IMPROVING TRANSPERSION EFFICIENCY IN SUGARCANE

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Water – a major driver of yield:
A plant needs to draw in CO$_2$ for photosynthesis, but cannot help but lose water at the same time...
Photosynthesis rate closely related to conductance

![Graph showing the relationship between A (μmol m\(^{-2}\) s\(^{-1}\)) and Conductance (mol m\(^{-2}\) s\(^{-1}\)). The graph includes data points for different species labeled as Q208, QBYC04-10951, QBYN05-20735, and QN66-2008.]
Definitions

*Water use efficiency*: Biomass produced per water used

Water used by crop = transpiration + soil evaporation + drainage
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**Water use efficiency**: Biomass produced per water used

Water used by crop = transpiration + soil evaporation + drainage

**Transpiration efficiency**: biomass produced per water transpired

Yield (t/ha) = Transpiration efficiency (t/ML) x Transpiration (ML/ha)
Transpiration efficiency (TE)

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Yield maximised by increasing transpiration OR increasing TE

No breeding up to now for high TE – breeding to date may be selecting against high TE due to competition effects in early growth (later)

Economic impact of improving TE is a complex question but may be very large:
- Depends on extent of genetic variation
- Depends on environment, and timing of stress for rainfed environments
- Depends on water costs and limitations in irrigated systems
There is important genetic variation for TE in sugarcane even in commercial types - eg:

<table>
<thead>
<tr>
<th>Clone</th>
<th>TE (g/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>QN66-2008</td>
<td>8.28</td>
</tr>
<tr>
<td>Q183</td>
<td>6.67</td>
</tr>
<tr>
<td>Q200</td>
<td>7.22</td>
</tr>
<tr>
<td>Q208</td>
<td>7.47</td>
</tr>
<tr>
<td>KQ228</td>
<td>5.95</td>
</tr>
<tr>
<td>LSD(P&lt;0.05)</td>
<td>1.46</td>
</tr>
</tbody>
</table>
...and variation may be even bigger in wild germplasm...
How important is this variation?

• In environments where available soil moisture has “run out” – increased yield will be proportional to TE
  - Eg. 40% increase in TE = 40% increase in yield
Targeting two applications in breeding:

1. Introgression and parental development
   - Seeking extreme responses in parental material for subsequent breeding

2. Routine selection in commercial breeding
Canopy temperature – new ways to cheaply measure large scale trials; & correlated with transpiration rate

TE \sim \frac{\text{Yield}}{1/\text{temperature}}
One complication - TE may be negatively genetically correlated with rate of transpiration.

Need to simultaneously measure conductance, or yield, for optimal selection.
Hypothesis - optimal selection index

• Yield + canopy temp measured several times at single site
  – Yield + TE a better predictor of yield in water limited environments
  – Theoretical predictions suggest this will improve gains from selection, but yet to be tested in practice through measuring realised gains
Summary

• Transpiration efficiency a key trait, but improvement probably hasn’t occurred in normal breeding because of components negatively related to yield and competitiveness

• High genetic variation in TE exists

• Ways to use this trait in breeding being explored
  – Introgression of extreme expression
  – Use in selection indices together with yield
Acknowledgements

• Funding - Sugar Research Australia, Department of Agriculture, Australia; Yunnan Academy of Agricultural Sciences, CSIRO

• Technical staff in SRA, CSIRO, YSRI