‘Characterising underutilised crop germplasm to realise added value supply chains’?

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Over 60% of global food supplies rely on four crops.
Europe

Even if markets alone were able to adjust for the demands, global agriculture is not open to ‘free trade’

Agricultural and policy support (esp. biofuels) in Europe encourages cereal and oilseed production

Source: FAOSTAT
• 125.8 million disability-adjusted life years by 2050, disproportionately affecting South-East Asia and sub-Saharan Africa

• Climate mitigation would avert more (48.2%) of this burden than public health interventions (26.6%)

Has African rice potential for improving Asian rice?

1. Crop (very) Wild Relatives

Phenotypic analysis of 120 *O. glaberrima* lines focused on photosynthesis traits compared to IR64 *O. sativa*

- GWAS analysis underway

Sophie Cowling, BBSRC DTP student
(Erik Murchie, Sean Mayes and Ranjan Swarup)

2. Translation from model plants – stress sensing in crops

The N-Degradon pathway and stress sensing in crops

Initial work has focused in Barley, testing the network identified in Arabidopsis (Dr Guillemina Mendiondo and colleagues)

As a collaborative project, we are now addressing the same questions in leafy Brassica species and are testing effects (Guille Mendiondo, Sean Mayes, Alberto Tanzi; GCRF funding)
3. Diversifying agriculture with resilient crops

More Recently:

**Moth Bean** Rahule Bhosale (UoN), India, Kasetsart Uni (Thailand), Jawaharlal Nehru Uni (India)

**Quinoa** Guille Mendiondo, (UoN), Buenos Aires Uni (Argentina), Brigham Young Uni (US).

**Amaranth**; UK, Malaysia, Tanzania

**Bambara groundnut**; Nigeria, Ghana, South Africa, Indonesia, Malaysia

**Proso millet**; UK, Sri Lanka, Malaysia

**Foxtail millet**; UK, China

**Winged bean**; UK, Thailand, Malaysia, Philippines

**Brassica rapa** Guillerminda Mendiondo

N-degradation pathway

GCRF project Zimbabwe, SA, Australia

Understanding the mechanisms of stress resistance in underutilised crops to build future crop resilience

Addressing both transient and prolonged stresses
Collect/purified germplasm to generate Association Panels genotypes by GBS (DArT Seq)

Accessing germplasm

Without viable seed any research is (literally) academic

Variation for traits within minor crops is often overlooked

Genome complete

Bambara groundnut

Winged bean

Genome complete

Moth Bean Genome also In assembly

A. tricolor Genome sequence Underway; with John Moore’s University, UK

Foxtail millet

Amaranth sp (inc 120 A. tricolor)

300 Genomes Resequence (x10)

Preliminary analysis - unpublished
Research Value Chain approach

Germplasm development/screening; trait of preferences

- Value added product development
- Crop modelling/prediction

Multi-locational testing
- Trait evaluation
- Molecular characterisation

Pre-breeding line development
- Selection
- Controlled crosses

Gap identification
- Farmer/consumer/processor input
- Socio-eco baseline studies
- Impact studies
Winged/goa bean (*Psophocarpus tetragonolobus*)

*(2n = 2x = 18)*

**Strengths:**
- annual or perennial vine
- grows in hot humid tropics
- nitrogen fixing
- “supermarket on a stalk”* - pulse, vegetable (leaves, pods), root/tuber
- leaf & pod: rich source of vitamins, minerals, fiber
- seed “soybean of the tropics”** & tuber: high in protein, carbohydrate

**Drawbacks**
- indeterminate growth habit
- anti-nutritional factor
- photoperiod sensitive
- variability within landraces
- limited value added products
- P&D management

**Opportunities**
- food and nutritional security (alternative plant-based protein source)
- income generation
- product development
- human dietary diversification
- animal feed
Development and interaction between plant architecture and yield-related traits in winged bean (*Psophocarpus tetragonolobus* (L.) DC.). *Euphytica*
**Sequencing approach:**

- Nuclei DNA prep
- Bionano DNA Fibre mapping
- Nanopore long read
- Illumina correction for nanopore
- Combined with mapping positions

**Genotype-by-sequencing** markers have a 64bp sequence tag; this can be placed on the physical genome assembly scaffolds and used to orientate the scaffolds and assign them to specific linkage groups, representing chromosomes.

<table>
<thead>
<tr>
<th>Pseudochromosome, using genetic maps,</th>
<th></th>
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</thead>
<tbody>
<tr>
<td>Scaffolds assigned to LGs</td>
<td></td>
</tr>
<tr>
<td>Cross XB (FP15 x Ma3; Tanzi et al., 2019)</td>
<td>32</td>
</tr>
<tr>
<td>Cross XT (Tpt10 x Ma3)</td>
<td>38</td>
</tr>
<tr>
<td>Unassigned scaffolds to LGs</td>
<td>10</td>
</tr>
<tr>
<td>Length of assigned sequences to LGs</td>
<td>530,283,461 bp</td>
</tr>
<tr>
<td>Length of unassigned sequences to LGs</td>
<td>5,848,080 bp</td>
</tr>
<tr>
<td>N50 pseudochromosome length</td>
<td>23,875,316 bp</td>
</tr>
</tbody>
</table>
Comparative analysis between winged bean and common bean, based on genes for Pt1&2 and Pv1&2

Manuscript close to submission

No close relative with a good genome
Diversity Analysis Results (Summary)

Accessions representing germplasm from public (USDA, IITA, MARDI, AVRDC) and private collections were genotyped using DArTseq (136 accessions).

Manuscript close to submission
Branches per plant in F2

lower yield: ↓ branches/plant
higher yield: ↑ branches/plant

2.6±1.6, n = 84

Manuscript close to submission
Breeding Ideotypes for morphology and yield
Fewer, but longer branches might increase the productivity while containing the vegetative biomass

Initial QTL detected for protein content (MQM):
- Gp2, 65cM, LOD 5.4
- Gp3, 103cM, LOD 3.6
- Gp7, 5cM, LOD 3.4

Initial QTL detected for Phytochemicals (IM):
- Gp3, 37.4cM, LOD 5.3 (Pod pattern)
- Gp4, 12.4cm, LOD 9.6 (Chlorophyll content)
- Gp5, 0cM, LOD 39 (Seed coat colour)

Transgressive segregation for protein content

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Options for further use of underutilised crops:

1. **Plant Breeders Without Borders**
   [www.bpwob.org](http://www.bpwob.org)

Responding to Community demand for breeding of minor crops
- 4 day workshop linking community and local research body/NGO
- Small-scale funding to support 5 years of variety development
- Encourage community ownership and also return of developed germplasm to genebanks for other to access

- “Bred by Farmers, for Farmers”
  
  *Mr Anthony Leddin, Crops for the Future, Bayer AG*
2. Reformulation – Improving nutritional content

Mineral content of noodle made with 100% wheat, 20% bambara groundnut flour and 6% moringa leaf powder Mean value followed by different alphabet in the same row is significantly different at p<0.05.

Adding Bambara groundnut or *moringa oleifera* flour to Noodles

[www.whatif-foods.com](http://www.whatif-foods.com)
3. Learning and developing new value chains for underutilized crops in Europe - RADIANT

EU H2020 project lead from Catholic University of Porto
Figure 3 | Flow of information and knowledge between RADIANT’s work packages, highlighting in different colours the different types of research areas that will work together to release the value UCs and dynamic value chains.

www.cropstoredb.org; www.cropsforthefutureuk.org;
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Genetic diversity analysis:
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Genetic mapping, QTL & eQTL:
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Sequence analysis:
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