Challenges of Cassava in India

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India’s position in Global Cassava Scenario

<table>
<thead>
<tr>
<th></th>
<th>Asia</th>
<th>World</th>
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<tbody>
<tr>
<td>Area</td>
<td>5</td>
<td>16</td>
</tr>
<tr>
<td>Production</td>
<td>4</td>
<td>9</td>
</tr>
<tr>
<td>Productivity</td>
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<td>1</td>
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</table>
CASSAVA GROWING BELT OF INDIA
Fig. 1: Area, Production and Productivity of cassava in India

Cassava area in India

- Tamil Nadu: 41%
- Kerala: 18%
- Andhra Pradesh: 10%
- Other states: 31%

Cassava production in India

- Tamil Nadu: 54%
- Kerala: 28%
- Andhra Pradesh: 6%
- Other states: 12%

Fig. 1: Area, Production and Productivity of cassava in India

Area and Production

- Production ('000 Mt)
- Productivity (t ha⁻¹)
- Area ('000 ha)

Year


Area and Production

0 10 20 30 40

Productivity

0 5 10 15 20 25 30 35 40
## Current Utilisation of Tapioca (%) in India

<table>
<thead>
<tr>
<th>Sector</th>
<th>Utilization of Tapioca</th>
<th>Kerala</th>
<th>Tamil Nadu</th>
<th>Andhra Pradesh</th>
<th>Other states</th>
<th>All India</th>
</tr>
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<tbody>
<tr>
<td>Human consumption</td>
<td>Fresh tubers</td>
<td>25</td>
<td>10</td>
<td>0.5</td>
<td>25</td>
<td>16.4</td>
</tr>
<tr>
<td></td>
<td>Parboiled chips</td>
<td>5</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>2.1</td>
</tr>
<tr>
<td></td>
<td>Fried chips</td>
<td>10</td>
<td>10</td>
<td>---</td>
<td>---</td>
<td>9.6</td>
</tr>
<tr>
<td>Industry</td>
<td>Sago</td>
<td>10</td>
<td>33.5</td>
<td>42.5</td>
<td>50</td>
<td>24.3</td>
</tr>
<tr>
<td></td>
<td>Starch</td>
<td>10</td>
<td>33.1</td>
<td>17.7</td>
<td>---</td>
<td>22.8</td>
</tr>
<tr>
<td></td>
<td>Dry chips</td>
<td>10</td>
<td>13.4</td>
<td>39.3</td>
<td>---</td>
<td>12.5</td>
</tr>
<tr>
<td>Animal feed</td>
<td>Fresh tubers</td>
<td>30</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>12.3</td>
</tr>
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</table>
Inadequate supply of food: A major threat for India (by 2020)?

Net shortage of food grains by 30 million tonnes (by 2020)
### Demand-Supply gap for Tapioca starch and sago in India by 2015-16

<table>
<thead>
<tr>
<th>Projected</th>
<th>Demand</th>
<th>Supply</th>
<th>Gap</th>
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<tr>
<td></td>
<td>(tonnes)</td>
<td>(tonnes)</td>
<td></td>
</tr>
<tr>
<td>Starch</td>
<td>6,05,113 (30,25,565)</td>
<td>3,54,196 (17,70,978)</td>
<td>2,50,917 (12,54,587)</td>
</tr>
<tr>
<td>Sago</td>
<td>3,05,819 (18,77,054)</td>
<td>2,74,007 (16,44,040)</td>
<td>31,812 (2,33,014)</td>
</tr>
</tbody>
</table>
Bridging the Gap?

30 million Mt of food grains ~ 80 million Mt of tubers.

Cassava can be one alternative to bridge the gap in food production by 2020.

To achieve this, some critical research areas need to be addressed.
CONSTRAINTS
Global

1. Low multiplication rate & Bulkiness of planting material
2. Biotic & abiotic stresses
3. Perishability
4. Limited product diversification
5. Poor exploitation of speciality markets.
6. Climate challenge

India

1. Bulkiness of planting material
2. Cassava mosaic and tuber rot diseases
3. Limited product diversification
4. Low extension agenda
5. No govt. policy support.
6. Poor exploitation of specialty markets
Constraints in the Industrial sector

- Competition from cheaper maize starch.
- Due to Globalization import of cassava starch poses threat to domestic starch industry.
- Declining raw material availability due to reduction in area under the crop.
- Marketing costs and margins are high due to involvement of many market functionaries and distance between production and marketing centers.
Cassava is used only to the extent of 5-10% in the compound feed formulations.

Demand for cassava in animal feed sector is declining due to availability of cheaper substitutes in the compound feed preparations.

Cassava demand as animal feed is seen only in Kerala.
Policy and Institutional Constraints

- No suitable price policy for cassava.
- No schemes for technology transfer.
- Absence of strong cassava lobby.
- Investment in research and development of cassava is decreasing vis à vis other crops like potato.
- Poor market intelligence.
CHALLENGES IN BREEDING ACTIVITIES

- Development of varieties tolerant/resistant to biotic & abiotic stress, yield and quality.

- Selection of varieties for site specific performance & wide adaptability- in wide range of cropping situations.

- Marker Assisted selection for quickening the breeding programme.

- Selection of varieties suitable for product development to meet market demand.
CHALLENGES IN BREEDING ACTIVITIES

- Popularization of crop varieties in far and distant areas.

- Innovative breeding methods: Triploidy, heterosis breeding, Male sterile and apomitic lines.

- Para-sexual methods and distant hybridization: Haploid Breeding.
CASSAVA BREEDING : CTCRI

Since beginning

- Clonal selection
- Hybridisation and selection
- Triploidy breeding
- Heterosis breeding

Released 17 varieties: triploid hybrid, top cross hybrids, short duration varieties, CMD resistant variety.
Improved cassava varieties released from CTCRI

High starch varieties

H165 – a short duration variety and field tolerant to CMD

H226- popular in industrial area and susceptible to CMD
Early, good cooking quality, grown in Paddy fallows
Challenges in cassava crop improvement in India: weaknesses, strength & strategies

The challenges in improvement of cassava productivity, quality and production to be addressed in India may be classified under two groups such as

- **Challenges in pre–breeding activities:** Shortage of Genetic variations and generic problems (Problems related to the genus) involved in cleaning, conservation and utilization are the weaknesses.

- **Challenges in breeding activities:** Generic problems in flowering and seed set among the varieties and slow rate of selection and multiplication are the weaknesses.
WIDENING THE GENETIC BASE: Strategy for Germplasm Exploration & Conservation

• **Field Gene Bank** – 1615 accessions
• **In vitro Active Gene Bank**: Protocols developed & standardized. 25% of Germplasm collections transferred to IVAG.
• **Core collections**: to be identified & assembled.

- More than 700 indigenous lines collected from South & North Eastern states of India.
- Fresh exploration and collection in the tropical areas of India to collect more indigenous lines.

**Germplasm exchange:**

- Exchange programme in operation with CIAT, Cali, Colombia: CMD resistant line Mnga-1 & CR lines received.
- Strengthen the exchange programme with IITA, Nigeria which existed earlier, but not in operation presently.
Biotic constraints of cassava Production in India

Cassava mosaic disease (Yield loss 20 to 88%)

Cassava Tuber Rot (Yield loss – upto 90%)
Importance of CMD in India

- More severe in states of Kerala and Tamil Nadu.
- Emerging as a problem in other states also.

Factors:

- Indiscriminate use of infected planting material
- Non-adoption of rogueing/clean cultivation practices
- In India association of three cassava mosaic viruses (ICMV, SLCMV & ACMV) were recorded.
- During the past 5 years SLCMV overtake ICMV in all the cassava growing areas
Distribution of Cassava mosaic viruses in India

Map showing the distribution of SLCMV, ICMV, SLCMV + ICMV, and ACMV in India.
Strategies for CMD Management

- Use of healthy planting materials
- Use of meristem derived plants
- Growing field tolerant varieties (Sree Padmanabha, H 165, Sree Sahya)
- Rogueing & strict field sanitation
- Vector control - Spray 0.03% Dimethoate
- Production of virus free planting material in vector free areas
- Breeding for resistance
- Transgenic cassava resistant to CMD being developed
- Planting of barrier crops like maize and spraying of aqueous leaf and root extracts of *Boerhavia diffusa* and *Mirabilis jalapa*
Development of varieties tolerant/resistant to biotic & abiotic stress, yield and quality

Conventional breeding using donor parents like TMS 30001 (Mnga-1) having resistant genes: Recombinant breeding & back cross breeding- lead to CMD resistant lines having stable yield and starch content. 63 lines selected.

CMR lines accepted by farmers- 50 to 60 t/ha yield: 25- 28% extractable starch content.

Sree Padmanabha- The first variety with CMD resistance released for cultivation in irrigated plains in Tamil Nadu (India).
164 CR lines were screened for CMD resistance

12 clones recorded high yield (>30t ha-1) coupled cassava mosaic disease resistance.

Cassava mosaic disease resistance coupled with high tuber yield was recorded by CR43-11, CR43-7 (66.67 t ha-1), CR54A-19 (57.61 t ha-1), CR54A-3 (58.03 t ha-1) CR35-18, CR43-8, CR43-2 (55.35 t ha-1) and CR20A-2 (55.97).

Highest starch content was observed in CR 59-8 (40.67%) followed by CR54A-43 (33.76%), CR 43-6 (28.95%) and CR 54A-3 (28.37).
Transfer of CMD resistance to elite Indian clones

• Developed hybrids with clones having good culinary quality viz. M4, Vellayani Hrazwa etc.

• Hybrids with multiple resistance (MNga-1 & CR lines) are under evaluation.

• Promising CMD resistant hybrids selected for on farm trial includes 9S273, 9S127, 9S113, 9S117, 9S163 & 9S278
Development of Transgenic cassava against Cassava Mosaic Viruses in India

- Full length genome of DNA – A & B of ICMV & SLCMV were cloned and sequenced
- Infectious clones of ICMV and SLCMV were developed
- Constructs developed
  - Replicase gene
  - Hairpin constructs with partial gene of Replicase or TrAP of SLCMV
- Totally 17 lines (replicase gene construct) from different events were challenge inoculated by grafting.
  - Highly susceptible – 6
  - Moderate susceptibility to tolerance – 11 - with different grades of disease symptom and after 3 months they recovered from symptom expression
Major disease problem in TN

No external symptoms in infected plants but could be identified only on the harvest of tubers. Tubers get discoloured and rot.

The causative organism was isolated and identified as *Phytophthora palmivora*.

Ridge planting, regulating irrigation, improvement of drainage condition, strict adherence to sanitation and use of *Trichoderma* sp helps in the management of the disease.
Papaya mealybug - *Paracoccus marginatus*

- Reported from India in 2008
- Over 60 host plants
- Female lays 100-600 eggs in cluster
- Waxy coating protects from penetrating insecticide
- Crawlers (early stages of larvae) are very active and move around, later stages are sedentary

Spiralling whitefly - *Aleurodicus dispersus*

- A major pest on cassava;
- Over 72 host plants reported from Kerala;
- Honey due excretion by this pest cause sooty mold
Mealy bug management

Before treatment

Mealy bug with waxy coating

CTCRI developed two biopesticide

Sakthi - Removes the mealy substance

Shreya - Kills all the stages

Mealy substance removed due to the treatment of biopesticide

After treatment
*Bemisia tabaci*: Cassava biotype is the vector for CMD
Innovative breeding methods- Triploidy breeding

**Technique:** Triploids developed by hybridization of induced tetraploids (Colchicine) with normal diploids.

**Advantages:** Triploids showed robust, growth, higher yield, starch content and novel characters like early maturity, shade adaptability and tolerance to mealy bug attack.

**Success Results:** Two triploid lines viz. 4-2 & 5-3 widely accepted for cultivation - 50 – 60 t/ha yield and 28 to 30% extractable starch.
CIAT-CTCRI PROJECT ON DIHAPLOID CASSAVA:

- Inbreeding led to release of rare alleles controlling flowering (cleistogamy, male sterility, bisexuality etc.), mosaic resistance, plant type (dwarfs, semi dwarfs) etc.

- Screening of thousands of seedlings ($S_1$ to $S_6$) for starch quality and other economic traits viz. early bulking, high leaf retention, low HCN, high protein etc. is in progress.
**Innovative breeding methods- Heterosis breeding**

**Technique:** Selfing to achieve homozygous lines top crosses of selfed lines with potential varieties to realise expressions of hybrid vigour.

**Successful Result:** Sree Rekha, Sree Prabha- top cross selections developed with 35 to 40 t/ha yield and extractable (24 to 26%) starch content. Sree Prabha- variety found suitable for low input cultivation.
Para-sexual methods and distant hybridization:

- **Para-sexual Methods**: Anther/Pollen culture and haploidy breeding.

- **Distant hybridization**: Interspecific hybrids of *M. esculenta* with *M. tristis*, *M. caerulescens* and *M. pseudoglaziovii* developed for higher yield and starch.
Pollen culture produced callus

Development of embryogenic callus

Regeneration

Healthy green plants
INTERSPECIFIC BREEDING PROGRAMME IN CASSAVA

OBJECTIVES

• CMD resistance
• High protein

MANIHOT SPECIES
M.caerulescens
M.tristis
M.peruviana
M.flabellifolia
M.pseudoglaziovii
M.epruinosa
M.dichotoma
M. anomal
Selection of varieties suitable for product development

**Strength:** Potential lines with nutrient qualities like high carotene, anthocyanin developed and maintained.

Lines with varying levels of Amylose and amylopectin content identified.

**Weakness:** Technology to be developed for diversified products.
BIOFORTIFICATION: β-Carotene

- Screening of CTCRI cassava germplasm (1664) for pro Vitamin A: 654 genetic stocks screened

- 21 clones had yellow flesh colour and β carotene content varied from 0.04 to 0.79 mg100g⁻¹

- 8 clones had more than 0.25 mg 100g⁻¹

- In the fourth cycle of gene pool improvement, the highest carotene content of 3985IU/100mg obtained.

- High carotene clones had poor cooking quality.

- High carotene clones suitable for making fried chips

- High crude protein lines – upto 10.4% on dry wt basis
Fried chips of Yellow fleshed cassava

Fried chips of White fleshed Cassava
Marker Assisted selection: Cassava mosaic disease resistance

- Two parents CO2 (Susceptible to CMD) and MNga-1 (Resistant to CMD) selected for developing mapping population and linkage map construction.
- The $F_1$ population (141) used for genotyping (in lab using PAGE gel) using 75 SSR markers.
- 89 segregating markers were used for linkage map construction and 47 markers were found to be linked into 14 different groups spanning 412.9 cM.

- **SSRY44**
- **NS136**
Mapping population comprising of recombinant inbred lines for tuber flesh colour available for identification of molecular markers and Marker assisted breeding.
Popularization of crop varieties in far and distant areas: True seed propagation

**Threat:** Development of heterozygous population from seedlings.

**Overcoming threat:** Heterozygosity controlled to a large extent using selective hybridization of chosen parental genotypes.

Uniformity of targeted characters like tuber yield and dry matter obtained by crossing male sterile line (Ambakadan) with Normal line (Sree Padmanabha), use of inbred lines, hybrid seeds with high combining ability.

**Programme implemented:** Seed and seedling progeny under evaluation in five different locations in India.
Net working with AICRP centers in State Agricultural Universities.
Production and certification of quality seed/planting material

- Essential for popularization of varieties among the stake holders.
- Full fledged system for seed certification to be established.
Production Technologies - Rapid multiplication of quality planting materials

Multiplication ratio enhanced from 1:10 to 1:60

Traditional technique

Minisett technique

5 setts

60 setts
Value added home front and industrial products from cassava

- Snack foods, pasta, extruded and fried food products
- Semolina
- Extruded products (improved textural attributes)
- Silage and poultry feed
Value added industrial products from cassava

- Modified starches: chemically, physically and enzymatically modified starches

  - Starch derived products: Sweeteners, Ethanol, Biodegradable plastics, Starch based adhesives

  - Cold water miscible starch
  - Starch based biodegradable graft-copolymers
  - Superabsorbent polymers (SAP)
  - Edible and composite biofilms
  - Functional oligosaccharides
Future thrust..../ Avenues for collaboration
Induction of tetraploidy in CMD resistant lines for the development of CMD resistant high starch triploid clones for industrial use.

Development of CMD resistant hybrids with earliness

Development of hybrids with altered starch quality traits (CIAT)

Development of transgenics with high protein, altered starch quality (DDPSC/CIAT)

Isolation of cassava clones with good chip making quality

Development of inbred lines/hybrids with high SCA for true seed propagation in nontraditional areas

Isolation of clones with tolerance to PPD

Development drought tolerant hybrids

Identification of molecular markers & marker assisted breeding
In Crop managements views....

• Quick and early field level diagnostic kit needs to be developed for CMD & Tuber rot.
• Molecular level investigation required for the uneven distribution of virus in the infected plant.
• Understanding of virus-vector relationship in the light of different biotypes.
• Understanding of the symptom expression variation of different cultivars in different locations.
• Use of bioinformatics and proteomics tools to study Plant-virus interactions.
• More gene constructs to be developed with novel approach
• Need to increase the transformation efficiency.
Functional Foods: Pasta, Extruded snacks food etc

Starch based novel products: composites and nano composites for sustained release of drugs, fertilizers and pesticides, soil mulches

Starch based biofilms: food and pharmaceutical applications

Improved machinaries for starch processing industries

Better exploitation in animal feed sector
THANK YOU

Welcome to CTCRI