

Knowledge to support risk assessment for deployment of GM sugarcane varieties

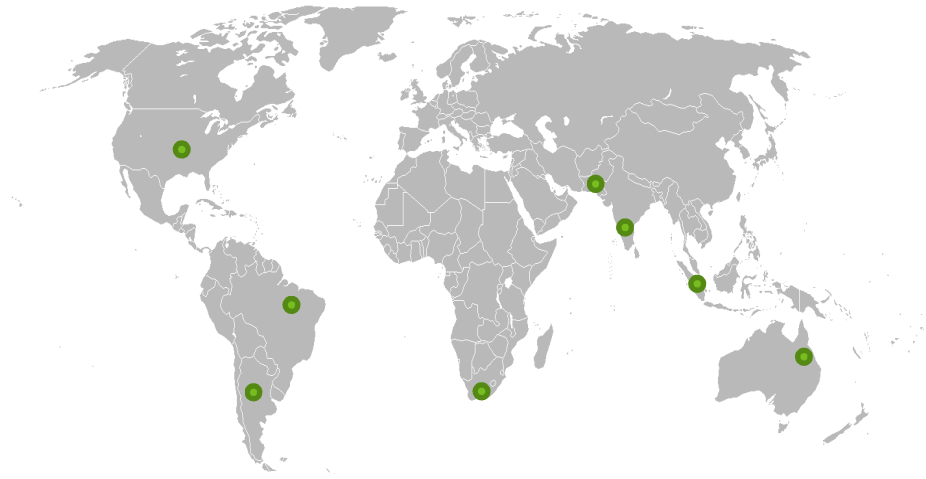
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CSIRO Agriculture Flagship, Australia

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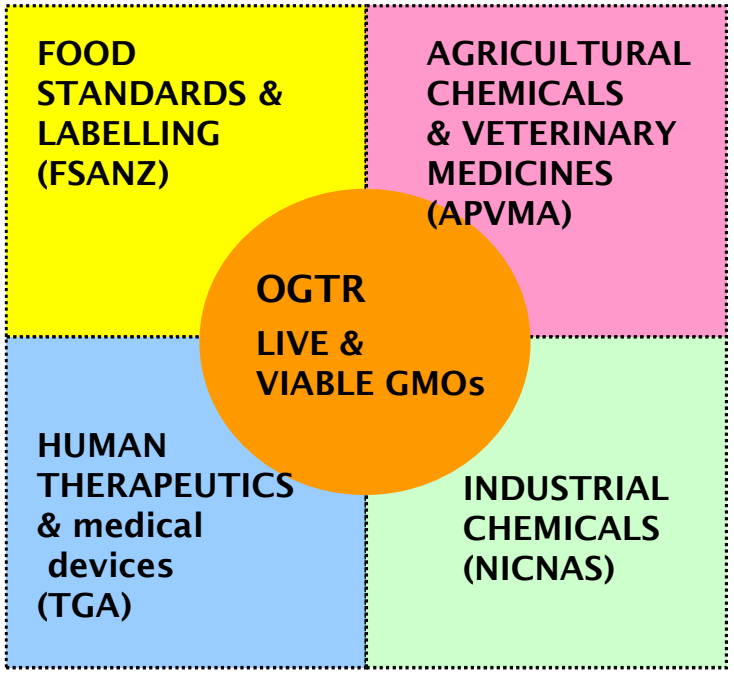
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Regulatory approval is a key step for implementation

GM sugarcane varieties are being developed in many countries



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- In Australia, the Office of the Gene Technology Regulator (OGTR) assesses all GM varieties
- Other regulatory agencies may also be involved

Knowledge to enable assessment was lacking

- Could the GMO cause harm to people or the environment?
- Is the risk higher from the GMO than from the parent organism?

Limited knowledge of reproductive biology





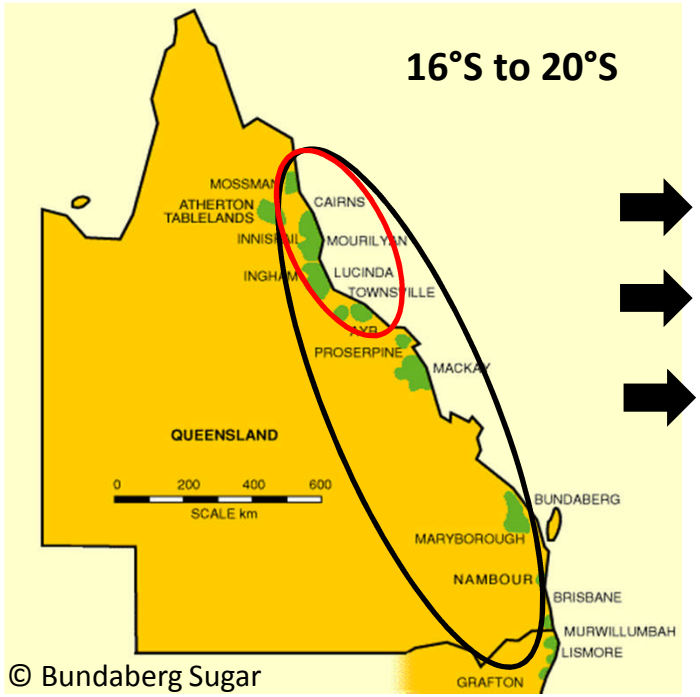
Published information may be inaccurate:
"Sugarcane is resistant to flowering in the field"
"Sugarcane is harvested before it flowers"

Field grown sugarcane can produce fertile seeds

- Flowering of commercial varieties and nearby wild relatives
- Extent of cross-pollination in commercial fields



Photo: Nader Sallam, SRA



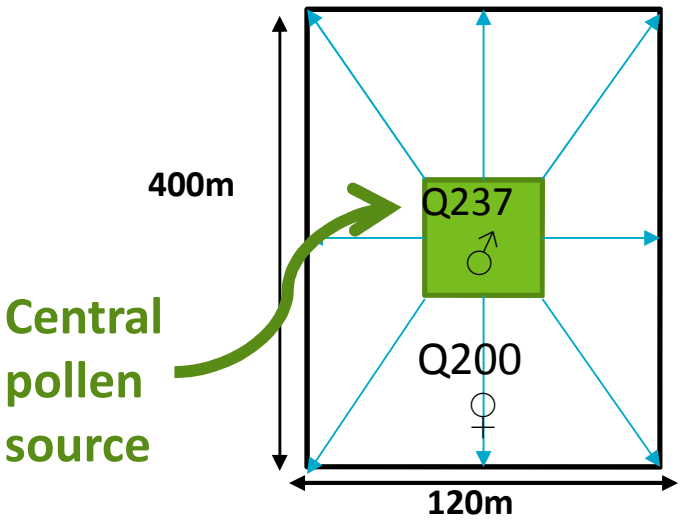
Abundant flowering

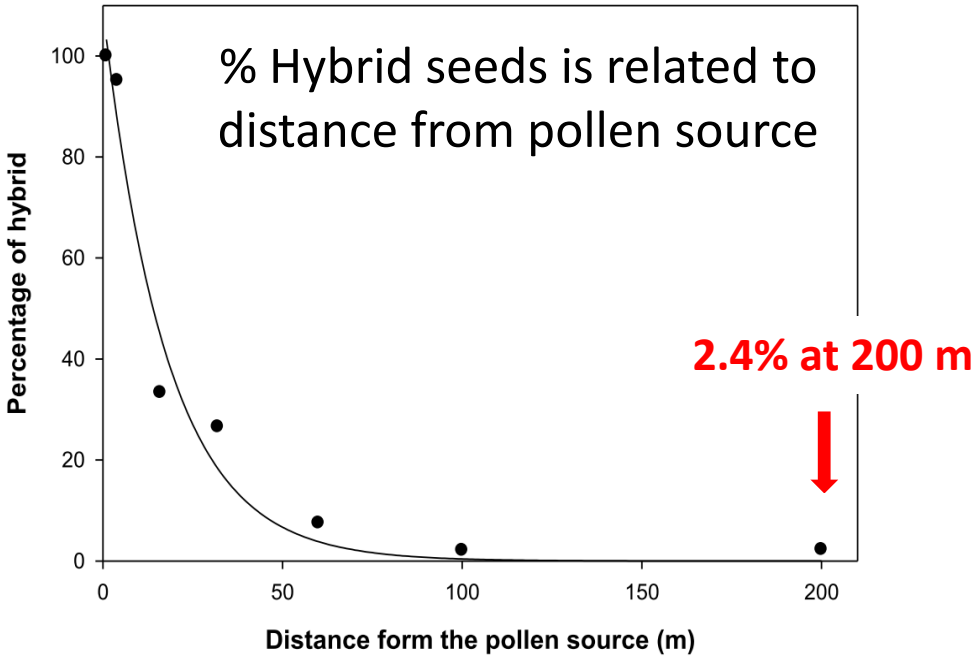
Viable pollen

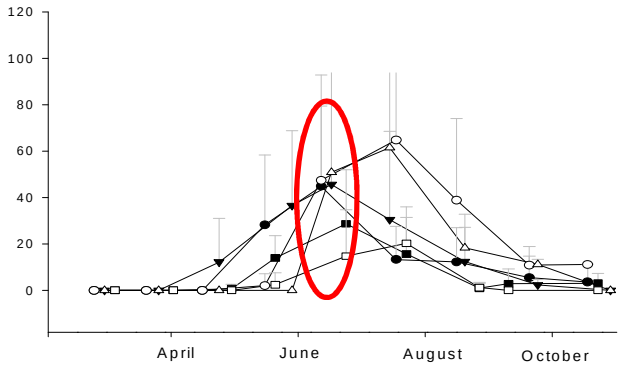
Viable seeds

Bonnett *et al*, 2010

Pollen can travel long distances and form viable seed







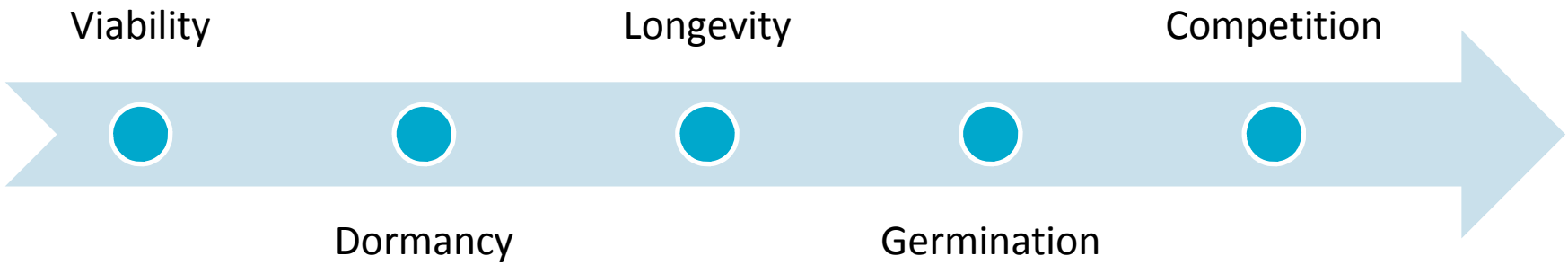
A sexually compatible weed species (*S. spontaneum*) has synchronous flowering

Bonnett et al. 2008 *Tropical Plant Biology* 1, 58–71.

Olivares-Villegas et al., manuscript in prep.

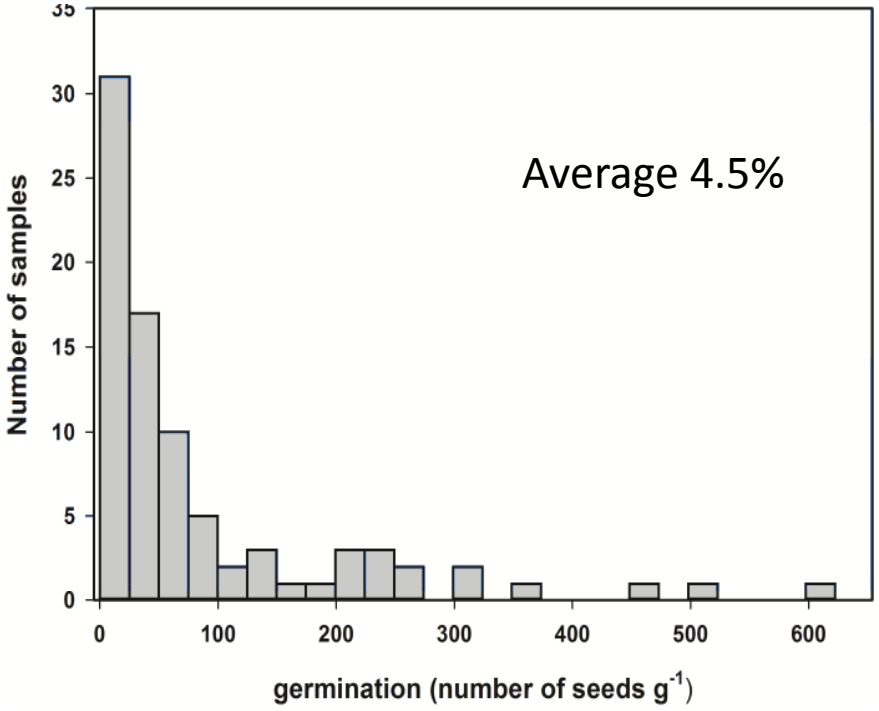
Study of the stages from seed to seedling

- **Fertile seeds are possible**
- **What might limit establishment?**

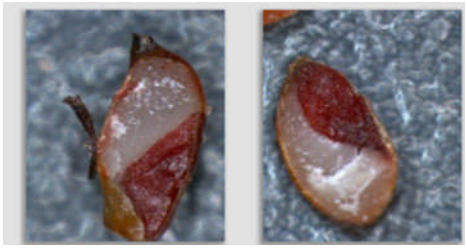


Low fertility and no dormancy

In samples from the field, the number of seeds that germinate is low per gram of fuzz



Tetrazolium staining shows that all viable seeds germinate
i.e. no dormancy period





Pierre *et al.* 2015 *Frontiers in Bioengineering and Biotechnology*, in press.

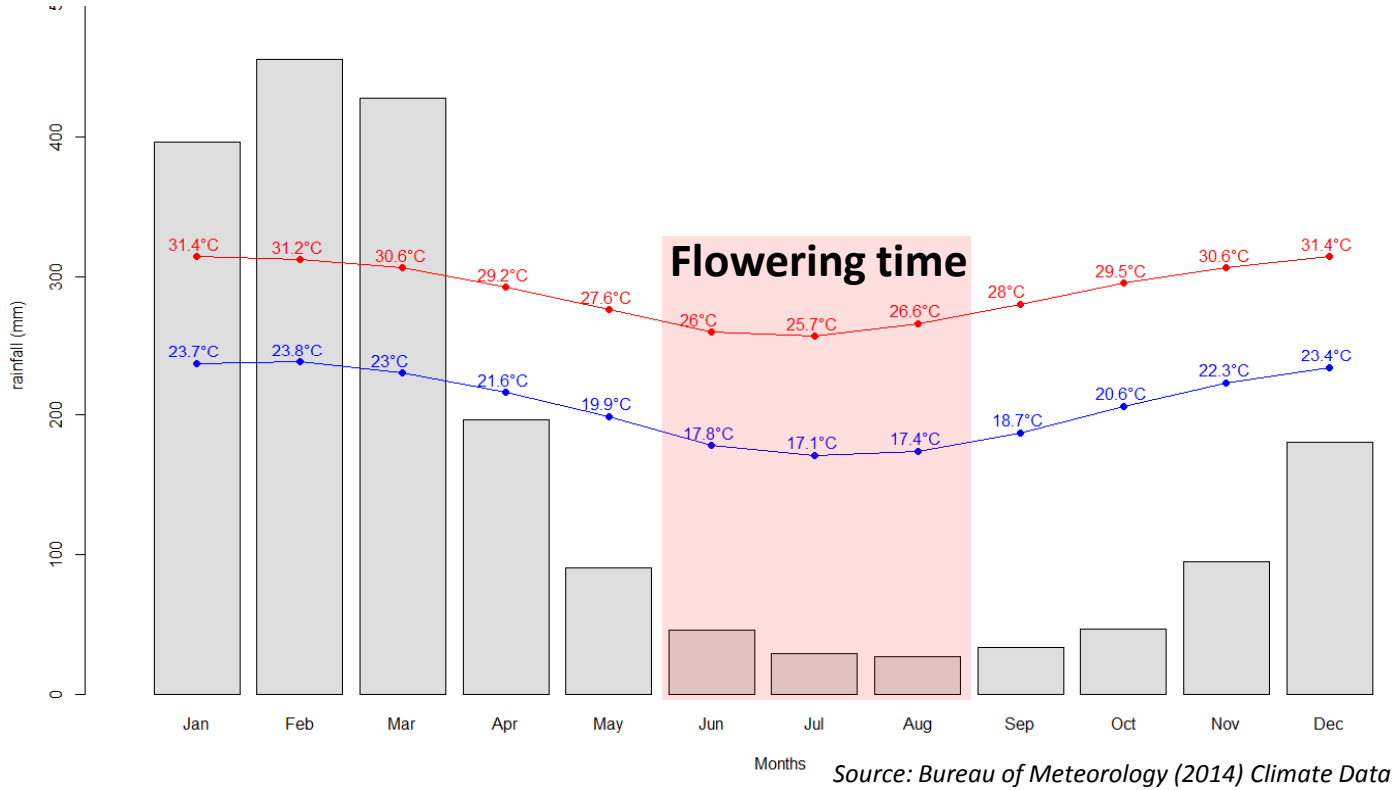
Environmental limits to germination

Published reports

$T_{optimal}$ ≈ 35-38°C

T_{base} ≈ ? (<25°C?)

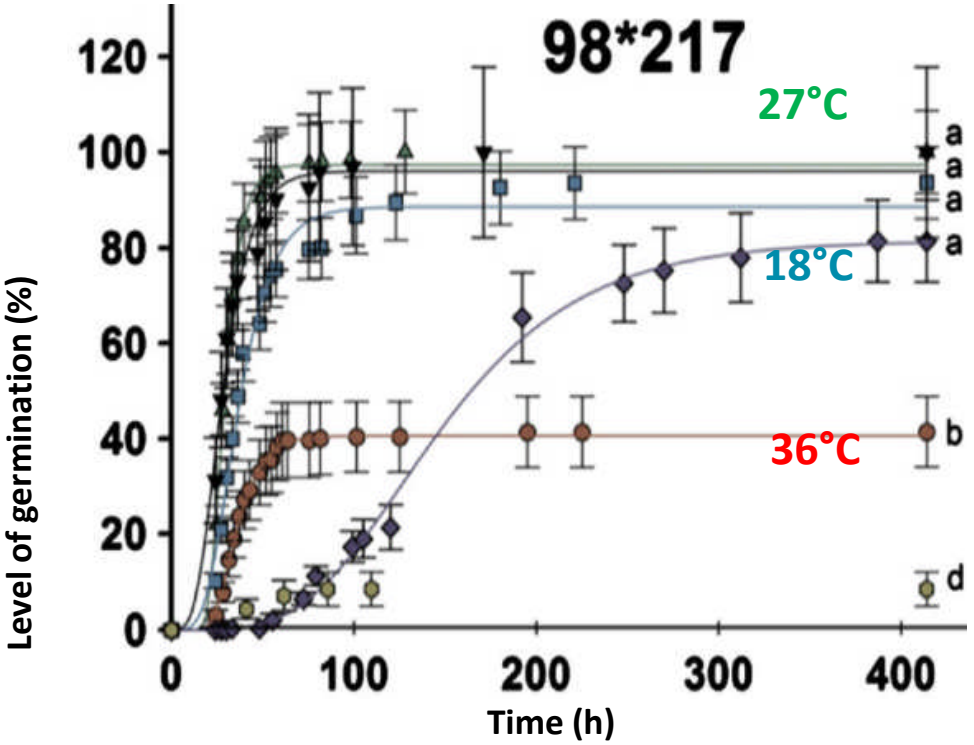
Temperature and rainfall in Cairns



Source: Bureau of Meteorology (2014) Climate Data Online.

Environmental limits: 1. Temperature

- Rates of germination at 18°C to 42°C were measured
- Seed from 8 crosses with parents originating from different countries
- Low temperature limits calculated **11.2°C to 16.4°C**

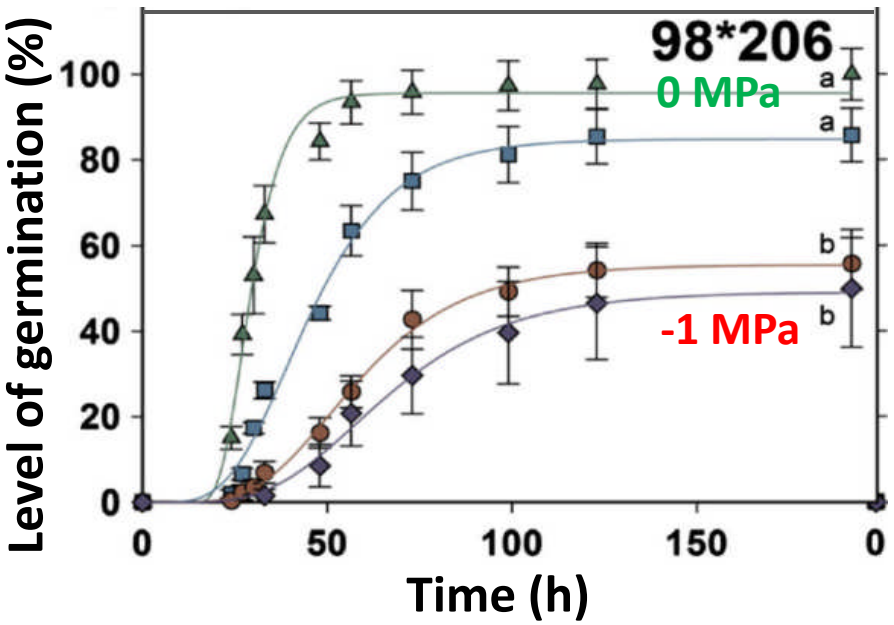


Temperature is unlikely to limit germination

Pierre *et al.*, Tropical Plant Biology 2014

Environmental limits: 2. Water availability

- Rates of germination at 0 MPa to -1 MPa were measured
- Seed from 4 crosses with parents originating from different countries
- Water potential limit calculated **-1.1 MPa to -1.5 Mpa**



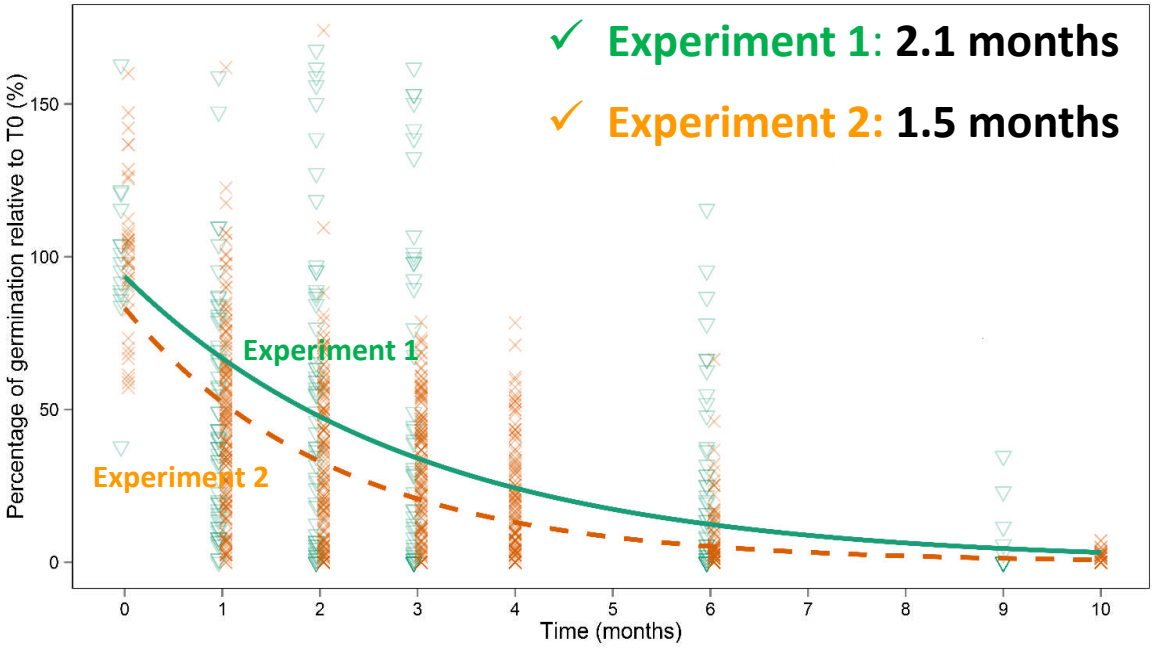
Water potential may be limiting

Pierre *et al.*, Tropical Plant Biology 2014

Can seeds survive until conditions improve?

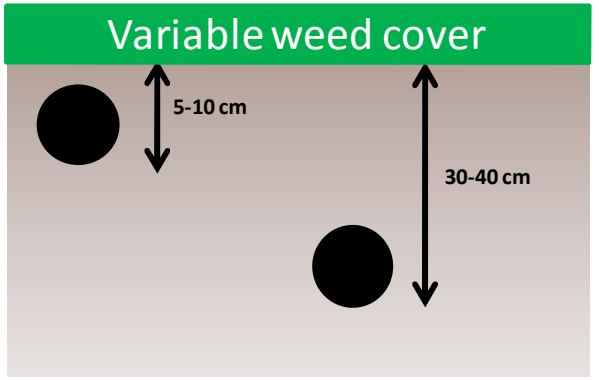
- Seeds buried and retrieved over 10 months
- 5 crosses x 2 sites x 2 depths x 2 seasons

Half-life:



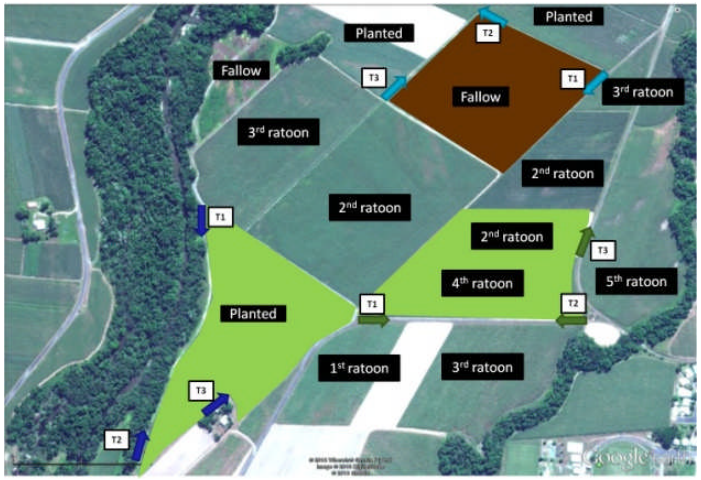




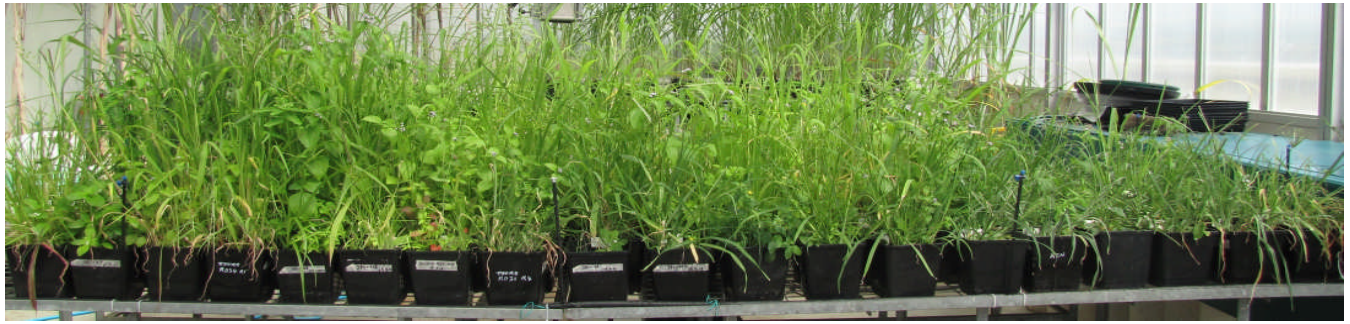


Seeds cannot survive long in the field

The soil seed bank contains few sugarcane seeds

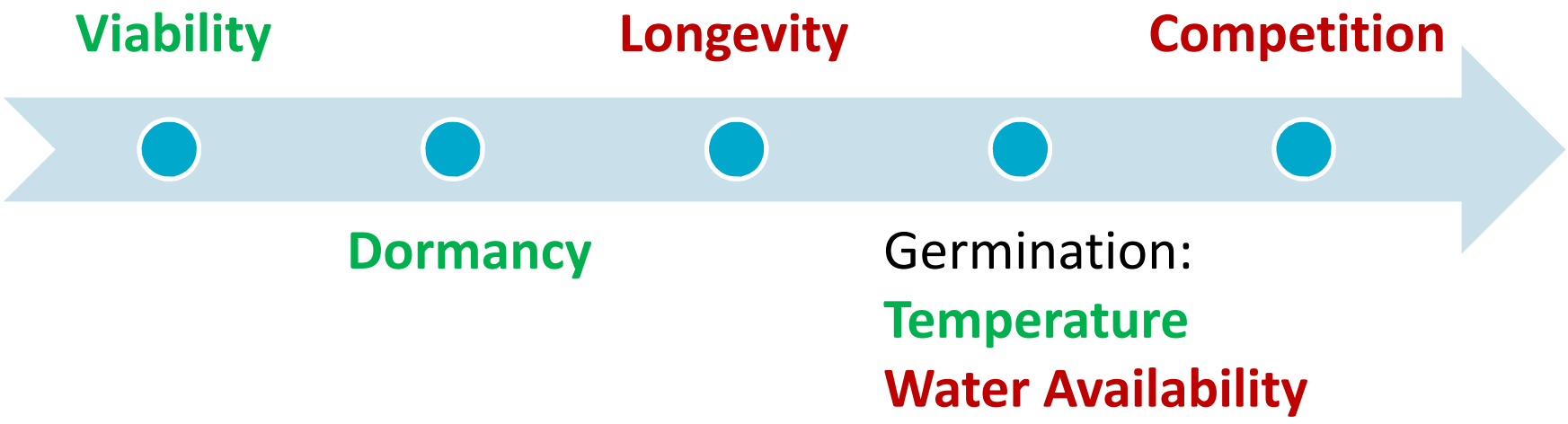


- Two sites with different field types
- Soil samples collected for 6 months after flowering
- Transferred to pots in glasshouse



12067 plants identified (40 spp., 13 families)
8 sugarcane seedlings = 0.06%

What limits seedling establishment?



Water availability, seed longevity and competition are the key factors that prevent establishment of sugarcane seeds in the field

Summary

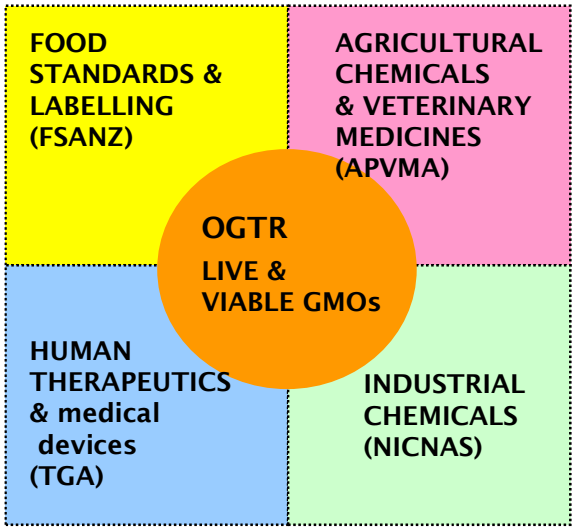
- First complete study of sugarcane reproductive biology
- Overall risk of seedling establishment is low
    - Fertile seeds are produced in regions where they could germinate
    - In Australian conditions, water availability limits germination
    - Seeds are short lived and cannot out-compete other plants
- GM traits that alter seed longevity or drought tolerance may increase risk
- Need for regulation based on local conditions

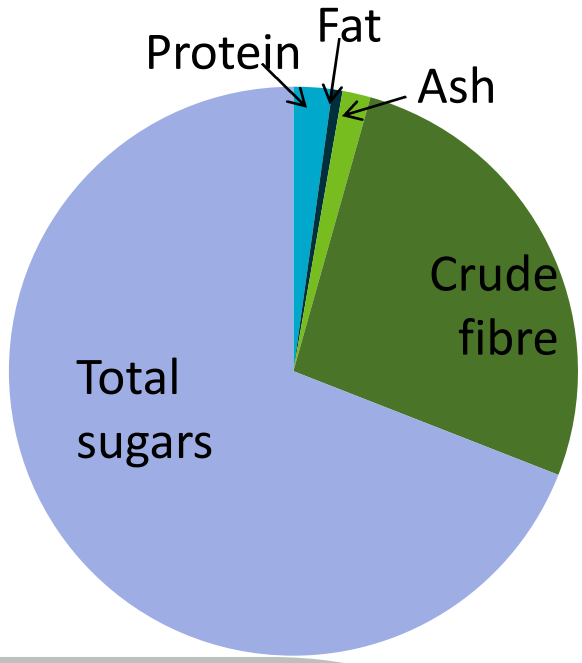
Panama: average monthly rainfall during sugarcane flowering 240 mm



Baseline information for food safety assessment

- Range of nutritional compositions in current varieties will be used to test equivalence
- Samples included variation for environmental conditions
- Defined range of proximates in Australian varieties
- Confirmed the presence of antinutrient dhurrin but at extremely low concentration





Rae et al. manuscript in preparation

Thank you

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