Cassava
Tropical Root Crop

- Manioc
- Tapioca
- Mandioca
- Yuca

Cassava
Domesticated species
No wild progenitors known

Euphorbiaceae
Manihot esculenta

Domesticated species

Plant – Perennial – 1-4 m tall – Enlarged root

"Potato" of the lowland tropics
- Starchy root
  - 30-40% starch
- Leaves edible
  - 30% protein

Two Centers of Domestication

Bitter Cassava
Venezuela and Northern Brazil

Sweet Cassava
Central America

Dietary staple when Spanish arrived

Distribution of Cassava

Early 1600s
Late 1700s
Early 1800s
Mid 1800s
Cassava is Adapted to the Lowland Tropics

“Potato” of the Lowland Tropics

Adaptation of Cassava

- Tropical to subtropical
  - No freezes
  - Minimum annual mean temperature
    - 17°C to 20°C (63°F to 68°F)
- Rainfall
  - 1000 to 1500 mm
  - Sensitive to waterlogging
  - Tolerant of drought

- Acid soils of low fertility
- Efficient at extracting nutrients
- Mycorrhizal associations
- Sensitive to
  - Saline
  - Calcareous - high pH
  - Waterlogging

- Harvest date flexible
  - 6 to 36 months
  - Harvest as needed
- Tolerant to foliage loss
  - Insect or disease attack
  - Drought or storms
- Subsistence crop

Cassava Production by Region

<table>
<thead>
<tr>
<th>Region</th>
<th>Production 1,000s mt</th>
<th>1,000s mt</th>
</tr>
</thead>
<tbody>
<tr>
<td>Africa</td>
<td>99,195</td>
<td>53%</td>
</tr>
<tr>
<td>Asia</td>
<td>54,923</td>
<td>30%</td>
</tr>
<tr>
<td>Americas</td>
<td>31,770</td>
<td>17%</td>
</tr>
</tbody>
</table>
Cassava Production in the World

FAOSTAT, 2003

Cassava Production and Yield

<table>
<thead>
<tr>
<th>Region</th>
<th>Production (1,000s mt)</th>
<th>Yield (mt/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Africa</td>
<td>99,195</td>
<td>8.9</td>
</tr>
<tr>
<td>Asia</td>
<td>54,923</td>
<td>14.7</td>
</tr>
<tr>
<td>Americas</td>
<td>31,770</td>
<td>12.6</td>
</tr>
</tbody>
</table>

FAOSTAT, 2003

Why low yield in Africa?

- Most in sub-Saharan region and grown dryland
- Soil fertility – P and K
- Cassava mosaic

Cassava is an Important Source of Calories in the Tropics

A Staple Food for Millions of People

Staple crops as sources of calories (billion kcal/day)

<table>
<thead>
<tr>
<th>Crop</th>
<th>Tropics</th>
<th>World</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rice</td>
<td>924</td>
<td>2043</td>
</tr>
<tr>
<td>Maize</td>
<td>307</td>
<td>600</td>
</tr>
<tr>
<td>Sugar</td>
<td>311</td>
<td>926</td>
</tr>
<tr>
<td>Cassava</td>
<td>172</td>
<td>178</td>
</tr>
<tr>
<td>Sorghum</td>
<td>147</td>
<td>208</td>
</tr>
<tr>
<td>Wheat</td>
<td>&lt;100</td>
<td>1877</td>
</tr>
<tr>
<td>Potato</td>
<td>54</td>
<td>434</td>
</tr>
<tr>
<td>Musa</td>
<td>62</td>
<td>74</td>
</tr>
<tr>
<td>Sweet Potato</td>
<td>30</td>
<td>208</td>
</tr>
</tbody>
</table>


Importance of Cassava

- Dietary source of calories
  - 4th in tropics after rice, sugar, and maize
- Primarily as food
  - 60-70%
  - Equally cooked fresh and processed
Cassava as Food

Preparation

✓ Fresh root
✓ Cooked, boiled, roasted, fried
✓ Sundried
✓ Detoxication by solution
  - Soaking, Boiling, etc.
✓ Detoxication by fermentation

20–30% as Feed
✓ Varies by region
  - Southeast Asia
    • 4% (also export)
  - Africa
    • 6%
  - Americas
    • 57%
✓ Also exported to developed countries
  • 30% of cassava used for feed

Cassava for industrial use
✓ 10% for industrial starch

Nutritional value of cassava

<table>
<thead>
<tr>
<th></th>
<th>1 kg cassava</th>
<th>RDA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbohydrates</td>
<td>347 gm</td>
<td></td>
</tr>
<tr>
<td>Calories</td>
<td>1,460</td>
<td>2,500</td>
</tr>
<tr>
<td>Protein</td>
<td>12 g</td>
<td>46 g</td>
</tr>
<tr>
<td>Fat</td>
<td>3 g</td>
<td></td>
</tr>
<tr>
<td>Ca</td>
<td>330 mg</td>
<td>500 mg</td>
</tr>
<tr>
<td>Iron</td>
<td>7 mg</td>
<td>8 mg</td>
</tr>
<tr>
<td>Vitamin C</td>
<td>360 mg</td>
<td>25 mg</td>
</tr>
</tbody>
</table>

Cassava as a Food

✓ Excellent source of calories
✓ Roots are a poor protein source
  - Leaves can be eaten and are good protein source
✓ Significant source of
  - Calcium and iron
  - Vitamin C
Toxicity

- Breaking cells
  - Glycosides converted to hydrocyanic acid
- Acute toxicity, death
  - Rare, only if eat raw tubers
- Chronic toxicity
  - Nervous system degeneration
  - Goiter

Mechanism of Toxicity

- Detoxification of cyanide in blood
  - Requires S
- Thus body needs more S-containing amino acids
  - Essential for development of nervous system
- Also interferes with iodine uptake of thyroid

Chronic Toxicity

- Nervous system degeneration
- Goiter

- Only where
  - 1 kg or more of fresh cassava roots consumed daily over extended period
  - Consumption of animal protein low
  - Consumption of iodine low

Cassava Production

Farm Characteristics

- Most of cassava in world
  - Grown under adverse
    - Climatological conditions
    - Soil conditions
  - On farms that are
    - Small
    - Poor
    - Marginal areas

Propagation

- Stem cuttings
  - Mature plant
    - 10-30 cm (4-12”) long
  - > 3 nodes
Propagation

- During root harvest
  - Harvest stem cuttings for planting of next crop

Cut stems into appropriate size in field

Storage of stem cuttings

- Bundle as meter long stems
  - Basal end in soil
  - 4-6 months
- Southern Brazil
  - Cool winters
  - Underground shelter or trench

Good quality planting material essential

- Minimum of 3 nodes
- Can increase yields up to 70%

Discard cuttings with insect or disease

Use pre plant dip of planting material

- Fungicide
- Insecticide
- Zinc sulfate, zinc deficiency very common

Density (plants/ha)

- 7,000 to 20,000

Position

- Vertical to horizontal
- 5-10 cm deep
- Higher population w/ low fertility or poor weed control

Plant beginning of wet season
Does Cassava DEPLETE the soil of nutrients?

Nitrogen Extraction

<table>
<thead>
<tr>
<th>Plant</th>
<th>Harvested kg/ton dry matter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cassava</td>
<td>10</td>
</tr>
<tr>
<td>Potato</td>
<td>15</td>
</tr>
<tr>
<td>Maize</td>
<td>12</td>
</tr>
<tr>
<td>Rice</td>
<td>18</td>
</tr>
<tr>
<td>Sorghum</td>
<td>13</td>
</tr>
<tr>
<td>Wheat</td>
<td>18</td>
</tr>
</tbody>
</table>

Phosphorous Extraction

<table>
<thead>
<tr>
<th>Plant</th>
<th>Harvested kg/ton dry matter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cassava</td>
<td>2</td>
</tr>
<tr>
<td>Potato</td>
<td>3</td>
</tr>
<tr>
<td>Maize</td>
<td>4</td>
</tr>
<tr>
<td>Rice</td>
<td>4</td>
</tr>
<tr>
<td>Sorghum</td>
<td>3</td>
</tr>
<tr>
<td>Wheat</td>
<td>2</td>
</tr>
</tbody>
</table>

Potassium Extraction

<table>
<thead>
<tr>
<th>Plant</th>
<th>Harvested kg/ton dry matter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cassava</td>
<td>22</td>
</tr>
<tr>
<td>Potato</td>
<td>6</td>
</tr>
<tr>
<td>Maize</td>
<td>4</td>
</tr>
<tr>
<td>Rice</td>
<td>11</td>
</tr>
<tr>
<td>Sorghum</td>
<td>4</td>
</tr>
<tr>
<td>Wheat</td>
<td>2</td>
</tr>
</tbody>
</table>

Calcium Extraction

<table>
<thead>
<tr>
<th>Plant</th>
<th>Harvested kg/ton dry matter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cassava</td>
<td>1.6</td>
</tr>
<tr>
<td>Potato</td>
<td>0.8</td>
</tr>
<tr>
<td>Maize</td>
<td>0.5</td>
</tr>
<tr>
<td>Rice</td>
<td>1.6</td>
</tr>
<tr>
<td>Sorghum</td>
<td>0.5</td>
</tr>
<tr>
<td>Wheat</td>
<td>0.6</td>
</tr>
</tbody>
</table>

Cassava is well adapted to lowland tropical soils

- Tolerant of
  - Low fertility soils
  - Acid soils
  - High aluminum levels
- Respond well to fertilizer applications
  - Low requirement for N
  - High requirement for P and K
Does Cassava Deplete Soils?

- Not more than other crops
  - Able to extract nutrients from soils of low fertility - mycorrhizal associations
  - Produce better under low fertility than other crops
- Adjust top growth to fertility present so only show symptoms in extreme cases

Weed control

- Newly planted cassava grows slowly
  - Critical to control the first 3-4 months when it is establishing
- Hand weeding
  - Most common
  - 2 to 6 weedings
- Herbicides - normally with some hand weeding

High density and Weed Control

<table>
<thead>
<tr>
<th>Planting Density</th>
<th>Yield MT/ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>0</td>
</tr>
<tr>
<td>Low</td>
<td>10</td>
</tr>
<tr>
<td>High</td>
<td>20</td>
</tr>
<tr>
<td>Very High</td>
<td>25</td>
</tr>
</tbody>
</table>

Level of Weed Control

<table>
<thead>
<tr>
<th>Level of Weed Control</th>
<th>Yield MT/ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>0</td>
</tr>
<tr>
<td>Good</td>
<td>20</td>
</tr>
</tbody>
</table>

Intercropping and Weed Control

<table>
<thead>
<tr>
<th>Intercropping</th>
<th>Yield MT/ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alone</td>
<td>24.8 t/ha</td>
</tr>
<tr>
<td>With Bean</td>
<td>16.6 t/ha (67%) and 2 t/ha cowpeas</td>
</tr>
<tr>
<td></td>
<td>19.7 t/ha (79%) and 0.6 t/ha peanuts</td>
</tr>
</tbody>
</table>

Cassava intercropped with grain legumes - Thailand

- Cassava alone
  - 27.6 t/ha
- Cassava with soybeans
  - 26.7 t/ha (97%) and 0.7 t/ha soybeans
- Cassava with peanuts
  - 24.6 t/ha (89%) and 0.9 t/ha peanuts

Cassava intercropped with grain legumes - India

- Cassava alone
  - 24.8 t/ha
- Cassava with cowpeas
  - 16.6 t/ha (67%) and 2 t/ha cowpeas
- Cassava with peanuts
  - 19.7 t/ha (79%) and 0.6 t/ha peanuts
Cassava intercropped with grain legumes - Costa Rica

- **Cassava alone**
  - 16.8 t/ha
- **Cassava with dry beans**
  - 15.2 t/ha (90%) and 1.5 t/ha dry beans

Advantages of Intercropping

- Weed, pest, and disease suppression
- Nutritional complementation
  - Combine starch with protein crops
- Legumes fix nitrogen
- Yield per land area usually greater
- Early return on investment
  - Grain legumes harvest after 2-4 months
  - Cassava after 9-24 months

Is Cassava Pest Proof?

- Tolerant of loss of foliage
  - Loses part of yield but not all
- No critical stage for yield formation
  - Cereals when stressed at certain stages lose all yield
- There are diseases that kill plant - these will eliminate yield

Distribution of Cassava Pests

<table>
<thead>
<tr>
<th>Pest</th>
<th>Asia</th>
<th>Africa</th>
<th>Americas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thrips</td>
<td>XXX</td>
<td>XXX</td>
<td>XXX</td>
</tr>
<tr>
<td>Mites</td>
<td>XXX</td>
<td>XXX</td>
<td>XXX</td>
</tr>
<tr>
<td>Hornworm</td>
<td>XXX</td>
<td>XXX</td>
<td>XXX</td>
</tr>
<tr>
<td>Whiteflies</td>
<td>XXX</td>
<td>XXX</td>
<td>XXX</td>
</tr>
<tr>
<td>Grasshoppers</td>
<td>XXX</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mealybugs</td>
<td>XXX</td>
<td>XXX</td>
<td>XXX</td>
</tr>
<tr>
<td>Scales</td>
<td>XXX</td>
<td>XXX</td>
<td>XXX</td>
</tr>
</tbody>
</table>

Mite Damage

- Outbreaks during dry season
  - Up to 50% loss
- Protection
  - Resistance
  - Biological
    - Predator mites
    - Ladybugs
    - Beetle larva
    - Lacewings

Hornworm Damage

- Defoliate the plants
  - 20% yield loss per attack
- Protection
  - Biological
    - Wasp predators
    - Wasp houses in fields
Thrips Damage
- Feed on young leaves
  - Reduce leaf area
  - 30% yield loss
- Protection
  - Resistance

Scale Damage
- Feed on cells in stems
  - Debilitate plant
  - Reduce stand if on stem cuttings
- Protection
  - Insecticide dip of stem cuttings
  - Biological control

Whitefly Damage
- Feed on cells in leaves
  - Debilitate plant
  - Yield loss of 80%
- Protection
  - Resistance

Defoliation by other pests
- Defoliation causes a 20% yield loss

Distribution of Cassava Diseases
<table>
<thead>
<tr>
<th>Disease</th>
<th>Asia</th>
<th>Africa</th>
<th>Americas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bacterial blight</td>
<td>XXX</td>
<td>XXX</td>
<td>XXX</td>
</tr>
<tr>
<td>Superelongation</td>
<td>XXX</td>
<td></td>
<td>XXX</td>
</tr>
<tr>
<td>Frogskin</td>
<td>XXX</td>
<td></td>
<td>XXX</td>
</tr>
<tr>
<td>Cercospora</td>
<td>XXX</td>
<td>XXX</td>
<td>XXX</td>
</tr>
<tr>
<td>Cassava Mosaic</td>
<td>XXX</td>
<td>XXX</td>
<td></td>
</tr>
</tbody>
</table>

Superelongation
- Fungal disease
  - Only in Americas
  - 100% yield loss
- Protection
  - Resistance
  - Treatment of stem cuttings
Cassava Bacterial Blight

- **Bacterial disease**
  - Widespread
  - 100% yield loss
- **Protection**
  - Resistance
  - Certification of health of stem cuttings

African Mosaic Virus

- **Virus**
  - Whitefly vector
  - Africa and India
  - Up to 90% yield loss
- **Protection**
  - Resistance
  - Rogueing
  - Certification of health of stem cuttings

Pests and Diseases of Cassava

- **Tolerant of foliage loss**
  - Most insects and disease
- **Complete loss if disease/pest**
  - Systemically infects plant
  - Kills plant
- **Control mainly based**
  - Biological control
  - Resistance
- **Low value crop so pesticide application not usually economical**

Harvest

- **Flexible harvest time**
  - Stores well in ground
  - 6 to 24 months
    - Fresh, 6-15 mo
    - Industrial, 18-24 mo
  - Quality lower if harvest late

Harvest by hand

- Cut off at 30 cm
- Pull/dig
- Cut off roots

Harvest aids

- Chain/pole lever
- Tractor mounted digger

Harvest

- **Harvest by hand**
  - Cut off at 30 cm
  - Pull/dig
  - Cut off roots

Harvest aids

- Chain/pole lever
- Tractor mounted digger
Cassava Production Zones

- **Lowland Tropics**: Mean temp > 22°C
  - Dry season
  - Humid
  - Acid, infertile savannas
- **Highland Tropics**: Mean temp 17-22°C
- **Subtropics**, Warm summer, cool winter

Lowland Tropics

- Most important production zone
- Dry season - 50% of production
  - 800-2000 mm, 3-6 month dry season
  - Light, acid soils of low fertility
- Humid
  - 1500+ mm rain, well distributed
  - Acid, infertile savannas
  - 3-6 month dry season
  - Very acid, infertile soils
  - Underutilized lands

Cooler Zones

- **Highland Tropics** (1500 to 2300 m)
  - Well distributed rain
  - No freezes
- **Subtropical Zones**
  - Most rain during summer
  - Cool winter/hot summer

Selecting variety adapted to zone is critical

Maximum Yields of Crops

<table>
<thead>
<tr>
<th>Crop</th>
<th>Max./yr.</th>
<th>Kcal/ha/day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cassava</td>
<td>71 t/ha</td>
<td>250</td>
</tr>
<tr>
<td>Maize</td>
<td>20 t/ha</td>
<td>200</td>
</tr>
<tr>
<td>Sw. potato</td>
<td>65 t/ha</td>
<td>180</td>
</tr>
<tr>
<td>Rice</td>
<td>26 t/ha</td>
<td>176</td>
</tr>
<tr>
<td>Wheat</td>
<td>12 t/ha</td>
<td>110</td>
</tr>
<tr>
<td>Banana</td>
<td>39 t/ha</td>
<td>80</td>
</tr>
</tbody>
</table>

Potential Yields with Management

- **Lowland tropics** (10 - 12 months)
  - Good fertility 30 - 35+ t/ha
  - Mod. fertility 25 - 35 t/ha
  - Acid infertile 15 - 25 t/ha
- **Highland tropics** (14 - 18 months)
  - Mod. fertility 20 - 30 t/ha
- **Subtropics** (10 - 20 months)
  - Mod. fertility 20 - 40 t/ha
Marketing

✓ Fresh roots
  – Consumed within a week of harvest
✓ Storage
  – High humidity & fungicide, 2-3 weeks
  – Refrigeration, not readily available
  – Freezing, very expensive
✓ Dried products

Future Demand

✓ Dried/processed cassava products
  – Cheap source of calories
  – Income increase, use decrease
✓ Fresh cassava
  – Rural areas, cheap calorie source
  – Urban area, often a luxury item
✓ Novel uses
  – Bread, HFS, feed, protein source

Any Questions?