GE Crop Development and Deployment in Africa: Case of Pod Borer Resistant (PBR) Cowpea

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Storyline

- Cowpea & it’s production challenges
- The intervention
- Safety assessment & regulatory approval
- Stewardship & deployment
- Next steps
Cowpea (*Vigna unguiculata* L. *Walp*)

- Most economically important legume in West Africa
- World production – over 5.4 million tons of dried cowpeas with Africa producing nearly 5.2 million.
- Major food crop & source of dilatory protein ($\approx$25%), fiber and iron for over 200 million people; weaning diet for babies
- Street food in most of West and Central Africa
- Important forage crop in West/Central Africa & the Sahel
- Source of livelihoods for women
- Nitrogen-fixing & important for soil fertility
Some Cowpea based African delicacies
Challenges of Cowpea production

- Low productivity 140-400kg/ha against a potential >2000Kg/ha
- Poor agronomic practices
- Parasitic weeds
- Diseases
- Insect pest pressure in field and storage
Major Insects Pests in the Field

- **Pod Sucking Bugs** (Clavigralla spp.; Hemiptera: Coreidae)
- **Aphis craccivora** Koch; Hemiptera: Aphidae
- **Flower Thrips** (Megalurothrips sjostedti Tryborn; Thysanoptera: Thripidae)
- **M. vitrata** adult
- **M. vitrata** larvae
Types of Damage on Cowpea

- Attack on the floral part
- Typical *Maruca vitrata* attack on cowpea pods
- Attack on cowpea grain
The Legume Podborer Problem

- **Legume Podborer** (*Maruca vitrata* Fabricius; Lepidoptera: Crambidae) one of the most damaging insect pest of cowpea with yield losses as high as 80%
- No genetic resistance against maruca
- Chemical spraying: ineffective; additional production cost (6-10 sprays)
- Time wasting, drudgery, human and environmental health risks

INDUSTRY
Nigeria spends $400m annually on pesticides – Nigerian Stored Products Research Institute (NSPRI)
Published October 6, 2017
PBR Cowpea Partnership
(A Public Sector Effort)

Enhancing access of smallholder farmers in SSA to cowpea varieties with resistance to Pod Borers

Tech Provider
Bayer

Tech license

Transformation
CSIRO

AATF
Project Co-ordination

Regulatory Compliance
Communication & outreach

Field testing & Trait introgression
NARS: IAR, INERA, CSIR-SARI & Bunda

NGICA

KH Trust

DDPSC

Seed Multiplication and Distribution

F F F F F F

NARS, NGOs, Seed Co., CBO

On farm demonstration
Consumer acceptance
Seed distribution systems
Product stewardship
PBR Cowpea – Development

- Transformation Carried out at CSIRO, Australia
- Developed using *Bt-Cry1Ab* to transform the cowpea variety IT86D1010 through the use of *Ti-Agrobacterium tumefaciens* transformation system

Several events tested & **709A** was selected as lead event based on performance in the field and molecular characterization

The promising event **709A** was used to backcross the Cry1Ab into farmer’s preferred varieties
Evaluation of the efficacy of the Bt-Cry1Ab transgene to control *M. vitrata*. Plants were artificially infested with first instar neonate larvae under confined environment (20 larvae/plant & repeated 3 times from 35 days after planting); RCBD trial replicated 4 times, means are followed by their standard errors.

<table>
<thead>
<tr>
<th>Lines</th>
<th>Number of Pods/plant</th>
<th>Pod length (cm)</th>
<th>Maruca damaged Pods (%)</th>
<th>Total grain yield/plant (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>IT97KT (PBR)</td>
<td>21 ± 2</td>
<td>14.5 ± 0.5</td>
<td>0.0 ± 0.0</td>
<td>23.6 ± 2.3</td>
</tr>
<tr>
<td>IT97KN</td>
<td>10 ± 2</td>
<td>8.3 ± 0.5</td>
<td>15.7 ± 4.5</td>
<td>13.2 ± 2.2</td>
</tr>
</tbody>
</table>

1. 10 pods per plant were measured
2. Differences were highly significant according to the paired t-test, p<0.01
Comparison of the grain yield performance of PBR-Cowpea with the grain yields of two conventional cowpea in farmers managed trials in three localities in Nigeria; in each six farmers were selected to conduct the trial so that each farmer constitutes a block.

<table>
<thead>
<tr>
<th>Lines</th>
<th>Localities</th>
<th>Minjibir (Kano State)</th>
<th>Bakura (Zamfara State)</th>
<th>Zaria (Kaduna State)</th>
</tr>
</thead>
<tbody>
<tr>
<td>IT97KT (PBR)</td>
<td></td>
<td>1061.1&lt;sup&gt;a&lt;/sup&gt;</td>
<td>584.4&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2999.3&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Sampe10</td>
<td></td>
<td>79.0&lt;sup&gt;b&lt;/sup&gt;</td>
<td>283.3&lt;sup&gt;b&lt;/sup&gt;</td>
<td>796.1&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Local</td>
<td></td>
<td>0.0&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.0&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.0&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

Friedman nonparametric test was used to analyze the data, and the tukey mean separation test was used to separate the means. Means followed by the same letters are not significantly different at 0.05 level.
Pod-Borer Resistant Cowpea evaluations

In confined-agronomic or confined farmers managed field trials the PBR-cowpea consistently gave higher grain yields (20-80%) than the conventional cowpea variety while it reduced the need for insecticidal sprays from 6-10 times to 2.
Molecular characterization

- Introduced DNA present at a *single insertion site* of the T-DNA region derived from plasmid pMB4 that was stably inherited over multiple generations as a single genetic locus according to Mendelian rules of inheritance.
- The inserted DNA was comprised of *one complete copy* of the plasmid pMB4 T-DNA
- The *site of insertion* of the T-DNA was mapped to a region on chromosome 2 of the cowpea genome
- *No vector backbone*
Food and Feed Safety Assessment

- Proximate: Grains, Leaves and fodder
  - No significant difference between GM and non-GM (P > 0.1)
- Mineral Composition
  - No significant difference between GM and non-GM (P > 0.1)
- Phytic acid
  - No significant difference between GM and non-GM (P > 0.7)
- The genes are not similar to any gene(s) known to cause allergenicity
- Cry1Ab and NPTII proteins are unlikely to be toxic or allergenic to humans or animals
- Gene has long history of safe use in many crops (over 20 years)
Environmental Safety Assessment

• Field comparisons did not identify any significant differences that would indicate any unintended change in the *weediness* or *invasiveness* of conventional cowpea cultivars.

• *Gene flow* between domesticated and wild cowpea does occur, but does not represent hazards to the environment, human or animal health, or biodiversity.

• PBR cowpea does not display any altered plant pest potential.

• PBR cowpea will not result in altered impacts on *non-target organisms*, except for the target lepidopteran insect species (e.g., *Maruca vitrata*).
Regulatory Approval for PBR Cowpea (a significant milestone in Africa)

- The regulatory dossier for commercial release of the PBR cowpea (event AAT-709AA-4) in Nigeria was prepared and submitted to the Nigeria NBMA.
- Review process was carefully managed and permit was issued.
Important Considerations Around PBR

Cowpea Stewardship

- Smallholders context – < Acre farm sizes, seed saving, seed mixing, compliance, etc
- Resistance management – IRM plan
- Other insects exists – IPM plan
- Monitoring – Post release monitoring
Stewardship & IRM Plans were developed

Highlights on IRM requirements:

• Village or community level refuge
• Non-Bt cowpea serving as a refuge must be located within 400m of the field planted with Bt cowpea
• Seed mixtures of $Bt$ and non-$Bt$ cowpea are not permitted.
• The refuge and $Bt$. cowpea must be of similar maturity.
Stakeholders education for proper use of product

- Product profile
- Technology use guide
- Level of control to expect
- “Unexpected damage”
- Dealing with groups with contrasting views - anti-GM activists
- Refuge requirement
- Village-level training on IRM
Deployment Activities - Nigeria

**Variety registration & release (December 2019)**
- NPTs (27 on-farm; 16 on-station)
- Variety registration & release committee to meet in December 2019

**Seed Production**
- Sub-licensing agreement for production of foundation seed signed & foundation seed production ongoing
- Negotiation with seed companies for certified seed production ongoing
- Training on stewardship requirements ongoing
- Commercial cultivation planned for July 2020

**Seed Certification by NASC**
- Breeder seeds certified
- Foundation seeds planted by a seed company & currently undergoing certification
- Certified seeds – to be planted
Next Steps …

• Deregulation – Ghana & Burkina Faso

• New cowpea with pyramided modes of action (Cry1Ab+Cry2Ab) is actively underway and the first products may be available within five years

• Commercial licensing agreements with seed companies

• Implement Commercialization plan

• Implement Stewardship and IRM plans
Lessons

• The NBMA Act 2015 allows NBMA to make the final decision – this reduced political interference
• Pragmatic partnership is fundamental
• Stakeholder engagement must be pre-emptive
• Proactive public awareness where the biotech developer sets or re-sets the agenda is expedient
• Communication has to be strategic – e.g. segmented to tactically address the concerns of each target group.
Acknowledgement
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Ndeewo nu !!

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