Spatial variation within agricultural fields and site-specific crop management

Use of mobile maps and satellite information in PA

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Content

- Introduction to precision agriculture (PA)

- Use of maps in crop management
  - Specific case of variable rate application of a specific group of herbicides using biomass maps
  - Variable rate application of soil herbicides using soil maps

- Concluding remarks
Precision Agriculture

- PA is a farming management concept based on observing and responding to intra-field variations.
  - It relies on new technologies like satellite imagery, nearby sensors for soil, climate and crop properties, information technology, decision support, specific implements and geospatial tools.
  - It is aided by farmers’ ability to locate their precise position in a field using satellite positioning systems like GPS.
  - Autonomous vehicles and robots will be used in this concept more and more.
Images of precision agriculture
State of the art use satellites in PA

- The many satellites around the world support PA with
  - References for positing systems
  - Qualitative and quantitative crop information
- Positioning systems allow controlled traffic farming
  - Nearly 10% of farms in NL have auto pilot systems
- Satellite sensors provide data for
  - Land use monitoring
  - Crop and yield monitoring
  - Optimization of crop management
Controlled traffic farming (auto pilot system on tractor and additional machine guidance)

GPS / Galileo / GLONASS, Beidou / GNSS

Displays

Steering angle sensor

Hydraulic valve

Navigation Controller
Ground sensors used in crop protection
Agro robots

- Platforms for crop management
Agro Robots – current projects WUR

- Autonomous sprayers
  - Strawberry
  - Orchards
- Autonomous weed robot ‘Ruud’
Variable rate application of pesticides

- Case of potato haulm killing
Ground sensor - VRA (MLHD PHK) 2005

Reglone

Minimum effective dose (l/ha)

Reflection parameter CropScan

Legenda
- Meetpunten
Interpolatie
Dosering (l/ha)
- 1.50 - 1.75
- 1.76 - 2
- 2.01 - 2.25
- 2.26 - 2.5
- 2.51 - 2.75
- 2.76 - 3.00
Project on use of satellite images (2009-2011) in VRA PHK

- To study spatial variation in aboveground biomass of potato crops
- To quantify the potential of herbicide saving when canopy density VRA is applied in chemical potato haulm killing
- To explore the potential of VRA dosing of potato haulm killing herbicides with satellite images of crops
Sensors/satellites

Cropscan

Yara N Sensor (ALS and passive)

Terra (Aster sensor), Worldview-2 and TerraSAR-X satellites
<table>
<thead>
<tr>
<th>Type</th>
<th>Sensor</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hand-held</td>
<td>Cropscan</td>
<td>Nadir view. MSR87 has 8 wavebands of 20 nm width centered at 460, 510, 560, 610, 660, 710, 760 and 810 nm. MSR16 used in Valthermond has 16 wavebands of 20 nm width centered at 460, 490, 510, 560, 610, 670, 700, 720, 730, 740, 760, 780, 810, 870, 900, 970 and 1080 nm. MSR16 used in Reusel has 16 wavebands of 20 nm width centered at 490, 530, 550, 570, 670, 700, 710, 740, 750, 780, 870, 940, 950, 1000, 1050 and 1650 nm (other set of filters used).</td>
</tr>
<tr>
<td>Tractor-mounted</td>
<td>Yara N-Sensor (passive)</td>
<td>Tractor-mounted, uses ambient light, oblique view, reflectance measured at 10 nm intervals between 450 and 900 nm (old “blue” model), or between 600 and 1100 nm (new “white” model)</td>
</tr>
<tr>
<td>Tractor-mounted</td>
<td>Yara N-Sensor (ALS)</td>
<td>Tractor-mounted, uses light source, oblique view, reflectance measured at undisclosed wavelengths</td>
</tr>
<tr>
<td>Satellite</td>
<td>Terra (EOS AM-1)</td>
<td>Imagery from the ASTER (Advanced Spaceborne Thermal Emission and Reflection Radiometer) sensor on this satellite was used. Pixels of 15 x 15 m². Wavebands B2 630-690 nm (red), 770-895 (NIR). Revisit frequency: every 16 days, though image recording can be more frequent due to steerable sensor.</td>
</tr>
<tr>
<td>Satellite</td>
<td>WorldView-2</td>
<td>Pixels of 1.8 x 1.8 m². Wavebands B2 630-690 nm (red) and 770–895 (near-IR 1). Revisit frequency: 2-3 days in The Netherlands</td>
</tr>
<tr>
<td>Satellite</td>
<td>TerraSAR-X</td>
<td>Pixels approx. 5x5m, HV-HH polarization</td>
</tr>
</tbody>
</table>
Data sets

- 2004 – 2011 (from > 20 potato fields)
- Point measurements (Cropscan)
- Line scans (Yara N Sensor)
- Fields scans (Satellites)
Equations and dosing algorithm

- \( WDVI = R_{v,810} - \left( \frac{R_{s,810}}{R_{s,660}} \right) \times R_{v,660} \)

- \( D = \min[ 3.0, 0.38 \times \exp( 4.9 \times WDVI ) ] \)
Comparison nearby and remote sensing data points in analysis:

\[
\sqrt{\left( x_{N-sensor} - x_{pixel} \right)^2 + \left( y_{N-sensor} - y_{pixel} \right)^2} < 5
\]
Relation between Cropscan and Aster WDVI

- \( y = 0.92x \)
- \( y = 0.82x \)
Satellite WDVI and dosage advise (Reglone)

- \( \text{WDVI}_{cs} = R_{v,810} - (R_{s,810}/R_{s,660}) \times R_{v,660} \)
- \( D = \min \left[ 3.0, 0.38 \times \exp(4.9 \times \text{WDVI}_{cs}) \right] \)
  plus
- \( \text{WDVI}_{cs} = 0.88 \times \text{WDVI}_{sat} \)
gives
- \( D = 0.377 \exp(4.34 \times \text{WDVI}_{sat}) \)
Relation between scale and herbicide reduction potential of VRA

Resolution Aster sensor: 15 x 15 m (st)

Grid size: 1*st to 9*st
Scale dependent herbicide reduction of VRA on 13 fields

How to read the graph

Grid size: dosage range
(# fields with herbicide red. versus total number of fields)

15 x 15 m: 1 – 2.1 L/ha
(13/13 herbicide reduction)

30 x 30 m: 1.2 – 3 L per ha
(12/13 herbicide reduction)

45 x 45 m: 1.5 – 3 L per ha
(10/13 herbicide reduction)

Etc.
Demonstration of VRA potato haulm killing herbicides with remote sensing biomass maps
Use of remote satellite images in potato haulm killing
Figure x. Worldview-2 image, 15-08-2011, Flevoland. Test parcel for variable rate application in yellow outline (above). WDVI image of test parcel (lower-left). Reglone dose instruction map (lower-right)
Spray map PHK using UAV biomass map and PHK-algorithm Reglone (sept 2011)
Figure x. UAV image transferred to WDVI (left). Image transferred to Reglone dose map, 33 x 10m blocks (right).
Conclusions from the study

- Algorithms have been developed to relate satellite WDVI to minimum effective doses of potato haulm killing herbicides
- The potential of herbicide reduction is scale dependent
- The concept of RS based dosage recommendation of potato haulm killing herbicides was demonstrated
- So, both satellite and nearby sensor images can be used in VRA of pesticides in agriculture and other crop management
Other use of satellite images in PA

- VRA of fungicides / growth regulators
- VRA of crop nutrients
- Yield monitoring and prediction
- Crop development stage monitoring
- Crop stress monitoring
- Soil properties assessment
VRA soil herbicides

Lutum map made with gamma radiation sensor -> spray map on akkerweb
End of presentation

More info:

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Plaatje yield potential of field
Plaatje crop management

- Soil map and plant density
- Idem soil herbicide
- MLHD PHK
- Fertilization
- Irrigation
- CDS fungicides
- Pavements ImagJ sportsfields
Crop and yield monitoring

- Vragen Sander
- Mijn akker
- Combineren
- Fenology and quality
Concluding remarks

- Battle ground and remote sensing
- Standardization
- Platforms

- Challenges
- Stress detection