Training package 4:
Information and Communication Technologies (ICT) Devices

Case 1:
Variable rate application of nitrogen fertilizer

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Acknowledgement

- This presentation has been developed in a close collaboration with SEGES
- SEGES is a Danish agricultural knowledge organization
- SEGES builds bridges between research and practical farming (advisors to the agricultural advisors)
- SEGES is a part of the Danish Agriculture & Food Council that represents the farming and food industry of Denmark.

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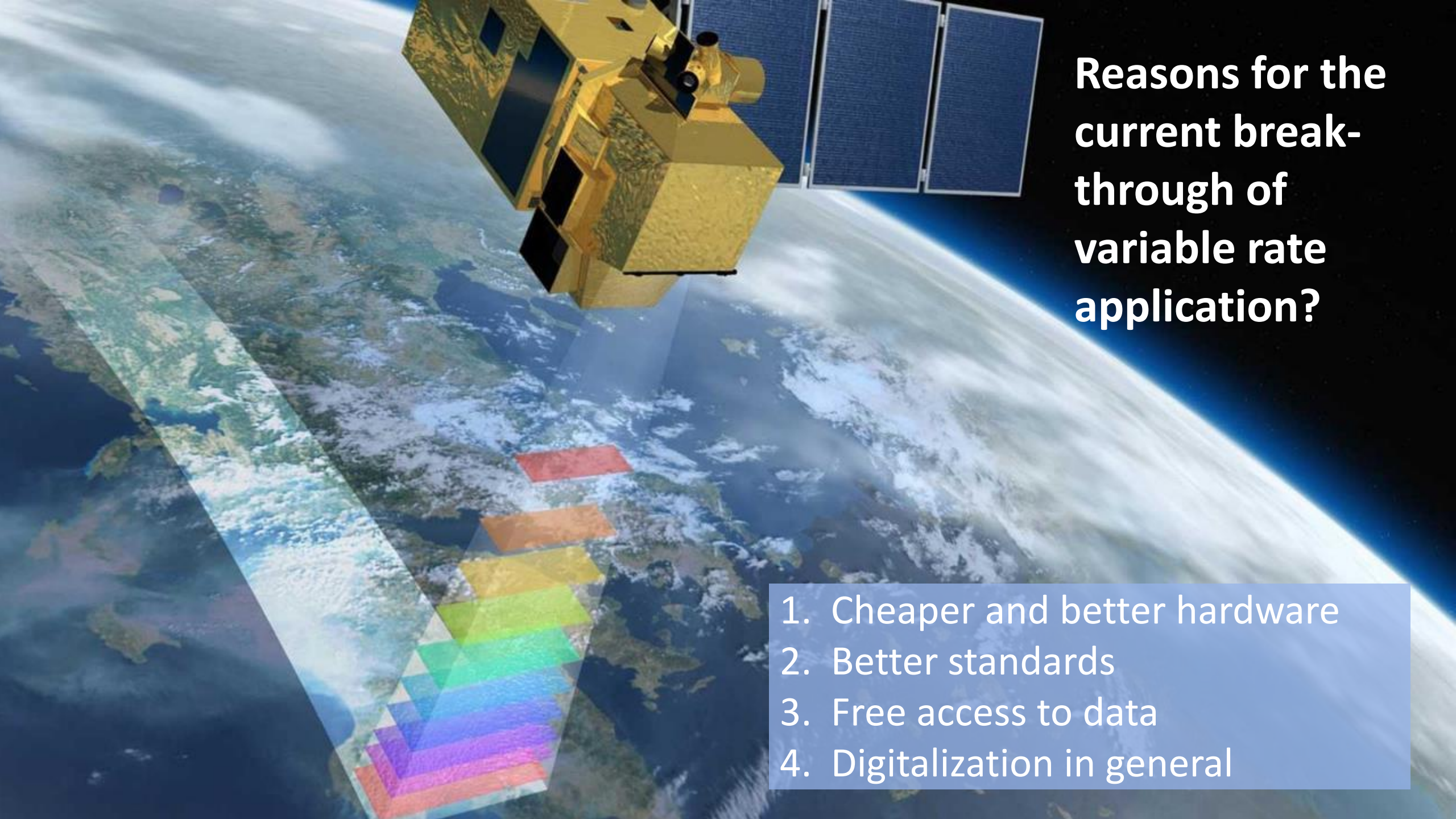
Variable rate application of nitrogen fertilizer

SEGES



Reasons for the current break-through of variable rate application?

1. Cheaper and better hardware
2. Better standards
3. Free access to data
4. Digitalization in general

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Is variable rate application of fertilizer going to make you rich?

- Danish field trials with variable rate application have shown:
  - Surplus yield of winter wheat: 0.6 hkg grain per ha
  - Surplus yield in winter rape: 0.2-0.4 hkg seeds per ha
  - The more variation in the field – the more benefits of variable rate application!

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What is the theoretical background behind the principles of redistribution of nitrogen fertilizer?

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Why does variable rate application of nitrogen work?

- Most fields have a certain amount of variation in the soil conditions, topography etc.
- By applying knowledge about this variation it is possible to optimize the yield response of every kg nitrogen fertilizer applied to the field
- When the uptake of nitrogen is improved the leaching is reduced.

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What are the specific benefits from variable rate application of nitrogen fertilizer?

- Higher yields
- More uniform harvest quality
- Reduced lodging and harvest complications
- Reduced need for growth regulation
- Reduced nitrogen leaching
- Improved goodwill from society by taking up new agricultural methods
- Professional satsifaction by using the potential given by the available machinery and technology.

The goal is to fertilize every spot optimally

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Where is the response of nitrogen fertilizer largest?

- Is it in areas with a strong crop where the yield is expected to be highest?
- Is it in areas with a weak crop, where the soil can not supply sufficient amounts of nitrogen, such that the crop needs help from applied fertilizer?

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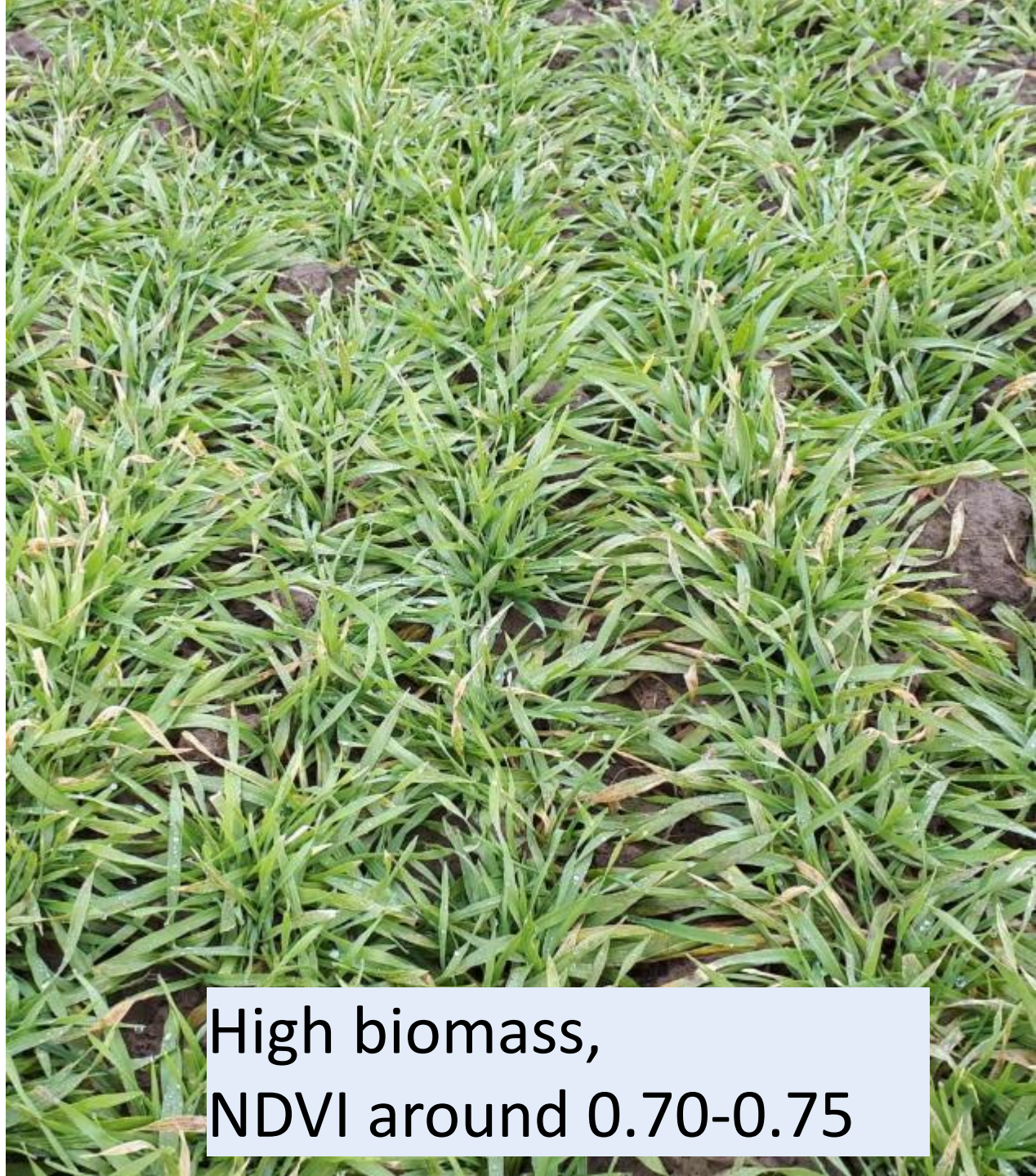
Measurements of the crop's biomass as an indicator of the soil's ability to supply nitrogen to the crop

- Uneven crop growth in late autmn or early spring is often caused by differences in nitrogen supply from the soil pool
  - In areas with high level of mineralization the crop has received sufficient amounts of nitrogen, so the crop is strong
  - In areas with low level of mineralization the crop has not received sufficient amounts of nitrogen from the soil, so the crop is weak
- Therefore, the density of the crop (the biomass) can be used as an indicator for the capacity of the soil to supply nitrogen to the crop.


Low biomass,
NDVI around 0.30-0.40


High biomass,
NDVI around 0.70-0.75

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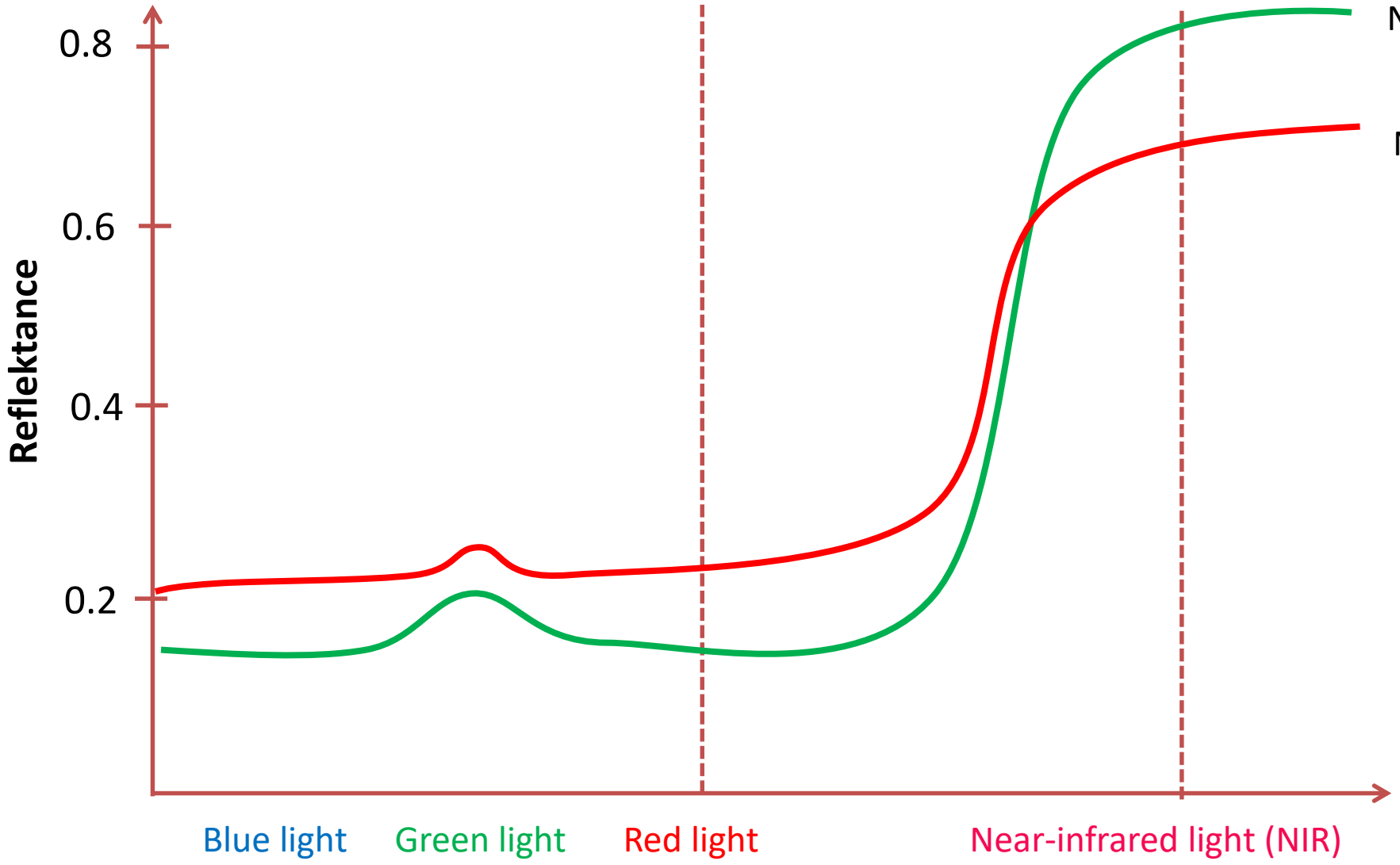
How is NDVI calculated?

$$NDVI = \frac{NIR - red}{NIR + red}$$



$$NDVI = \frac{0.85 - 0.15}{0.85 + 0.15} = 0.70$$

$$NDVI = \frac{0.75 - 0.25}{0.75 + 0.25} = 0.50$$

Area with strong crop

Area with weak crop

Example of a biomass map in a Danish winter wheat field

Vælg cellestørrelse 20x20 Skift cellestørrelse

Vælg strategi Manuel

Vegetationsindekset er inddelt i fem lige store intervaller og værdierne ligger mellem 0,0 og 1,0. Den gule farve viser lav bio-masse og den grønne høj biomasse. Indtast den ønskede mængde for hvert af de 5 intervaller. Vil du læse mere om hvordan du skal vurdere N-tildelingen i forhold til vegetationsindekset, så klik på

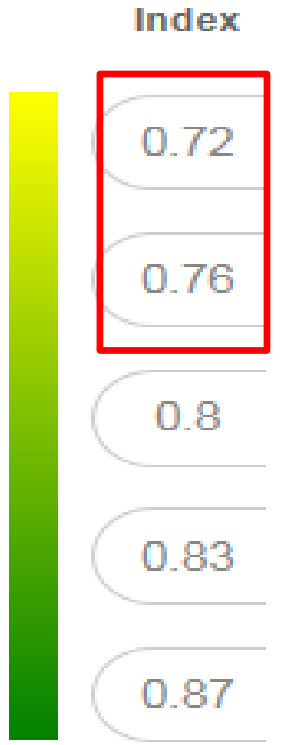
Index	kg/ha	Areal
0.60		0.23 ha
0.66		0.11 ha
0.72		0.36 ha
0.77		1.77 ha
0.83		2.64 ha
		0.24 ha

The measured NDVI values of the field range from 0.60 to 0.83. The range is divided evenly into 5 categories.
Yellow means low biomass, green means high.

SEGES

Biomass map and estimation of the field variation

- It can be complicated to estimate the variation directly from the biomass map
- CropSAT can be used to get an impression of the variation. Here steps are
  0.76 – 0.72 = 0.04:
- If the steps of the scale are:
  - Under 0.02: Small variation ➔ VRA not relevant
  - 0.02 - 0.04: Some variation ➔ VRA maybe relevant
  - Above 0.04: Large variation ➔ VRA very relevant



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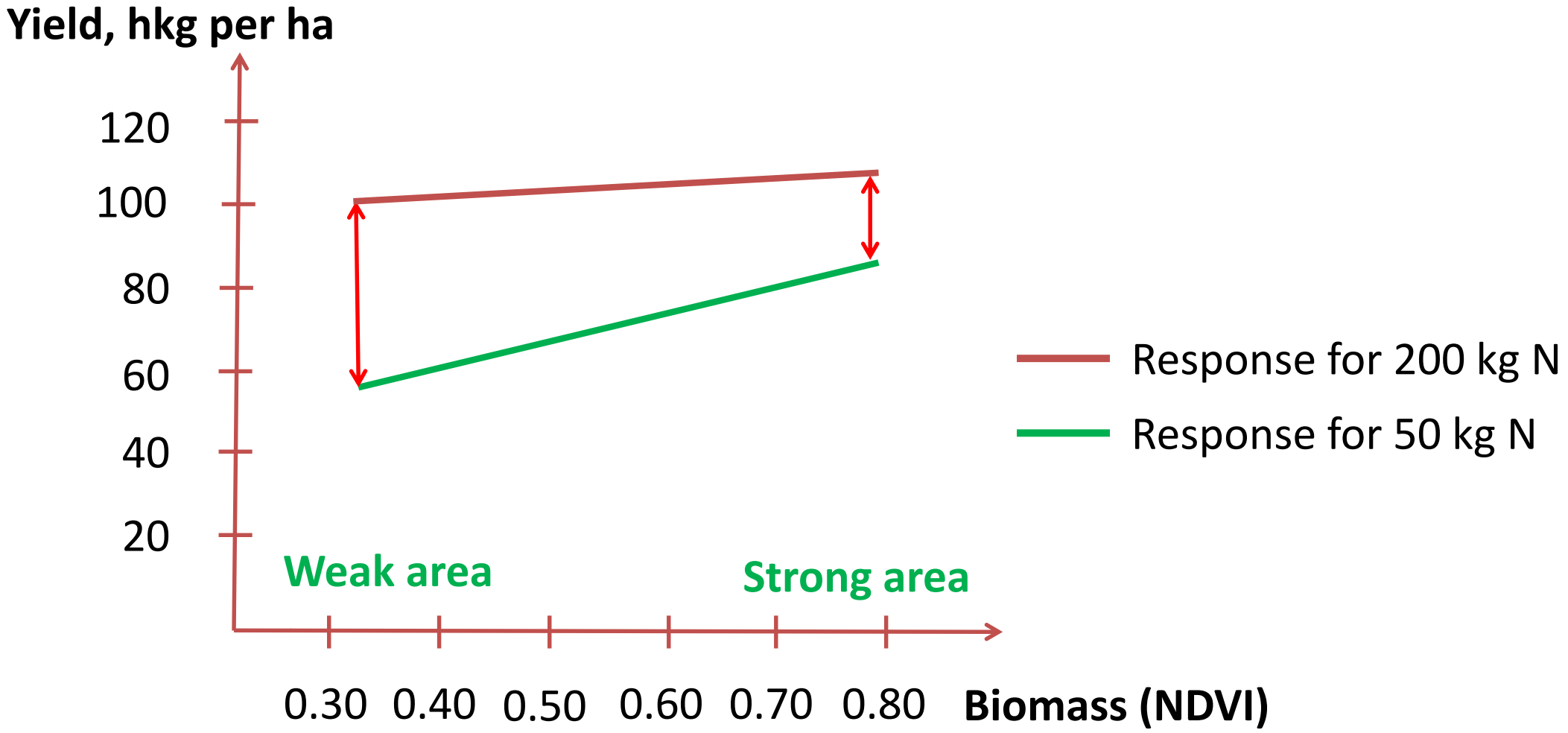
Yield response in dense and sparse areas of the field



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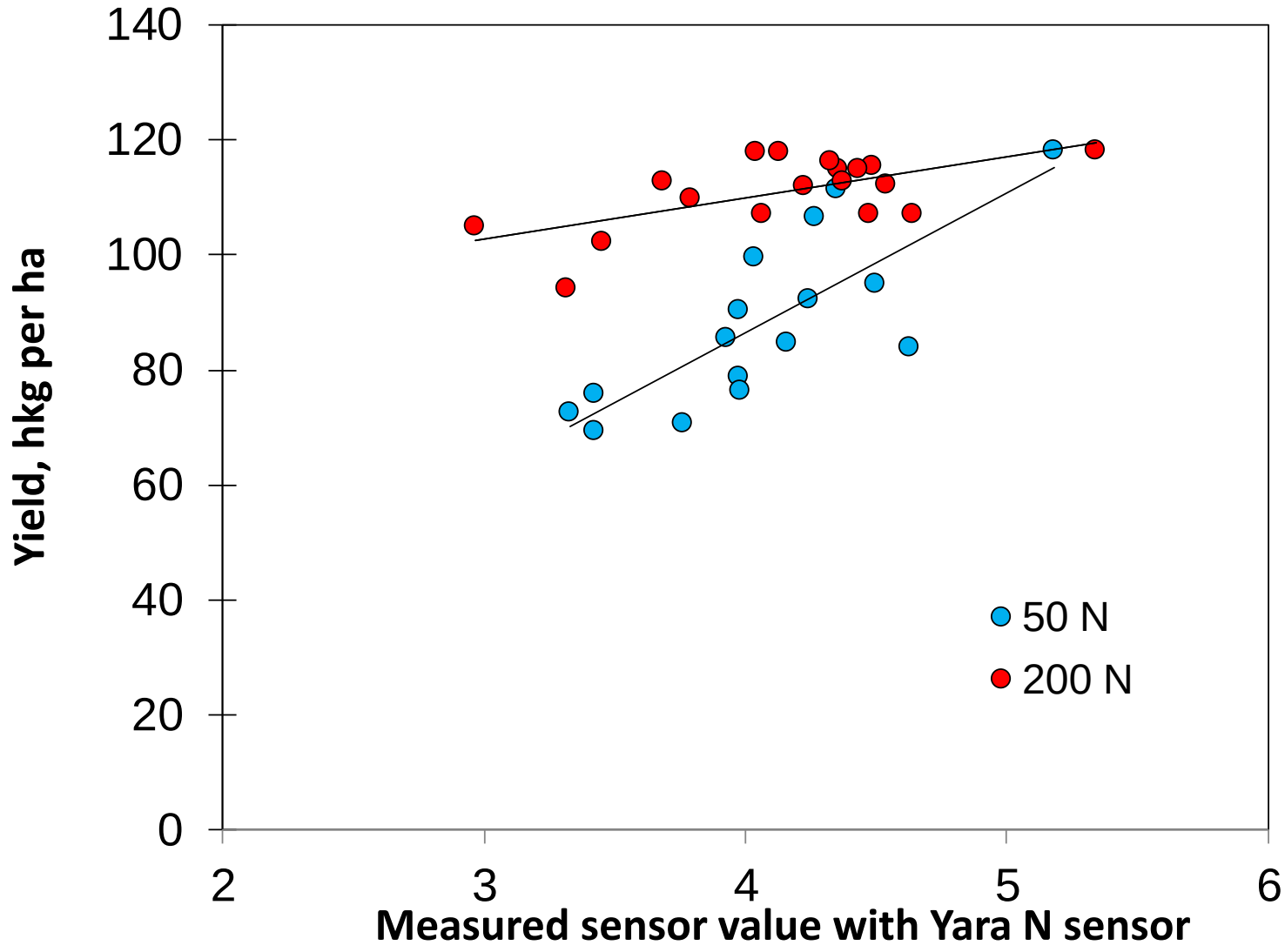
Relation between yield and sensor value



SEGES Source: SEGES National Field Trials 2016, pp. 214-216

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The Robin Hood principle:

”Take from the rich and give to the poor!”

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No rules without exceptions!

Main rule: In order to even out the differences in the field's ability to support the crop with nitrogen:

- Take from the rich and give to the poor! (reduce nitrogen in dense crop areas and increase in sparse crop areas)

Exception: In cases when the field is not able to make use of the additional nitrogen (e.g. headland areas, water holes, areas with risk of lodging, structural damage, reduced germination, slugs, ...):

- Make manual corrections in areas where the additional nitrogen cannot be used by the crop for increased yield.

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How to make a VRA map?

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The three steps of a VRA map

Step 1:
Determine the nitrogen need such that it fits the field on average. What is the total needed amount and what amount has been applied already?

Step 2:
Make a general VRA map from a biomass map

Step 3:
Make manual adjustments to the VRA map based on knowledge to the field and specific observations.

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Step 1: Determine the nitrogen need for the field

- Evaluate the yield potential from the actual, local conditions
- Update the total nitrogen need based on the cultivation experience. Is the yield going to be higher or lower than expected?
- How much nitrogen is applied based on animal manure?
- Consider the strategy for dividing applications. Which amount of nitrogen should the field receive on average for this application, before considering variable rate application?

Step 2: Make a general VRA map based on a biomass map

- A variable rate application map is created in a computer program and the map is stored in a file format that it can be loaded by the tractor terminal
- There are multiple programs for VRA maps, e.g. CropSAT, CropManager, FarmWorks and SMS
- CropSAT og CropManager have procedures to autmatically produce maps from biomass data measured by satellite.

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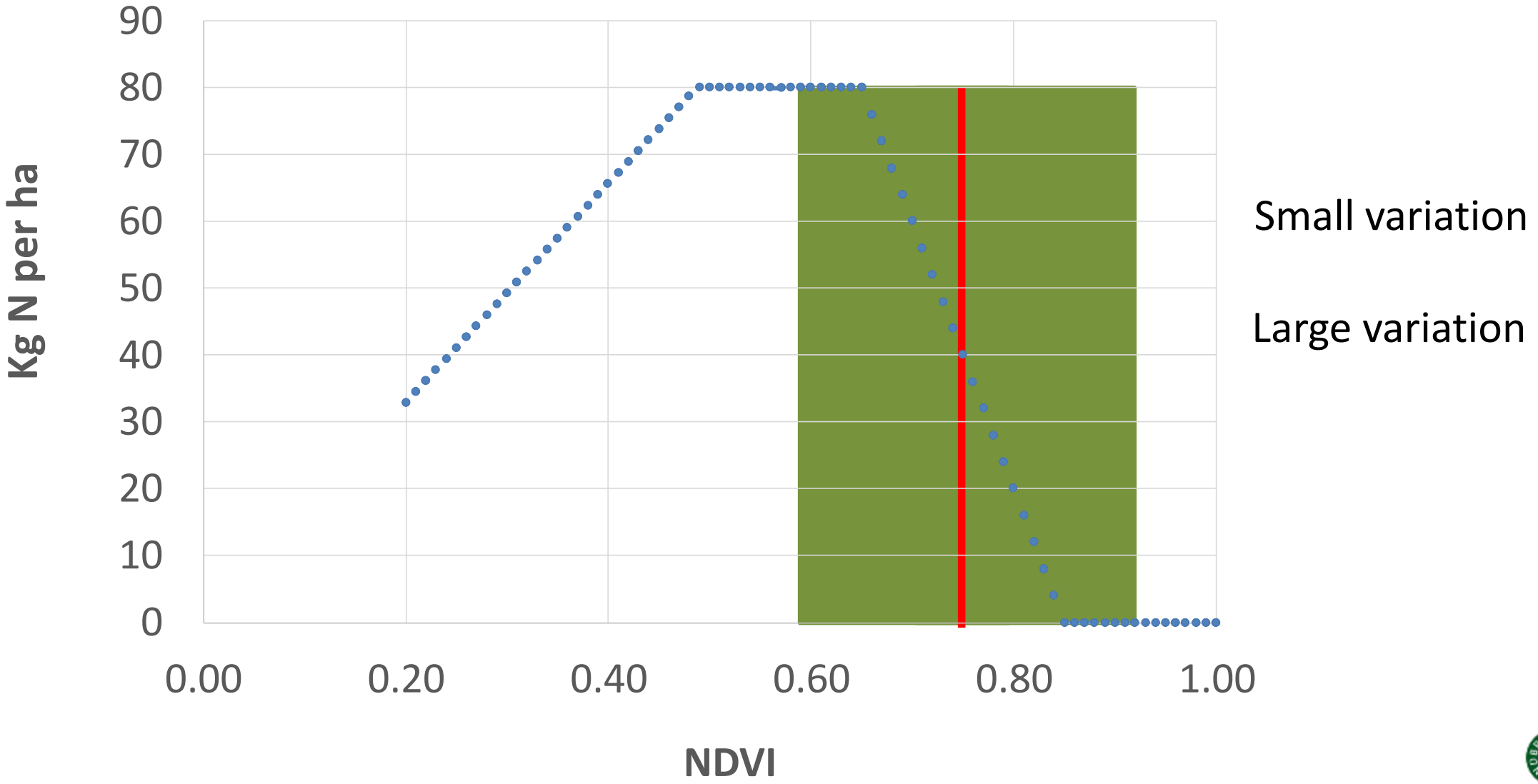
Illustration of the SEGES model for 3rd N application in winter wheat – redistribution of 40 kg N per ha




10 x 10 meter


20 x 20 meter


30 x 30 meter

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Step 3: Individual adjustments for holes, fences, headlands, lodging, damage areas etc.

- Here, other matters is at stake, than the ability of the soil to make nitrogen available for the crop.
- Reduced yield potential ➔ reduced nitrogen need
- Example: If the yield potential in an area with winter wheat is 20-30 hkg less than the average level of the field then the rate can be 0 kg for that area, if 40 kg N is applied at the third application.

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Export the VRA map and drive!

When the three steps have been made for all fields you are ready to export the VRA maps in a proper data format and load them to the tractor's terminal.

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Redistribution of nitrogen between fields

- It is possible to redistribute the total nitrogen so one field with high yield potential receives more on behalf of another field with lower potential
- Here satellite images of biomass cannot be used, as differences may be due to different sowing dates, variety etc.
- Instead use an estimate of the yield potential:
  - Lower yield potential than expected ➔ reduce N need with 1.5 kg N per hkg
  - Higher yield potential than expected ➔ increase N need with 1.5 kg N per hkg

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Summary

- The increased yield caused by VRA may seem modest, but if you have the VRA equipment already it is a cheap benefit!
- Increased yield is only one good reason for VRA of nitrogen
- In general nitrogen is redistributed from strong (dense) crop areas to weak (sparse) crop areas
- The more variation in the field – the more need for nitrogen redistribution
- Follow the three steps:
  1. Estimate the average nitrogen need
  2. Create a general VRA map
  3. Adjust the map manually from your knowledge of the field.

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DEVELOPMENT OF A TRAINING PROGRAM FOR ENHANCING THE USE OF ICT TOOLS IN THE IMPLEMENTATION OF PRECISION AGRICULTURE

Project coordinator

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