MONITORING WATER USE EFFICIENCY OF IRRIGATED SUGARCANE PRODUCTION IN MPUMALANGA USING SEBAL

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Introduction

Background
• Irrigation water supply in SA is limited
• Pressure to demonstrate efficient use
• Measure to manage crop water use
• Remote sensing (RS) could help

Objectives
For Mpumalanga sugarcane
• Evaluate the accuracy of SEBAL estimates of
  – crop water use (ET),
  – crop water status (ETdef)
  – biomass production (ΔTDM)
• Quantify spatial variation in ET, ΔTDM, water use efficiency (BWUE)
• Explore ways of using RS information to promote efficient use of irrigation water
In this presentation

- **Method**
  - Study area
  - SEBAL
  - Field measurements

- **Results**
  - SEBAL validation
  - Spatial variation in ET, Etdef, ΔTDM, BWUE
  - Supporting management of irrigated sugarcane production

- **Conclusions**
• Thirteen fields on four commercial and two small-scale farms
  • Different soils, crop cycles, row spacings
  • Drip, centre pivot and portable overhead irrigation systems
  • Seven different varieties
Surface Energy Balance Algorithm for Land

• Inputs:
  – Remotely sensed radiance in visible, near-infrared and thermal red part of spectrum
  – Weather data
• Calculates the radiation and energy balance
• Calculates actual and potential crop water use (ET, ETpot), canopy cover, crop growth (ΔTDM), and water use efficiency (BWUE)
• Weekly ET, Etdef = (ETpot-ET), ΔTDM, BWUE = ΔTDM/ET at 30 m resolution
Ground measurements

- Soil water status
  - Capacitance probes
- Evapotranspiration
  - Surface renewal system (energy balance method with sensible heat flux, soil heat flux, net radiation)
- Crop growth and yield
  - Canopy cover
  - Biomass components
Results
Validation results for field G1
Biomass validation

\[
y = 1.006x + 5616.8 \\
R^2 = 0.7684
\]
Validation summary

<table>
<thead>
<tr>
<th>Variable</th>
<th>Slope</th>
<th>Intercept</th>
<th>R²</th>
<th>n</th>
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<tbody>
<tr>
<td><strong>2011/12</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Canopy cover (%)</td>
<td>1.02</td>
<td>-9.75</td>
<td>0.543</td>
<td>93</td>
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<tr>
<td>ET (mm/week)</td>
<td>1.05</td>
<td>4.9</td>
<td>0.721</td>
<td>29</td>
</tr>
<tr>
<td>Biomass (t/ha)</td>
<td>0.84</td>
<td>14.6</td>
<td>0.783</td>
<td>24</td>
</tr>
<tr>
<td><strong>2011/12 and 2012/13 pooled</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Canopy cover (%)</td>
<td>1.01</td>
<td>-10.5</td>
<td>0.774</td>
<td>196</td>
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<tr>
<td>ET (mm/week)</td>
<td>1.31</td>
<td>2.63</td>
<td>0.781</td>
<td>51</td>
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<tr>
<td>Biomass (t/ha)</td>
<td>1.01</td>
<td>5.6</td>
<td>0.768</td>
<td>116</td>
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</table>
Spatial estimates of seasonal values

- Evapotranspiration (ET)
- ET deficit (ETdef)
- Dry biomass yield (TDM)
- Water use efficiency (BWUE)
ET

![Bar graph showing frequency of actual evapotranspiration in mm/season across different ranges. The graph includes bars for frequencies of 0-2000, 2000-4000, 4000-6000, 6000-8000, 8000-10000, 10000-12000, 12000-14000, and 14000-16000. The map on the right side shows the distribution of evapotranspiration across various locations, including Baberton, Hectorspruit, and Komatipoort.](image)
TDM

![Graph showing actual biomass production in Ton/ha/season with frequency in pixels on the Y-axis and actual biomass production on the X-axis. The graph includes bars representing frequency for different biomass production ranges.]

![Map indicating locations of Komatipoort and Hectorspruit.]
UNLOCKING THE POTENTIAL OF SUGAR CANE

BWUE

Komatipoort
Malelane
Baberton
Nelspruit
Hectorspruit

Biomass water use efficiency [kg/m³]

Frequency [pixels]

Biomass water use efficiency
kg/m³

Hectorspruit
Komatipoort
Baberton
## Summary

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<thead>
<tr>
<th>Parameter</th>
<th>ML</th>
<th>25th %</th>
<th>50th %</th>
<th>75th %</th>
<th>Max</th>
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<tbody>
<tr>
<td><strong>ET (mm/385 days)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MALELANE MSA</td>
<td>89</td>
<td>892</td>
<td>1070</td>
<td>1200</td>
<td>1760</td>
</tr>
<tr>
<td>KOMATI MSA</td>
<td>63</td>
<td>780</td>
<td>982</td>
<td>1150</td>
<td>1686</td>
</tr>
<tr>
<td>Biomass (t/ha/385 days)</td>
<td>0</td>
<td>32</td>
<td>47</td>
<td>58</td>
<td>94</td>
</tr>
<tr>
<td>BWUE (kg/m³)</td>
<td>0.0</td>
<td>3.6</td>
<td>4.5</td>
<td>4.9</td>
<td>6.3</td>
</tr>
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<table>
<thead>
<tr>
<th>Parameter</th>
<th>ML</th>
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<tbody>
<tr>
<td><strong>ET&lt;1000mm</strong></td>
<td>40</td>
<td>53</td>
</tr>
<tr>
<td>Biomass &lt; 35 t/ha (≈90 t cane/ha)</td>
<td>30</td>
<td>34</td>
</tr>
<tr>
<td>BWUE&lt; 4 kg/m³ (≈9.5 t cane/100 mm)</td>
<td>36</td>
<td>33</td>
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</table>
Potential value of SEBAL data

Spatial and temporal analysis of irrigated crop performance

• Poorly performing fields identified by high ETdef and /or low BWUE

• Detect problems early, focus management and extension effort on priority areas at field, farm and regional level
Field 17

Buffelspruit Shabangu

Stress index from Probe data (%)

ETdef (mm/Week)

- SEBAL

- Field values

- 0

- 5

- 10

- 15

- 20

- 25

- 30

- 35

- 40

- 45

- 10-Sep-11

- 03-Nov-11

- 23-Dec-11

- 11-Feb-12

- 01-Apr-12

- 21-May-12

- 10-Jul-12

- 29-Aug-12

- 18-Oct-12
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Field 17

Nov 11          Dec 11     Jan12            Feb12
Mar 12   Apr12       May12                  Jun12
Jul12      Aug12

Buffelspruit Shabangu

- SEBAL
- Field values

Stress index from probe (%)
Conclusions

• SEBAL estimates of ET and TDM reasonably accurate
• Substantial spatial variation in ET, TDM and BWUE in Mpumalanga sugarcane production
• Room for improving productivity and efficiency of sugarcane production
• RS is a useful tool for monitoring WUE – retrospective benchmarking, near real-time identification of problem areas
• Technology proven – requires user friendly packaging and commercialization for wide implementation
Acknowledgments

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  – WRC and DAFF, SASRI, UKZN
    – (WRC project K5/2079//4, WRC Report No. TT 602/14)
• SASRI technical team
• Pieter Cronje of TSB
• SA Canegrowers’ Association
• Sugarcane farmers
Remote sensing platforms

- Satellite
  - Landsat (30 m, ≈14 days)
  - Modis (200 m, daily)
  - Many others

- Airborne
  - Drones
Electromagnetic radiation

- All bodies emit and reflect radiation
- Body temperature determines long wave radiation
- Transpiration determines canopy temperature
- Stomatal conductance (and hence transpiration and carbon fixation) can be deduced from thermal radiation
- Combined with the energy balance, ET and biomass growth can be estimated: SEBAL, METRIC