‘Bemestingstechnieken maken het verschil’

Fertilizer technology makes a difference

Prof. Josse De Baerdemaeker

Department of Biosystems
KU Leuven

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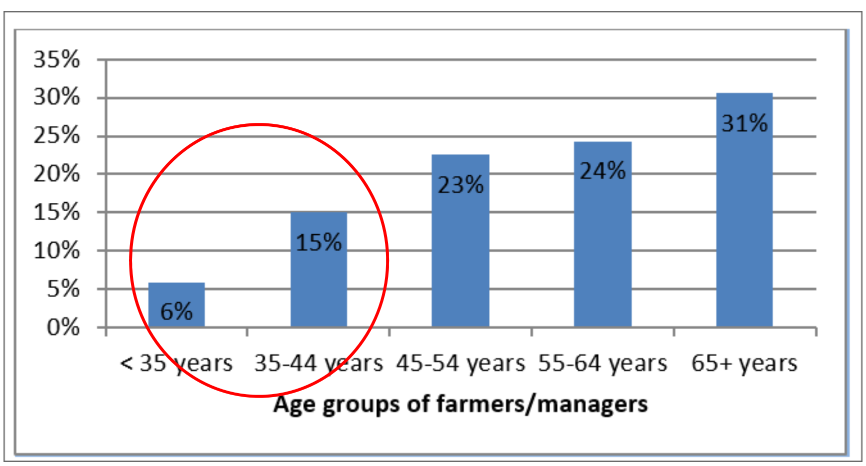
EU farmers/ farm managers by age group, 2013



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20:20 Wheat®

20:20 Wheat® aims to provide the knowledge base and tools to increase wheat yield potential (in the UK) to **20 $t.ha^{-1}$** within the next **20 years**

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Crop growth…..

- Crop growth can be
  - Potential growth (all conditions optimal)
  - Limited growth (for example shortage of N, water,...)
  - Reduced growth (pests and diseases, weeds,...)
- Problem is to determine the potential growth and which are the limiting or reducing factors
- Limiting and reducing factors may vary from place to place in a field

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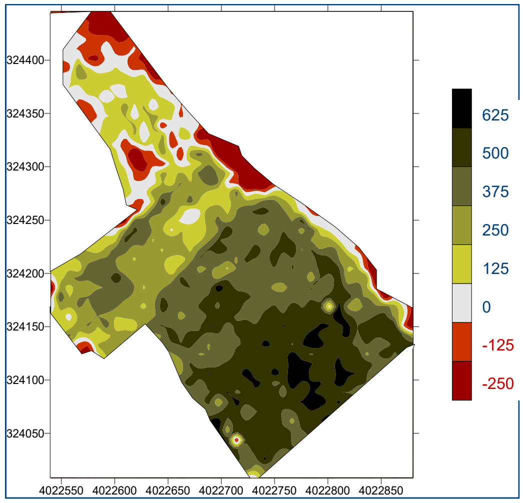
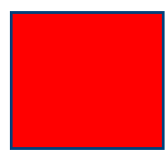
Financial profit *(Euro/ha)*

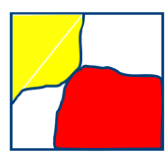


Precision Agriculture :
Management Scales & Approaches

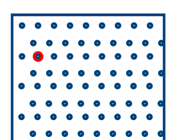
- Conventional Farming & Traditional Management — Field scale & One rate



- Precision Farming & Site Specific Management — Sub-Field & Variable rate

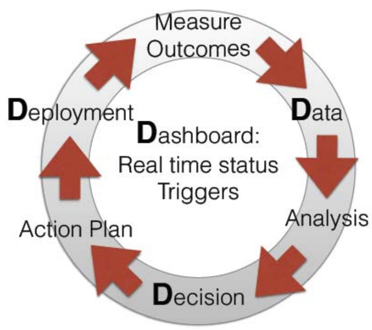


- Single-Plant-Care & Robotic Management — Single Plant Individual rate



Q. Zhang, 2012, at International Network of Precision Agricultural Centers, Richland, WA

Management cycles in agriculture



- LONG cycles: soil structure & fertility
- YEARLY cycles: soil prep., crop growth and Nitrogen
- SHORT cycles: weeds, insects, diseases, irrigation, harvest
- 24 hour cycles: mites in citrus, storms & hail

Marc Vanacht at ISTPA 2014, Beijing, September 2014

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Smart farming: analysis and information

- Correct observation: visually, sensors…
- Correct documentation (soil, previous crops and treatment…)
- Correct analysis

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Smart farming: decisions

- Correct genotype
- Correct dose
- Correct chemical/biological compound

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Smart farming: actions

- Correct place
- Correct time
- Correct (climatic) conditions
- Correct (use of) equipment

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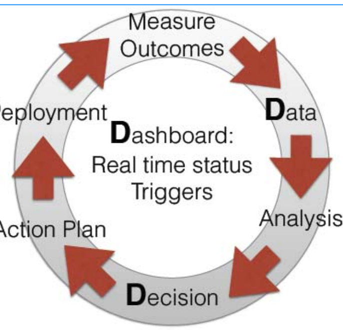
Innovations: from descriptive to prescriptive

Sensing and monitoring

Deployment and implementation



Data handling and storage

Information collection and decision support

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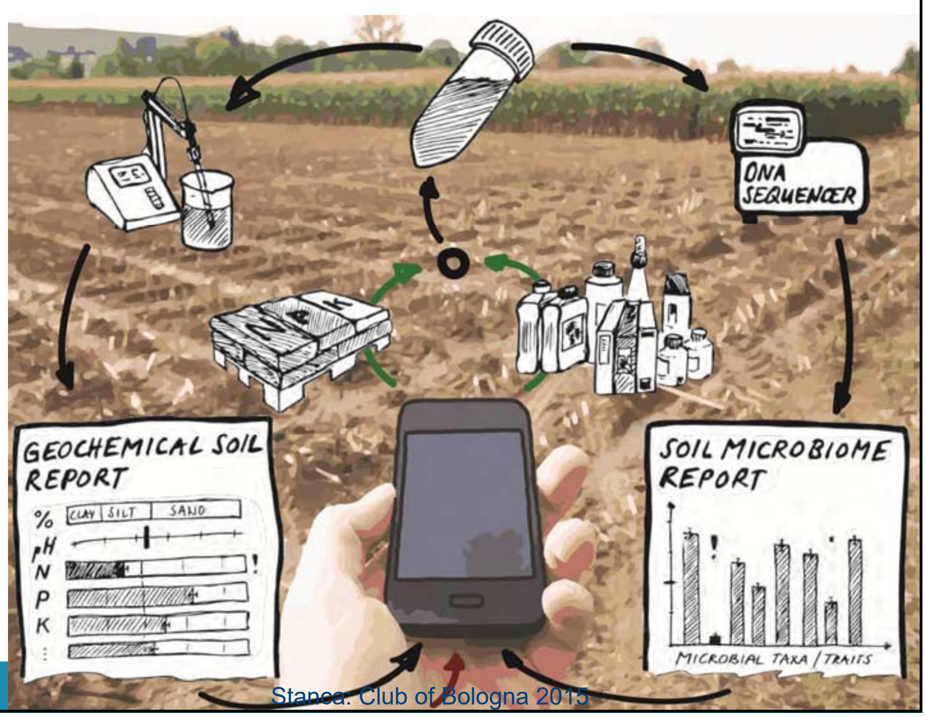

Stanca: Club of Bologna 2015

Proximal sensing of spatially variable soils

1. **electrical and electromagnetic sensors** measure electrical resistivity/conductivity or capacitance affected by the soil composition
2. **optical and radiometric sensors** use electromagnetic waves to detect the level of energy absorbed, reflected, or emitted by soil particles;
3. **mechanical, acoustic, and pneumatic sensors** measure spatially variable interaction between a measuring tool and soil;
4. **electrochemical sensors** use ion-selective material, producing a voltage output in response to the activity of selected ions

Adamchuk, V.I. and R.A. Viscarra Rossel. 2011. Precision agriculture: proximal soil sensing. In: *Encyclopedia of Agrophysics*, 650-656, J. Gliński, et al.,, eds. New York, New York: Springer.

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Topsoil Mapper

GEOPROSPECTORS

- Non-contact system for measuring soil parameters in real time.
- Automatically detects a range of soil parameters
  - compacted patches,
  - degree of saturation with water and
  - soil type,
- Transmitter and receiver coils detect
  - the apparent conductivity down to a depth of 1.1m.
  - software prepares 3D soil maps

https://www.agritechnica.com/en/innovations/innovations-2015/

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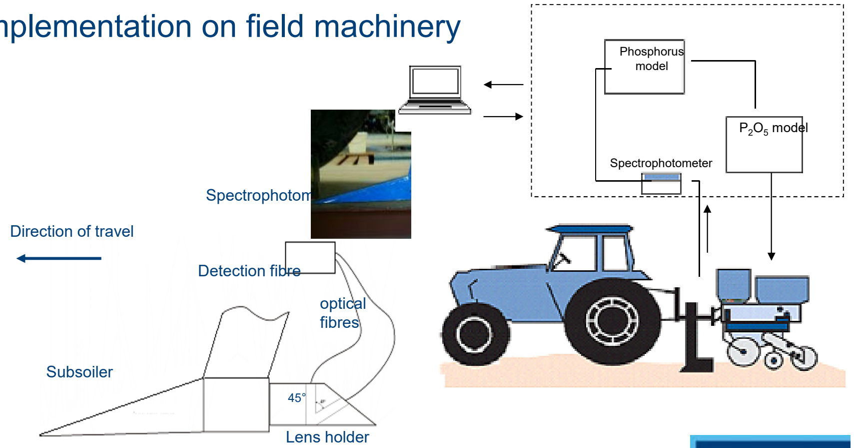
Development of a sensor-based fertiliser (P) applicator

- **Optical Soil sensor** to gather the soil P information
- **P model** to predict soil P from fresh soil;
- Implementation on field machinery



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Laser Induced Breakdown spectroscopy

- Soil nitrogen, and phosphorus: with LIBS using a sample chamber under a partial vacuum or argon purge and optimizing instrumentation for each specific element (1)
- NERCITA, China, at an August 2017 meeting announced a portable LIBS tool for N with a measurement duration of 2 sec.

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(1) R.D. Harris et al., Measuring Soil Carbon and Nitrogen Using Laser-Induced Breakdown Spectroscopy (LIBS). Los Alamos National Laboratory, Los Alamos, NM 87545

Plant-microbe interaction

- Beneath the surface of the earth, an influential community of microbes mingles with plant roots
- spatial variability in available substrate and environment for soil microbial activity
- spatial heterogeneity of microbial activity has received less attention to improve local soil (and crop) management

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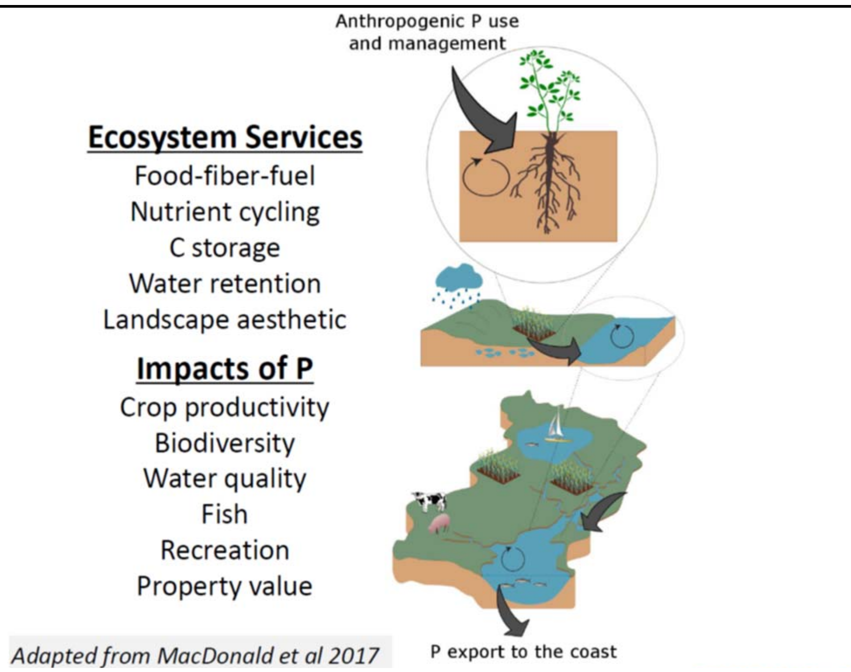
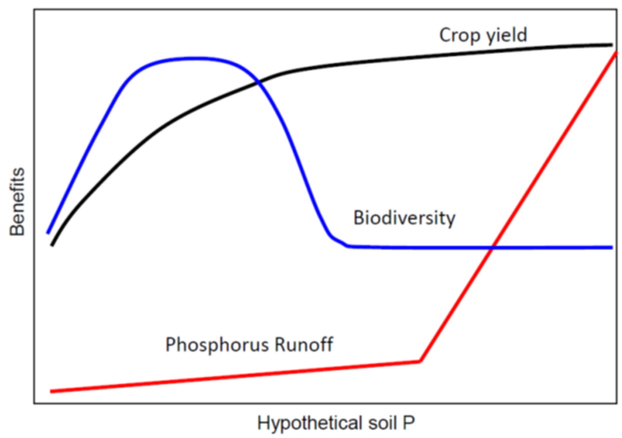


http://phosphorus.ipni.net/ipniweb/region/nane.nsf/0/1B2DE95D06B8C1E08525813B004DA51D/$FILE/Bruulsema%20CSSS%202017.pdf

manage agriculture to achieve benefits aside from just productivity?



Weintraub, Johnson, et al.

Sustainable Phosphorus Alliance

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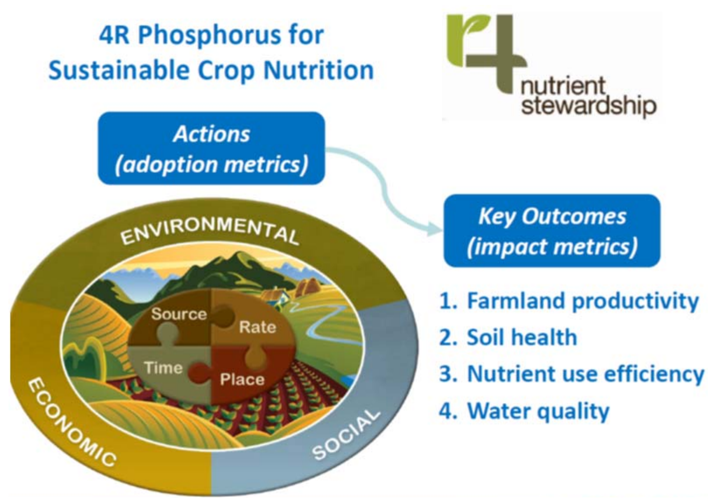
https://phosphorusalliance.org/files/2017/05/NSF_Report_Weintraub.pdf

IPN 4R method for Phosphorus management

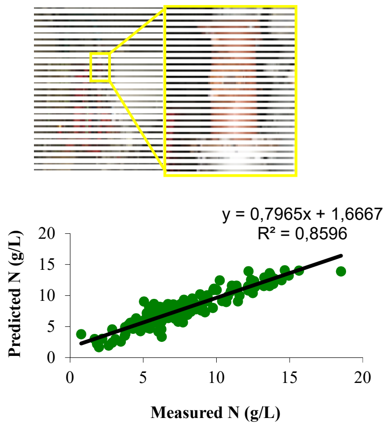
IPN: International Plant Nutrition Institute

- Right Source
- Right Rate,
- Right Time
- Right Place).



http://phosphorus.ipni.net/ipniweb/region/nane.nsf/0/1B2DE95D06B8C1E08525813B004DA51D/$FILE/Bruulsema%20CSSS%202017.pdf

Precision fertilization with manure



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Connected Nutrient Management

- Planning and optimization with a holistic, overall observation of the harvest history and includes technologies for highly precise fertilizer application.
- Farmers will be able to precisely determine, apply and document nutrient demands (nitrogen, phosphates etc.) for specific sub-areas, regardless of the type of organic or artificial fertilizer used.
- Since nutrient distribution is optimized according to sub-area demands and vegetation times,
- It provides a higher level of nutrient efficiency and also optimizes nutrient balances.

https://www.agritechnica.com/en/innovations/innovations-2015/

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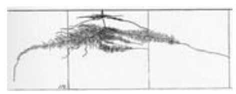
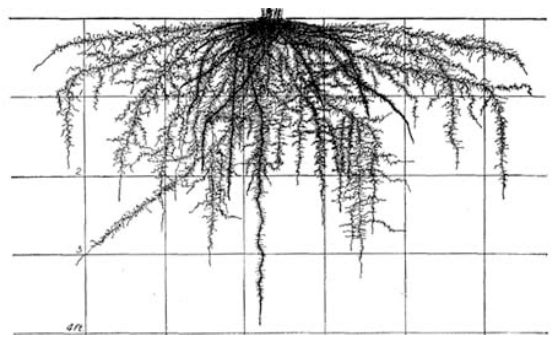
Root development: scale of nutrient use



Root system of sweet corn 16 days after planting. The growth of the secondary root system is well under way



Root system of sweet corn 8 weeks old.

JOHN E. WEAVER and WILLIAM E. BRUNER. ROOT DEVELOPMENT OF VEGETABLE CROPS McGRAW-HILL BOOK COMPANY, Inc. NEW YORK, LONDON. 1927

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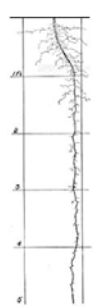
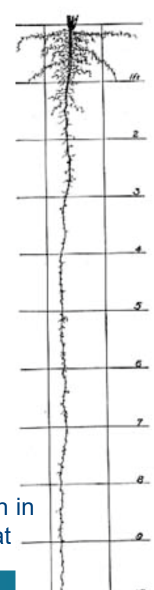
Root development: scale of nutrient use

Alfalfa plant 63 days old.



Alfalfa root 4.5 months old.



Two-year-old alfalfa root grown in rich lowland soil. Water table at depth of 12 feet.

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Variety selection in precision agriculture
Matching root morphology to soil conditions?

New equipment challenge…?
New management challenge….?

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Fertiliser N requirements

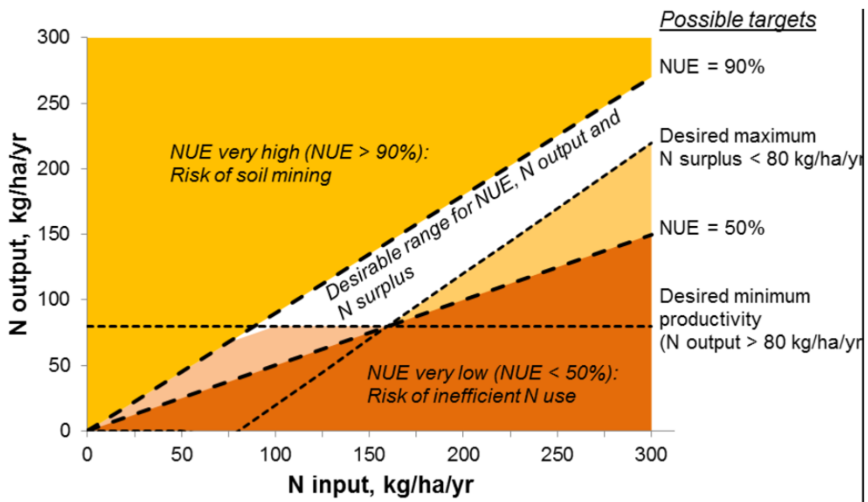
$$\text{Fertiliser N requirement}\left(\text{kg ha}^{-1}\right) = \frac{\text{CND}\left(\text{kg ha}^{-1}\right) - \text{SNS}\left(\text{kg ha}^{-1}\right)}{\text{FNR}\left(\%\right)}$$

Fertiliser N from knowledge of three components:

- Crop N Demand (CND) by optimized crop,
- Soil N Supply (SNS) in absence of fertilizer
- Fertiliser N Recovery (FNR), % N applied into the optimised crop.

D. R. Kindred et al., Spatial variation in Nitrogen requirements of cereals, and their interpretation. Advances in Animal Biosciences: Precision Agriculture (ECPA) 2017, 8:2, pp 303–307

Nitrogen Use Efficiency: at field scale?



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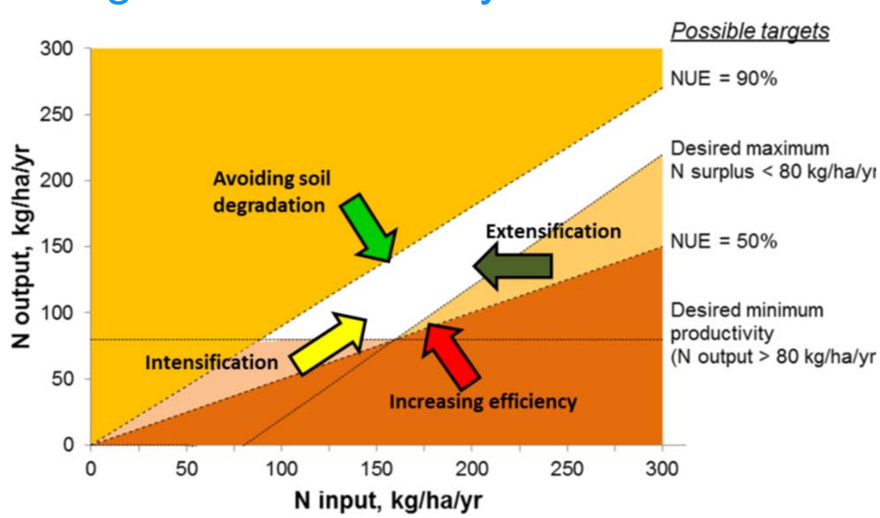
EU Nitrogen Expert Panel (2015) *Nitrogen Use Efficiency (NUE) - an indicator for the utilization of nitrogen in agriculture and food systems*. Wageningen University, Alterra, PO Box 47, NL-6700 Wageningen, Netherlands.

Nitrogen Use Efficiency: field scale?



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EU Nitrogen Expert Panel (2015) *Nitrogen Use Efficiency (NUE) - an indicator for the utilization of nitrogen in agriculture and food systems*. Wageningen University, Alterra, PO Box 47, NL-6700 Wageningen, Netherlands.

Nitrogen or chlorophyll content in canopies or leaves

- Tissue analysis
  - Kjehldahl
- Electrical meters
  - Nitrogen Ion selective electrodes
  - Electrical impedance spectroscopy
- Leaf level optical measurements
  - Leaf transmittance (SPAD)
  - Chlorophyll fluorescence (polyphenols-Dualex, Multiplex)
- Canopy level reflectance measurements
  - Ground based active or passive sensors
  - UAV or airplane
  - satellite

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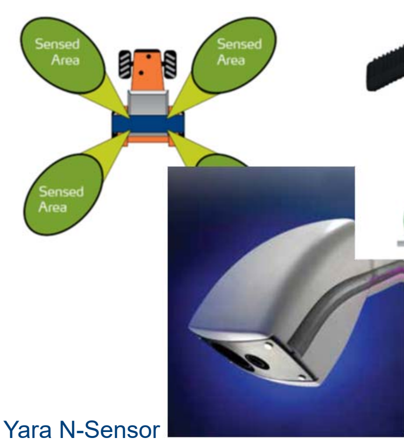
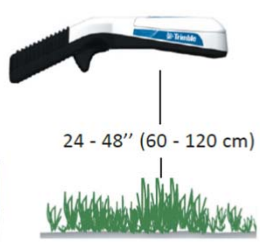
Active optical sensors for N





Greenseeker

OptRx Crop Sensors, based on a virtual reference strip.

Yara N-Sensor
- Absolute-N calibration (based on crop model and other information), or
- rolling calibration during operation

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UAV-unmanned aircraft for crop monitoring: weeds, disease, growth,…

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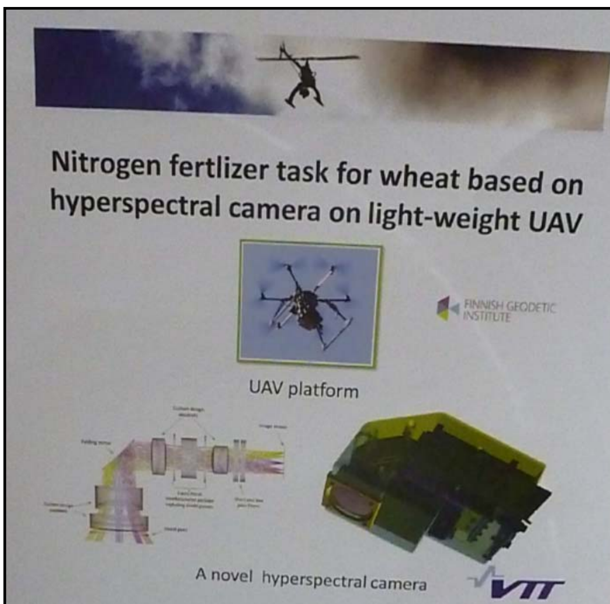

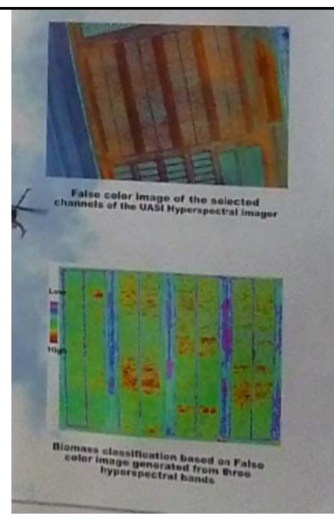

Potato plant health and biomass monitoring using UAV and hyperspectral camera

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MTT and VTT Finland

Vegetation index and crop diseases

- Optical sensing, using reflectance, fluorescence or thermal imaging can detect diseases at early stages for mapping to drive control strategies. Moshou D, et al. 2011
- Vegetation indices were suitable to detect differences in the reflection between healthy and diseased plants.
- But there was no specific vegetation index for only one of the diseases.
- Also the sensitivity of the indices was not very high.
- More vegetation indices have to be tested.

Use of Vegetation indices to detect plant diseases. Kerstin Gröll, Simone Graeff, Wilhelm Claupein
Institute for Crop Production and Grassland Research, Hohenheim, Germany

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Variable Rate Fertilizer Application

Shutterstock

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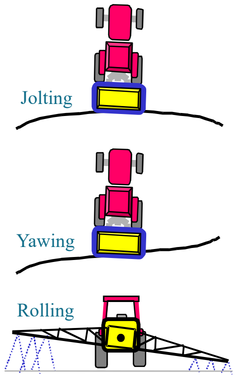
Need for appropriate equipment for precision crop production



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Plant to Plant Variability

.

- Some management related causes of plant to plant variability:
  - Deviations in planting depth and seed spacing,
  - Uneven nutrient application and crop residue distribution,
  - Wheel-track compaction,
  - Weed competition,
  - Plant population level.

(Andrade and Abbate, 2005), (C. R. Boomsma, T J. Vyn, 2010)

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Plant to Plant Variability

- Environment-related causes of plant to plant variability:
  - Variations in insect feeding
  - Variations in disease pressure
  - Micro-climate variations
  - Inherent soil spatial variability(Andrade and Abbate, 2005).
  - Soil moisture and temperature effect on seed emergence
- No-tillage farming: more risk for this plant-to-plant variability

(Andrade and Abbate, 2005), (C. R. Boomsma, T J. Vyn, 2010)

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Account for plant and row variability

- Yield monitors don't characterize variability at plant or row level
- Many potential causes, but uneven fertilizer delivery/availability is likely involved
- Recognize that early plant roots don't extend very far
- Corn is often unable to recover from short periods of nutrient stress during early season

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Precision near row placement

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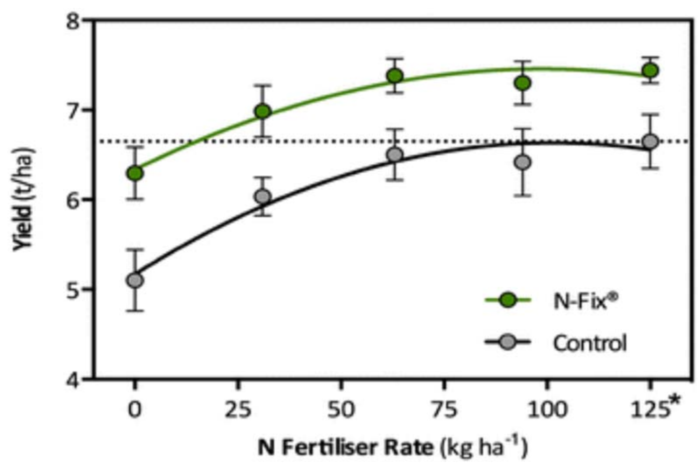
N-fixation technology can help…



Yield of wheat inoculated with NFix® against uninoculated controls in an independent N fertilizer trial

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David Dent and Edward Cocking. Agriculture & Food Security. 2017. **6**:7

Precision Agriculture Environmental Benefits: N- fertilizer use

Process:

- Nitrogen fertilizer application for optimal crop growth and production

PA Technology:

- Crop vegetation index based on optical sensors
- Soil nutrient maps, crop models
- Variable rate nitrogen fertilizer application according to crop requirements and local conditions

Expected benefits:

- Improvement of nitrogen use efficiency.
- Reduction of residual nitrogen in soils by 30 to 50 %

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Precision agriculture and environment

- Precision agriculture tools and concepts enable reduction of environmental impact of agriculture
- Optimizing G.A.P. based on PA:
  - Reduction of fungicide use versus increased mycotoxin risk
  - Optimal fertilizer use versus total biomass and mycotoxin risks
  - Reduce crop damage from pest for reduced fungal infections
- PA is the road towards optimal use of inputs for food production:
  - Can also lead to optimal land use whereby secure food supply is possible using only the most productive land
  - To certify that a farmer is operating in the framework of environmentally friendly good agricultural practices

G.A.P.= Good Agricultural Practices

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Precision agriculture implementation challenges

How do we translate precision agriculture advances:

- into feasible techniques (not necessarily only large complex machines)
- practiced by trained farmers around the world
- irrespective of the scale of farming?

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G x E x T x M

Precision agriculture: optimize the combination of

- Genetics
- Environment
- Technology
- Management

Precision agriculture as a mindset

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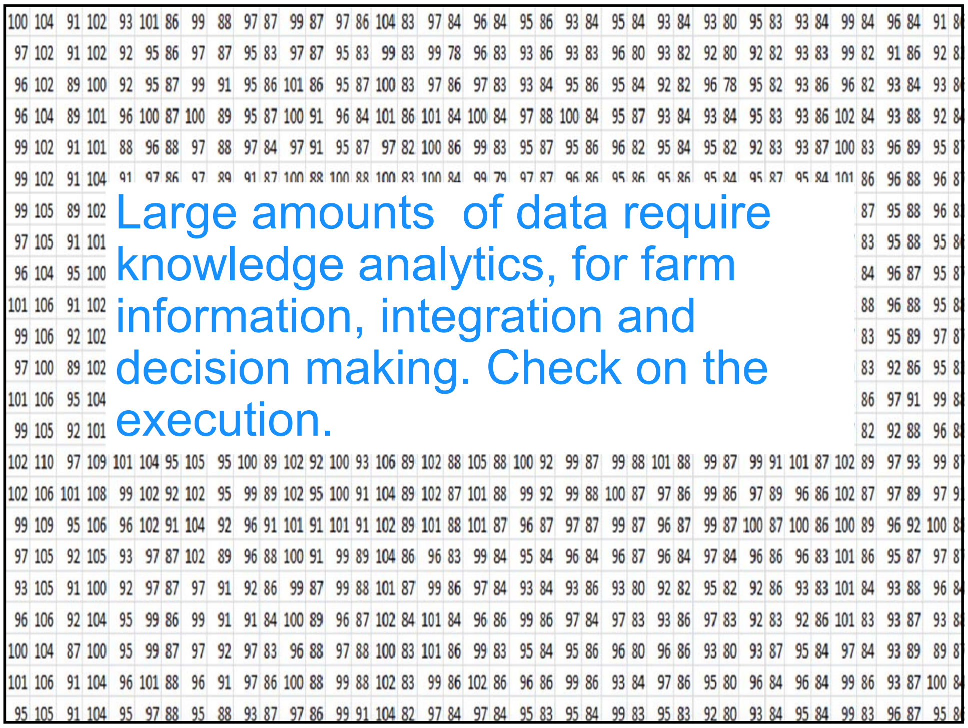
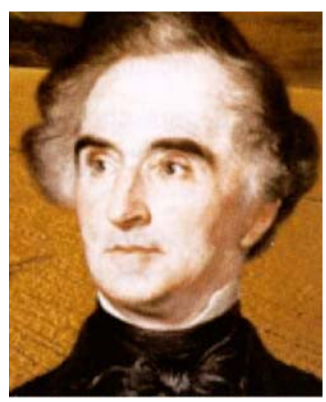


„... . One day (it was **around 1850**) Liebig said:

The farmer will be able to assess the exact yield during harvest like a bookkeeper is doing in a well controlled factory; then by simple calculations he could determine highly precise all substances which he has to replace in each field, also by amount, to restore the fertility (85).



→ ***"Precision Farming by Balance on Field-scale"*** **!**

Brock, H.: Justus von Liebig. Braunschweig: Vieweg Verlagsgesellschaft 1999, p. 148.

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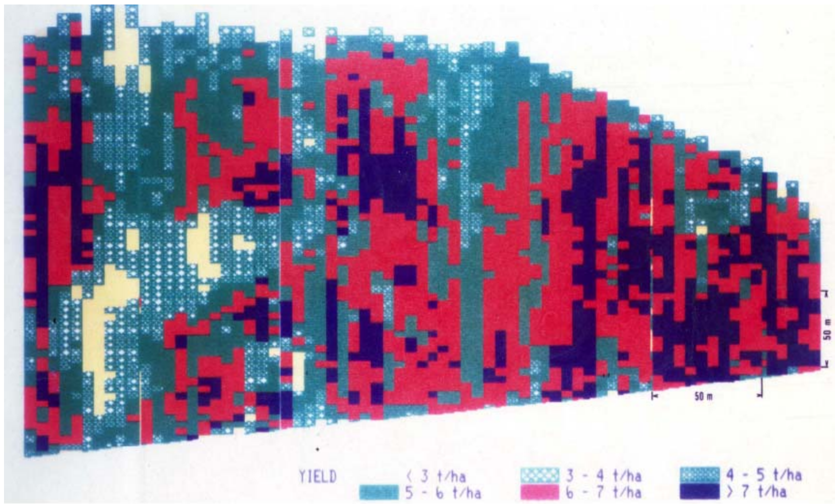
Translation by © Auernhammer 2011 at ACPA2011



Wheat Yield 1986 Leuven