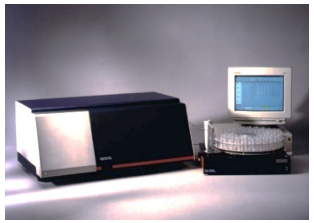
The Tecator Kjeltec™ paves the road for simpler, safer, less timeconsuming and more cost efficient Kjeldahl analysis.

1980

Analysis of individual bacteria or somatic cells leads to dramatic improvements in raw milk quality.

1997

FOSS acquires Perstorp Analytical and improves consistency of analysis results throughout the grain industry via NIR.



1999

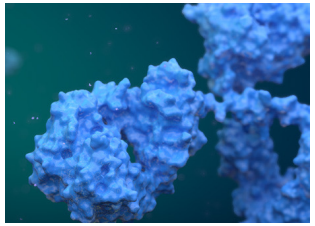
WineScan introduces FTIR analysis as an effective way of improving quality throughout the wine making process.

2003

Introduction of X-ray analysis of meat allows entire batches of meat to be checked for fat

2014

For the Indian market, FOSS introduces the tiny milk analyser, MilkoScreen™, for milk quality testing and adulteration screening



2016

FOSS acquires Soft Flow in Hungary, adding extensive knowledge within bio-technology

2020

The MilkoScan FT3 with new, patented automatic standardisation which eliminates the need to perform time consuming standardisation checks with chemical reagents.

ANALYTICS BEYOND MEASURE

CORE TECHNOLOGIES

- NIR
- FT-IR
- X-RAY
- IMAGE ANALYSIS
- FLOW CYTOMETRY
- CHEMOMETRICS

FOSS

ANALYTICS BEYOND MEASURE

INDUSTRY LEADING SOLUTIONS
FOR INDUSTRY LEADING CUSTOMERS

FOSS

ANALYTICS BEYOND MEASURE

LABORATORIES

DAIRY

RAW MILK TESTING

WINE

MEAT

FEED & FORAGE

GRAIN & OILS

KEY FIGURES

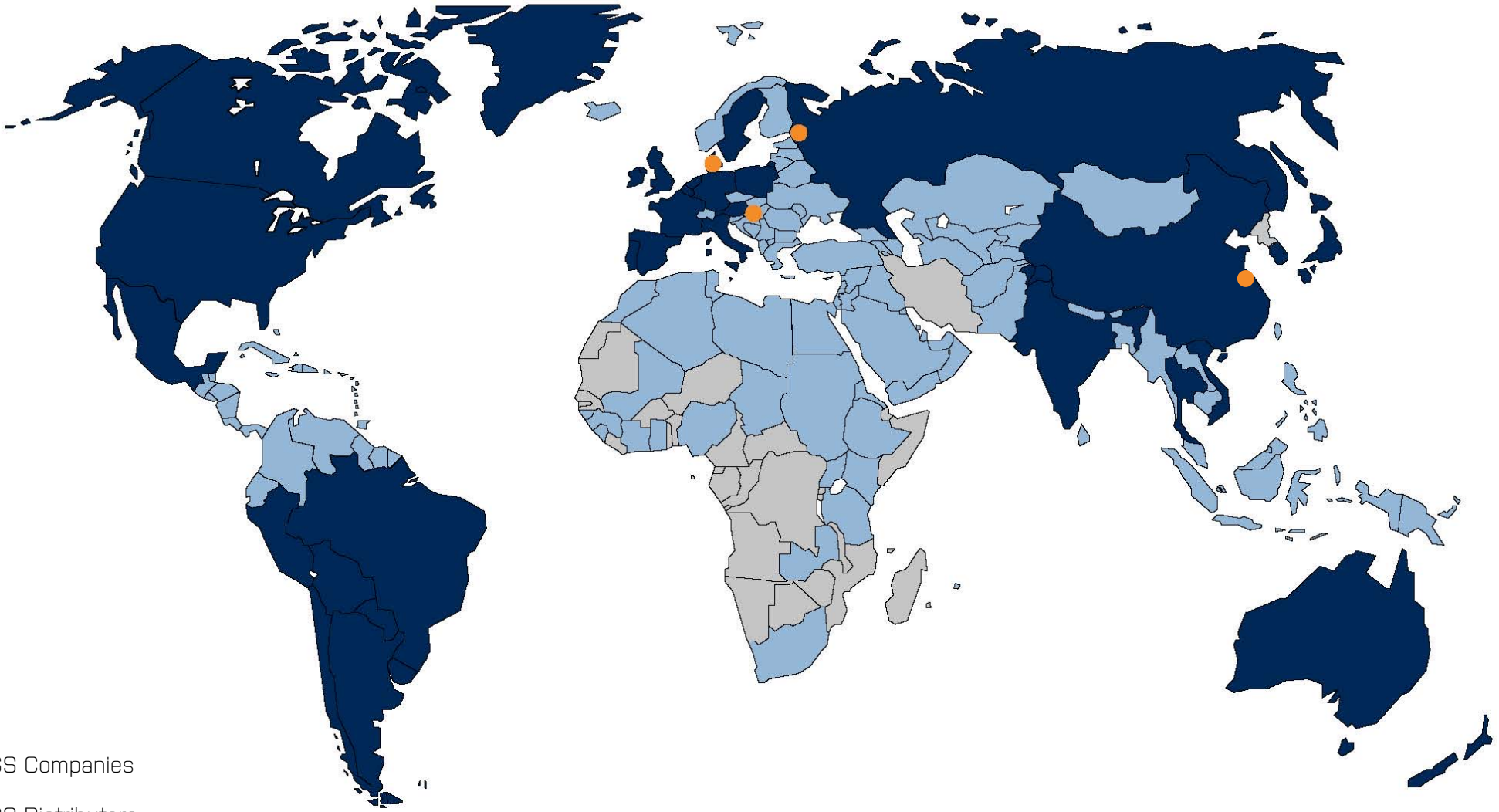
FOSS

100%	A 100% family-owned company – HQ in Denmark
99%	99% of turnover outside Denmark
288 mill.	A turnover of 288 million EUR in 2020
AAA	AAA-rated by D&B
> 24%	EBITA of > 24% of turnover
> 54%	Solvency ratio > 54%

ANALYTICS BEYOND MEASURE

GLOBAL PRESENCE

FOSS



FOSS Companies

FOSS Distributors

FOSS RDM Centres

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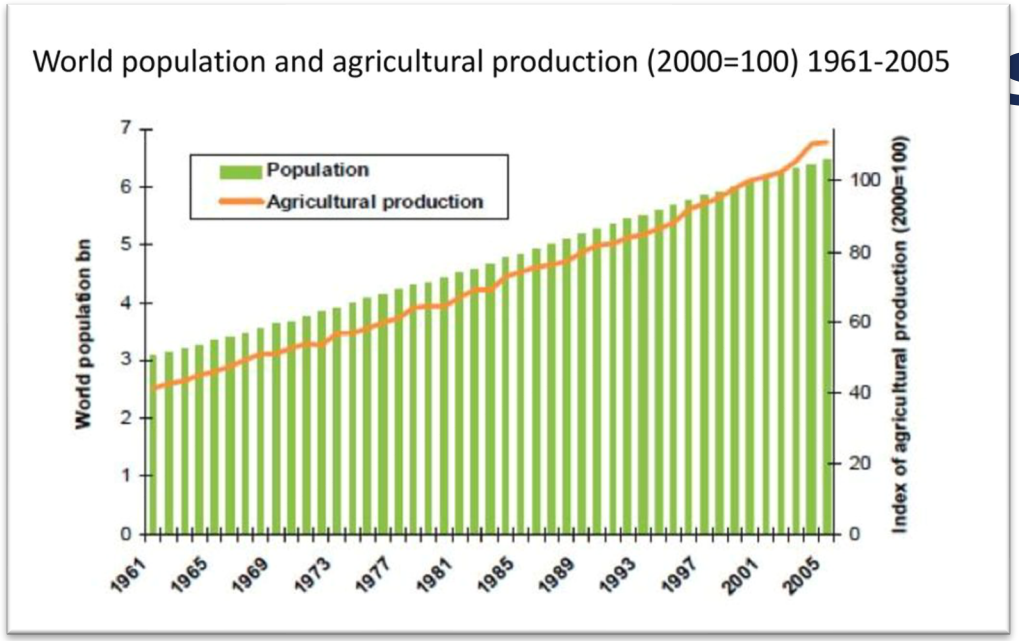
MOTIVATION

- Feeding worlds population requires optimized farming and fertilization strategies
- Soil analysis is key!- “If you don’t measure it, you can’t manage it”

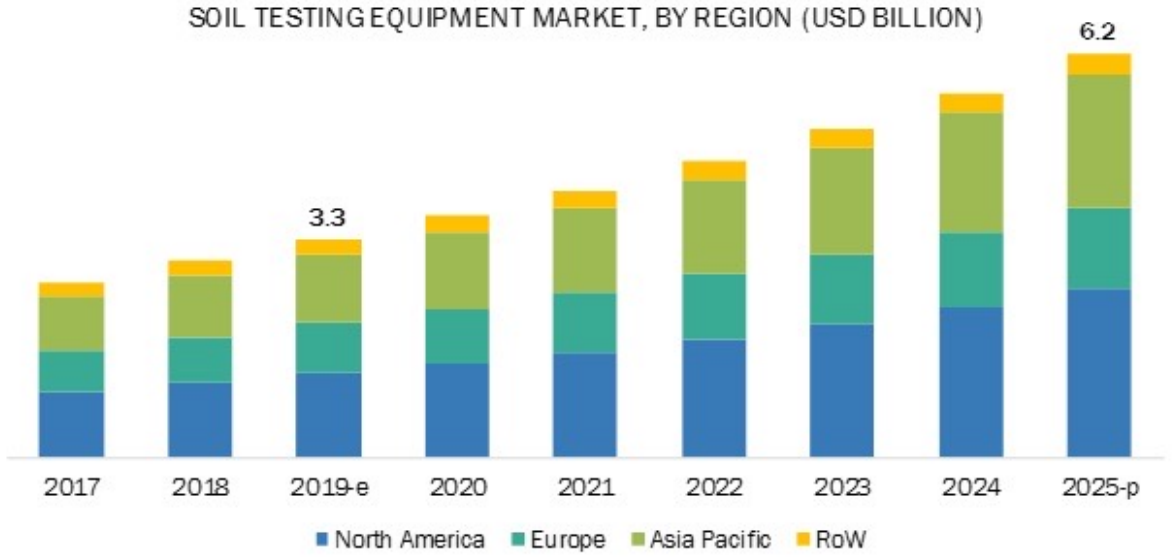
- Some soil analysis methods are slow, labor intensive and may require use of harsh chemicals
  - Most form 1st half of 20th century



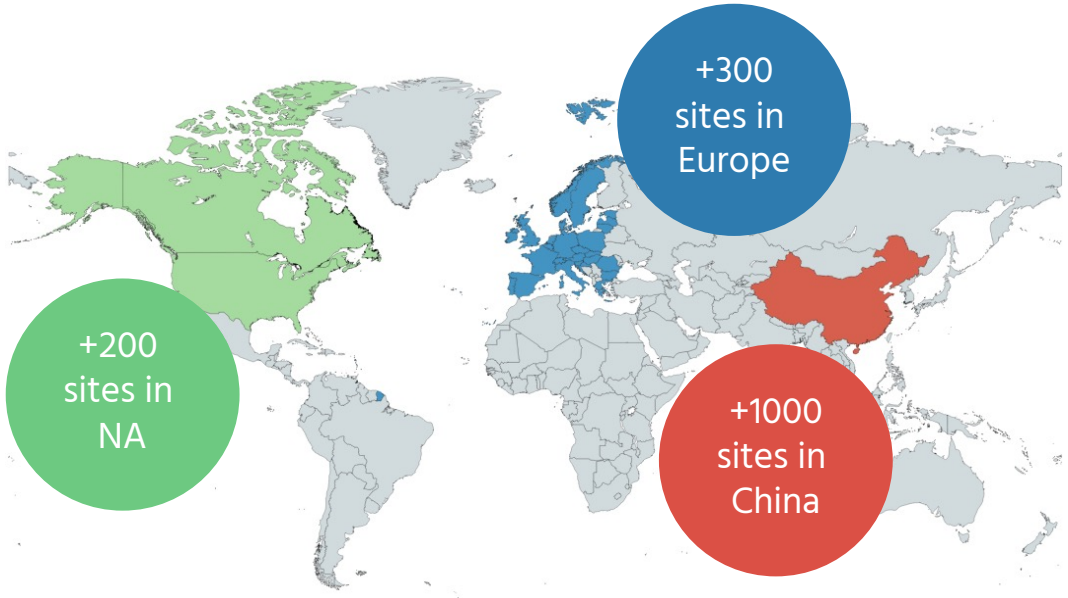
MARKET DEVELOPMENT

- Development of soil testing follows general trends
- Annual growth ca. 10-15%
- Consolidation of labs

- Driven by
  - Soil management
  - Legislation
  - Megatrends

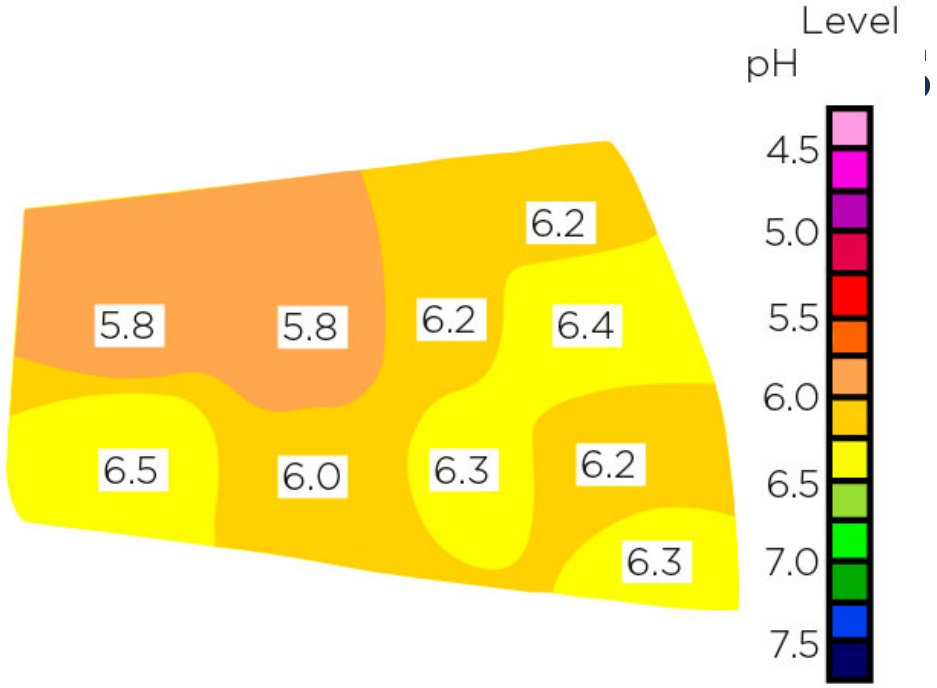


Soil testing laboratories

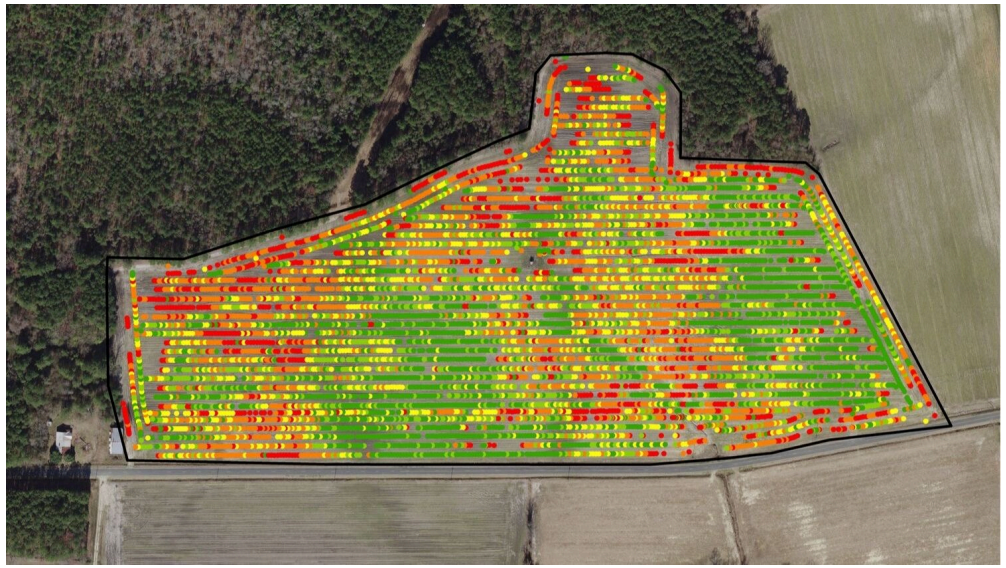


MEGATREND: PRECISION FARMING

- Soil is diverse, but traditional analysis are expensive
- Reduced analysis and reduced productivity
- Low cost sensors and measurements for increased insight and yield



ANALYTICS BEYOND MEASURE



esa European Space Agency

Syngenta Group

YARA

NASA

PHOSAGRO®

JOHN DEERE

Wesfarmers

CLAAS

MASSEY FERGUSON

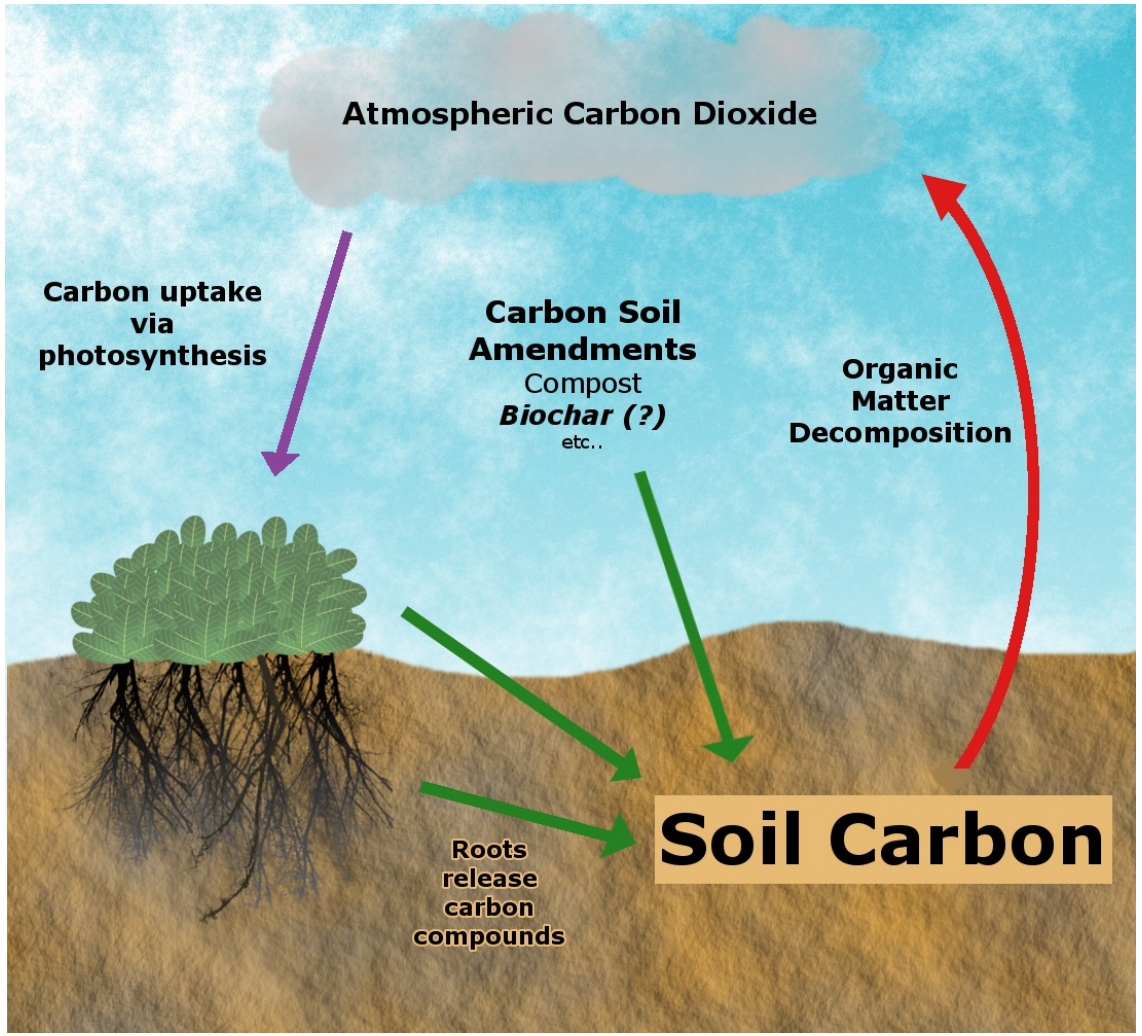
Kubota

MEGATREND: CO2 SEQUESTRATION IN SOIL

FOSS

- Healthy soil contains carbon (SOC)
- SOC levels are known to have decreased
- CO_2 sequestration by improved land use
- Seen as a win-win initiative

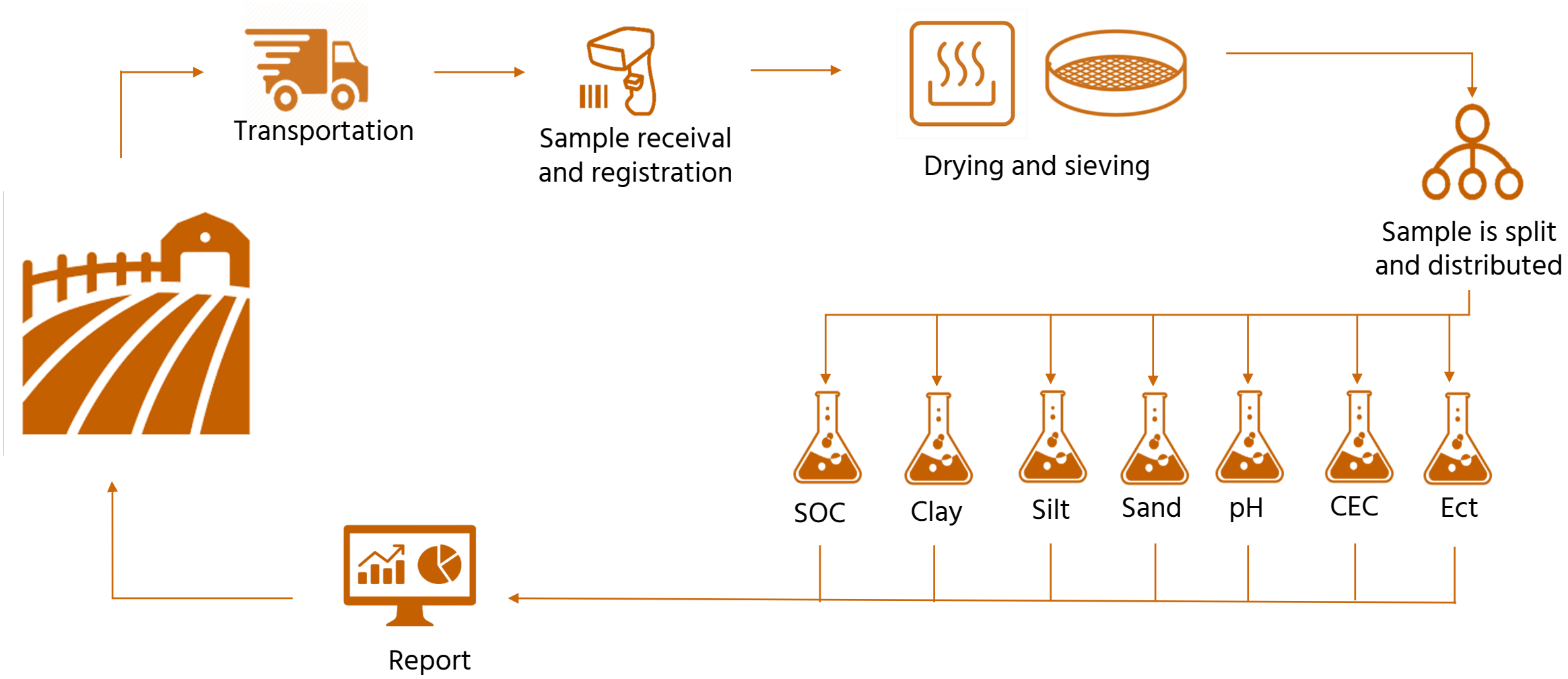
- Substantial rollout of platforms and investments



ANALYTICS BEYOND MEASURE

SAMPLE WORKFLOW
– FROM THE CUSTOMERS SITE TO THE LAB

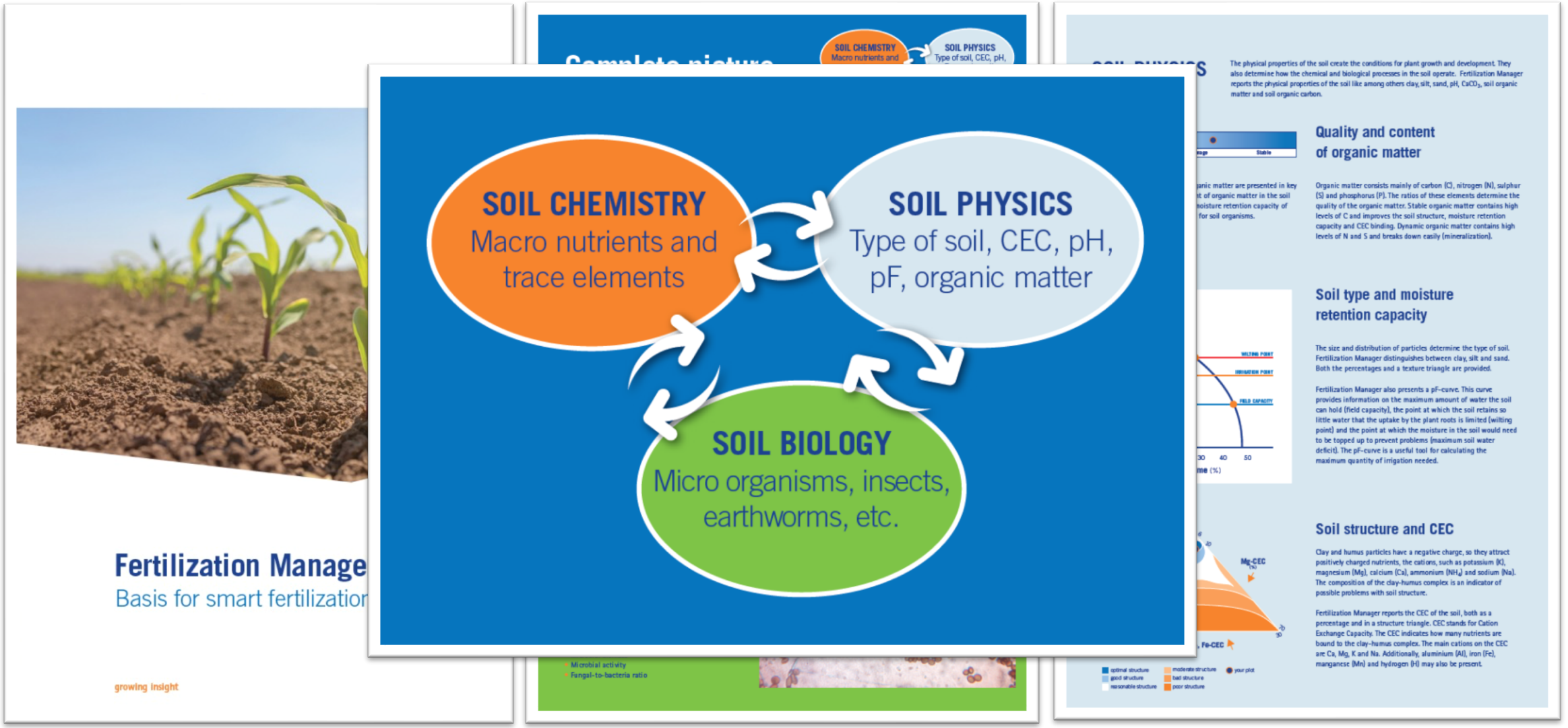
FOSS



ANALYTICS BEYOND MEASURE

SOIL REPORT

FOSS



ANALYTICS BEYOND MEASURE

PARAMETERS

- Very many parameters can be analyzed
  - Site dependent
  - Season dependent
  - Crop dependent

- Spectroscopy can tackle few, but central parameters

Parameter	Accuracy range (RMSEP)**
SOC (%)	0.35 to 0.40%
Clay (%)	2.6 to 7.4%
Silt* (%)	2.5 to 6.5%
Sand* (%)	4.3 to 11.5%
pH*	0.4 to 0.5
CEC* (cmol(+)/kg)	2.5 to 2.7

Pakete Bodenuntersuchung NIRS

Parameter	Methode	Basis	Basis Plus	Profi	Premium - Düngekompass	Bodenart	Kationenaustauschkapazität (KAK)
N-Vorrat	NIRS	x	x	x	x		
C/N-Verhältnis	berechnet	x	x	x	x		
N-Nachlieferung	NIRS	x	x	x	x		
S-verfügbar	CaCl2				x		
S-Vorrat	NIRS		x	x	x		
C/S-Verhältnis	berechnet		x	x	x		
S-Nachlieferung	NIRS		x	x	x		
P-verfügbar	CaCl2			x	x		
P-Vorrat	NIRS	x	x	x	x		
K-verfügbar	CaCl2				x		
K-Vorrat	NIRS	x	x	x	x		
Ca-verfügbar	CaCl2		x	x	x		
Ca-Vorrat	NIRS		x	x	x		x
Mg-verfügbar	CaCl2				x		
Mg-Vorrat	NIRS	x	x	x	x		
Na-verfügbar	CaCl2				x		
Na-Vorrat	NIRS				x		x
Säuregrad (pH)	NIRS	x	x	x	x		x
C-organisch	NIRS	x	x	x	x		
Organische Substanz	NIRS	x	x	x	x	x	
C/OS-Verhältnis	berechnet		x	x	x		
Kohlensaurer Kalk	NIRS	x	x	x	x	x	
Ton	NIRS	x	x	x	x	x	
Schluff	NIRS	x	x	x	x	x	
Sand	NIRS	x	x	x	x	x	
<16 µm	NIRS	x	x	x	x	x	
Ton-Humus (KAK)	NIRS			x	x		
CEC-Besatz	NIRS			x	x		x
Ca-Besatz	NIRS			x	x		x
Mg-Besatz	NIRS			x	x		x
K-Besatz	NIRS			x	x		x
Na-Besatz	NIRS			x	x		x
H-Besatz	NIRS			x	x		x
Al-Besatz	NIRS			x	x		x
Krümelbarkeit	berechnet		x	x	x		
Verschlämmungsrisiko	berechnet		x	x	x		
Erosionsempfindlichkeit	berechnet		x	x	x		
Wasserhaltevermögen	berechnet		x	x	x		
Microbial biomass	NIRS				x		
Mikrobielle Aktivität	NIRS	x	x	x	x		
Pilze/Bakterien-Ratio	NIRS				x		
Düngeempfehlung	berechnet	soil based	soil based	soil based	crop and soil based		
Organische Substanzbilanz	berechnet	x	x	x	x		
Strukturdreieck	berechnet			x	x		x
Texturdreiecks	berechnet	x	x	x	x		
pF-Kurve	berechnet		x	x	x		
P-Pufferkapazität	berechnet				x		
EC	NIRS	o	o	x	x	o	o
Spurenelemente: Si, Fe, Zn, Mn, Cu, Co, B, Mo, Se	CaCl2	o	o	o	o	o	o

x: im Paket enthalten
o: optional zubuchbar

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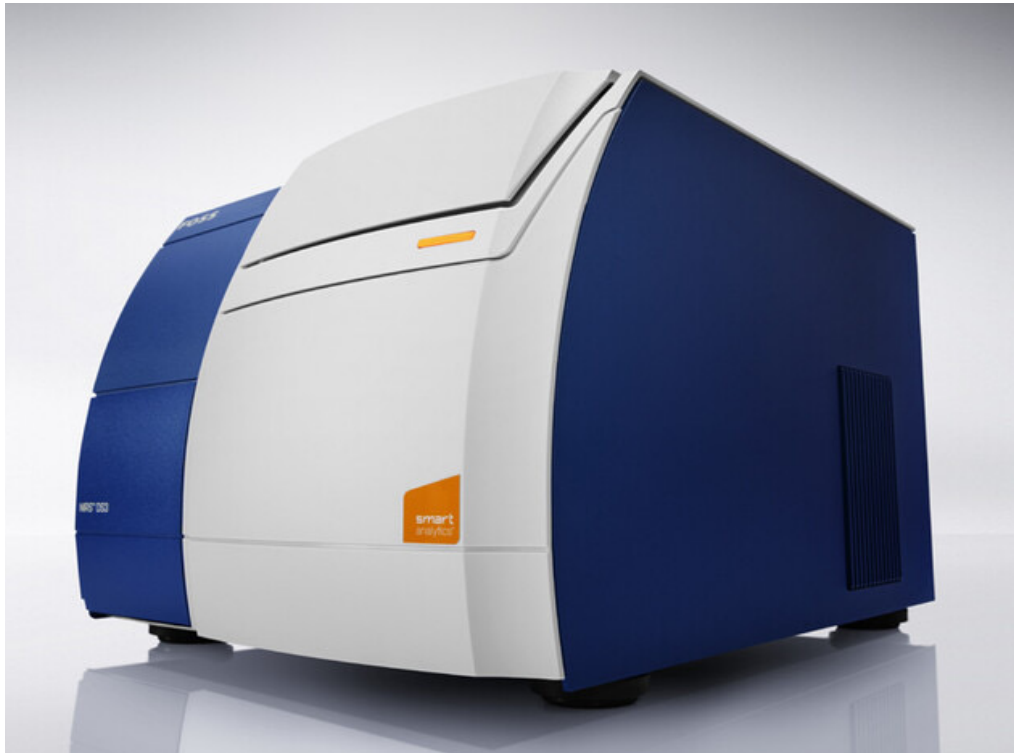
BENCH NIR SOLUTIONS FROM FOSS

DS3

FOSS



Main benefits

- Top performing NIR analyzer
- Wavelength range of 400 - 2500 nm
- Fully standardized: Identical performance across instruments
- IP 65
- Fast and easy to use
- Digital services and calibration options

ANALYTICS BEYOND MEASURE

SOIL APPLICATION PACKAGE

FOSS

ANALYTICS BEYOND MEASURE

DS3

FOSS NIR instrument and accessories : DS3, sample cups etc.

Digital Services

Data management, calibration development, maintenance and distribution

Digital Training

Training (eLearning) courses in use of instruments and FOSS' digital solutions for customers and SSS'

Application Guide

Application guide covering expected performance and step by step guide for sample handling and calibration development using Foss Digital Services

Starter Data Pack

Starter data package with FOSS owned reference and scans data for soil analysis

EXAMPLE FROM PROJECT WITH MAJOR SOIL LAB

FOSS

- "NIR error" comparable to "REF error" (RMSEP)

Parameters	NIR error	REF error
SOC (%)	0.38	0.31

- Outliers are apparent … but where is the error
  - Re-analysis showed that in **all of the cases** the reference value was incorrect
- Sources of error:
  - Weighing
  - Manual data transfer
  - Down-sampling

Origin of error	NIR	REF
Method		
Sample preparation		
Sampling		

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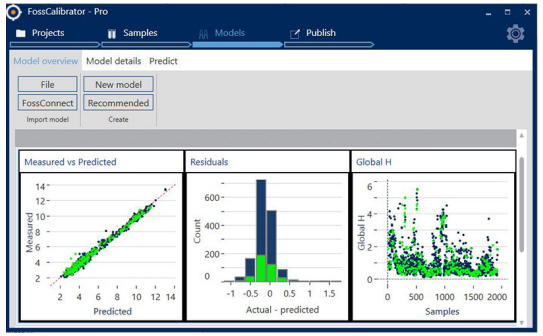
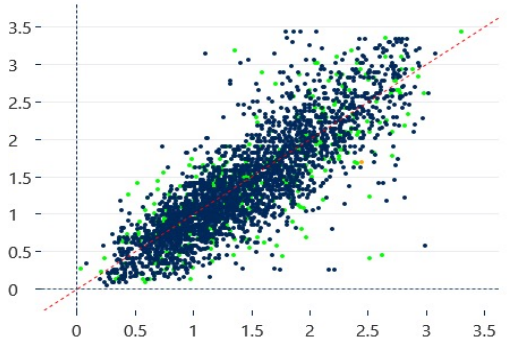
CONCLUSIONS

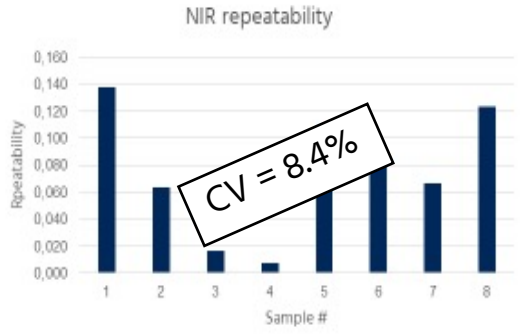
FOSS

- NIR for soil:
  - Fast, and easy to use, and cost effective
  - Minimal sample preparation
  - Easy database management and calibration development via dedicated SW
  - 100% of investigated outliers due lab error
  - Better repeatability than reference

- **NIR is a very suitable technology for handling large amounts of soil samples with high variance**







ANALYTICS BEYOND MEASURE

THANK YOU

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APPLICATION GUIDE

FOSS

Soil is very complex matrix. Global models are not yet available.

Massive amounts of local data is readily available for reference laboratory.

DIY application development has been made accessible for end user

Contact FOSS local representative!

Content	Appl. Guide	Appl. Note
Description of application	✓	✓
Description of instrument	✓	✓
Description of sample prep.	✓	✓
Description of sample presentation	✓	✓

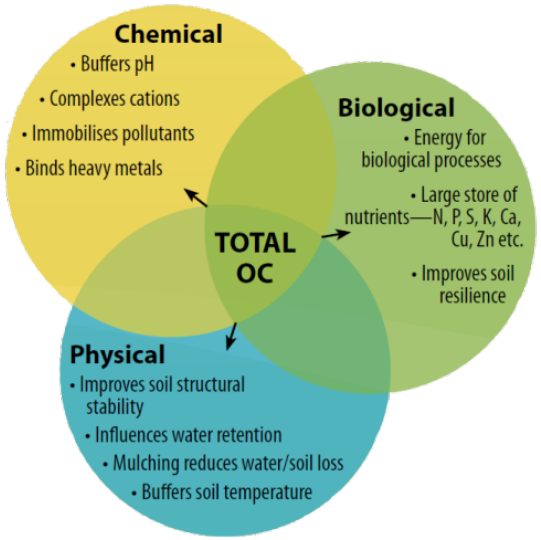
ANALYTICS BEYOND MEASURE

REFERENCE METHODS – SOIL ORGANIC CARBON

FOSS

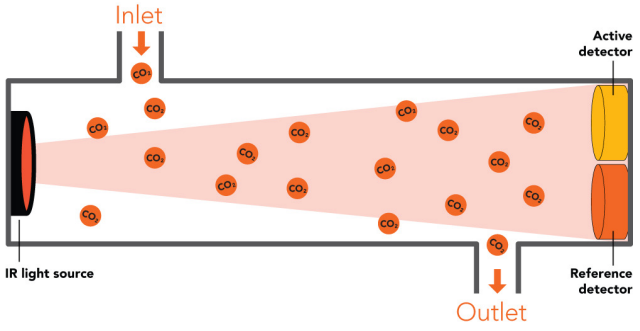
Descriptive of overall soil health

Relevant for CO_2 sequestration



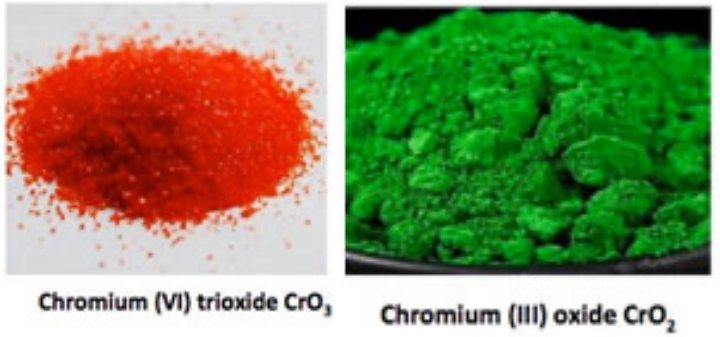
Method 1: Elemental analysis

- Gasify and analyse by NDIR
  - SOC + heat → CO2
- Pro: Automated, hands-off
- Con: Expensive apparatus, downsample



Method 2: Walkley Black

- Oxidize C by chromic acid and colorimetry/titration
  - SOC + Cr(VI) → Cr(III)
- Pro: Simple equipment
- Con: Hazardous chemicals, downsample



Chromium (VI) trioxide CrO_3 Chromium (III) oxide CrO_2

ANALYTICS BEYOND MEASURE

REFERENCE METHODS - TEXTURE

- Particle size distribution
    - Water and nutrient holding, aeration, tillage
- Gravimetry/sedimentation
- Pro: Simple and cheap
- Con: Labour intensive, slow, need for chemicals, footprint