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SCOPE OF THIS STUDY

Study Methodology

• Over 60 sector interviews with experts, agencies, NGOs, farmers, traders and companies
• Interviewed personnel at all levels of the value chain

Stakeholder Interviews

Hypotheses Confirmation

• Confirmed the value of identified interventions
• Refined interventions to address key constraints

• Integration of desk study findings with field research
• Estimated impact of interventions based on results of on-the-ground interviews
• Vetted potential partners for identified interventions

Analysis

Key Deliverables include:

• Situational assessment of crop constraints, detailed market maps and in-depth value chain analysis to verify Phase I findings and refine recommended interventions
• Recommended refinements and focus for interventions
• Assessment of impact for key interventions at the SHF level
• Results of partner identification and vetting analysis
• Plantains are the third most important crop in Ghana by production (FAO, 2014) behind Cassava and Yams, and considered to be in the top four staples for the country.
• Ghana is the world’s largest producer of plantains, accounting for over 3.5 million MT.
• Plantains are farmed on 337,000 Ha where average farm sizes are around 0.8 Ha, placing estimates for total households farming plantains at over 400,000.
• One hectare of plantain is also estimated to account for 0.75 full time laborer equivalent.

• Macro-propagation techniques (PIBS) offer a promising opportunity for rapid and inexpensive multiplication of clean planting materials.
• Plantain experiences large post-production losses (30%+), but has better processing characteristics than other cooking banana varieties.
• Eliminating perishability and bulk challenges by localizing dryers and building processor capacity will grow alternative markets for plantains and reduce surpluses.

• Interventions have been refined to focus on access to clean planting materials (CPM) via macro propagation, localizing drying facilities, and market development and organization.
• Plantain has strong processing characteristics and building a strong value-added products sector is integral to addressing wastage, and developing the market.
• Access to clean planting material will help improve on-farm yields.
• Building capacity with processors and organizing markets will improve demand.

• There are few public sector partner candidates, and no ongoing plantain programs; private sector companies round out the list of potential partners:
  • Clean Planting Material – CSIR-CRI (Dr. Dzomeku), Biochemical Products, CLP II
  • Localizing Dryers – CSIR-FRI, AgDevCo, DADTCO, Neat Fufu, Elsa Foods
  • Market Development – AGRA (FOSCA), CSIR-FRI, Freshpac Ltd., Amanfrom Farms
1 SECTOR FUNDAMENTALS
PHASE 2 GHANA PLANTAIN EXECUTIVE SUMMARY

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     - Market Development – AGRA (FOSCA), CSIR-FRI, Freshpac Ltd., Amanfrom Farms
GHANA IS THE LARGEST PRODUCER OF PLANTAINS IN THE WORLD, BUT HAS NEGLIGIBLE FRESH MARKET EXPORTS

**Global Comparison of Top Plantain Producers**

### Production of Plantain (2012)

- Ghana: 3.6 Million MT
- Cameroon: 3.5 Million MT
- Colombia: 3.3 Million MT
- Rwanda: 3.2 Million MT
- Nigeria: 2.8 Million MT
- Peru: 2.0 Million MT
- Côte d’Ivoire: 1.6 Million MT
- Myanmar: 1.0 Million MT

### Value of Plantain (2012)

- Ghana: $734
- Cameroon: $712
- Colombia: $617
- Rwanda: $665
- Nigeria: $578
- Peru: $413
- Côte d’Ivoire: $326
- Myanmar: $206

**Key Plantain Facts**

- Plantains grow particularly well in West African agro-climatic conditions.
- As a result, four of the top eight producers are in West Africa (Ghana, Cameroon, Nigeria, and Côte d’Ivoire).
- African countries account for the majority of global production (62% of total plantain production).
- Ghana is the largest producer of plantains in the world, growing over 3.5 million MT (≈13% of global production).
- Combined exports of plantain from Africa are barely one tenth of one percent of the global export market.

1 FAOSTAT, 2012
GHANA NATIONAL PRODUCTION IS 3.6 MILLION TONS, GROWN ON OVER 300,000 HECTARES

Global Comparison

Production Statistics for Select Food Crops in Ghana

Area Planted (2012)

<table>
<thead>
<tr>
<th>Crop</th>
<th>Thousand Ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maize</td>
<td>1,042</td>
</tr>
<tr>
<td>Cassava</td>
<td>869</td>
</tr>
<tr>
<td>Yam</td>
<td>426</td>
</tr>
<tr>
<td>Plantain</td>
<td>337</td>
</tr>
<tr>
<td>Sorghum</td>
<td>231</td>
</tr>
<tr>
<td>Cocoyam</td>
<td>196</td>
</tr>
<tr>
<td>Rice</td>
<td>189</td>
</tr>
<tr>
<td>Millet</td>
<td>172</td>
</tr>
</tbody>
</table>

Production (2012)

<table>
<thead>
<tr>
<th>Crop</th>
<th>Thousand MT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maize</td>
<td>1,950</td>
</tr>
<tr>
<td>Cassava</td>
<td>14,547</td>
</tr>
<tr>
<td>Yam</td>
<td>6,639</td>
</tr>
<tr>
<td>Plantain</td>
<td>3,556</td>
</tr>
<tr>
<td>Sorghum</td>
<td>280</td>
</tr>
<tr>
<td>Cocoyam</td>
<td>1,270</td>
</tr>
<tr>
<td>Rice</td>
<td>332</td>
</tr>
<tr>
<td>Millet</td>
<td>180</td>
</tr>
</tbody>
</table>

Plantain production (and subsistence consumption) is concentrated in the Southern regions of Ghana where over 50% of the population resides.

1 FAOSTAT, 2012
IN GHANA, PLANTAIN HAS SIGNIFICANT SOCIOECONOMIC IMPORTANCE AS A PRIMARY SOURCE OF BOTH FOOD AND INCOME

**Total Population:** 25,700,000 (2014)
**Avg. Family Size:** 4-5 persons
**Total SHF HHs:** 2,800,000
**SHFs (Plantain HHs):** 400,000+
**% of SHFs:** 14%

**Total Land:** 22,754,000 Ha
**Arable Land:** 3,950,000 Ha
**Land Under Plantain:** 337,000 Ha
**% of Arable Land:** 8.5%

**Total Production:** 3,556,000 tons
**# of SHFs (Plantain):** 400,000+ SHFs
**Total Area (Plantain):** 337,000 Ha
**Avg. Farm Size:** 0.8 Ha
**Yield per Ha:** 10.5 tons/Ha

Farmers: Context Network Analysis from aggregated primary and published source research findings
Crop: FAOSTAT; "Socioeconomic Importance of Plantain Cultivation in Ghana", The Journal of Animal and Plant Sciences; B. M. Dzomeku; 2011
Several plantain programs focused on improving crop practices and disseminating Sigatoka-tolerant planting materials (FHIA-21) ran consecutively from 2000-2008. (Refer to Appendix 3 for full details.)

Between 2003 and 2009 plantain yields rose significantly from about 8 T/Ha to 11 T/Ha – a 35% increase.

Since 2009, increasing area has once again become the primary contributing factor to production growth, accounting for 53% of total production increases, while yields have declined marginally to about 10.5 T/Ha.
PLANTAIN IS REGULARLY INTERCROPPED WITH OTHER IMPORTANT CASH AND FOOD CROPS

The most common intercropping for plantain is with cocoa. The young cocoa plants benefit from a shade canopy that plantains can provide. During the three years it takes for cocoa to mature, plantain accounts for the majority of income, after which cocoa takes the lead. Plantain is then gradually phased out.

Plantain and cassava is another common intercropping pairing. Both are reliable food security crops, and are often eaten together. Fufu is a popular local dish made by mashing fresh plantain and cassava. It is a staple food product for rural farmers and national favorite as well.

The third system that is widespread in Ghana, is growing plantain with cocoyam (taro). Often this is in conjunction with cocoa farming as well. While the cocoa is young, plantain and cocoyam are grown together. As the cocoa matures, cocoyam and plantains are pushed to the periphery.

OPPORTUNITY
Work with the cocoa growers assn. to fund TC / commercial macro-propagation for farmers

OPPORTUNITY
Outgrower farmers for fufu flour can handle both crops
PLANTAIN IS A PRIMARY STAPLE CROP AND IMPORTANT SOURCE OF RURAL INCOME, ACCOUNTING FOR AS MUCH AS 50% OF FARM REVENUE

Ghana Market Share
(by Usage)\(^1\)
3.6 Million MT Production

- Eaten On-Farm: 20%
- Fresh Market: 70%
- Chips: 8%
- Flour: 2%

- Plantain is an important co-staple food crop in Ghana, but due to yields and farm sizes, the majority is sold fresh.
- For rural farmers, plantain is important in many local dishes: fufu, ampesi, red red, kelewele, and roasted fresh.
- Processing still represents a small portion of total production (\(\approx 10\%)\).
- Processed goods for plantains are primarily chips and flour.
- Chips can be made from green or ripe fruits and are sold along roadsides, in vendor stalls, and at urban retailers.
- Plantain flour can be used for a variety of products: baked goods, baby formula, box mixes, but is primarily for fufu flour.
- These estimates do not take into account wastage or on-farm losses.

\(^1\) Source: Context Network analysis based on field research and farmer interviews
While plantain provides food security for rural farmers, the majority of production is sold vs. consumed on-farm.

20% on-farm consumption

In Ghana, average consumption per person is estimated to be **85kg per year**.\(^1\)

Roughly **710,000 MT** is consumed on farm in local dishes such as fufu, ampesi, and kelewele.

<table>
<thead>
<tr>
<th>Compound Production</th>
<th>Bush or Complex System</th>
<th>Plantation Farming</th>
<th>Plantain / Cocoa Intercropping</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Consume 100% of plantain production</td>
<td>• Consume ~20% of production, depending on season, size and system</td>
<td>• Consume 5-15% of production</td>
<td></td>
</tr>
<tr>
<td>• Small area devoted to plantain, grown around the compound or homestead</td>
<td>• Complex mixture inter-cropped with cassava, cocoyam, maize, etc.</td>
<td>• Typically mono-cropped with higher yields and a large surplus to sell</td>
<td></td>
</tr>
<tr>
<td>• Traditional methods, low yields, minimal land prep and maintenance</td>
<td>• Sell surplus for extra income</td>
<td>• Better access to markets, some use of inputs and improved farming practices</td>
<td></td>
</tr>
</tbody>
</table>

\(^1\) “Agriculture in Ghana – Facts and Figures 2012”, Ministry of Agriculture/SRID, August 2013
FRESH MARKET IS PRIMARY SALES CHANNEL FOR PLANTAIN; IN GHANA, VALUE CHAIN TIGHTLY CONTROLLED POST-FARMGATE

Plantain in Ghana

- On-farm consumption varies, but is usually far surpassed by the amount of production sold to the fresh market. Differences in consumption patterns are caused by size of family, crop systems, land size, etc.
- In total, **2.5 million MT** of plantains are sold into the fresh market and bought in local, regional or urban markets and a variety of retail locations.
- Beyond farmgate, the value chain has been liberalized, but due to lack of regulation, is run like a cartel by market queens at the organized markets.¹
- The majority of plantain production comes from farmers with small landholdings and large families – they are price takers with little power.¹

MS. SYLVIA ABENA SEDUA
Vendor, Ejisu Market

- Purchases in small batches from farmers in Sanse (30km away)
- Hires labor and vehicle to bring them to market in Ejisu
- Sells about 400¢ ($110) in volume daily
- After stall taxes of 4¢ daily, she ends up with about 20-30¢ in profit ($5-8)

OPPORTUNITY
Develop relationships between market queens² and farmer groups to guarantee market supply and reduce on-farm waste for farmers (estimated @ 30%)

¹ “Socioeconomic Importance of Plantain Cultivation in Ghana”; The Journal of Animal and Plant Sciences; B. M. Dzomeku; 2011
² Market Queens (MQs) run the more organized regional and urban markets, determining who can sell, what quantity they can sell, and price ranges. They also organize middle women (MW), manage vendors and work with traders associations.
STRONG DEMAND FOR PLANTAIN CHIPS, BUT PROCESSING EFFORTS ARE NOT ORGANIZED ENOUGH TO SERVE EXPORT MARKETS

Chips are a Popular Snack

- **Price:** 1¢ Year-round (roadside price)
- **Size:** Varies (more in high season)
- **Type:** Green/Salty and Ripe/Sweet
  - Shelf life of 2-4 weeks (better packaging gets longer life)
  - Sweet chips are more popular with kids; salty is preferred type for adults
  - Some vendors sell year-round, others operate seasonally
  - Price is uniform for ease of transactions, bag size will vary by season/cost

Processing Efforts are Small-Scale and Fragmented

- **Smallest processors** are housewives operating seasonally and using household labor for chip preparation.
- **Mid-size players** operate year-round, but still buy from markets (not farmers), have limited access to credit via microfinance.
- **Larger companies** have a flexible labor pool, dedicated vendors, and source from farmers, BUT have difficulty meeting export order size and consistency demands.

OPPORTUNITY
Organize chip processors into associations; conduct business training and build capacity; link to export markets
FUFU FLOUR OFFERS CONVENIENT ALTERNATIVE AND MAY ACTUALLY BE CHEAPER THAN HOMEMADE FUFU IN LOW SEASON

**Quick Facts**
- Unit Size: 700g
- Price Range: 9-11¢ (retail)
- Ingredients: Plantain (60%) Cassava (40%) (optional) Potato Starch (10%)
- Stores: Large (ex: Shoprite); Small (ex: gas stations)
- Other: Export Markets

**Benefits**
- Convenience (Time and Effort)
- Minimal Taste Difference
- On-Trend (Growing Urban, Middle-Class, etc.)
- Relatively Cheaper during Low Season

**Seasonal Variation in Fufu Cost**

**Target Market:** Urban, Middle Income Families; Working Singles; Dual-Income HHs; Select Institutional Markets

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1. “Socioeconomic Importance of Plantain Cultivation in Ghana”; The Journal of Animal and Plant Sciences; B. M. Dzomeku; 2011
2. Assumptions for Home Cost #1 and #2 include pulp cost adjustment, labor cost equivalent, and different price increase scenarios.
BLACK SIGATOKA REPRESENTS THE LARGEST DISEASE CONSTRAINT FOR PLANTAIN IN GHANA; DISEASE-FREE CLONES ARE FOCUS SOLUTION

Black Sigatoka (BLSV)

Improved practices (de-leafing, irrigation, spraying) can reduce the impact of the disease, but are cost prohibitive. Several resistant hybrids have proved genetically unstable.\(^1\) FHIA-21 exhibits tolerance and acceptable sensory attributes.

Black Leaf Streak Virus\(^1\) vectored by Black Sigatoka

Macro-Propagated Clones are Promising

- Black Sigatoka is major constraint across West Africa as all land races are highly susceptible.
- Research indicates that yield losses on poor soil in West Africa is 33% and 76% for first and second cycle respectively.\(^2\)
- Micro-propagation efforts are still nascent and very costly.
- New research on macro-propagation multiplication rates and cost model is extremely promising.
- One small humidity chamber (2sqm) can multiply 4-10,000 disease-free suckers in 3.5 months.


\(^3\) Demonstration at Crop Research Institute in Kumasi, Ghana
FHIA-21 VARIETY IS HIGHER YIELDING, SIGATOKA TOLERANT AND HIGHLY RATED BY CONSUMERS; REPRESENTS PROCESSING OPPORTUNITY

FHIA-21 is a high-yielding, French plantain-type hybrid, resistant to Black Sigatoka

- Honduras Foundation for Agricultural Research (Fundación Hondureña de Investigación Agrícola or FHIA) is a not-for-profit research facility which seeks to develop new disease-resistant breeds of banana and plantain.
- FHIA-21 is a French plantain-type hybrid produced in 1987. Most agronomic characteristics of FHIA-21 are very similar to those of False Horne plantain.
- When tested against local varieties for sensory experience, FHIA-21 was rated equally (i.e. good substitute).¹

FHIA Benefits²

+ Tolerant to Black Sigatoka
+ Resistant to Fusarium Wilt (TR1/2)
+ Large Bunches (22-27kg; max of 35kg)
+ Yield about Double to False Horn
+ Excellent Processing Qualities (easier to peel than False Horn)
+ Short Plant: 3.5-4m (less lodging)
- Shorter “Green Life” (more perishable post harvest than False Horn)
- Bruises Easily (large bunches should be transported in hands to reduce effect)
- Susceptible to Nematodes

Increased Yields up to 100%³

¹ “Comparative Study on the Agronomic, Nutritional Values, and Consumer Acceptability of FHIA-21 in Ghana”; B.M. Dzomeku et. al.; 2008
³ ProMusa Information Forum Profile of FHIA-21, http://www.promusa.org/FHIA-21
LIMITED ACCESS TO CREDIT, POOR RESEARCH LINKAGES AND COLLUSIVE VALUE CHAIN PLAYERS HAMPER MARKETS

Constraints in the enabling environment and infrastructure

- National roads are good, but coverage is limited to main thoroughfares and regional connection highways.
- Roads in more rural areas where the majority of plantains are grown are not as extensive or well-paved.
- Electronic market information systems are not readily available for market pricing on plantains.

Unreliable

- Redundant testing and certification requirements for processed goods adds costly and time-consuming steps for new processors (three tests per product, done at the same lab).
- Minimal protection for exports and sea freight; shipment delays due to inefficiency or corruption represent additional risk.
- Government program for bananas, not plantains, which only account for 2% of combined production.

Restrictive/Unhelpful

Infrastructure

Business and Finance Environment

Industry Bodies and Sector Policies

Research and Extension Services

Constrained

- Access to finance is extremely poor for individual farmers; bank rates are excessively high as well (30%+).
- Informal credit is often required by middle-women, aggregators, vendors and Market Queens, further reducing farmer profit and selling power.
- Cultural aversion to contract-based business dealings leads to additional risk for serious players.

Needs Better Linkage

- Crop Research Institute has developed extremely promising macropropagation techniques for multipliers and farmers.
- CRI breeding programs are working on Sigatoka tolerant varieties; have completed acceptance research on FHIA-21 which is the most successful tolerant type currently.
- Extension services are virtually non-existent for plantains; there are currently no ongoing programs in the sector.
Value Chain Opportunities
PHASE 2 GHANA PLANTAIN EXECUTIVE SUMMARY

1 SECTOR FUNDAMENTALS

- Plantains are the third most important crop in Ghana by production (FAO, 2014) behind Cassava and Yams, and considered to be in the top four staples for the country.
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  - Localizing Dryers – CSIR-FRI, AgDevCo, DADTCO, Neat Fufu, Elsa Foods
  - Market Development – AGRA (FOSCA), CSIR-FRI, Freshpac Ltd., Amanfrom Farms
TOTAL PLANTAIN PRODUCTION IS OVER 3.5 MILLION MT; EVEN AS A STAPLE CROP, 80% IS SOLD VS. 20% CONSUMED ON-FARM

Ghana Plantain Subsector Map
Pathways mapped by relative levels of volume

PRODUCTION
Farmers → 80% Sold (2.85 MMT)

COLLECTION
Middle Women → Village Traders

WHOLESALE/AG REGREGATION
Wholesalers / Aggregators / Market Queens → Processors

RETAIL
Rural Retail → Market Vendors

CONSUMERS
Urban (Fresh) Hhss → HHs, Hotels / Restaurants, Institutions

Urban Retail → Processed

Rural Consumers → HHs

Source: Context Network analysis based primarily on value chain interviews.
1 Banana and Plantain Value Chain: West Africa; Evans School of Policy Analysis and Research (EPAR); Prof. Leigh Anderson et al.; August, 2013
2 “Socioeconomic Importance of Plantain Cultivation in Ghana”; The Journal of Animal and Plant Sciences; B. M. Dzomeku et al.; 2011
**SEGMENTATION FOR PLANTAINS IS BASED ON MAJOR FARMING SYSTEMS EMPLOYED IN GHANA; VARIATION WITHIN SYSTEMS REMAINS HIGH**

**CONTEXT NETWORK ESTIMATES**

<table>
<thead>
<tr>
<th>Cultivation Methods/ Farming Systems¹</th>
<th>Total # SHFs</th>
<th>Avg. Size of Farm</th>
<th>Agronomic Practices</th>
<th>Total Amt. Produced</th>
<th>Consumed / Sold</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plantation Farming</td>
<td>&lt;1% (1,000)</td>
<td>&gt;3 Ha</td>
<td>High Input</td>
<td>70-90 MT (14-18 T/Ha)</td>
<td>&lt;1/99% ≤80T sold</td>
</tr>
<tr>
<td>Plantain/Cocoa Intercrop</td>
<td>15% (60,000)</td>
<td>1-3 Ha</td>
<td>Low Input</td>
<td>16-20 MT (8-10 T/Ha)</td>
<td>10/90% ≤16T sold</td>
</tr>
<tr>
<td>Compound Production System*</td>
<td>25% (99,000)</td>
<td>&lt;0.2 Ha (&lt;half acre)</td>
<td>Traditional</td>
<td>0.8-1.0 MT (8-10 T/Ha)</td>
<td>100/0% none sold</td>
</tr>
<tr>
<td>Bush Farming/ Complex System</td>
<td>60% (240,000)</td>
<td>0.5-1 Ha</td>
<td>Traditional/ Low Input</td>
<td>8.0-11.2 MT (10-14 T/Ha)</td>
<td>20/80% ≤7.6T sold</td>
</tr>
</tbody>
</table>

*Source: Context Network Research and Analysis, September, 2014

NOTE: “Consumed/Sold” amounts are estimates based on consumption ranges gathered in primary farmer interviews. These were combined with information from additional industry average plantain consumption per person and production estimates to provide a reality check on first hand perspective.

*Bananas and plantains are grown in various convenient points around a compound or homestead.

1 Banana and Plantain Value Chain: West Africa; Evans School of Policy Analysis and Research (EPAR); Prof. Leigh Anderson et al.; August, 2013
INPUT AND PRODUCTION CONSTRAINTS REDUCE ACTUAL YIELDS, BUT FARMERS CITE MARKETS AS THE LARGEST CURRENT CHALLENGE

Major constraints along the value chain

**Clean planting material** – pest and disease pressure increase in vegetatively propagated plantain plantations

**Mulching is not practiced** – lack of available materials, cost, and labor requirements constrain mulching practice

**Low fertilizer usage** – minimal composting and manure; poultry manure is used in some low input systems

**Staking** – lodging (due to heavy winds at time of fruiting) can wipe out crop without proper staking

**Processors far from production areas** (high transport cost and wastage from ripening/bruising)

**Consistency and source of supply** are issues due to seasonal volatility and side selling

**High capital investment required for processing at scale**

**Strong and growing demand for plantain products; still developing, but increasingly sophisticated players**

**Labor** – plot mgmt. requires intensive labor; cost for moving bunches to roadside to sell (borne by farmers, not traders)

**Water** – need to do water harvesting or be in a high rainfall area, yields decline and increase in disease susceptibility

**Crop and Disease Management** – de-leafing (both dead and diseased leaves), de-suckering, weeding, disposal

**Demand for plantains is strong**

**High Transportation Costs** – perishable and bulky

**“Market Queens”** – tightly control who is allowed to sell and at what price; farmers often forced to sell on informal credit

**Numerous middle-women, aggregators and wholesalers**
MACRO-PROPAGATION OFFERS SIGNIFICANT YIELD IMPROVEMENT, ESPECIALLY WHEN COUPLED WITH THE FHIA-21 HYBRID

Potential Benefits of Macro-Propagation

Pest-Free
- Cleaning techniques for removing nematodes resulted in a 60% increase in yield in the first cycle in on-farm trials.²
- Short plantation life in Ghana means that weevil impact can be dramatically reduced with clean planting materials.³

Improved Varieties
- FHIA-21 has a higher tolerance for Black Sigatoka than traditional cultivars. As a result, yields are twice as high in field trials.⁴
- Research showed that there was no significant difference between FHIA-21 and apantu in comparative sensory evaluations.⁵
- FHIA-21 is also shorter in height, and wider in girth, which makes it less susceptible to lodging.

Additional Revenue Stream
- For farmer multipliers.

1 "Nematode pests of plantain: A case study of Ashanti and Brong Ahafo regions of Ghana"; Dr. Osei et al.; January 2013
3 9% to 48% yield reduction from plant crop to third ratoon crop in plantain. (Encyclopedia of Entymology, Springer, 2008)
4 “Agronomic and Physio-Chemical Evaluation of FHIA-21 in Ghana”; CSIR-CRI, Dr. Dzomeku et al.; 2007
5 “On-Farm Evaluation and Consumer Acceptability Study of Selected Tetraploid Musa Hybrid in Ghana”; CSRI-CRI, Dr. Dzomeku et al.; 2008
CROP RESEARCH INSTITUTE HAS DEVELOPED MACRO-PROPAGATION UNITS SIZED FOR MULTIPLIER SALES AND ON-FARM USE

**Multiplication Timeline**

1. **Clean & Prep Explant**
2. **Explant Incubation** (3 weeks)
3. **Sucker Harvesting** (5 weeks)
4. **Bagging & Hardening** (6 weeks)

3.5 months for 60-80x multiplication rate

**Dimensions:** 2m x 1m (2sqm)
- **Explants:** 100 (@ 0.5kg per explant), 72 (@ 1.0kg per explant)
- **Output:** 15-20 suckers per week (x4)
- **60-80x multiple (max 100x)**
- **24,000-32,000 suckers** (indicated max is 40,000)
- **Cost:** 86¢ (approx. $23.25)

**NOTE:** ¢ stands Ghanaian Cedis

**Dimensions:** 2.5m x 4m (10sqm)
- **Explants:** 400+
- **Output:** 15-20 suckers per week (x4)
- **60-80x multiple (max 100x)**
- **24,000-32,000 suckers** (indicated max is 40,000)
- **Cost:** 1,129¢ (approx. $305)

**NOTE:** ¢ stands Ghanaian Cedis

Multiplication chambers designed for different purposes: Mini Chamber for on-farm replanting, expansion of fields, and some community sales; Medium Chamber is for farmers or individuals interested in semi-commercial multiplication.

---

1 Demonstration and Commentary by Dr. Beloved Dzomeku; Crop Research Institute (CRI); Kumasi, Ghana; July 2014
MINI CHAMBER USES LOCAL MATERIALS TO ACHIEVE MINIMUM COST; MEDIUM CHAMBER PROVIDES SCALE AND DURABILITY

### Mini Chamber

**Higher Cost, More Plantlets, Increased Durability**

<table>
<thead>
<tr>
<th>Item</th>
<th>Detail</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sawdust</td>
<td>6x 50kg bags</td>
<td>No cost</td>
</tr>
<tr>
<td>Polysheets</td>
<td>2x 8mx16m sheets</td>
<td>20¢</td>
</tr>
<tr>
<td>Blocks</td>
<td>12x @ 1.5c apiece</td>
<td>18¢</td>
</tr>
<tr>
<td>Fork Sticks</td>
<td>6x</td>
<td>No cost</td>
</tr>
<tr>
<td>Long Poles</td>
<td>3x</td>
<td>No cost</td>
</tr>
<tr>
<td>Machetes</td>
<td>1x</td>
<td>6¢</td>
</tr>
<tr>
<td>Knives</td>
<td>1x</td>
<td>6¢</td>
</tr>
<tr>
<td>Twine</td>
<td>---</td>
<td>6¢</td>
</tr>
<tr>
<td>Water Cans</td>
<td>2x</td>
<td>30¢</td>
</tr>
<tr>
<td><strong>TOTAL COST</strong></td>
<td></td>
<td><strong>86¢ ($24)</strong></td>
</tr>
</tbody>
</table>

**NOTE:** 1¢ (GHS) = $0.27 (USD)

### Medium Chamber

<table>
<thead>
<tr>
<th>Item</th>
<th>Detail</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metal Frame</td>
<td>1x</td>
<td>600¢</td>
</tr>
<tr>
<td>Polysheets</td>
<td>30x 8mx16m sheets</td>
<td>300¢</td>
</tr>
<tr>
<td>Blocks</td>
<td>52x @ 1.5c apiece</td>
<td>78¢</td>
</tr>
<tr>
<td>Sawdust</td>
<td>6x 50kg bags</td>
<td>No cost</td>
</tr>
<tr>
<td>Knives</td>
<td>1x</td>
<td>6¢</td>
</tr>
<tr>
<td>Twine</td>
<td>---</td>
<td>15¢</td>
</tr>
<tr>
<td>Water Cans</td>
<td>2x</td>
<td>30¢</td>
</tr>
<tr>
<td>Transport</td>
<td>---</td>
<td>50¢</td>
</tr>
<tr>
<td>Labor</td>
<td>---</td>
<td>50¢</td>
</tr>
<tr>
<td><strong>TOTAL COST</strong></td>
<td></td>
<td><strong>1,129¢ ($305)</strong></td>
</tr>
</tbody>
</table>

**NOTE:** 1¢ (GHS) = $0.27 (USD)

**Assumptions:** Sawdust is readily available and usually for free (mills are eager to dispose of it); frame for mini chamber can be assembled from sticks and poles; sandcrete blocks and polysheets are universally available.

1 Cost Details provided by Dr. Beloved Dzomeku; Crop Research Institute (CRI); Kumasi, Ghana; July 2014
THE CRI METHOD OF MACROPROPAGATION COULD GENERATE LARGE NUMBERS OF CLEAN PLANTLETS, ON-FARM, AND AT LOW COST

Hardening
• After harvesting the new suckers from the explants, they must be placed in bags of sterile loamy soil.
• Hardening commonly occurs under sophisticated netting, but 60% shade is the only requirement.
• After six (6) weeks in the bags, the plantlets are ready to be sold.

<table>
<thead>
<tr>
<th>Item</th>
<th>Detail</th>
<th>Cost¹ (per 1,000)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shade Structure</td>
<td>One or more</td>
<td>No cost</td>
</tr>
<tr>
<td>Plastic Bags</td>
<td>Roll of 100 @ 1-2¢</td>
<td>15¢</td>
</tr>
<tr>
<td>Sterile Soil</td>
<td>1 load @ 150¢ (fills 3,500 bags)</td>
<td>43¢</td>
</tr>
<tr>
<td>Labor</td>
<td>Various Tasks (=10 days @ 15¢/d)</td>
<td>154¢</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td><strong>212¢ ($57)</strong></td>
</tr>
</tbody>
</table>

NOTE: ¢ stands Ghanaian Cedis

ASSUMPTIONS

<table>
<thead>
<tr>
<th>Chamber Cost</th>
<th>Mini Chamber</th>
<th>Medium Chamber</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suckers (#)</td>
<td>7,500</td>
<td>30,000</td>
</tr>
<tr>
<td>Hardening Cost</td>
<td>$210²</td>
<td>$756²</td>
</tr>
<tr>
<td>Healthy + Sold</td>
<td>61%³</td>
<td>72%⁴</td>
</tr>
<tr>
<td>Revenue</td>
<td>$622</td>
<td>$2,919</td>
</tr>
<tr>
<td><strong>Net Profit</strong></td>
<td><strong>$388</strong></td>
<td><strong>$1,858</strong></td>
</tr>
<tr>
<td>Profit Margin</td>
<td>62%</td>
<td>64%</td>
</tr>
</tbody>
</table>

Multiplication Rate by Plantain Variety⁵ (using PIBS method)

<table>
<thead>
<tr>
<th>Variety</th>
<th>Average # of Suckers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asamienu</td>
<td>92</td>
</tr>
<tr>
<td>FHIA-21</td>
<td>86</td>
</tr>
<tr>
<td>Apantu</td>
<td>75</td>
</tr>
<tr>
<td>Oniaba</td>
<td>24</td>
</tr>
</tbody>
</table>

Profit Margin:
- Asamienu: 62%
- FHIA-21: 64%
- Apantu: 64%
- Oniaba: 24%

1 Cost Details provided by Dr. Beloved Dzomeku; Crop Research Institute (CRI); Kumasi, Ghana; July 2014
2 Assumes hired labor and 15% economies of scale beyond 10,000 suckers; ³⁴ 90% healthy plantlets, 80% sold, and mini chamber uses 1,000 on-farm
5 “Response of Selected Local Plantain Cultivars to PIBS (Plants Issus de Bourgeons Secondaires) Technique”, CSIR/CRI, Dr. B.M. Dzomeku; 2014
PLANTAIN FARMING IS AN IMPORTANT SOURCE OF RURAL INCOME AND, DUE TO LABOR REQUIREMENTS, JOBS AS WELL

“Plantain forms an integral component of most of the complex farming systems.” 93% of surveyed farmers are intercropping.

While level of extension services is low (less than 15% have been trained), the adoption rate for FHIA-21 was around 10%.

Also, expansion and crop rotation is common (96% had planted new area in the previous year).\(^1\) (n=259)

### MOST IMPORTANT CONSTRAINTS\(^1\)

Ranked by 259 farmers across the three largest production regions (Brong Ahafo, Ashanti, and Eastern). Others not shown.

- **Production**
  - Credit (29%)
  - Weeds (23%)
  - Labor (13%)
  - Disease (9%)

- **Marketing**
  - Low Price (27%)
  - Traders Dictating Price (24%)
  - Over Production (10%)

- **Contribution of Plantain to Total Annual Income\(^1\)**
  - 48% - (All)
  - 44% - (Male)
  - 53% - (Female)

### LABOR MATH\(^1\)

One hectare of plantain generates an average of 0.75 permanent jobs per year.

There are 337,000 Ha of plantain cultivated in Ghana.

This results in approximately 250,000+ permanent jobs.

Equivalent to 50,000 families of five devoted to plantain.

---

\(^{1}\) “Plantain Production Practices in the Ashanti, Brong Ahafo, and Eastern Regions of Ghana”, A.A. Dankyi et al.; CRI/CSIR; 2007
VALUE CHAIN OPPORTUNITIES

PLANTAIN HAS HEAVY LABOR REQUIREMENTS FOR PRODUCTION; WEEDING, BUNCH TRANSPORT AND LAND PREPARATION ARE BIGGEST

Production cost economics for plantain
$USD per Hectare
(Conversion: 3.7 Ghanaian Cedis = $1USD)

Farm Budget for Traditional Complex System Farming

Based on field research with farmers in the Brong Ahafo, Ashanti and Eastern Regions; conducted by Context Network

NOTE: TIC = Total Input Costs, TLC = Total Labor Costs, TVC = Total Variable Costs

† Sources indicated that 70-80% of tasks were handled by hired labor, Hole Digging and Planting were frequently done with family labor.
Production cost economics for plantain
$USD per Hectare
(Conversion: 3.7 Ghanaian Cedis = $1USD)

Farm Budget for Low Input Complex System Farming
Based on field research with farmers in the Brong Ahafo, Ashanti and Eastern Regions; conducted by Context Network

Suckers are 48% of TIC
Weeding is 27% of TLC

NOTE: TIC = Total Input Costs, TLC = Total Labor Costs, TVC = Total Variable Costs

† Sources indicated that 70-80% of tasks were handled by hired labor, Hole Digging and Planting were frequently done with family labor.
Drying and processing facilities are situated near Accra and far from major production zones.

**Distant Processors**

- In Ghana, 55% of plantains come from over 150km away from Accra (to NW).
- Perishability and bulk add to transportation costs and increase risk along the way.
- Shipping bunches also exports nutrients away from the farms (peels/peduncle).
- 65-80% weight reduction and increased durability from drying plantains.

Production areas are up to 350km away from Accra (Sunyani). Perishability and bulk add costs for all downstream players, including flour processors.

Most major processors only have drying facilities and plants in and around Accra. They must buy plantains at market prices, or handle risky and expensive sourcing from production regions.
Currently, flour companies purchase fresh plantain at market and handle the risk and logistics of bringing them to their facilities in and around Accra.

Instead, drying plants should be localized (moved closer to the primary production regions) so that the value chain challenges resulting from perishability and bulk can be minimized or eliminated.

Buying surplus during the glut season benefits both the farmers (less wastage) and the processors (lower prices).

Potential Benefits

- **65-75% Weight Reduction** (30-40% from peel/peduncle; 50-60% water content)
- Reduced Perishability
- Improved Durability
- Fewer Middlemen
- Less Vulnerable to Extortion
- Contract Appropriate
- Creates Local Jobs
- Provides Outlet for Surplus
- Keeps Peels Closer to Farm
FLOUR PROCESSING STEPS CAN BE DIVIDED BETWEEN LOCALIZED DRYERS AND URBAN “FINISHERS”, THEREBY LOWERING COSTS

The first several steps are all labor intensive (sorting, washing, blanching, peeling, and sometimes slicing).

Moving drying facilities further from Accra will lower labor costs and drive local job growth.

Peels and peduncles will also remain local and can be used for compost in farmer plots (K).

Slicing (usually), cooking and drying are mechanized steps.

Additional machinery and value-added processing and branding can remain in larger cities. Dried plantain slices can be purchased or sourced from localized dryers.

CHALLENGES
1. Consistent Power Supply
2. Locally Based Equipment
3. Training Staff to Operate
4. Capital Intensive
### DRYING TECHNOLOGIES PRESENT TRADEOFFS BETWEEN COST AND THROUGHPUT; QUALITY ALSO A CONSIDERATION

**BIN DRYERS**

<table>
<thead>
<tr>
<th>Power Source:</th>
<th>Hybrid</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capacity:</td>
<td>1.5-2T</td>
</tr>
<tr>
<td>Drying Time:</td>
<td>10-12hr*</td>
</tr>
<tr>
<td>Cost:</td>
<td>18-20,000¢ (≈$5,250)</td>
</tr>
<tr>
<td>Fuel:</td>
<td>100L/T</td>
</tr>
<tr>
<td>Other:</td>
<td>FRI designed an inexpensive bin dryer that was then fabricated for several of the smaller flour processors. Bin dryers are cheap, higher throughput than the electric dryers, easy to operate and more durable.</td>
</tr>
</tbody>
</table>

*One processor said up to 24 hours.*

**COMPARTMENT DRYERS**

<table>
<thead>
<tr>
<th>Power Source:</th>
<th>Electric</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capacity:</td>
<td>300-500kg</td>
</tr>
<tr>
<td>Drying Time:</td>
<td>10-12hr</td>
</tr>
<tr>
<td>Cost:</td>
<td>14-16,000¢ (≈$4,050)</td>
</tr>
<tr>
<td>Fuel:</td>
<td>100L/T</td>
</tr>
<tr>
<td>Other:</td>
<td>Need consistent power supply, but output quality can be better. Does not require turning or tossing of dried materials to avoid burning. Equipment is more high maintenance. Perceived as inferior value to bin dryers.</td>
</tr>
</tbody>
</table>

**FLASH DRYERS**

<table>
<thead>
<tr>
<th>Model #1:</th>
<th>4 Cyclone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power Source:</td>
<td>Hybrid</td>
</tr>
<tr>
<td>Throughput:</td>
<td>200kg/hr</td>
</tr>
<tr>
<td>Cost:</td>
<td>$45,000</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Model #2:</th>
<th>6 Cyclone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power Source:</td>
<td>Hybrid</td>
</tr>
<tr>
<td>Throughput:</td>
<td>600kg/hr</td>
</tr>
<tr>
<td>Cost:</td>
<td>$55,000</td>
</tr>
<tr>
<td>Other:</td>
<td>Significantly higher cost, but much better throughput and product uniformity. No plantain flour processors are currently using. More scalable technology and good for processing other crops.</td>
</tr>
</tbody>
</table>

**Note:** Costs exclude installation, training & commissioning; and freight.
DRYER PROFITABILITY IS STRONG; CAPITAL REQUIREMENTS ARE THE LARGEST CHALLENGE

COMPARTMENT DRYER COST MODEL

<table>
<thead>
<tr>
<th>Item</th>
<th>Detail</th>
<th>Cost (per day)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>COSTS</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plantains</td>
<td>3-400 bunches (2.5-2.8T)</td>
<td>1,750¢</td>
</tr>
<tr>
<td>Labor</td>
<td>Peeling: 10 Women</td>
<td>200¢</td>
</tr>
<tr>
<td></td>
<td>All Other¹: 6 Men</td>
<td>120¢</td>
</tr>
<tr>
<td>Electric</td>
<td>1,200¢ per month</td>
<td>40¢</td>
</tr>
<tr>
<td>Total Cost (¢)</td>
<td>600kg dried output</td>
<td>2,110¢</td>
</tr>
<tr>
<td>Total Cost ($)</td>
<td>Convert @ 3.7 ¢/$</td>
<td>$570</td>
</tr>
<tr>
<td><strong>REVENUE</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. of Boxes Filled</td>
<td>60% of 700g boxes</td>
<td>1,429</td>
</tr>
<tr>
<td>Wholesale Price</td>
<td>Average price/box</td>
<td>6¢</td>
</tr>
<tr>
<td>Revenue (¢)</td>
<td>60% of total wholesale</td>
<td>5,143¢</td>
</tr>
<tr>
<td>Revenue ($)</td>
<td>Convert @ 3.7 ¢/$</td>
<td>$1,390</td>
</tr>
<tr>
<td>Daily Margin ($)</td>
<td>TC – Wholesale Value</td>
<td>$820</td>
</tr>
<tr>
<td>Daily Margin (%)</td>
<td>Daily Margin/Revenue</td>
<td>59%</td>
</tr>
</tbody>
</table>

NOTE: ¢ stands Ghanaian Cedis

Facility runs 6 days/week for 6 months/year (90T production).

Daily figures do not include overhead, depreciation, rent or packaging.

Processors estimated that net profit margin per box of fufu flour was between 20-30%.

Source: Context Network analysis based on interview with the Manager of a Neat Foods drying facility in Kumasi.
MARKET QUEENS ARE EITHER COLLUDING CARTELS OR ORGANIZING INFLUENCES, DEPENDING ON WHO YOU ASK

Market Queens (MQ) run the larger, regional markets along with traders associations

- Market Queens control who can sell at their markets and on which days. They also typically determine a quantity and price range for the produce. They often make farmers sell to middlemen once they are already at the market.¹²
- According to Deborah, Queen of Makola market in Accra, “I am responsible for organizing the women vendors, organizing community markets and becoming a center for distribution. As queen, you get access, not money.”³
- Farmers lament that they have no ability to negotiate prices and couldn’t sell at markets even if they brought their own bunches to sell. They can be forced to sell on informal credit with a promise for some cash post-sale.
- Others argue that Market Queens minimize abrupt price fluctuations and offer some market stability especially for perishable crops with strong seasonal supply cycles.
- Even when organized, farmers have little market power as their only access to large markets is through traders. Farmers usually have little success in dictating the terms between themselves and the market queens.⁴
- Market traders (MQ) can adjust the amount that is shipped to the fresh market in the major urban-located markets, but have no influence over the smaller markets situated in the production areas where farmers are free to sell.⁵

Good or bad, MQs do have a strong influence on the plantain fresh markets. Negotiating with MQs might not improve prices, but they could guarantee sales.

¹ “Socioeconomic Importance of Plantain Cultivation in Ghana”; The Journal of Animal and Plant Sciences; B. M. Dzomeku et al.; 2011
³ “The CEO’s of Ghana’s Markets are the Commodity Queens”; Article on US Embassy website; accessed September 2014; http://lipdigital.usembassy.gov/st/english/article/2002/11/200211121659455ellis@pd.state.gov0.4453089.html#axzz3CgEKd6pZ
ADDRESSING CURRENT VALUE CHAIN CONSTRAINTS COULD IMPACT OVER 75% OF SHFS IN GHANA (300,000+)

Constraints

**Inputs**
- Input affordability and access is limited – credit for inputs and farm expansion is priority for farmers
- Traditional planting materials that perpetuate pest and disease issues

**Production**
- Fertilizer usage is low; access to irrigation is limited; plantain production is labor intensive
- Poor pest and disease management
- Low transfer of improved production techniques, technologies and info

**Processing**
- Processors run at small volumes and are disconnected from SHFs
- Access to capital constrains growth
- Consistency of supply limits exports
- Complex and redundant product testing and certification

**Market**
- Low power; traders dictate price
- Market Queens control who sells, quantities to be sold, and at what price
- Low prices in peak production season

Total Farmer Impact

- **+300,000** could benefit from improved macropropagation techniques
- **+230,000** could benefit from increased processor demand and access to alternatives to fresh markets
- **+120,000** could benefit from market development and organization

Production is constrained by access to credit and inputs, as well as poor planting material.

However, markets remain the largest challenge for Ghana – the largest plantain producer in the world.

Source: Context Network analysis

Based on 400,000 SHFs for Ghana, 300K could benefit from increased inputs and clean suckers (all but compound system farmers), 230K could benefit from increased processing and localized dryers (Brong Ahafo and Ashanti), and 30% from marketing training and market linkages.
KEY CONSTRAINTS UNDERLYING THE UNREALIZED POTENTIAL

Constraints on plantain market map

**Pests and Diseases:** Plant susceptibility to pests and diseases reduces yields by over 50% in many cases.

**Input Availability:** SHFs often lack both the capital and ability to access fertilizer, mulch, and irrigation.

**On-Farm Losses:** Perishability, glut, and cost to get plantains to the road cause loss of ripe plantains before sale.

**Access to Markets:** Only touch point is MW and traders; inability to leapfrog VC steps; lower negotiating power.

**Market Queens (MQs):** More organized, regional markets are controlled by MQs who determine who can sell and at what price.

**Storage/Transportation:** Perishability, bulk and poor conditions lead products to deteriorate at ambient temps and increase cost.

**Disconnected Markets:** Processors are not in main value chain; they are about 10% of the market; mostly in Accra.

**Informal Credit:** MW, traders and MQs, can subsidize input costs or insist on delayed payment until they sell the bunches.

**Export Losses:** Inconsistent supply, poor organization, unreliable delivery times – reduces ability to serve market.

**Testing & Certification:** Companies bear the high cost of certifying new food products, even though tests are done 3x and in the same lab.
3 Interventions & Impact
PHASE 2 GHANA PLANTAIN EXECUTIVE SUMMARY

1. SECTOR FUNDAMENTALS
   • Plantains are the third most important crop in Ghana by production (FAO, 2014) behind Cassava and Yams, and considered to be in the top four staples for the country.
   • Ghana is the world’s largest producer of plantains, accounting for over 3.5 million MT.
   • Plantains are farmed on 337,000 Ha where average farm sizes are around 0.8 Ha, placing estimates for total households farming plantains at over 400,000.
   • One hectare of plantain is also estimated to account for 0.75 full time laborer equivalent.

2. VALUE CHAIN OPPORTUNITIES
   • Macro-propagation techniques (PIBS) offer a promising opportunity for rapid and inexpensive multiplication of clean planting materials.
   • Plantain experiences large post-production losses (30%+), but has better processing characteristics than other cooking banana varieties.
   • Eliminating perishability and bulk challenges by localizing dryers and building processor capacity will grow alternative markets for plantains and reduce surpluses.

3. INTERVENTIONS & IMPACT
   • Interventions have been refined to focus on access to clean planting materials (macro propagation), localizing drying facilities, and market development and organization.
   • Plantain has strong processing characteristics and building a strong value-added products sector is integral to addressing wastage, and developing the market.
   • Access to clean planting material will help improve on-farm yields.
   • Building capacity with processors and organizing markets will improve demand.

4. STAKEHOLDER PROFILES
   • There are few public sector partner candidates, and no ongoing plantain programs; private sector companies round out the list of potential partners:
     - Clean Planting Material – CSIR-CRI (Dr. Dzomeku), Biochemical Products, CLP II
     - Localizing Dryers – CSIR-FRI, AgDevCo, DADTCO, Neat Fufu, Elsa Foods
     - Market Development – AGRA (FOSCA), CSIR-FRI, Freshpac Ltd., Amanfrom Farms
THREE HIGH LEVEL INTERVENTION STRATEGIES HAVE BEEN VALIDATED THROUGH FIELD RESEARCH AND GROUND TRUTHING

Key

1. Access to Clean Planting Materials

2. Localizing Dryers & Building Capacity

3. Market Development & Organization

NOTE: Certain aspects of Intervention #2 and #3 will be addressing the same constraints (ex: On-Farm and Export Losses).
RECOMMENDED INTERVENTIONS FOCUS ON MACROPROPAGATION TO RAISE YIELDS AND PROCESSING TO REDUCE WASTAGE AND SURPLUS

1 **Clean Planting Material**
   - Disseminate macropropagation techniques to farmer groups and lead farmers; set up multipliers; encourage tissue culture support in cocoa systems.
   - **Clean** – pest and disease free plantlets
   - **Improved** – FHIA-21 has improved yields and higher tolerance to Black Sigatoka
   - **Scalable** – rapid and low-cost multiplication using humidity chambers

2 **Localize Flour Dryers & Build Capacity**
   - Provide business assistance and access to credit for dryers near production hubs to improve local demand and lower costs.
   - **Credit Support** – encourage relocating dryers into production hubs, loan guarantees for starting a facility
   - **Business and Financial Training** – record keeping, profit analysis, forecasting, market research, information systems and promotion

3 **Market Development & Organization**
   - Organize processors into associations to improve ability to handle export demand:
     - **Processor Associations**
     - **Marketing** – training, testing compliance, link to buyers, market research and promotion
   - Capacity building to support growth of value-added plantain products:
     - **Credit Support**
     - **Regulatory Involvement**
   - Link farmers to market queens and processors to ensure sales

**Key Linkages: A) Financial Support, B) Improved Technologies, and C) Customers/Markets**

- a) Loan guarantees for macro-prop multipliers, processors, and exporters
- b) Dissemination of improved techniques for macro-prop, drying facilities, and packaging
- c) Link companies with export capacity to reliable buyers
MACRO-PROPAGATION PRESENTS THE MOST COST EFFECTIVE AND SCALABLE WAY OF MULTIPLYING AND DISSEMINATING CLEAN PLANTING MATERIAL

INTERVENTION #1: CLEAN PLANTING MATERIAL (MACRO-PROPAGATION)

<table>
<thead>
<tr>
<th>Constraints Addressed</th>
<th>Potential Solutions</th>
<th>Issues + Considerations</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Reduced Yields</strong></td>
<td><strong>Tissue Culture:</strong></td>
<td>Challenging landscape for scalable production/dissemination of clean planting materials:</td>
</tr>
<tr>
<td><em>Driven by</em></td>
<td>Mass multiplication of plantain suckers from clean plantain tissue (either mother gardens or gene banks).</td>
<td>- Only TC lab has limited volume (20K suckers)</td>
</tr>
<tr>
<td><strong>Pests:</strong></td>
<td><em>(NOTE: No large-scale players in Ghana; the only one sells at roughly triple the cost.)</em></td>
<td>- Extension assistance lacks funding and awareness</td>
</tr>
<tr>
<td>• Nematodes (up to 30-50% yield reduction)</td>
<td><strong>Macro-Propagation:</strong></td>
<td>- Affordability of materials</td>
</tr>
<tr>
<td>• Weevils (up to 30-70% yield reduction)</td>
<td>PIBS method has high multiplication rate (60-80x) with minimal cost, and low required training and inputs.(^1)</td>
<td></td>
</tr>
<tr>
<td><strong>Diseases:</strong></td>
<td><strong>Suggested Implementation:</strong></td>
<td></td>
</tr>
<tr>
<td>• Black Sigatoka (20-50% yield reduction)</td>
<td>MACRO-PROPAGATION offers a new solution that is rapidly scalable (60-80x in 3.5 months), uses local materials, and needs minimal cash outlay. On-farm and commercial size options are available.</td>
<td></td>
</tr>
<tr>
<td><strong>Cost of Suckers</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• 30 pesewas to 1 cedi</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(=≈$0.10-0.30 per sucker)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1. “Response of Selected Local Plantain Cultivars to PIBS(Plants Issus de Bourgeons Secondaires) Technique”; CSIR/CRI, Dr. B.M. Dzomeku; 2014
## INTERVENTION #1: CLEAN PLANTING MATERIAL (MACRO PROPAGATION)

### Key Intervention Elements
- Access to pest and disease free planting material
- Dissemination of improved varieties (ex: FHIA-21) that are widely accepted
- Farmer training on identification of good suckers for explants
- Techniques for paring and cleaning explants
- Humidity chamber assembly classes
- Business training and assistance for multipliers

### Potential Programs Formats

#### Tissue Culture Distribution

**On-Farm (Macro Propagation)**
- Small chambers, low cash outlay
- Supports farm/village sucker needs, with extra sold locally for side income

**Multipliers (Macro Propagation)**
- Larger chambers, some capital outlay
- Business training and assistance for farmer entrepreneurs

#### Gain to SHF (est.)
- **Pest-Free** (no weevils or nematodes – up to 60% yield increase Y1)
- **Speed & Scalability** (large # of plantlets quickly available – 3.5 months)
- **Improved Varieties** (pest and disease-tolerant - improved varieties tolerant to Black Sigatoka, such as FHIA-21)

#### Size, Scalability & Timing
- **On-Farm**
  - Initial investment: $24
  - Scale: 5-8,000 suckers
  - Assemble in a day on 2sqm of space

- **Multipliers**
  - Initial Investment: $305
  - Scale: 20-30,000 suckers
  - Assistance to source fabricated frame
  - Several days to assemble; 10 sqm

### Key Dependencies & Risks
- **Farmer Acceptance** – must build awareness of the benefits of clean plantlets and PIBS model
- **Training** – selection practices, cleaning techniques, sucker collection, chamber maintenance, and hardening process
- **Labor** – chambers do not require much labor, but tasks must be performed correctly to achieve desired outcomes

### Potential Partners
- **Crop Research Institute** – established in 1964 and is one of the 13 Institutes of the Council for Scientific and Industrial Research (CSIR) of Ghana. Handles ongoing research and breeding programs for plantain in Ghana.
- **Dr. Beloved Dzomeku** – leading plantain researcher in Ghana; pioneered the research into adapting the PIBS technique to local environments and development of the low cost humidity chambers; essential resource for any plantain project in Ghana.
- **Biochemical Products Ghana Ltd.**
- **Cocoa Livelihoods Program**
ADDRESS VALUE CHAIN CONSTRAINTS ASSOCIATED WITH PERISHABILITY AND BULK BY LOCALIZING DRYING FACILITIES

INTERVENTION #2: LOCALIZE DRYING FACILITIES & BUILD CAPACITY

<table>
<thead>
<tr>
<th>Constraints Addressed</th>
<th>Potential Solutions</th>
<th>Issues + Considerations</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Perishability:</strong> dried plantain chips can last months and can be stored for later sale</td>
<td><strong>Processor-Owned Facilities</strong></td>
<td>Processors are geographically disconnected from production</td>
</tr>
<tr>
<td><strong>Bulk:</strong> 65-75% less weight (lower transport cost)</td>
<td>• Shift existing drying equipment to production hubs</td>
<td>Large percentage of production is wasted due to lack of access to markets other than fresh market</td>
</tr>
<tr>
<td><strong>Durability:</strong> product is no longer vulnerable to bruising</td>
<td>• Or, buy more locally sourced equipment to raise capacity</td>
<td>Companies can use facilities for multiple crops and process year-round - evening out supply timing</td>
</tr>
<tr>
<td><strong>Inconsistent Supply:</strong> can now aggregate dried product and even out supply variation</td>
<td>• Hire and train local staff and labor (for manual and mechanized tasks)</td>
<td></td>
</tr>
<tr>
<td><strong>Exporting Nutrients:</strong> peels and arms stay nearer to farms</td>
<td><strong>Independently Run Dryers</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Surpluses:</strong> alternative to fresh market; absorbs local surplus</td>
<td>• Build or rent a facility</td>
<td></td>
</tr>
<tr>
<td><strong>Seasonality:</strong> facilities can dry other crops (eg. cassava) when prices rise</td>
<td>• Source appropriate equipment (slicers, blanchers, dryers)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Solicit contract purchases of dried materials from urban processors</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Develop network of farmers and local markets to supply inputs for drying operations</td>
<td></td>
</tr>
</tbody>
</table>

**Suggested Implementation:**

LOCALIZING DRYERS & BUILDING CAPACITY will address a number of value chain constraints and be beneficial to both processors and smallholder farmers. It also improves the overall market.
## INTERVENTION #2: LOCALIZE DRYING FACILITIES & BUILD CAPACITY

### Key Intervention Elements
- Credit support and loan guarantees for existing processors or new dryers
- Business and financial training – record keeping, forecasting, inventory mgmt., promotion and purchase contracts
- Organizing sourcing channels – using existing farmer groups and participants in other interventions (i.e. PIBS) to supply dryers
- Guidance through product testing and compliance hurdles

### Potential Programs Formats

#### Processor-Owned
- Relocate or build new facilities at plantain production or transit hubs
- Larger facilities to drive scale

#### Independently Run
- Local entrepreneur or existing business
- Smaller facilities could be more rural
- Sell on contract to urban processors

#### Processor / Dryer Partnership

### Size, Scalability & Timing

#### Processor-Owned
- Up to a year for facility, equipment and installation to be completed
- Large-scale, faster dryers

#### Independently-Run
- Rent a location (or already own a spot)
- Small-scale, less sophisticated dryer
- Bin dryers can be locally manufactured
- 1T capacity per day

### Key Dependencies & Risks
- **Power Supply**: dryers require consistent source of electricity
- **Locally Based Equipment**: repairs and maintenance must occur on-site
- **Skilled Labor**: workers must be trained on the machinery and the procedures (for both manual and machine components)
- **Access to Capital**: building a facility, purchasing equipment, and staffing require deep pockets

### Gain to SHF (est.)
- **Improved Sales**: (access to alternative to fresh market)
- **Reduced Wastage**: (dryers buying more during peak season - 10% less wasted)
- **Soil Improvement**: (can purchase cheap compost material from the drying facility for improving soil quality)

### Potential Partners
- **Neat Fufu**: largest plantain processor in Ghana, synonymous with fufu flour, heavy radio advertising
- **Elsa Foods**: second largest fufu flour processor, produces many different products mainly for export
- **Selasie/Leemex**: other, smaller fufu flour processors
- **Food Research Institute**: also a member institute of CSIR in Ghana, developed fufu flour products and a drying prototype that was shared with processors
- **DADTCO**: private Dutch company specializing in agricultural social entrepreneurship in Africa, created a mobile based model for drying cassava
- **AgDevCo**: NGO focused on investing in agribusiness
DADTCO MODEL – “IF THE FARMER CANNOT COME TO THE FACTORY, LET’S BRING THE FACTORY TO THE FARMER”

DADTCO has developed AMPUs for processing cassava in Ghana.

The mobile units coordinate rural supply and reduce moisture content of ground cassava to 55%, near farmgate.

Cake is then brought to a central drying facility where moisture is reduced to 10% with commercial flash dryers.

“One AMPU costs $1 million, has a capacity to handle 30T per day. GM estimates that it takes roughly three years to break even with cassava.” - Eelco Bakema, General Manager
### Sales Channels Other Than the Fresh Market Must Be Developed in Order to Utilize Surplus Production

### Intervention #3: Market Organization & Development

<table>
<thead>
<tr>
<th>Constraints Addressed</th>
<th>Potential Solutions</th>
<th>Issues + Considerations</th>
</tr>
</thead>
</table>
| **Farmers:** market conditions disadvantage farmers and make them price takers | **Form Processor Associations:**  
- Marketing Training  
- Lobby and Industry Liaison  
- Links to Export Markets | Assumption is that there is pent up demand in the market for supply. Companies are selling all their flour currently with little hassle. Serving export markets requires:  
- Consistent Quality  
- Consistent Supply  
- Government and Regulatory Support |
| ➢ Seller Power | ➢ **Build Value-Added Processing Capacity:**  
- Link processors to financial institutions (especially groups)  
- Leverage associations to streamline regulatory process for product certification | |
| ➢ Market Access | ➢ **Link Farmers to Markets:**  
- Contract purchases may be unrealistic, but linking established farmers groups to market queens / processors will ensure sales | |
| **Processors:** operations are profitable but small-scale; growing is risky; unable to serve export markets | ➢ Marketing Skills  
➢ Access to Credit  
➢ Fragmented Markets  
➢ Consistency of Supply  
➢ Testing and Compliance | |

**Suggested Implementation:**

**PROCESSOR ASSOCIATIONS** and other steps to organize the markets and build value-added plantain processing that can serve domestic / export markets.
### INTERVENTION #3: MARKET DEVELOPMENT & ORGANIZATION

#### Key Intervention Elements
- Identify existing farmer group networks
- Identify clusters of small processors (i.e. Assin Foso or Kumasi chip fryers)
- Create processor associations to leverage group benefits – access to credit, training, unified voice, etc.
- Develop training modules for business, marketing and technical training
- Help build business plans, get capital for expansion, certify new products, and promote domestic and export sales

#### Potential Programs Formats
- **Cluster Model**
  - Identify farmer groups around proposed drying facilities
  - Train on plantain macropropagation and TC/cocoa-plantain methods
  - Link farmer groups and market queens/processors

- **Association Development**
  - Train and support the organization of a “Plantain Processors Association”

- **Market Maker** – find export customers

#### Size, Scalability & Timing
- **Cluster**
  - Networks of farmer groups in proximity to localized dryers

- **Association**
  - National level association for ongoing market support and development, and leveraging political support for reg. Δ’s
  - Local associations for aggregation

- **Market Queen Linkages**
  - Needs to be further explored (CLPII).

#### Key Dependencies & Risks
- **Management**: recordkeeping, leadership, and hierarchy
- **Cohesiveness**: acting as a group (i.e. no side-selling, honoring contracts)
- **Consistent Demand**: incentive for organization deteriorates without a market; must ensure large orders
- **Financial Support**: access to loan instruments for building capacity; business training for small enterprises
- **Product Certification Assistance**

#### Gain to SHF (est.)
- **Market Access** (linkages to market queens to guarantee a sales channel)
- **New Markets** (chips and flour processors will offer alternative to fresh market)
- **Consistent Market** (building linkages and increasing sales channels, will increase demand consistency)

#### Potential Partners
- **AGRA (FOSCA)** – Farmer Organization Support Center for Africa; will be able to identify key farmer groups
- **Food Research Institute** – also a member institute of CSIR in Ghana, developed fufu flour products and a drying prototype that was shared with processors
- **Freshpac Ltd.** – food processor (plantain chips) using nucleus farming model for sourcing
- **Amanfrom Farms** – largest plantain plantation in Ghana
- **Churchill Chips/NKM Investments** – medium size chip processors in Accra and Kumasi, respectively
- **A&D Trading** – fresh market exporter; organized a chip fryers association
AMANFROM FARMS FORERUNNER IN PRIVATELY OWNED COMMERCIAL PLANTATIONS IN GHANA; FORMING NUCLEUS SYSTEM WITH FRESHPAC LTD

Amanfrom is the largest plantain plantation in Ghana (155 ac)

- They are a mono-cropped commercial plantain enterprise that produces for Freshpac Ltd., the "Ghana’s Foremost Plantain Chips Producer."
- Freshpac is building a nucleus system around the plantation – engaging local stakeholders in organization and improved practices to build supply.
- The farm was initially producing maize but it later ventured into plantain production. It transports the produce to Fresh Pac Limited at Tema which turns them into chips for export.¹
- This type of system comes at a time when the political environment is in alignment with the commercialization of plantain production (see below).

MOFA Minister Clement Kofi Humado believes it was time the private sector "is assisted and encouraged" to go into large-scale commercial production of Ghana's staple foods.

After a visit to Amanfrom Farms Limited, said to be the biggest plantain farm in the country, at Makyiniabre, in the Brong Ahafo Region, Humado advocated the motivation of local farmers to produce in large quantities.

"The over-concentration on the large scale production of cereal crops - maize and rice - is not enough to meet the ever-growing food demand in the country," he said.²

¹ “Ghana: Humado Votes for Plantain, Cassava and Cocoyam”, article on www.AllAfrica.com; posted on 30 September 2014
² “Agric Minister weeps over bad farm roads”; article from Business News; 27 September 2013
### Plantain Production Revenue Added
*assumes starting yield is slightly below national average*

<table>
<thead>
<tr>
<th>$USD/ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current Farmer Margin</td>
</tr>
<tr>
<td>Yield Gain</td>
</tr>
<tr>
<td>New Revenue Stream</td>
</tr>
<tr>
<td>At full adoption the interventions would increase farmer margin over 210%</td>
</tr>
<tr>
<td>Intervention #1</td>
</tr>
<tr>
<td>Intervention #2</td>
</tr>
<tr>
<td>Intervention #3</td>
</tr>
</tbody>
</table>

#### Interventions & Impact

- **Intervention #1**: Loss improvement of 10% from selling surplus to local dryers
- **Intervention #2**: Revenue stream from selling suckers under the PIBS model; low number of multipliers
- **Intervention #3**: Loss improvement of 5% from improved sales channels, better linkages (e.g., Market queens), and more consistent demand

---

**POTENTIAL FARMER MARGIN IMPACT OF PLANTAIN INTERVENTIONS AT FULL ADOPTION, REPRESENT ~210% INCREASE, INCLUDING SUCKER SELLING**
INTERVENTION #3 IS PERCEIVED TO BE THE MOST RISKY DUE TO NON-ADOPTION (CULTURAL) AND PARTNER RISK (LOW MANAGEMENT EXPERIENCE)

<table>
<thead>
<tr>
<th>Int #1: Clean Planting Material</th>
<th>Int #2: Localize Flour Dryers &amp; Build Capacity</th>
<th>Int #3: Market Development &amp; Organization</th>
<th>Int #4: Key Linkages – Finance, Tech, and Customers</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>RISK ASSESSMENT</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operational</td>
<td>Low</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Complexity, Execution, Un-tested, Scale</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-Adoption</td>
<td>Med.</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Cultural, Conservatism, Lack of Perceived Benefit</td>
<td></td>
<td></td>
<td>Low</td>
</tr>
<tr>
<td>Partner Risk</td>
<td>Low</td>
<td>Med.</td>
<td>High</td>
</tr>
<tr>
<td>Compatibility, Management Experience</td>
<td></td>
<td></td>
<td>Med.</td>
</tr>
<tr>
<td>Overall Risk</td>
<td>Low</td>
<td>Med.</td>
<td>High</td>
</tr>
<tr>
<td>Qualitative Foundation Priorities</td>
<td></td>
<td></td>
<td>Med.</td>
</tr>
</tbody>
</table>

**QUALITATIVE FOUNDATION PRIORITIES**

- Gender equality benefits: ✓
  - Women Manage Value Chain
- Environmental sustainability: ✓
  - Disease Resistance
  - Less Waste / Soil Management
- Health: ✓
  - Quality Prod.; Improved Nutrition
  - Durable Food Products
  - More Income = More Balanced Diet

✓ Enables qualitative foundation priorities

CONTEXT
### Annual Net Financial Benefit per Farmer

<table>
<thead>
<tr>
<th>Benefit per farmer from Int. #1:</th>
<th>Benefit per farmer from Int. #1:</th>
<th>Benefit per farmer from Int. #2:</th>
<th>Benefit per farmer from Int. #3:</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>(yield increase from clean suckers)</em></td>
<td><em>(revenue gains from selling macro-propagated suckers)</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$352</td>
<td>$388</td>
<td>$169</td>
<td>$84</td>
</tr>
</tbody>
</table>

**Net benefit per farmer per annum**: $993

**Aggregate SHF benefit per annum**: $69 MM

**Assumptions of Context Network Analysis:**
- 0.8 ha of plantain grown per farmer
- $346 price per ton estimate
- INT #1 – 40% yield gain potential and additional revenue stream if farmer sells suckers from PIBS model
- INT #2 – 10% loss improvement from selling surplus to local dryers
- INT #3 – 5% loss improvement from improved market sales channels and demand
PHASE 2 GHANA PLANTAIN EXECUTIVE SUMMARY

1. SECTOR FUNDAMENTALS
   - Plantains are the third most important crop in Ghana by production (FAO, 2014) behind Cassava and Yams, and considered to be in the top four staples for the country.
   - Ghana is the world’s largest producer of plantains, accounting for **over 3.5 million MT**.
   - Plantains are farmed on **337,000 Ha** where average **farm sizes are around 0.8 Ha**, placing estimates for **total households farming plantains at over 400,000**.
   - One hectare of plantain is also estimated to account for **0.75 full time laborer equivalent**.

2. VALUE CHAIN OPPORTUNITIES
   - Macro-propagation techniques (PIBS) offer a promising opportunity for rapid and inexpensive multiplication of clean planting materials.
   - Plantain experiences large post-production losses (30%+), but has **better processing characteristics** than other cooking banana varieties.
   - Eliminating perishability and bulk challenges by **localizing dryers and building processor capacity** will grow alternative markets for plantains and reduce surpluses.

3. INTERVENTIONS & IMPACT
   - Interventions have been refined to focus on access to clean planting materials (macro propagation), localizing drying facilities, and market development and organization.
   - Plantain has strong processing characteristics and **building a strong value-added products sector is integral to addressing wastage**, and developing the market.
   - Access to clean planting material will help improve on-farm yields.
   - Building capacity with processors and organizing markets will improve demand.

4. STAKEHOLDER PROFILES
   - There are few public sector partner candidates, and no ongoing plantain programs; private sector companies round out the list of potential partners:
     - **Clean Planting Material** – CSIR-CRI (Dr. Dzomeku), Biochemical Products, CLP II
     - **Localizing Dryers** – CSIR-FRI, AgDevCo, DADTCO, Neat Fufu, Elsa Foods
     - **Market Development** – AGRA (FOSCA), CSIR-FRI, Freshpac Ltd., Amanfrom Farms
IN GHANA, THERE ARE MANY POTENTIAL PRIVATE SECTOR PARTNERS, BUT FEW PUBLIC – NO PLANTAIN PROGRAMS CURRENTLY RUNNING

<table>
<thead>
<tr>
<th>Intervention #1</th>
<th>Clean Planting Material</th>
<th>Intervention #2</th>
<th>Localize Dryers</th>
<th>Intervention #3</th>
<th>Market Development</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crop Research Institute</td>
<td>✓</td>
<td>Food Research Institute</td>
<td>✓</td>
<td>Dr. Beloved Dzomeku</td>
<td>✓</td>
</tr>
<tr>
<td>Food Research Institute</td>
<td>✓</td>
<td>Crop Research Institute</td>
<td>✓</td>
<td>Cocoa Livelihoods Program</td>
<td>✓</td>
</tr>
<tr>
<td>Dr. Beloved Dzomeku</td>
<td>✓</td>
<td>Food Research Institute</td>
<td>✓</td>
<td>AgDevCo</td>
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<td>Cocoa Livelihoods Program</td>
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<tr>
<td>Food Research Institute</td>
<td>✓</td>
<td>DADTCO</td>
<td>✓</td>
<td>Food Research Institute</td>
<td>✓</td>
</tr>
</tbody>
</table>

Source: Context Network interviews
IN GHANA, THERE ARE MANY POTENTIAL PRIVATE SECTOR PARTNERS, BUT FEW PUBLIC – NO PLANTAIN PROGRAMS CURRENTLY RUNNING

<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Intervention #1 Clean Planting Material</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Intervention #2 Localize Dryers</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Intervention #3 Market Development</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
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</tr>
</tbody>
</table>

Source: Context Network interviews

Adjacent Area for Potential Cooperation
## Stakeholder Profiles

**Interventions #1 (Clean Planting Material) and #3 (Market Development) Have Strong Potential Partners**

<table>
<thead>
<tr>
<th>Target Intervention</th>
<th>Leadership / Management</th>
<th>Ability to Scale</th>
<th>Financial Sustainability</th>
<th>Existing Traction(^1)</th>
<th>Related Experience(^1)</th>
<th>Overall Fit</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Government / NGO</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CSIR-CRI Clean Planting Material / Market Development</td>
<td>Strong</td>
<td>---</td>
<td>Strong</td>
<td>Strong</td>
<td>Strong</td>
<td>STRONG</td>
</tr>
<tr>
<td>CSIR-FRI Localize Drying Facilities / Market Development</td>
<td>Medium</td>
<td>Medium</td>
<td>Low</td>
<td>Strong</td>
<td>Strong</td>
<td>STRONG</td>
</tr>
<tr>
<td>Dr. Dzomeku ALL</td>
<td>Strong</td>
<td>---</td>
<td>---</td>
<td>Strong</td>
<td>Strong</td>
<td>STRONG</td>
</tr>
<tr>
<td>CLP II Clean Planting Material</td>
<td>Strong</td>
<td>Strong</td>
<td>Strong</td>
<td>Low</td>
<td>Medium</td>
<td>MEDIUM</td>
</tr>
<tr>
<td>AGRA (FOSCA) Market Development</td>
<td>Strong</td>
<td>Strong</td>
<td>Strong</td>
<td>Low</td>
<td>Low</td>
<td>MEDIUM</td>
</tr>
<tr>
<td><strong>Private</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Biochemical Products Clean Planting Material</td>
<td>Medium</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Strong</td>
<td>LOW</td>
</tr>
<tr>
<td>Freshpac Ltd. Localize Drying Facilities / Market Development</td>
<td>Strong</td>
<td>Strong</td>
<td>TBD</td>
<td>Strong</td>
<td>Strong</td>
<td>STRONG</td>
</tr>
<tr>
<td>Amanfrom Farms Localize Drying Facilities / Market Development</td>
<td>Medium</td>
<td>Strong</td>
<td>TBD</td>
<td>Medium</td>
<td>Strong</td>
<td>STRONG</td>
</tr>
<tr>
<td>Churchill/NKM Market Development</td>
<td>Medium</td>
<td>Medium</td>
<td>Medium</td>
<td>Medium</td>
<td>Strong</td>
<td>MEDIUM</td>
</tr>
<tr>
<td>A&amp;D Trading Market Development</td>
<td>Medium</td>
<td>Low</td>
<td>Medium</td>
<td>Low</td>
<td>Low</td>
<td>LOW</td>
</tr>
</tbody>
</table>

\(^1\) These criteria are directly related to plantain efforts in Ghana, not other operations.
INTERVENTION #2 (LOCALIZING DRYING FACILITIES) WILL NEED TO BE RUN IN PARTNERSHIP WITH THE MAJOR EXISTING FLOUR DRYERS\(^1\)

<table>
<thead>
<tr>
<th></th>
<th>Target Intervention</th>
<th>Leadership / Management</th>
<th>Ability to Scale</th>
<th>Financial Sustainability</th>
<th>Existing Traction</th>
<th>Related Experience</th>
<th>Overall Fit</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSIR-FRI</td>
<td>Localize Drying Facilities / Market Development</td>
<td>Medium</td>
<td>Medium</td>
<td>Low</td>
<td>Strong</td>
<td>Strong</td>
<td>STRONG</td>
</tr>
<tr>
<td>Dr. Dzomeku</td>
<td>ALL</td>
<td>Strong</td>
<td>---</td>
<td>---</td>
<td>Strong</td>
<td>Strong</td>
<td>STRONG</td>
</tr>
<tr>
<td>AgDevCo</td>
<td>Localize Drying Facilities</td>
<td>Strong</td>
<td>Strong</td>
<td>Strong</td>
<td>---</td>
<td>Strong</td>
<td>STRONG</td>
</tr>
<tr>
<td>DADTCO</td>
<td>Localize Drying Facilities</td>
<td>Strong</td>
<td>Strong</td>
<td>Medium</td>
<td>Strong</td>
<td>Medium</td>
<td>MEDIUM</td>
</tr>
<tr>
<td>Neat Foods</td>
<td>Localize Drying Facilities</td>
<td>Strong</td>
<td>Strong</td>
<td>Strong</td>
<td>Strong</td>
<td>Strong</td>
<td>STRONG</td>
</tr>
<tr>
<td>Elsa Foods</td>
<td>Localize Drying Facilities</td>
<td>Strong</td>
<td>Medium</td>
<td>Strong</td>
<td>Strong</td>
<td>Strong</td>
<td>STRONG</td>
</tr>
<tr>
<td>Selasie Farms</td>
<td>Localize Drying Facilities</td>
<td>Medium</td>
<td>Low</td>
<td>Medium</td>
<td>Medium</td>
<td>Strong</td>
<td>MEDIUM</td>
</tr>
<tr>
<td>Leemex</td>
<td>Localize Drying Facilities</td>
<td>Medium</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Medium</td>
<td>LOW</td>
</tr>
<tr>
<td>Freshpac Ltd.</td>
<td>Localize Drying Facilities / Market Development</td>
<td>Strong</td>
<td>Strong</td>
<td>TBD</td>
<td>Strong</td>
<td>Strong</td>
<td>STRONG</td>
</tr>
<tr>
<td>Amanfrom Farms</td>
<td>Localize Drying Facilities / Market Development</td>
<td>Medium</td>
<td>Strong</td>
<td>TBD</td>
<td>Medium</td>
<td>Strong</td>
<td>STRONG</td>
</tr>
</tbody>
</table>

\(^1\) Additional partners to be identified in subsequent phases.
# POTENTIAL IMPLEMENTATION PARTNERS FOR INTERVENTIONS IN GHANA

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSIR-Crop Research Institute (CRI)</td>
<td>CRI, established in 1964 and one of the 13 Institutes of the Council for Scientific and Industrial Research (CSIR) of Ghana, includes development/dissemination of plantain improved technologies, e.g. rapid, low cost macro-propagation of clean planting material.</td>
</tr>
<tr>
<td>CSIR-Food Research Institute (FRI)</td>
<td>FRI, established in 1963 and part of CSIR, conducts market-oriented applied research and provides technical services and products to the food industry, e.g. plantain flour processing, drying facilities and training to entrepreneurs on the most efficient use of these facilities. FRI provides access to its drying facilities for first time users.</td>
</tr>
<tr>
<td>Dr. Beloved Dzomeku</td>
<td>Dr. Dzomeku is the Senior Research Scientist, Plantain Research Program Leader and Plantain Physiologist at CRI. He is widely recognized as the key leader in plantain research efforts in Ghana. He is a member of the West African Agricultural Productivity Program – National Centre of Specialization (WAAPP-NCOS)'s Scientific Committee. Dr. Dzomeku pioneered initial efforts in establishing “humidity chambers” for on-farm for rapid multiplication of clean plantain material and continues to refine and expand these efforts.</td>
</tr>
<tr>
<td>Biochemical Products Ghana Ltd.</td>
<td>Biochemical Products, wholly Ghanaian owned, is the only commercial plant tissue culture laboratory in Ghana solely dedicated to the production of plantains and bananas. Potential to produce 1 million plantain suckers for large scale production. Owner and Managing Director, Dr. Sammy Sackey, maintains an elite collection of nine plantain cultivars with a potential to produce 1 million plantain suckers for large scale production.</td>
</tr>
<tr>
<td>Cocoa Livelihoods Program (CLPII)</td>
<td>The World Cocoa Foundation (WCF) is an international foundation that promotes a sustainable cocoa economy. It includes cocoa and chocolate manufacturers, processors, supply chain managers, representing more than 80% of the global cocoa market. Second phase of the BMGF-funded Cocoa Livelihoods Program (CLP II) with WCF in Côte d’Ivoire, Ghana, Nigeria and Cameroon will include credit for farmers for input purchase / improved planting material.</td>
</tr>
<tr>
<td>AgDevCo</td>
<td>AgDevCo is a UK-based social impact investor and agribusiness project developer operating exclusively in the agriculture sector in Africa. They focus on food security through not-for-profit investments and provide capital in the form of debt and equity into early stage agribusinesses. They are currently active in Mozambique, Ghana, Zambia, Malawi and Tanzania.</td>
</tr>
<tr>
<td>DADTCO</td>
<td>Dutch Agricultural Development and Trading Company (DADTCO), a social enterprise committed to providing farmers with guaranteed markets is active in Nigeria (cassava flour), Mozambique (first ever commercial-scale cassava-based beer) and Ghana (cassava - HQCF).</td>
</tr>
<tr>
<td>AGRA (FOSCA)</td>
<td>Farmer Organization Support Centre in Africa (FOSCA), established by AGRA with support from BMGF, is active in Ghana, Mali, Mozambique and Tanzania with a focus on linkages between farmers and traders.</td>
</tr>
<tr>
<td>Name</td>
<td>Description</td>
</tr>
<tr>
<td>--------------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Neat Foods</td>
<td>Neat Foods started production of plantain fufu flour in 2009 and has a factory in Accra and Kumasi (150 miles from Accra). Exports approximately 1,200 MT annually to US and UK, mainly to diaspora. Owner also runs Peace FM, the biggest radio station in Ghana, and advertises fufu flour heavily on radio.</td>
</tr>
<tr>
<td>Elsa Foods</td>
<td>Elsa Foods’ owner, Elizabeth Maldini, produces instant fufu powders, fermented and unfermented cassava flour, spiced millet breakfast cereal, fortified infant cereal, and contract packaging of palm oil and soya flour. She exports approximately 50 MT/year of plantain fufu flour to Germany, UK, Australia and the Netherlands as well as a 20 foot container monthly to Charlottsfelds International Food Distributers in NJ.</td>
</tr>
<tr>
<td>Selasie Farms</td>
<td>Mrs. Fafli Azaglo, owner of Selasie Farms, produces approximately 24 MT of plantain fufu flour. She sells approximately 80% locally and exports the balance to Australia (5 years). She produces small quantities of plantain chips and sells to hospitals, schools and supermarkets.</td>
</tr>
<tr>
<td>Leemex</td>
<td>Leemex Food, a subsidiary of Leehouse Chemical, was incorporated as a food processing company in 2002 and licensed to manufacture and export African gourmet foods. Plantain fufu flour is part of their product line. Factory in Ghana. Total Annual Sales Volume: US$1 Million - US$2.5 Million</td>
</tr>
<tr>
<td>Freshpac Ltd.</td>
<td>FreshPac operates a modern fresh fruit juice and farm produce sale/distribution system in Ghana and abroad. They are the self-proclaimed, largest producer of plantain chips in Ghana. They source their plantains from Amanfroms Farms, the largest plantain plantation in Ghana.</td>
</tr>
<tr>
<td>Amanfrom Farms</td>
<td>Amanfrom Farms Limited, said to be the biggest plantain farm in the country with 155 acres under plantain, is located in Makyiniabre, in the Brong Ahafo Region. They are the main suppliers for Freshpac Ltd. and are working with them to develop a nucleus farming system within the local communities.</td>
</tr>
<tr>
<td>Churchill Chip / NKM Investments</td>
<td>Mr. Mensah Nicholas Kusi, owner of NKM Investments, produces plantain chips and exports on demand. Can produce 40ft container of plantain chips if demand warrants. Churchill Chips is an Accra-based chip manufacturer – can do a 20ft container every two weeks. Also in produce procurement and agro-logistics.</td>
</tr>
<tr>
<td>A&amp;D Trading</td>
<td>Peter Dramani, CEO, established A&amp;D Trading in August 2013 as a plantain chip export enterprise. He is involved in contract farming in Brong-Ahafo (rural area). He has a South African client who ordered two containers (total of 60MT) in boxes of 20, 25, and 30kg. He has exported two containers of fresh plantain to Zambia, Togo and Senegal.</td>
</tr>
</tbody>
</table>
Appendix
APPENDIX 1 – CONTACTS (OVERVIEW)

TOTAL Contact Count = 61 Interviews
APPENDIX 2a – CONTACTS

COMPLETED DESK STUDY INTERVIEWS

Phase I

1. Dr. Beloved Dzomeku, senior research scientist, Plantain Research Program Leader, Crops Research Institute (CRI), Council for Science and Industrial Research (CSRI). Developed rapid macropropagation techniques (humidity chambers) for on-farm use and for commercial multiplication of clean plantain planting material.

2. Dr. Ernest Asiedu, former Manager of the Staple Crops Program; currently with West and Central African Council for Agricultural Research and Development (CORAF/WECARD). $600,000 three year (2010-2013) plantain program in Ghana, Cameroon, Congo, DRC, Togo and Benin ended in 2013.

3. Dr. Sammy Sackey, owner/Managing Director of Biochemical Products Ghana (TC) and Professor at the Department of Biochemistry Cell and Molecular Biology and Acting Director of the Institute of Applied Science and Technology. Potential (subject to external funding) to produce 1 million TC plantain suckers. Has contract with Ghana Cocoa Board for 500,000 plantain suckers.

4. Elizabeth Maldini, owner of Elsa Foods, exports plantain fufu flour (60 MT/month) to Charlottfields International Food Distributors in New Jersey, and Germany, UK, The Netherlands and Australia.

5. Peter Dramani, CEO of A&D Trading Ghana Lt. (established 2013) has exported plantain chips to Senegal and Togo. Advocates for an Plantain Exporters Association to consolidate orders and even out variable demands adversely affecting small processors.
APPENDIX 2a – CONTACTS

COMPLETED DESK STUDY INTERVIEWS

Phase I

6. Francis Opoku Ware, owner of Weamapok Farms (established 2008), exports ($24,000/year) plantain chips to Pakistan, South Africa, Ireland and Australia. Orders from US, Germany, Jordan, Belgium, South Africa, China, and Nigeria exceed his ability to fill – needs to mechanize (including labels with nutritional information).

7. Mr. Mensah Nicholas Kusi, owner of NKM Investments (established in 2005) exports plantain chips to The Netherlands and other countries on demand.

8. Mr. Godwin Adordie of Praise Exports (established 2009; staff of 100), processes12 different food types for export to US, Canada, UK, The Netherlands, Australia, Germany and Norway. Sources plantain from 10 lead farmers (each with 10-15 suppliers) and provides inputs and financing; factory in Accra. 90% of plantain fufu flour is exported to UK, The Netherlands and Australia.

9. Henry and Cynthia’s Chips is a small family concern established in 2009 which sells locally.

10. Mrs. Faflai Azaglo, owner of Selasie Farms, produces approximately 24 MT/year of plantain fufu flour of which 80% is sold locally to hospitals, schools and supermarkets and 20% is exported to Australia.

11. Mr. Brenyah of Neat Foods which started production of plantain fufu flour in 2009. Factories located in Kumasi (150 miles from Accra; 3.5 hr) and in Accra. Exports 1,200 MT/year to US and UK. Notifies his suppliers by phone every 2 weeks.
APPENDIX 2b – CONTACTS

COMPLETED IN-COUNTRY INTERVIEWS

Phase II


2. Elizabeth and Ernest Malindi, Elsa Foods. Established in 1996 for production of plantain fufu flour. Exports to USA, RSA and Europe. 240 MT/yr to NJ.


4. Kow Sam, Freshpac, Ltd: cassava, maize, plantain and cocoa with focus on high end packaging. Contracts and social interventions with farmers. Estimated 10% of chips market (3,500 MT).

5. Three Markets: (1) Kwahu Nsaba (20 vendors), (2) Pra River Junction (32 members) and Ejisu. Provided information on labor costs, produce prices, spoilage losses, government taxes, stall fees, etc.

6. Nicholas Kusi, MKM Investments, exports plantain chips on demand. Advocates for a small processors cooperative to serve large orders and receive assistance on certification of products with food administration (complex, inefficient, cumbersome process).

For further detail on interview contacts, please refer to the complete contact list in excel.
APPENDIX 2b – CONTACTS

COMPLETED IN-COUNTRY INTERVIEWS

Phase II

7. Amanfrom Farms Ltd., located in Nkoranza, has contract with FreshPak for processed plantain.

8. Abraham at Neat Food’s fufu dryer in Kumasi. Use two electric steam cookers and three electric dryers.


10. Mr. Addadae, Ministry of agriculture. Market queens finance farmers. Fufu flour is "in vogue“.

11. Mr. Vincent Manu, BMGF-funded Cocoa Livelihoods Program (CLP II) with World Cocoa Foundation (WCF) in Côte d’Ivoire, Ghana, Nigeria and Cameroon includes farmer credit for inputs.


13. Mr. Godwin Adordie, Praise Exports. Produced plantain fufu flour for 4-5 years but stopped due to inconsistent supply.


For further detail on interview contacts, please refer to the complete contact list in excel.
### APPENDIX 3 – OTHER HISTORICAL PROGRAM EFFORTS IN GHANA PLANTAINS

<table>
<thead>
<tr>
<th>Period</th>
<th>Project</th>
<th>Donor</th>
</tr>
</thead>
<tbody>
<tr>
<td>1997-2000, 2003-2007</td>
<td>Establishment of a delivery system for healthy improved <em>Musa</em> germplasm with field tolerance to banana streak virus (BSV) in Ghana</td>
<td>GATSBY Charitable Foundation</td>
</tr>
<tr>
<td>2000-2002</td>
<td>Production of bananas and plantains in the peri-urban zones of Ghana</td>
<td>Bio-diversity International</td>
</tr>
<tr>
<td>2002-2005</td>
<td>Plantain Target Project</td>
<td>USAID</td>
</tr>
<tr>
<td>2006-2008</td>
<td>Addressing micronutrient deficiencies in urban and peri-urban populations in West and Central Africa through <em>Musa</em>-based foods</td>
<td>Bio-diversity International</td>
</tr>
<tr>
<td>2006-2008</td>
<td>Developing plantain – coconut intercropping systems for the coastal belt of Ghana</td>
<td>Government of France</td>
</tr>
</tbody>
</table>

Source: Owusu-Bennoah et al, 2007

---

1 “An Assessment of the Plantain System’s Innovation Support for Fufu Flour Production in Ghana”; Bismark Agyei Yeboah; June 2008
APPENDIX 4 – ADDITIONAL SEGMENTATION COMMENTARY

1. Plantain/Cocoa Intercrop
2. Bush Plantain
3. Taungya Farming System
4. Compound Production System
5. Plantation or Contract Farming

*Banana and Plantain Value Chain: West Africa; Evans School of Policy Analysis and Research (EPAR); Prof. Leigh Anderson et al.; August, 2013*

In Ghana, agriculture accounts for about 37.4% of the gross domestic product (GDP) and employs 56% of the total economically active population. It is predominantly practiced in smallholder, family-operated farms, which produce about 80% of Ghana’s total agricultural output. About 2.74 million households operate a farm or keep livestock and 90% of farm holdings are less than 2 ha in size. Women are the predominant producers of the annual crops. In addition, this sector contributes an average of 12% and 8% to tax revenue and total revenue, respectively. Therefore, Ghana cannot achieve economic growth and poverty reduction without a significant improvement in the agricultural sector.

*“Typology of Irrigation Systems in Ghana”; International Water Management Institute (IWMI); Namara et al. Working Paper 142; 2010*
A nationwide survey of 400 plantain farmers and 156 sellers conducted in Ghana identified four main channels through which plantain reach consumers (Dzomeku et al., 2011)²:

- producer to wholesaler to retailer
- producer to retailer
- wholesaler to agri-industry
- producer to agri-industry

Source: Akinyemi et al., 2010

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1 Banana and Plantain Value Chain: West Africa; Evans School of Policy Analysis and Research (EPAR); Prof. Leigh Anderson et al.; August, 2013

2 “Socioeconomic Importance of Plantain Cultivation in Ghana”; The Journal of Animal and Plant Sciences; B. M. Dzomeku et al.; 2011
Backup or Alternate Slides
(Value Chain)
**SMALLHOLDER YIELDS AND INCOMES CAN BE SIGNIFICANTLY RAISED WITH IMPROVED PRACTICES AND INPUTS**

Farmer Income Economics for Two (2) Farmer Segments
$USD per Ha, based on primary sources and published data

<table>
<thead>
<tr>
<th></th>
<th>Traditional farming systems (low cash outlay)</th>
<th>Low-Input farming systems (moderate cash outlay)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Production Cost</td>
<td>$921</td>
<td>$1,926</td>
</tr>
<tr>
<td>Average yield per Ha</td>
<td>7.9 MT</td>
<td>10.5 MT</td>
</tr>
<tr>
<td>Farmgate price per kg</td>
<td>$0.259</td>
<td>$0.346</td>
</tr>
<tr>
<td></td>
<td>0.96 GHC</td>
<td>1.28 GHC</td>
</tr>
<tr>
<td>Total Revenue (value of production)</td>
<td>$2,045 (sells ≈75%)</td>
<td>$3,635 (sells ≈85%)</td>
</tr>
<tr>
<td>Gross Margins(^2)</td>
<td>$1,123</td>
<td>$1,709</td>
</tr>
<tr>
<td>Gross Margin (%)</td>
<td>55%</td>
<td>47%</td>
</tr>
</tbody>
</table>

Source: Context Network analysis combined with national average yield figures

\(^1\) Assumes 100% of production sold; traditional farmers would need to sell 45% of production to breakeven

\(^2\) Additional labor and inputs raised yields and total profit/Ha
KEY CONSTRAINTS UNDERLYING THE UNREALIZED POTENTIAL

Pests and Diseases: Plant susceptibility to pests and diseases reduces yields by over 50% in many cases.

Input Availability: SHFs often lack both the capital and ability to access fertilizer, mulch, and irrigation.

On-Farm Losses: Perishability, glut, and cost to get plantains to the road cause loss of ripe plantains before sale.

Access to Markets: Only touch point is MW and traders; inability to leapfrog VC steps; lower negotiating power.

Market Queens (MQs): More organized, regional markets are controlled by MQs who determine who can sell and at what price.

Storage/Transportation: Perishability, bulk and poor conditions lead products to deteriorate at ambient temps and increase cost.

Disconnected Markets: Processors are not in main value chain; they are about 10% of the market; mostly in Accra.

Testing & Certification: Companies bear the high cost of certifying new food products, even though tests are done 3x and in the same lab.

Informal Credit: MW, traders and MQs, can subsidize input costs or insist on delayed payment until they sell the bunches.

Export Losses: Inconsistent supply, poor organization, unreliable delivery times – reduces ability to serve market.

Small-scale Ops: Chip fryers are often seasonal vendors who semi-regularly fry chips for extra cash.

Input Availability: SHFs often lack both the capital and ability to access fertilizer, mulch, and irrigation.

On-Farm Losses: Perishability, glut, and cost to get plantains to the road cause loss of ripe plantains before sale.

Access to Markets: Only touch point is MW and traders; inability to leapfrog VC steps; lower negotiating power.

Market Queens (MQs): More organized, regional markets are controlled by MQs who determine who can sell and at what price.

Storage/Transportation: Perishability, bulk and poor conditions lead products to deteriorate at ambient temps and increase cost.

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Disconnected Markets: Processors are not in main value chain; they are about 10% of the market; mostly in Accra.

Testing & Certification: Companies bear the high cost of certifying new food products, even though tests are done 3x and in the same lab.
INVESTIGATE SUCKER PARING FOR LOWER COST MULTIPLICATION ALTERNATIVE IN UGANDA

Reported Yields for various planting materials under low and high input packages

Table 5

<table>
<thead>
<tr>
<th>Planting material</th>
<th>Input</th>
<th>Plant Crop</th>
<th>First Ratoon</th>
<th>Second Ratoon</th>
<th>Third Ratoon</th>
<th>Fourth Ratoon</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Estimated yield (t ha⁻¹)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tissue cultured plants</td>
<td>Low</td>
<td>9.1 (116)</td>
<td>6.4 (122)</td>
<td>4.7 (95)</td>
<td>3.7 (79)</td>
<td>1.5 (40)</td>
<td>25.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pared and hot-water treated suckers</td>
<td>Low</td>
<td>6.7 (126)</td>
<td>6.3 (117)</td>
<td>4.8 (95)</td>
<td>4.0 (83)</td>
<td>2.5 (53)</td>
<td>24.3</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>17.5 (119)</td>
<td>13.6 (121)</td>
<td>9.4 (89)</td>
<td>9.7 (95)</td>
<td>6.4 (69)</td>
<td>56.8</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pared suckers</td>
<td>Low</td>
<td>7.9 (130)</td>
<td>7.1 (123)</td>
<td>6.1 (99)</td>
<td>4.4 (89)</td>
<td>2.7 (61)</td>
<td>28.2</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>11.9 (115)</td>
<td>11.7 (114)</td>
<td>10.5 (101)</td>
<td>10.6 (99)</td>
<td>7.5 (76)</td>
<td>52.2</td>
</tr>
<tr>
<td>Suckers untreated</td>
<td>Low</td>
<td>5.5 (101)</td>
<td>4.2 (92)</td>
<td>3.1 (75)</td>
<td>2.8 (66)</td>
<td>0.8 (27)</td>
<td>16.4</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>10.5 (113)</td>
<td>10.0 (104)</td>
<td>10.1 (103)</td>
<td>9.7 (101)</td>
<td>6.9 (69)</td>
<td>47.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pared suckers</td>
<td>Low</td>
<td>7.3 (87)</td>
<td>4.5 (64)</td>
<td>3.4 (56)</td>
<td>2.7 (50)</td>
<td>1.4 (27)</td>
<td>19.3</td>
</tr>
</tbody>
</table>

For each treatment number of plants planted was 144 at the beginning of the experiment.

a Low input = non-mulched; high input = mulched.
b Yield was estimated according to the formula provided by Hauser and van Asten (2010): (plant density (plants ha⁻¹) x proportion of plants that produced a bunch (%) x mean bunch mass (kg)/100,000 = yield (t ha⁻¹). Statistical tests were not done because of estimated values.

1 “Performance of tissue-cultured versus sucker-derived East African highland banana (Musa AAA-EA) under high and low input systems in Uganda”; Björn Niere et al.; IITA and University of Bonn; November 2013