Fast-track breeding of high-yielding varieties of *Artemisia annua*

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Aims of the CNAP Artemisia Research Project

- to identify plants of *A. annua* with increased yields of artemisinin.
- to field trial plants, confirm heritability of high yield trait and select the best lines
- to develop robust and stable high yield varieties which will slot into the current supply chain for ACTs
- to deliver high-yielding seed to the ACT supply chain in as short a timeframe as possible
- to reduce the cost of ACTs
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Scientific strategy

- induced variation
  - forward (trait) screen
  - identify individuals with high artemisinin yield
  - develop robust new varieties
- natural variation
  - reverse (genetic) screen
  - marker assisted breeding
Starting material

• Artemis - developed by Mediplant and currently used commercially. Yielding from 0.6 to 1.2% depending on the location

• collection of other varieties from various locations including Vietnam and East Africa
Summary of Breeding Routes

Route 1: Forward Screen
Route 2: Natural variation from the Artemis gene pool
Route 3: QTL analysis of Artemis
Route 4: Use of natural populations
Route 5: Association study of natural variation
Route 6: Heteroduplex mapping
Route 7: Combining traits
Delivery timeline

- Phase 1: Routes 1, 2 & 3a
  - 2008-2011
- Phase 2: Routes 3b-6
  - 2012-2013
- Phase 3: Route 7
  - 2014-2015

% Artemisinin / unit dry weight
Scientific strategy

- **induced variation**
  - forward (trait) screen
  - reverse (genetic) screen
- **natural variation**
  - marker assisted breeding

*identify individuals with high artemisinin yield*

*develop robust new varieties*
Route 1: Forward (trait) Screen

- high throughput screen of M2 (selfed) plants for artemisinin yield
  - Chloroform dip
  - UPLC MS with 2.5 min run time
- identify high yielding individuals and confirm trait in the field
- ~1000 plants screened every two / three weeks.
Forward Screen Update

- screened 21,000 / 25,000 plants
- identified 230 high yield individuals (between 1.5 and 3 fold higher than Artemis)
Forward Screen Status

- experimental trials will characterise
  - metabolite content
  - trichome density
  - biomass traits (height, fresh weight, leaf area, nodes)
  - vegetative stage
  - plant architecture

to determine field performance and establish basis of high yield trait

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Project status

- multiple lines exhibiting increased yield in artemisinin identified using a forward screen.
- first heritability data suggests a significant proportion of these are due to genotype
- mapping populations established in 3 different environments and genetic map constructed.
- mutations in target genes identified with potential to increase yield of artemisinin
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Potential yield improvement from Phase 1 routes already known ~ 2-4% artemisinin per unit dry weight

Potential High Yielder identification
Heritability testing/Backcrossing
Experimental Field Trials
Commercial Field Trials

Potential yield known
True yield known

Earliest date to market

EARLIEST DELIVERY - 2011
Minimum target yield improvement is double the yield of Artemis
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