Applications of Precision Agriculture and Remote Sensing

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Site-Specific Management (SSM) and Precision Agriculture

- SSM is the management of the crop at a spatial scale less than that of the entire field.
- PA is the use of information technology to achieve SSM.
Premises on which adoption of SSM is based

- Significant within-field variability exists in factors that influence crop yield.
- The causes of this variability can be identified and measured.
- Information from these measurements can be used to effectively modify crop management practices.
- The improvement in economic yield justifies the cost.
Dealing with Salt Affected Soil
Sources of variability in irrigated production systems

- Soil texture
- Salinity
- Soil depth
Factors influencing soil salinity in the western San Joaquin Valley

- Re-use of irrigation water from other fields
- Pre-existing fossil salts from seabed deposits
- Elevated water table
- Seepage from drainage canals
Classification of salt-affected soils

- **Saline**: EC > 4 dS/m, ESP < 15
  - Can be ameliorated by leaching

- **Saline-sodic**: EC > 4 dS/m, ESP > 15
  - Leaching alone converts to sodic
  - Requires amendments in addition

- **Sodic**: EC < 4 dS/M, ESP > 15
  - Prone to breakdown in structure
  - Poor infiltration properties
Most common soil amendments

- Gypsum
- Sulfur
- Sulfuric acid
Reclamation of saline-sodic soils is well suited to site-specific management

- Amendments are relatively expensive
- Salt-affected areas tend to be distributed in patches within a field
- Calculation of amount of amendment to apply is fairly exact
Linking EM38 and NDVI measurements to detect and quantify stress

NIR -> R
R -> G
G -> B


PLATE 2 Oblique normal color (a) and color infrared (b) aerial photographs showing a portion of the University of Wisconsin—Madison campus, June 27, 1968, 11:00 A.M. The football field has artificial turf with low near-infrared reflectance. (For major discussion, see Section 2.9.)
Normalized Difference Vegetation Index

\[ \text{NDVI} = \frac{(\text{IR} - \text{R})}{(\text{IR} + \text{R})} \]
Examples of NDVI

\[
\text{NDVI} = \frac{25 - 40}{25 + 40} = -0.23
\]

R: 25 (IR)
G: 40 (R)
B: 140 (G)

\[
\text{NDVI} = \frac{175 - 20}{175 + 20} = 0.79
\]

R: 175 (IR)
G: 20 (R)
B: 20 (G)

NIR -> R
R -> G
G -> B
Linking Soil EC$_a$, NDVI, and Yield
Soil Quality

Vegetation

Yield
Close-up

J&J 16.5 (NDVI 09/99)
NDVI can be used to detect other types of stress

- Water stress trials at WSREC
Fresno County Site 9-15-97
NDVI on East (Sandy) and West (Loamy) Sides
Remote Sensing of Nitrogen Stress

NDVI vs Date, WSREC N Trial, 1998

Date
NDVI
55 kg/ha
110 kg/ha
165 kg/ha
220 kg/ha

0 0.2 0.4 0.6 0.8 1 1.2

Date
Example of the use: variable rate N application
Improving profit with VRT

- *Increase income*
  Apply N where needed to increase yields

- *Cut costs*
  Don’t apply N where it’s not needed

- VRT N is profitable when the sum of increased income and savings is greater than the cost of the VRT program.
Steps of site-specific N management program

- On a location by location basis:
  - Estimate yield potential
  - Estimate available soil N
  - Use variable rate technology to adjust the N application rate
Directed soil sampling

- Based on previous year’s yield map, divide the field into 3 zones (high, medium, low yield).
- Take soil samples at 3 widely scattered locations in each zone (9 total).
- Test sample for residual N (and Ec if salinity is suspected).
Example: 2002 trial based on 2001 yield map
Soil N

Sheely 6-4: 2002 Nitrate Nitrogen

0 to 1 ft

1 to 2 ft

2 to 3 ft

Trial
S6-4 N 1 ft (ppm)
3 - 13
14
15 - 30
Field Boundary

Trial
S6-4 N 2 ft (ppm)
9 - 20
21 - 28
29 - 43
Field Boundary

Trial
S6-4 N 3 ft (ppm)
14 - 24
25 - 28
29 - 36
Field Boundary

400 0 400 800 1200 1600 Feet

1:12000
All major components
Management zones

Sheely 6-4: 2002 Variable Rate Zones

**Med Zone 2:**
- Mean Residual Nitrate N: 23 ppm (50 lbs/ha)
- Higher EC values in the north indicate lower yield potential.
- Apply: 50 lb N

**High Zone 3:**
- Mean Residual Nitrate N: 22 ppm (44 lbs/ha)
- Lower EC values in the south indicate higher yield potential.
- Apply: 110 lb N
Resulting application map

Medium N Zone
EC 2.8 to 5.0 > lower yield potential
Mean residual N > 50 lb/a
Apply: 140 - 50 = 90 lb/a

High N Zone
EC 1.4 to 3.5 > higher yield potential
Mean residual N > 44 lb/a
Apply: 164 - 44 = 110 lb/a
Yields from 2002 Sheely Trial

<table>
<thead>
<tr>
<th>N applied (lbs/acre)</th>
<th>Lint Yield (lbs/acre)</th>
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<tbody>
<tr>
<td>0</td>
<td>55</td>
</tr>
<tr>
<td>250</td>
<td>103</td>
</tr>
<tr>
<td>500</td>
<td>148</td>
</tr>
<tr>
<td>750</td>
<td>VRT</td>
</tr>
<tr>
<td>1,000</td>
<td></td>
</tr>
<tr>
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<td></td>
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<td>1,500</td>
<td></td>
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<tr>
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<tr>
<td>2,000</td>
<td></td>
</tr>
<tr>
<td>2,250</td>
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</tbody>
</table>
Economic analysis

- Overall question: Does variable rate N application reduce costs sufficiently to overcome the increased cost of implementing the VRT program?
- Partial budgets computed for each of the test sites
VRT Cost per Acre

Equipment, sampling & mapping

Equipment Cost

$2.35/A
VRT Breakeven profit increase ($/A)

- Breakeven profit increase at 500 acres: $10.24
- Equipment, sampling & mapping
Conclusions

- Substantial savings in fertilizer even with conservative VRT N management
- For all 3 sites profit increased primarily from decrease in N use and not from increasing N use
- Breakeven fertilizer savings decreases with acreage increase
- Breakeven acreage decreases with increases in fertilizer, labor, or fuel costs
Conclusions, contd.

- Profit margin can be increased by using the equipment for other purposes or for other crops.

- Some recommended potential uses:
  - Variable rate soil amendment application.
  - Variable rate Pix on cotton
  - Variable rate seeding