Research progress in bambara groundnut and other underutilised crop species

Presentation for

Bogor Agriculture University (IPB)
Tuesday 14th February 2017

By Dr Aryo Feldman
Sr. Research Coordinator
International research centre dedicated to underutilized crops
Field research centre in 49 ha ex-oil palm estate
• Largest UK University-based community of plant and crop scientists

• Ranked No 2 for Research Power

• 28 research laboratories >150 researchers
Building a Global Alliance

e.g. 32 Global, 20 national partnerships established since 2012

Crops For the Future: Global alliance for research, development and use of underutilised crops

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Four crops provide more than half of the world food

- We depend on a small number of major crops to feed over 7 billion people
- Can these major crops, by themselves, feed 9 billion people in hotter, more volatile climates?
Change in potential average yields for maize, potatoes, rice, and wheat in 2050

Source: [www.nationalgeographic.com/climate-change](http://www.nationalgeographic.com/climate-change)
‘New Crop Varieties Can’t Keep Up with Global Warming’

52% of all fertile, food-producing soils globally now degraded or severely degraded

IMPACTS OF CLIMATE CHANGE

By 2030, nine out of 10 of the major crops will experience reduced or stagnant growth rates, while average prices will increase dramatically as a result, at least in part, due to climate change.

- **Maize**: 12% growth rate decrease, 90% price increase
- **Rice**: 23% growth rate decrease, 89% price increase
- **Wheat**: 13% growth rate decrease, 75% price increase
- **Other Crops**: 8% growth rate decrease, 83% price increase

(UNCCD 2015)
SDG2: Zero Hunger

Production

Postharvest & Supply Chain

Processing

Nutrition & Functionality

Moringa oleifera

Bambara groundnut

Ambarella

Postharvest Handling Practices (PHP)

Point of intervention / Gas analysis

Crops For the Future
Traceability of nutrients through the human food chain

Improving & retaining micronutrient availability

Production  Postharvest  Processing  Bioavailability

RVC

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We must put nutrition at the heart of our food systems

- **Diversify** the global diet
- Transition from *sustenance* to *nourishment*
- Deliver an Evidence-Base for *Climate Smart Nutrition*

**RVC**

- Compositional Analysis
- Food Processing
- Functionality and Nutrition

- Recipes
- Evidence
- Cultures
- Behaviour
SDG2: Zero Hunger

- Sesbania
- Barramundi
- Black soldier fly larvae
- Moringa

‘Disruptive innovation’
- Wealth generation
- Sustainable aquaculture
- Environmental security
Novel, cost-effective Aquafeed: Black Soldier Fly and underutilised crops

**Perspective**

- Nutritional enhancement of BSF larvae fed with underutilised crops
- Feed formulation using nutritionally improved insect meal
- Feed trial using novel feed on juvenile Barramundi
- Feeding trial at adult stage to evaluate colour, texture and taste

**Impact**

- Reduced usage of FMFO/potential reduction in cost
- Processing technologies for feeds and ingredients
- Improved production performance

**Timeline**

- 12 months
Sustainable Agricultural Landscape Diversification

- Productive intercropping systems
- Improved crop models to include underutilised crops
- Expand crop models to include multicropping

Napier grass intercropped with Bambara groundnut for biomass production

Hilly land

Early plantation life - Without cover crops

Space below pylons

Upgrading bio-oil (lignocellulosic biomass) to cooking and heating fuel for rural communities
UK

Malaysia
Improving and delivering micronutrients
We need a Systems Approach to diversify agriculture
CFF research approach for nutritional security

*Testing the Research Value Chain for crop diversification: `Farm to Fork’*

“Demand-led, world quality research on underutilised crops”
Paris, 7 December, 2015
Tun Abdullah Ahmad Badawi signs Declaration on Agricultural Diversification

Global Action Plan for Agricultural Diversification (GAPAD)

Call upon States, intergovernmental organisations, and the non-government sector to diversify agriculture
Bambara Groundnut: A crop for the future

- ‘the seed that satisfies’
- Sole-crop or intercrop
- Drought tolerant & nitrogen-fixing

- Better use of water resources
- Improved nutritional security
- Resilience to shocks of climate change

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Macronutrient content of legumes (%)

- Soybean
- Kidney beans
- Cowpea
- Broad beans
- Chickpea
- Bambara groundnut
- Female RDI *
- Male RDI *

0 20 40 60 80 100

Protein Carbohydrates Fat

*Recommended daily intake: National Academy of Sciences
Food security & poverty alleviation
Research on Winged Bean (*P. tetragonolobus*)

- Investigate winged bean plant architecture, vegetative growth, and development

- Looking into how these traits are controlled, interact, and relate to productivity
Research on Winged Bean (*P. tetragonolobus*)

Molecular Markers Development (SSRs)

TTTCAGTTATTACATGCTCACTGATCTCAACAACCTTCGCAAATGCTCCCAATTT
AGGGTTTTCAAGATTGGGATTCGCCGTGTGGTTTGCGACATCCATGGCGTTCCATC
TACGCGCTGACGCAAACGTTCCGCACACCCTTCTCCGTCCGAGAATCGCT
TGCTGTGAGATTCCGGTTCTTTCTTTCTTTTCTTTCTTTCTTTCTTTCTTT
TGATTATGTGATT
TTCATCCGAGATTCCGAGAGCTGCTGCTGCCCCTTCATCATCATGATTATATT
TGATGATT**CATTGTTTTGGTGTTCAACGTGTATGATGA**

Accessions Characterisation, Controlled Crosses, Progeny Assessment

![Diagram showing molecular markers and genetic crosses](image-url)
Multi-locational field trials

Supported by EU

The International Treaty
On Plant Genetic Resources
for Food and Agriculture

Food and Agriculture
Organization of the
United Nations

Crops For the Future

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Collaboration with Green World Genetics
Global average = 1,137 kg ha\(^{-1}\)
### Farmer’s field, Pendang, Kedah

<table>
<thead>
<tr>
<th>line</th>
<th>seed no. per plant</th>
<th>seed weight (g)</th>
<th>yield (kg ha(^{-1}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bogor -1</td>
<td>42</td>
<td>0.47</td>
<td>1,196</td>
</tr>
<tr>
<td>Zebra Cream -10</td>
<td>48</td>
<td>0.36</td>
<td>1,039</td>
</tr>
<tr>
<td>Sik Farmer Red (Songkhla 1)</td>
<td>33</td>
<td>0.29</td>
<td>576</td>
</tr>
<tr>
<td>IITA 686 -13</td>
<td>31</td>
<td>0.28</td>
<td>521</td>
</tr>
<tr>
<td>Getso -5</td>
<td>12</td>
<td>0.30</td>
<td>227</td>
</tr>
<tr>
<td>Cream with brown white eye</td>
<td>10</td>
<td>0.18</td>
<td>107</td>
</tr>
</tbody>
</table>

### GWG farm, Kuala Terengganu, Terengganu

<table>
<thead>
<tr>
<th>line</th>
<th>pod no. per plant</th>
<th>seed weight (g)</th>
<th>yield (kg/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>IPB Bam6</td>
<td>78</td>
<td>0.95</td>
<td>1,489</td>
</tr>
<tr>
<td>Cikur 2.1</td>
<td>72.2</td>
<td>0.93</td>
<td>1,350</td>
</tr>
<tr>
<td>100B16ANAM-C</td>
<td>74.4</td>
<td>0.69</td>
<td>1,032</td>
</tr>
</tbody>
</table>

### GWG farm, Batu Arang, Selangor

<table>
<thead>
<tr>
<th>line</th>
<th>pod no. per plant</th>
</tr>
</thead>
<tbody>
<tr>
<td>IPB Bam6</td>
<td>35-45</td>
</tr>
<tr>
<td>Cikur 2.1</td>
<td>35-43</td>
</tr>
<tr>
<td>Songkla</td>
<td>10-15</td>
</tr>
<tr>
<td>IITA-686</td>
<td>10-15</td>
</tr>
</tbody>
</table>
Genetic diversity in bambara groundnut

Examples of phenotypic variation

IITA-686  DipC  Tiga Necaru
SSR-based genetic diversity analysis (PCA)
Genetic maps

Three populations with genetic maps so far, segregating for different traits

1. Photoperiod sensitivity
2. Growth habit (domesticated x domesticated)
3. Growth habit (domesticated x wild)

Composite linkage groups consisting of DArT, SSR and DArTseq markers; manuscript submitted to Genome
Socio, Economics and Policy

Improving livelihood of local communities

Value Chain research in Indonesia
- Assessment of co-operative model set up for BG cultivation, and production of raw material for direct commissioning of processing by the farmers, socio-economic impact on local community

End user research in sub-Saharan Africa
- Acceptance of local community towards BG as a crop, and as a food source (Ghana, Nigeria and Tanzania)
- Understanding consumption, utilisation, marketing constraints
Global research partners
List of collaborative institutions

Europe
• Mediterranean Agronomic Institute of Bari, Italy
• University of Nottingham, United Kingdom

Africa
• Ministry of Agriculture, Botswana
• University for Developmental Studies, Ghana
• Council for Scientific and Industrial Research-Crop Research Institute, Ghana
• International Institute of Tropical Agriculture, Nigeria
• University of Ibadan, Nigeria
• Tshwane University of Technology, South Africa
• University of KwaZulu Natal, South Africa
• Crop Breeding Institute, Zimbabwe

Asia
• Bogor Agricultural University, Indonesia
• University of Brawijaya, Indonesia
• Universitas Muhammadiyah Gresik, Indonesia
• University of Nottingham, Malaysia
• Kasetsart University, Thailand
• Songkhla Field Crop Research Center, Thailand

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BamNetwork - exemplar knowledge community for other underutilised crops

- Website for the international Bambara groundnut community
- Links researchers, farmers and end users for collaboration
- Future plans: File Transfer Protocol (FTP), FTP portal, data exchange, & development of a sister site for Winged bean

[www.bambaragroundnut.org](http://www.bambaragroundnut.org)
Digital Innovation

- Knowledge Platform
- Geospatial Mapping
- Diversification Analytics
- Field Data
- Fish Feed Experiments
- Domes Data
- Growth Chambers Data
CropBASE: Diversification Tool

**Input:**
- Data Entry Literature
- International Databases Integration
- Government Local Data
- Crowd Sourcing

**Main Database**

**Backup Database**

**Data Processing**

- Climate Data + Soil Data = Suitability Index

**Output:**
- Climate & Soil Suitability Map
- Crop Ranking
Climate and growth modelling

- Model predictions for crop growth in Malaysia for 2 African landraces: Uniswa Red and S19-3 with CropBASE colleagues
- Provide baseline data for future field experiments for proof of concept

See: Karunaratne et al. 2010, Agricultural and Forest Meteorology
Example: Climate change predictions for Bambara groundnut in Malaysia
Find out more at
www.cffresearch.org
www.bamyield.org
www.bambaragroundnut.org
and
Facebook, YouTube and Twitter