DRONE-BASED ASSESSMENT OF AUTUMNAL RAPE GROWTH

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Structure

I. Autumnal Rape Growth & Multispectral Data

II. Drone-Based Data Acquisition
   - Data Quality: Information Content & Stability
   - Time Slots for Data Acquisition

III. Comparison with the Satellite-Based Approach

IV. Summary
Contributor to N-Balance Surplus

- One of the Major Crops in Germany (> 10 % of Arable Land\(^1\))

- 100 kg N/ha Mean N Surplus of Winter Oilseed Rape\(^2\) (WOSR) (Legal Limit: 3-Year-Average of 50 kg N·ha\(^{-1}\))

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\(^1\)German Federal Statistical Office; URL: [https://www.destatis.de/DE/Presse/Pressemitteilungen](https://www.destatis.de/DE/Presse/Pressemitteilungen), last visit: 2019-04-05, 12:20.

\(^2\)Henke et al., 2007.
Optimizing N Management

- Algorithm for Site-Specific N Fertilization of WOSR\(^3\)
  - **Autumnal Canopy N** as Predictor for the Optimal N Fertilization Rate\(^4\)
  - **Multispectral Measurements** (Vegetation Indices) to Characterize WOSR-Growth\(^5\)

\(^3\)Pahlmann et al., 2017.
\(^4\)Henke et al., 2009.
\(^5\)Müller et al., 2008.
Autumnal Acquisition of Multispectral Data

- Handheld
- Tractor

https://www.obergembeck-agrar.de/raps-biomassescan.html, last visit: 2019-05-29, 14:00.
Autumnal Acquisition of Multispectral Data

- Handheld
- Tractor
- Satellite (Sentinel 2, MSI)

<table>
<thead>
<tr>
<th>Return Interval</th>
<th>2 – 3 Days</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bands</td>
<td>12 Bands</td>
</tr>
<tr>
<td>Resolution</td>
<td>10 – 60 m</td>
</tr>
</tbody>
</table>

Autumnal Acquisition of Multispectral Data

- Handheld
- Tractor
- Satellite (Sentinel 2, MSI)
- Dronal Approach (eBee+, Parrot Sequoia)

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Weight</strong></td>
<td>700 g</td>
</tr>
<tr>
<td><strong>Endurance</strong></td>
<td>50 min</td>
</tr>
<tr>
<td><strong>Max. Wind Speed</strong></td>
<td>45 km·h⁻¹</td>
</tr>
</tbody>
</table>

Autumnal Acquisition of Multispectral Data

- Handheld
- Tractor
- Satellite (Sentinel 2, MSI)
- Dronal Approach (eBee+, Parrot Sequoia)

### Table

<table>
<thead>
<tr>
<th>Bands</th>
<th>Green, Red, Red Edge, Near Infrared</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resolution</td>
<td>Centimetre Range</td>
</tr>
<tr>
<td>Min. Sun Irradiance</td>
<td>3000 lx (&gt; 24 W·m⁻²)</td>
</tr>
</tbody>
</table>

Picture source: [https://www.parrot.com/files/s3fs-public/resize_produits_home_locale_0.png](https://www.parrot.com/files/s3fs-public/resize_produits_home_locale_0.png), last visit: 2019-05-03, 8:45.
Work on Field Trials & Farms

Autumn 2017 & 2018:
18 Sampling Dates:

- Multispectral Flight
- Destructive Sampling of N Shoot
- Calculation of Vegetation Indices
- Correlation with N Shoot
Correlation of Measured N Shoot and Drone-Based Vegetation Index (Near Infrared/Red).
Correlation of Measured N Shoot and Drone-Based Vegetation Index (Near Infrared/Red).

6Data from Sunshine log of Sequoia Camera or, if not available, from Deutscher Wetterdienst (ftp://ftp-cdc.dwd.de/pub/CDC, 2019-05-03, 15:45).
Correlation of Measured and Drone-Based N Shoot (Vegetation Index: Near Infrared/Red, Data\textsuperscript{6} $> 125 \text{ W} \cdot \text{m}^{-2}$).

\textsuperscript{6}Data from Sunshine log of Sequoia Camera or, if not available, from Deutscher Wetterdienst (ftp://ftp-cdc.dwd.de/pub/CDC, 2019-05-03, 15:45).
Weather-Related Time Slots: Drone

- Relevant Time Slot for N Shoot-Mapping:
  Early November – Mid December (First Freezing)
- Requirements to Be Fullfilled for at Least 3 Consecutive Hours:
  - No Precipitation
  - Wind Speed < 12 m·s⁻¹
  - Irradiance ≥ 125 W·m⁻²

→ 2017: 12 Days & 2018: 8 Days

Preliminary Conclusion

- Drone-Based Multispectral Data Sensitive to Autumnal N Uptake

- Calibration Samples Required at Dim Irradiance Conditions (< 125 W·m⁻²)

- Data Acquisition by Drone in Autumn Possible
  (During Relevant Time Period at Least 8 Flight Days per Year)

Weather-Related Time Slots: Satellite

- Relevant Time Slot for N Shoot-Mapping:
  Early November - Mid December (First Freezing)
- Requirements to Be Fullfilled During Data Acquisition
  (Return Interval 2 - 3 Days, at ~10:50 a.m.):
  - Cloudless Sky

SATELLITE-BASED DATA ACQUISITION

Cloud Coverage⁶ as Bar Graphs During the Relevant Period for N Shoot-Mapping at the Overpass Dates and Time of the Sentinel Satellites (~10.50 a.m.)⁷, Depicted as Yellow Points.

→ Only Nov-16-2018 Definitely Cloudless
→ Other Time Slots Possible, but Not Guaranteed

⁶Data from Deutscher Wetterdienst (ftp://ftp-cdc.dwd.de/pub/CDC, 2019-05-03, 15:45) &
Cloud Coverage\textsuperscript{6} as Bar Graphs During the Relevant Period for N Shoot-Mapping at the Overpass Dates and -Time of the Sentinel Satellites (~10.50 a.m.)\textsuperscript{7}, Depicted as Yellow Points.

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\textsuperscript{6}Data from Deutscher Wetterdienst (ftp://ftp-cdc.dwd.de/pub/CDC, 2019-05-03, 15:45) &

\textsuperscript{7}Data from ESA (https://scihub.copernicus.eu/dhus/#/home, 2019-05-06, 13:00).
Information Content of Satellite-Data


Left: Drone-Based NDVI-Map (15 Nov 2018, Resolution: 12 x 12 cm),
Right: Satellite-Based NDVI-Map (16 Nov 2018, Resolution: 10 x 10 m)⁷.

Information Content of Satellite-Data: Drone-Based Calibration

1. Drone-Based Maps of N Shoot (> 125 W·m⁻²)

2. Drone- & Satellite Data in Same Grid (10 x 10 m)

3. Calibrate Satellite Data with Drone Data
   \[ N \text{ Shoot} \text{Satellite} = a \times \exp(b \times \text{NDVI}_{\text{Satellite}}) \]

4. Predict N Shoot\text{Satellite} & Compare with N Shoot\text{Drone}

Left: Drone-Based NDVI-Map (15 Nov 2018, Resolution: 12 x 12 cm),
Right: Satellite-Based NDVI-Map (16 Nov 2018, Resolution: 10 x 10 m)⁷.

SATELLITE-BASED DATA ACQUISITION


<table>
<thead>
<tr>
<th></th>
<th>Farm Site 1 (2017), Satellite = Nov 06, Drone = +0d</th>
<th>Farm Site 2 (2017), Satellite = Nov 19, Drone = -2d</th>
<th>Farm Site 3 (2018), Satellite = Nov 16, Drone = -1d</th>
</tr>
</thead>
<tbody>
<tr>
<td>$R^2_{\text{adj}}$</td>
<td>0.50</td>
<td>0.72</td>
<td>0.39</td>
</tr>
<tr>
<td>MAE</td>
<td>10.0 kg N·ha$^{-1}$</td>
<td>7.6 kg N·ha$^{-1}$</td>
<td>6.9 kg N·ha$^{-1}$</td>
</tr>
<tr>
<td>$\Delta$Range</td>
<td>-16.7 kg N·ha$^{-1}$</td>
<td>-25.9 kg N·ha$^{-1}$</td>
<td>-28.1 kg N·ha$^{-1}$</td>
</tr>
</tbody>
</table>

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Summary

• Data Acquisition in Autumn Remains Challenging

• Drone-Data Convinces (Sensitive to N Uptake, Available Time Slots for Data Acquisition)

• Alternative / Complementary Use of Satellite-Data Questionable (Data Availability, Information Content Requires Further Examination)
References


