The cassava revolution in Vietnam

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1) Cassava - third most important export crop in Vietnam;

2) Cassava Conservation and Sustainable Development in Vietnam;

3) Cassava in Vietnam: Trends, Challenges and Direction
Cassava is a traditional crop in Vietnam, grown all over the country. One season in the North and 3 seasons/2 years in the South of Vietnam.

In 2015, the area under Cassava was 560,000 ha, producing 19 tons/ha, with a total of 10.5 million tons of fresh root.

By area and production volume, cassava is the third most important crop after rice and corn.

Third by export return, after rice and coffee, with an export value of 1.5 billion USD in 2015.

Large scale and small scale farms. 70% of the production is for export.
In 2014 from the 9.7 million tons:
• 30% serves the domestic demand for food, animal feed, starch, pharmaceuticals, biofuel and industrial alcohol,
• 70% is exported.
• Cassava Producing, processing, consuming, researching and developing are opportunities, prospects of farmers and

(Nguyen Van Bo, Hoang Kim 2013)
The basis of Vietnamese agriculture is rice. Cassava is planted on the upper parts.

Intercropping in sloppy land}

Cassava in poor soil

Intensive Cassava production
During the past 20 years cassava has become the third most important export crop in Vietnam – real revolution!
Revolution started from Improvement of productivity!

Between 1960-2000 - Productivity was about 8 tons/ha.
- Cassava was considered as soil degrading, causing soil erosion.
- No significant economic value, not recommended for expansion.
- No processing, used exclusively for food and feed.
- Since introduction new improved material from CIAT in late 80’s productivity started to grow rapidly.
- By the year 2015, productivity raised more then doubled, achieved 19 tons/ha

Cassava productivity from 1960-2010

Cassava productivity in Vietnam and the world for

- Higher than LAC, Africa and world average

- But still lower than Asia average, Thailand, India and Indonesia.

- Big different of productivity between regions: North mountain provinces: 12 tons/ha, Southeast – 32 ton/ha

Improvement of productivity enlarged area and production

- Area changed from 164.300 ha in 1995 to 560000 in 2015. More then tripled in 20 years

- Production volume increased from 1.62 million tons in 1995 to 10.5 million tons in 2015. More then 6 times

- Export return from 0.0 in 1995 to 1.5 billion USD. Ranged cassava in third importance among crop after rice and coffee

- Provide job and income for million people

**Source:** FAOSTAT, 2014, cited by Hoang Kim et al., 2014a.
Cassava production in Vietnam by regions

Cassava production by regions in 2013

- **North provinces:**
  - 1,500,500 tons of fresh roots
  - 15.40%.

- **North Central Coast and South Central Coast:**
  - 3,017,900 tons of fresh roots
  - 30.97%.

- **Central Highland Region:**
  - 2,526,400 tons of fresh roots
  - 25.93%.

- **South Eastern region:**
  - 2,433,800 tons of fresh roots
  - 24.98%.

Areas of cassava by regions of Vietnam
- Less in delta area. Mostly in highland, hilly and mountain regions

**Source:** Hoang Long et al. 2014; Hoang Kim, Nguyen Van Bo, Hoang Long, Nguyen Trong Hien, Hernan Ceballos and Reinhardt Howeler 2013
Revolution in cultivation technology: from hand to mechanization

• In intensive areas techniques applied instead of hand labour
Planting cassava machine
Tending machine
Harvesting cassava machine
Grinding machine
Currently, there are many cassava processing plants that focus on industrial wastewater treatment, primarily in the North. Cassava has been widely used in factories around the country.

Vietnam has built and put into operation ethanol production plants, blending of raw materials for bio-E5, E10, with high reproducibility and environmental protection. With a high yield of cassava, producing 1 ton of waste alcohol to make gasoline E5 or E10.

Along with the expansion, production and processing of cassava, protect and improve the environment is one of the factors to ensure sustainable development.
Role of cassava dramatically changed...

- From neglected crop cassava became important crop in 4 regions: North provinces; Southeast; Middle part and Central High land.

- Poverty reduction; local food security but also for industry and export.

- New terms: cassava motocyclers; cassava houses and cassava cars
Cassava in National Biofuel program 2010-2025

“Biofuel program to 2015 and outlook to 2025”

- To 2015: 5% suplement; to 2025 10% suplement ethanol to gasoline
- Cassava has been defined as only suitable crop for biofuel in Vietnam in the next decades.
- This makes Vietnam different from other countries in choosing input material for biofuel production.

Source: Tran Cong Khanh synthetize from vietnam statistic
Groups of input material for bioethanol:
1. Carbonhydrat containing material: Rice, Maize, Sugar cane, Cassava, sorghum.
2. Cellulosic Material: Timber, waist of forest industry....
3. Agriculture waist: rice straw, grass, rice husk waist from maize, sugar cane, cassava ... production
4. Others: Organic waist, algea...

- Analyze comparative advantage of each groups, MOIT came to conclusion that Starch and Sugar containing input material have advantages in the term of technology availability and production cost.
- Among sugar and starch containing material cassava has a number of advantages, as: non- food crop, excess of production, cost of production...
- Cassava was defined as only suitable input material for bioethanol production.
Vietnam Cassava Society

-One of few crop has such society in the country.
- To coordinate activities of cassava business toward sustainable cassava production to maximize benefit of cassava.
Cooperation with CIAT is of vital importance

- Introduction of improved breeding lines/varieties. (*)
- Improve Cultivation technology.
- Diseases control (*)
- Soil, fertilizer management.
- Training

(*) Partners: AGI (Vietnam); CIAT and RIKEN (Japan). Located in Hanoi. Opened platform for all people who wish to work on Cassava Biotechnology.
Recent Improvement of Cassava production: A Successful Sample Cooperation with CIAT

- Improvement of yield and enlargement of area in the last decade make Vietnam become a sample for contribution of cassava to poverty alleviation rural development.
- Before cassava was considered to be a undesirable crop because of it’s low profit, soil erosion, soil degradation.
- Experience of cassava cultivation last decade showed that stable yield of 60-80 ton/ha is feasible, no soil degradation and soil erosion.
- Cassava become promising, competitive crop, giving high income in most of provinces of Vietnam. Starch and cassava chips have good market.
- Cooperation with CIAT was very important in achieving present status and future.
Cassava Conservation and Sustainable Development in Vietnam

http://cassavaviet.blogspot.com
New advances in cassava cultivation techniques in Vietnam

- Vietnam cassava conservation and sustainable development has yielded spectacular results in trials organized in Tay Ninh, Phu Yen, Dak Lak, and Dong Nai,

- Where farmers using the improved technologies and practices boosted cassava yields from 8.5 t/ha to 36 t/ha - an increase of more than 400 percent

(Hoang Kim, Reinhardt Howeler, Nguyen Thi Truc Mai, Nguyen Bach Mai 2015).
Cassava in Vietnam from FPR to 10T

Breeding, screening and evaluating of KM419, KM94, ... high yielding starch by new techniques. Field survey to agricultural production site

Adoption
Production of cassava by agro-ecological zones farmers with hand-on guidance of experienced Tay Ninh farmers

Diagnosis
Farmers, scientist, extension workers, business, government

Research
Verify technology to be adapted
Design of water management systems for selected site

Potential solution
Investment Project recommendation from Ministry of Agriculture for bank loan

Evaluation
FPR Trials

10T
10 techniques for intensification of cassava

Vietnam cassava processes conservation breeding sustainable development

Source: Hoang Kim, Nguyen Thi Truc Mai, Nguyen Bach Mai, Reinhardt Howeler, 2015
10 techniques (10T)

The objectives of the cassava cultivation techniques program are:
The productivity of cassava can be increased by the use of the most appropriate varieties as well as by using the most improved techniques methods of production, including 10 techniques (10T) for intensification of cassava production.

- 1. The use of the best planting materials (stakes) of the most appropriate varieties;
- 2. The optimum time of planting and harvesting, for maximum yield and economic value;
- 3. The appropriate fertilizer applications of the NPK fertilizer combine animal manure to improve soil fertility and increase yield;
- 4. The optimum plant spacing suitable for best cassava varieties and various soils;
- 5. To prevent pest and disease by IPM;
- 6. The improvement of the agronomic potential for cassava systems: intercropping cassava with groundnut and legumes crops; and crops rotation;
- 7. The application of herbicides and plastic mulch for weed control;
- 8. The appropriate method for land preparation and planting, to soil erosion control;
- 9. The development of water management system for cassava farming;
### Area, yield and production of cassava in Tay Ninh province (2000-2013)

<table>
<thead>
<tr>
<th>Year</th>
<th>Area (1000 ha)</th>
<th>Yield (t/ha)</th>
<th>Production (1000 tonnes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>8.0</td>
<td>12.0</td>
<td>9.6</td>
</tr>
<tr>
<td>2001</td>
<td>25.4</td>
<td>21.2</td>
<td>538.7</td>
</tr>
<tr>
<td>2002</td>
<td>31.7</td>
<td>21.5</td>
<td>682.3</td>
</tr>
<tr>
<td>2003</td>
<td>35.6</td>
<td>22.5</td>
<td>800.1</td>
</tr>
<tr>
<td>2004</td>
<td>38.6</td>
<td>23.3</td>
<td>898.7</td>
</tr>
<tr>
<td>2005</td>
<td>43.3</td>
<td>24.7</td>
<td>1,071.8</td>
</tr>
<tr>
<td>2006</td>
<td>45.1</td>
<td>24.8</td>
<td>1,120.7</td>
</tr>
<tr>
<td>2007</td>
<td>44.5</td>
<td>25.3</td>
<td>1,125.9</td>
</tr>
<tr>
<td>2008</td>
<td>47.8</td>
<td>26.2</td>
<td>1,248.6</td>
</tr>
<tr>
<td>2009</td>
<td>46.0</td>
<td>26.8</td>
<td>1,236.1</td>
</tr>
<tr>
<td>2010</td>
<td>40.1</td>
<td>28.6</td>
<td>1,150.7</td>
</tr>
<tr>
<td>2011</td>
<td>45.7</td>
<td>29.0</td>
<td>1,325.9</td>
</tr>
<tr>
<td>2012</td>
<td>45.4</td>
<td>30.0</td>
<td>1,317.6</td>
</tr>
<tr>
<td>2013</td>
<td>45.9</td>
<td>30.0</td>
<td>1,377.0</td>
</tr>
</tbody>
</table>

**Source:** GSO, 2014, cited by Nguyen Van Bo et al., 2013; Hoang Kim et al., 2014; Hoang Kim, Nguyen Thi Truc Mai, Nguyen Bach Mai, Reinhardt Howeler, 2015

Yield 60 tons/ha
Gross income: 115 million VND

On-farm trials using cassava variety HL-S11 in Tay Ninh
The key study areas have now expanded to the provinces of Dak Lak and Phu Yen. The adoption of new varieties and new advances in cassava cultivation techniques, cassava conservation and sustainable development have yielded spectacular results in trials organized there.

(Nguyen Thi Truc Mai et al., 2014a and 2015; Nguyen Bach Mai et al. 2014b; Tran Ngoc Ngoan et al., 2014 and 2015; Hoang Kim et al. 2015).

The adoption of new varieties and improved cassava cultivation techniques, has yielded spectacular results in trials organized in Phu Yen in 2015.  

Hoang Kim et al. 2015
Sustainable management of cassava in Asia
From research to practice

“The work summarized in this manual represents the best available advice from more than 50 years of combined research experience and work with farmers to understand their real-life challenges and opportunities.”

Quản lý bền vững sắn châu Á
Từ nghiên cứu đến thực hành
http://fa.hcmuaf.edu.vn/hoangkim
Cassava in Vietnam: Trends, Challenges and Direction
Trends and Challenges

- In 2015 the planting area of cassava was about 0.56 millions ha.
- In 2014, Vietnam export about 3.4 millions tons of cassava products.
- In 2015, Vietnam export about 4.0 millions tons of cassava products.
- About 90% cassava products export to China.

Figure 3: Cassava trade in Vietnam.
Source: Jin Shu Ren. 2015. Future prospect for tapioca production and trade in East Asia.
Trends and Challenges

- Close to China, the world's largest cassava market.
- 13 bio-ethanol factories with a capacity of 1.067.7 million liters of bio-ethanol per year,
- 66 industrial starch processing factories,
- More than 2000 manual cassava starch processing units.
- Cassava production, processing, consuming researching are opportunities, prospects of farmers and enterprises of Vietnam as well as many countries in the world,
- However, cassava, at the same time, faces many risks and constraints

(Nguyen Van Bo, Hoang Kim et al. 2013)
Main problems in Cassava production and consumption

- Crop competition
- Low yield and low genetic variability
- Diseases.
- Soil fertility degradation and erosion
- High labor requirements
- Pollution in processing
- Price fluctuations and instability of the market
Direction

Cassava Conservation and Sustainable Development in Vietnam emphasize the following five topics:

• 1. Determination of an appropriate strategy for cassava research and development cooperation with processing factories in establishing areas with a stable source of raw materials; use of cassava for 4F: Fuel (bio-ethanol), Flour (cassava starch), Food and Feed.

• 2. Selection and dissemination of high-yielding varieties with high starch contents and high tolerance of pest and diseases;
Role of biotechnology

Goal: to develop Cassava varieties resistant to main pests and diseases, with high and quality starch contend

- Development of molecular marker for resistance traits to abiotic and biotic stresses through molecular mapping, genome sequencing, GWAS
- Marker Assisted Selection
- Genetic engineering for resistance traits, starch contend and starch quality, resistances
- Establishment of disease free seedling system to provide quality planting material and prevent spreading of diseases

Established International Laboratory of Cassava Molecular Breeding (ILCMB) in Hanoi as opened platform for every body who wish to work on cassava biotechnology in the region
ILCMB – Mutation breeding activity: ion beam Irradiation

**Heavy ion beam mutagenesis**
- KM94 seeds produced in Vietnam
- Seed irradiation performed by RIKEN, Nishina, Japan with different doses: 50, 100, 150 Gy
- Irradiated seeds rescued by AGI, Vietnam
- Determination of suitable doses
- Characterization and selection for improved phenotype
- Current embryo rescued collection: > 1500 lines
- Novel phenotypes include:
  - early flowering
  - No branching
  - Long leaf retention
  - Abnormal tuber form

**Embryo rescue of irradiated seeds**
- Cassava seeds
- Heavy ion beam Irradiation at RIKEN
- Surface sterilization
- Embryo isolation
- Micropropagation
- Complete plant
- After 7 days
- Embryos in 17N

**Suitable irradiation dose determination**
![Graph showing survival rate vs. dose]

**RAPD analysis of irradiated collection**
![Image of RAPD analysis results]
Phenotype variations from ion beam irradiation

- Pandurate leaflobe
- Bloom in Hanoi
- 5 leaf lobes
- 9 leaf lobes
- Red petiole
- Green petiole
- High starch (30%)
- Purple apical leaf (parent)
- Dark green apical leaf
- Light green apical leaf
Induction of Friable Embryogenic Callus (FEC)

<table>
<thead>
<tr>
<th>No</th>
<th>Variety</th>
<th>FEC formation rate</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>HL2004-28</td>
<td>0%</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>KM94</td>
<td>9.36%</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>KM140</td>
<td>3.85%</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>KM419</td>
<td>ongoing</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>NA1</td>
<td>6.23%</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>KM987</td>
<td>0%</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>SHL11</td>
<td>ongoing</td>
<td></td>
</tr>
</tbody>
</table>

Notes:
- GFP: green fluorescent protein
- Dof1: maize transcription factor, enhances nitrogen assimilation for improved glutamate content (amino acid production)
- Vector: pZY101 and pCAMBIA


Successfully transformed cassava with GFP: 9

Successfully transformed cassava with Dof1: 16 lines

Transformed plants

Regeneration and selection for transformants

A: FEC 8 weeks in MSN medium. B: FEC 10 weeks in MSN medium. C: regenerated FEC transformed with GFP. D: fluorescent photograph of C. E & F: Dof1 transformants

Confirmation of transformed plants

Fig. Representative PCR products amplified with Dof1 F3/R3 primers. M: DNA Ladder Marker. Lanes 1-9: 9 lines of TMS60444. (+): Positive control; (-): Negative control without DNA template.
Friable Embryogenic Callus (FEC)
Mô sọ phổ hóa
gfp overexpressing lines
Dof1 overexpressing lines
ILCMB – Evaluation and dissemination and introduction to production of CIAT elite lines;

65 CASSAVA ELITE LINES

Jan – Feb 2016 Transfer of elite lines

AGI + partners
VIETNAM

Micro-propagation Evaluation Dissemination

CIAT COLOMBIA

Petiole-less High carotenoids White fly resistance Stable dry matter content Cassava bacterial blight resistance
Development of cassava disease free seedling system via tissue culture and disease indexing
Main contributors of ILCMB

Dr. Nguyen Van Dong
Dr. Yoshinori Utsumi
Dr. Kris Wyckhuys
Dr. Tomoko Abe
Dr. Motoaki Seki
Dr. Manabu Ishitani
Dr. Stef De Haan
Dr. Nguyen Anh Vu
Tong Thi Huong
Vu Anh Thu
3. Research on integrated cultivation techniques and transfer of appropriate cultivation techniques to farmers, from FPR to 10T, to increase the productivity and economic efficiency of cassava production in different eco-regions.

4. Research on the development of cassava processing technologies; Development of local and export markets for cassava products. Use of cassava leaves and roots in animal feeds and food processing. Cassava starch, ethanol effluent and byproducts transformation into animal feed and fertilizers.
5. Environmentally friendly issues and food security

Bio-fuels development from cassava should focus on building and expanding the raw material, paying attention to environmentally friendly technologies and food security. The development of the program is not only the direction of improved cassava production to increase output but also to focus on distribution systems, processing, consumption, regulate interest groups, improving economic performance quality products, competitive advantage, building a healthy environment and prosperous rural life.
Thank You for Your Attention