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Comparison of Normalized Green Red Difference Index (NGRDI) with NDVI and NDRE from Sentinel-2 data for the detection of biomass heterogeneity on agricultural fields

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Introduction and Scope

- The detection of biomass heterogeneity on arable fields allows the adoption of site-specific management operations and improved sampling.
  - This can improve sustainability and resource efficiency of farming.
- Remote sensing data from satellites, airplanes or drones and vegetation indices (VI) derived from different spectral bands facilitate the process.
- To promote the application of aerial images from planes or drones for cloudy conditions, indices based on spectral bands in the visible region are helpful.
  - The *Normalized Green Red Difference Index* (NGRDI) is a promising index candidate.
- Our study compares two well established indices for satellite data (NDVI, NDRE), which use infrared reflection, with the NGRDI over a full growing period.
- We indicate options for the applicability with remote sensing data from planes or drones.

Fig.1: Aerial image of winter barley taken on 26/05/2023 (Picture: Weier)

Georefe-rencing

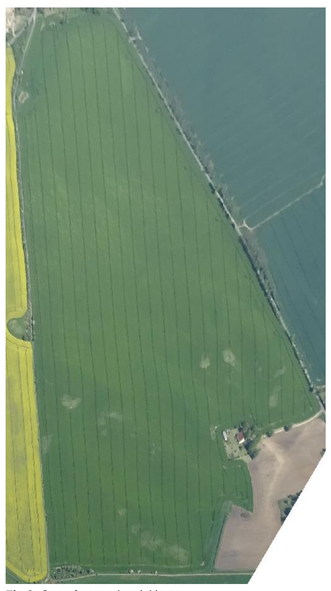

Fig.2: Georeferenced aerial image

NGRDI calculation

Fig.3: NGRDI of the aerial image

Material and Methods

- Arable field in **Northeast Germany**, Neubrandenburg -> 53,5807586° 13,3725785°
- **Winter barley**, growing season winter 2022 until summer 2023
- **Seeding date: 15/09/2022**
- Aerial images were taken with a **digital camera** at different phenological growth stages
- Corresponding sky clear ***Sentinel 2***- satellite images were acquired
- Vegetation index using solely the visible spectrum based on aerial and satellite images
  - **Normalized Green Red Difference Index** (NGRDI)= $\frac{GREEN-RED}{GREEN+RED}$ **[1]**
- Vegetation indices using Near-infrared (NIR) or Red Edge signal based on satellite images
  - **Normalized Difference Vegetation Index** (NDVI)= $\frac{NIR-RED}{NIR+RED}$ **[2]**
  - **Normalized Difference Red Edge Index** (NDRE)= $\frac{NIR-RED\ EDGE}{NIR+RED\ EDGE}$ **[3]**
- **Site quality**: Local knowledge used for ground reference of low, medium and high quality
- **Randomly distributed GIS grid points** covering the field for statistical analysis of VI's

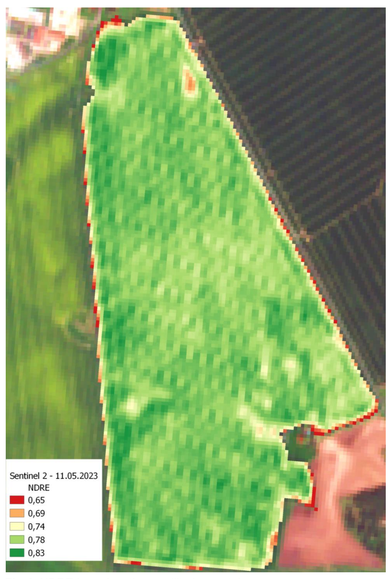

Fig.4: NDRE based on the satellite image taken on 11/05/2023 (based on: ESA, Sentinel 2)

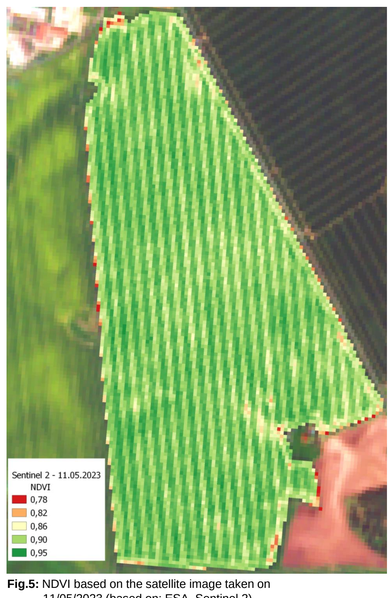

Fig.5: NDVI based on the satellite image taken on 11/05/2023 (based on: ESA, Sentinel 2)

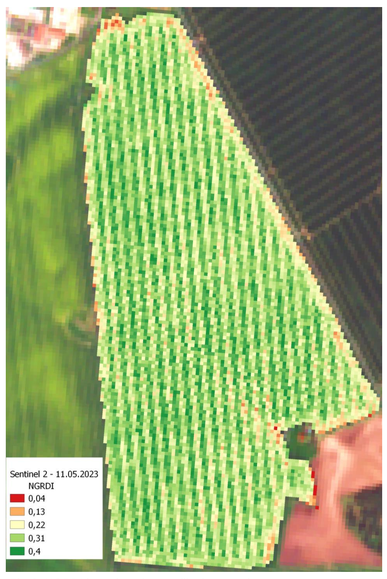

Fig.6: NGRDI based on the satellite image taken on 11/05/2023 (based on: ESA, Sentinel 2)

Results I – Processing of aerial images

- **Georeferencing** of original images (Fig. 1/2) and NGRDI calculation (Fig. 3)
- NGRDI shows **spatial trend** between the north and south site of the field (Fig. 3)
  - **due to oblique view** of original image
  - NGRDI not useful to detect site qualities
- **Low correlations** between NGRDI of aerial and all indices based on the satellite pictures at all image capture dates
- Improvements possible with NADIR drone data and/or image trend correction

Results II – Comparison of satellite based vegetation indices

- **Heterogeneity** in crop biomass detectable with all indices (Fig. 4-7)
- NDRE (Fig. 4)
  - **Old tramlines** from growing period 2019/2020 become visible (soil structure damage?)
- NDVI (Fig. 5)
  - Slightly **higher value range** compared to NDRE
    - Close to the **maximum value of *1* → Saturation of the index values**
    - → Leads to less biomass heterogeneity detection?
  - Current tramlines are visible and very prominent
- NGRDI (Fig. 6)
  - Considerably **lower value range** compared to NDRE and NDVI
  - **Current tramlines** are clearly visible and dominating (green reflection intensity?)

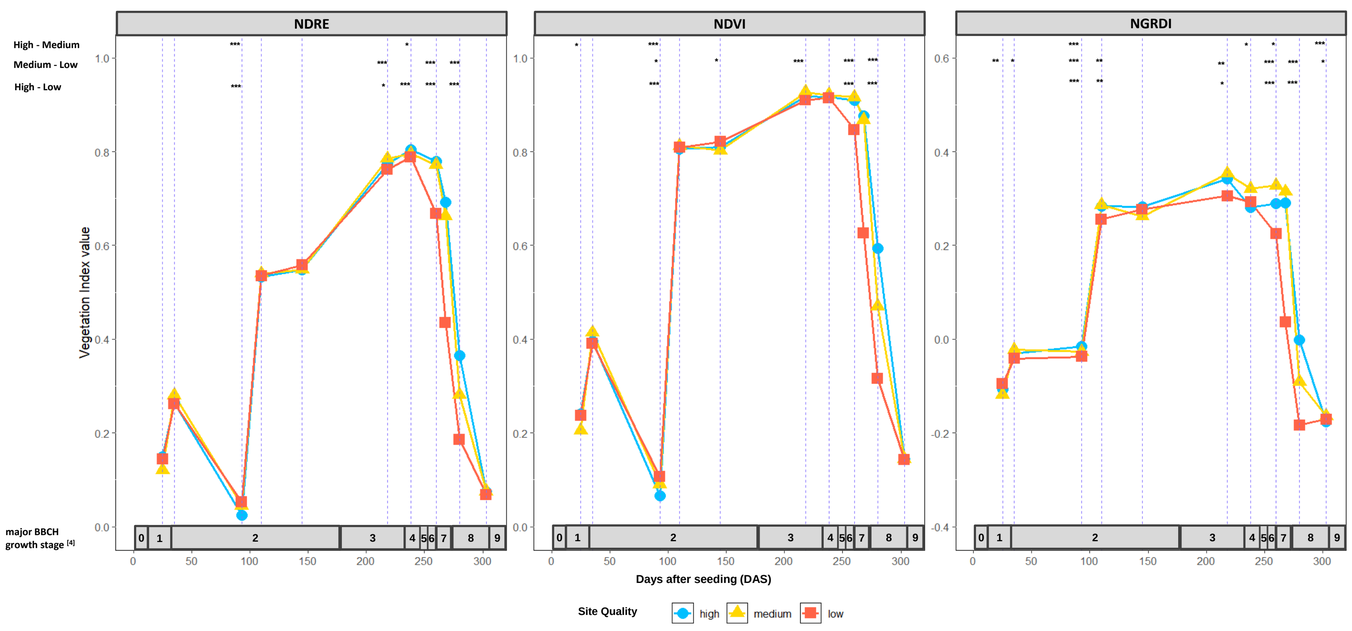

Fig.7: Time series of all vegetation indices with correlation analyses between different site qualities (own illustration based on: ESA, Sentinel 2) for the growing period at different development stages (see bottom and left margin). Statistically significant differences in average VI values for selected site quality contrasts (see top and left margin) for the respective date are indicated by stars in the upper region of the respective figure (* p<0.05, ** p<0.01, *** p<0.001, VI's extracted at random grid points).

Results III – Development of index values and separability of site qualities over time (Fig. 7)

- NDRE
  - In **December** (DAS= 93 days) **clear decline** in all values
  - In **January** (DAS = 110 days) **clear increase** in all values
  - Significant **differences** between sites in **booting** (DAS= 238 days)
- NDVI
  - **Similar progression** as NDRE - strong correlations except in May (DAS= 238 days)
  - In **December significant differences** between all site qualities
  - **Higher value range** in beginning of stem elongation (DAS = 218 days) than NDRE
- NGRDI
  - Distinctly **different development** and **range** of the values
  - In **December significant differences** between all site qualities
    - **No decline in values** unlike the other indices
    - In December and January **weak correlations** with NDRE and NDVI values
  - Index very successful for statistically **significant separation of site qualities**

Conclusions

- **Atmospheric influences** in oblique aerial images might explain low correlations between the aerial and satellite NGRDI values → high quality aerial images are necessary for NGRDI
- **Old tramlines** are only visible in NDRE images taken on April, May and June → old management practices (soil structure?) influence the **Red Edge reflection**
- **NDRE** can detect **biomass heterogeneity** in stem elongation and booting better than NDVI, possibly due to near saturation of NDVI
- **Decline** of NDRE and NDVI **values in December → frost** in November and December and considerably **mild temperatures in January** → impact of **weather conditions on crops** ?
- Greater **influence of the green reflection on NGRDI** → could falsify surrounding values and explain partially low to medium correlations with the other indices
- **NGRDI** is very good at separating significant **biomass differences** (**site qualities) in December**

References
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