Precise Nitrogen – Site-specific N application based on IoT sensor networks and image analysis in winter wheat.

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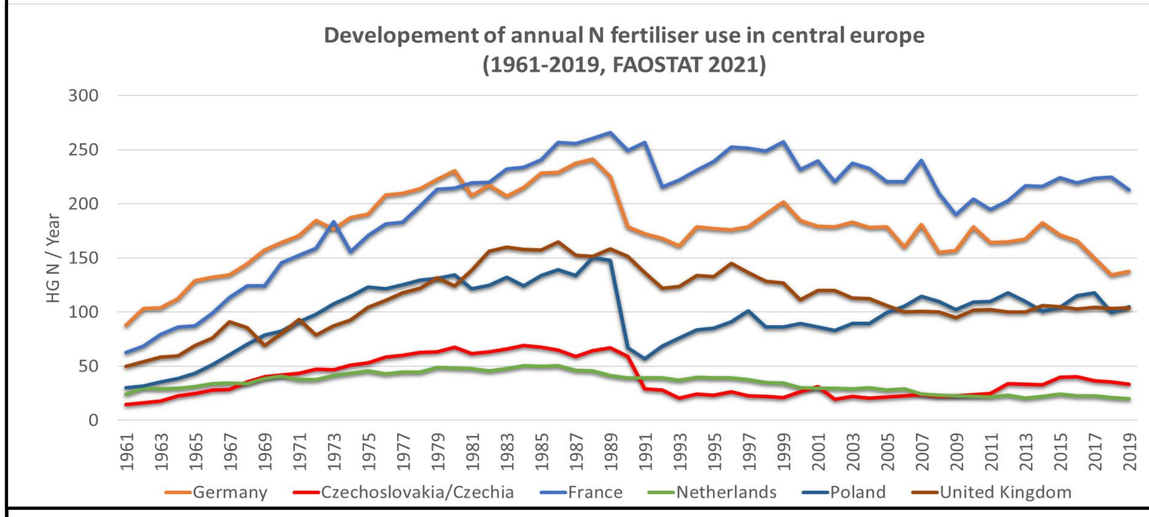
Basic idea and relevance:

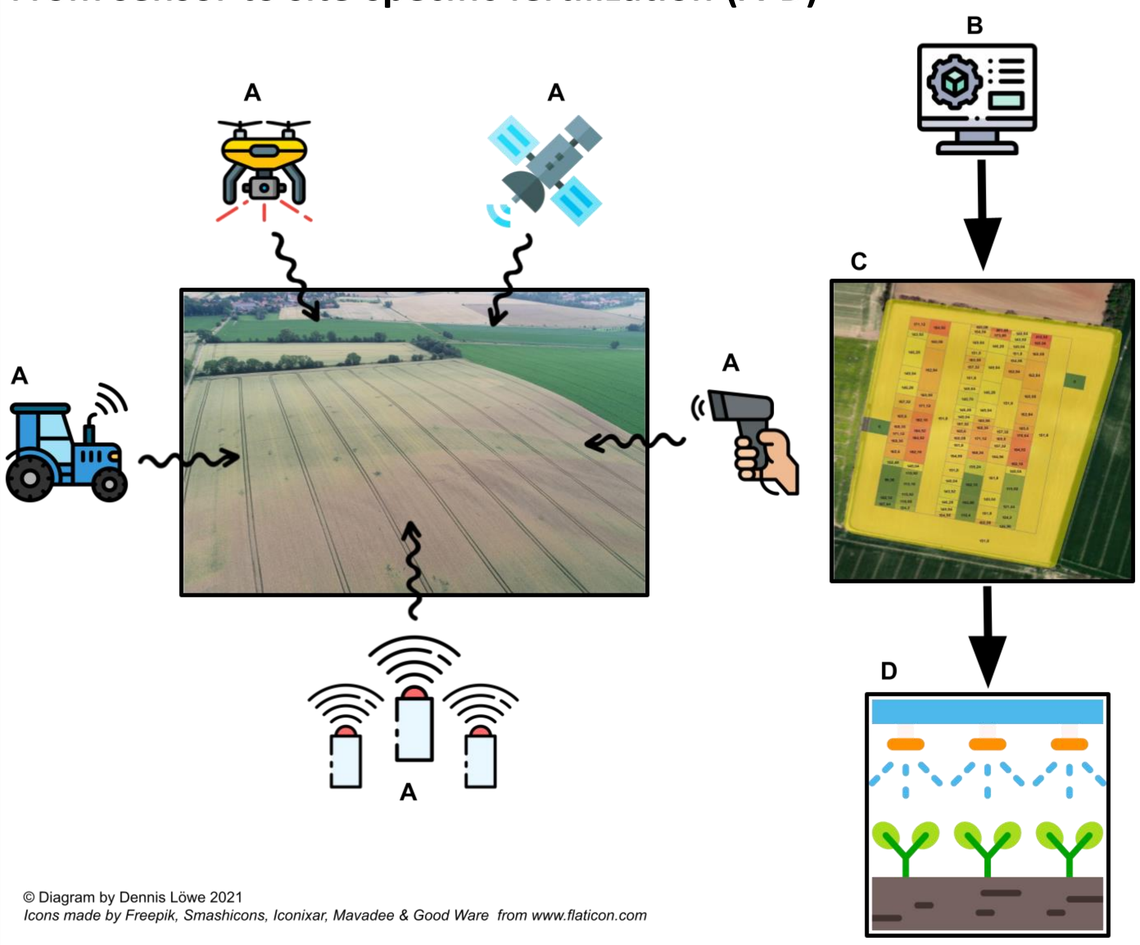
- Nitrogen is the macronutrient that is most limiting for plant growth [1].
- Nitrogen is often added via fertilizers to achieve more yield.
- Mismanagement can lead to low harvest or environmental problems [2].
- The global Nitrogen-Use-Efficiency (NUE) has fallen since the 1960s from 68% to 47% [3].
- Uniform fertilizer applications neglect the variability within the field.



Why is remote sensing important for precision farming?

- The methods used are mainly non-destructive.
- Remote sensing can cover large areas in a short period of time.
- The variation of the yield potential of a field can be optimally taken into account (Potentially more yield with less or the same amount of fertilizer).
- Lower fertilizer use results in lower leaching hazards and less potential harm to humans.
- A wide range of sensor systems for different applications is available.

From sensor to site-specific fertilization (A-D)



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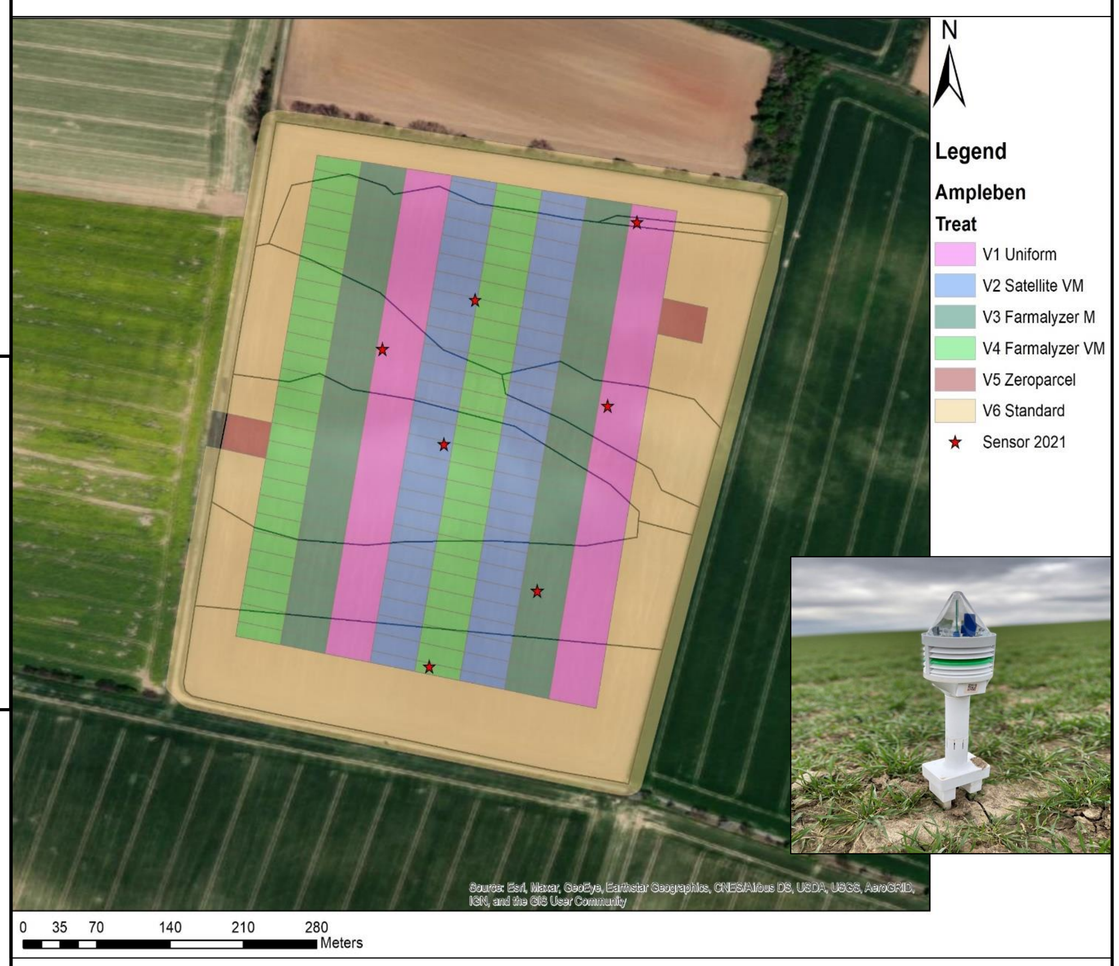
- **A:** Data is collected through the use of various sensors.
- **B:** Using geo-data software and various programming languages (e.g. R), the collected data is processed.
- **C:** The data are visualised and evaluated in common software (e.g. GIS programmes).
- **D:** A fertiliser recommendation is calculated on the basis of the processed data.

Experimental design and implementation in the project:

- Installation of strip trials in the vicinity of Braunschweig.
- Identification of sub-areas based on soil maps, satellite imagery and the Topographic Wetness Index (TWI).
- Installation of IoT-soil sensors networks in the various sub-sites.
- Creation of an grid for six different fertilization variants for each experimental plot.
- Determination of fertilizer use according to experimental variant.
- Preparation of an application map for the farmer.
- Accompanying UAV flights and on-field sampling.



V1: Uniform fertilizer application.
V2: Satellite based fertilizer application (variation of the spatial distribution).
V3: Farmalyzer based fertilizer application (variation of the spatial distribution).
V4: Farmalyzer based fertilizer application (variation of the spatial and volume distribution).
V5: Zero parcels (No fertilization).
V6: Standard fertilization (according to the DüVM).

First results:

- The creation of the application cards works fine.
- The grid cells need to be enlarged for improved fertilizer application.
- The influence of the sub-sites might be dominant to the fertilization variants.
- The yields of the different variants shows no significant differences.
- The soil sensors used provide only moderate results (wireless network problems).

Future plans:

- The use of additional remote sensing data and spectrometer data.
- An extensive vegetation accompanying field sampling.
- The use of additional test plots with other soil properties and sub-sites.
- The development of a guideline for agricultural remote sensing.
- A changeover of the wireless technology standard for the soil sensors.
- An publication on sensor systems in site-specific nitrogen fertilization.

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References:
[1] 贾南, Shah Jahan & Wahocho, Niaz & Laghari, Ghulam & Laghari, Abdul & Bhabhan, Ghulam & HussainTalpur, Khalid & Ahmed, Tofique & Wahocho, Safdar & Lashari, Ayaz. (2016). Role of Nitrogen for Plant Growth and Development: A review. Advances in Environmental Biology. 10. 209-218.
[2] Powell, Charles C.; Lindquist, Richard Kenneth (op. 1997): Ball pest & disease manual. Disease, insect, and mite control on flower and foliage crops. 2nd ed. Batavia (Illinois): Ball Publishing.
[3] Lassaletta, Luis; Billen, Gilles; Grizzetti, Bruna; Anglade, Juliette; Garnier, Josette (2014a): 50 year trends in nitrogen use efficiency of world cropping systems: the relationship between yield and nitrogen input to cropland. In: *Environ. Res. Lett.* 9 (10), S. 105011. DOI: 10.1088/1748-9326/9/10/105011.