Recent advances in tropical fruit research in India

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CONTRIBUTION TO AGRICULTURAL GDP

<table>
<thead>
<tr>
<th>Year</th>
<th>Contribution</th>
<th>Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>1950-51</td>
<td>0.5%</td>
<td></td>
</tr>
<tr>
<td>1995-96</td>
<td>18%</td>
<td>6%</td>
</tr>
<tr>
<td>2011-12</td>
<td>30.4%</td>
<td>11%</td>
</tr>
</tbody>
</table>

HORTICULTURAL PRODUCTION (MT)

<table>
<thead>
<tr>
<th>Year</th>
<th>Estimated Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010-11</td>
<td>234.5 MT</td>
</tr>
<tr>
<td>1991-92</td>
<td>96.6 MT</td>
</tr>
<tr>
<td>1950-51</td>
<td>25 MT</td>
</tr>
</tbody>
</table>

Estimated requirement 2016-17 – 345 MT
Trend of Fruit Crops in India

All India Production of Fruits At A Glance (in thousand MT)
<table>
<thead>
<tr>
<th>Fruits</th>
<th>India</th>
<th>World</th>
<th>Highest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Banana</td>
<td>34.2</td>
<td>20.7</td>
<td>1. Indonesia (58.9) 2. Guatemala (40.9), 3. India (34.2) 4. Ecuador (33.3) 5. Mexico (30.3)</td>
</tr>
<tr>
<td>Grapes</td>
<td>21.1</td>
<td>9.8</td>
<td>1. India (21.1) 2. U.S.A (17.1) 3. China (16.0) 4. Chile (15.7) 5. Argentina (12.7)</td>
</tr>
<tr>
<td>Mango</td>
<td>7.2</td>
<td>7.7</td>
<td>1. Brazil (15.8) 2. Pakistan (10.7) 3. Indonesia (9.7) 4. China (9.4) 5. Mexico (9.3)</td>
</tr>
<tr>
<td>Orange</td>
<td>9.3</td>
<td>18.2</td>
<td>1. Turkey (36.3) 2. South Africa (35.8) 3. USA (32.6) 4. Brazil (24.7) 5. Egypt (23.5)</td>
</tr>
<tr>
<td>Papaya</td>
<td>40.7</td>
<td>28.9</td>
<td>1. Dominicana Republic (312.7) 2. Guatemala (89.8) 3. Indonesia (86.7) 4. China, Taiwan province of (58.4) 5. Mexico (50.1)</td>
</tr>
<tr>
<td>Pineapple</td>
<td>14.9</td>
<td>23.2</td>
<td>1. Indonesia (124.5) 2. Costa Rica (59.2) 3. Mexico (42.9) 4. Phillipines (41.0), 5. Brazil (40.9)</td>
</tr>
<tr>
<td>All fruits</td>
<td>11.6</td>
<td>11.3</td>
<td>1. Indonesia (22.3) 2. U.S.A (23.3) 3. Brazil (16.5) 4. Turkey (13.6) 5. Phillipines (13.2)</td>
</tr>
</tbody>
</table>
Gross returns from per hectare at 1999-00 prices * indicates at current prices
How role of Horticulture has changed?
Contribution of Crop Groups in Production (Value)

- Cereals: 32%
- Pulses: 4%
- Oilseeds: 9%
- Sugarcane: 6%
- Cotton: 5%
- Horticulture: 30%
- Others: 14%

9% area contribute 30.4% Value at constant prices and 30.73% at current prices
Institutional support to address the challenges

**Research ICAR**

**INSTITUTES (11)**
- IIHR, Bangalore
- IIVR, Varanasi
- IISR, Calicut
- CISH, Lucknow
- CITH, Srinagar
- CIAH, Bikaner
- CTCRI, Trivandrum
- CPRI, Shimla
- CPCRI, Kasargod
- CIARI, Portblair
- CRIC Nagpur

**DIRECTORATES (6)**
- Medicinal & Aromatic plants
- Onion & Garlic
- Oil Palm
- Mushrooms
- Cashew
- Floriculture

**NATIONAL RESEARCH CENTRES (6)**
- NRC Grapes
- NRC Banana
- NRC Litchi
- NRC Seed Spices
- NRC Orchids
- NRC Pomegranate

**11 Institutes**
- 6 Directorates
- 6 NRC’s
- 14 AICRP’s
- 251 Research Centres
- Dept. of Hort. in 35 SAU’s
<table>
<thead>
<tr>
<th>Fruit</th>
<th>Varieties</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mango</td>
<td>Pusa Arunima (Export quality)</td>
</tr>
<tr>
<td></td>
<td>Pusa Surya (Long self life)</td>
</tr>
<tr>
<td></td>
<td>Arunika (Anthracnose resistant)</td>
</tr>
<tr>
<td></td>
<td>Ambika (bright yellow with dark red blush, firm with scanty fibre)</td>
</tr>
<tr>
<td>Guava</td>
<td>Lalit (Pink pulp)</td>
</tr>
<tr>
<td>Grape</td>
<td>Pusa Navrang (Red pigmentation, juice making)</td>
</tr>
<tr>
<td>Papaya</td>
<td>Arka Prabhat (Gynodioecious - table fruit)</td>
</tr>
<tr>
<td></td>
<td>CO-8 (Red pulp - table)</td>
</tr>
<tr>
<td>Citrus</td>
<td>Phule Sharbati, Balaji acid lime</td>
</tr>
<tr>
<td>Jackfruit</td>
<td>Less gum type</td>
</tr>
</tbody>
</table>
Arka Prabhath

- Fruit wt: 1200 to 1500g
- Yield: 135 t/ha
- TSS: 13-14° Brix
- Cavity index: 28 - 32 %
Papaya CO.8

- Attractive red pulped dioecious variety
- No of fruits /tree: 75-80
- Average fruit weight: 2.20 kg.
- Highly suitable for processing and papain extraction
- Dec 2011; Undergoing MLT in AICRP centres
Evaluation of intergeneric hybrid progenies of papaya for PRSV tolerance

Parents: Arka Surya x V. Cauliflora
Number of progenies under evaluation (F5): 640

Field view of inter-generic progenies evaluated
Evaluation of intergeneric hybrid progenies of papaya for PRSV tolerance

Fruit weight: 600-800 g

TSS: 11.5 to 12.5° B

Pulp thickness: 2.95 - 3.05 cm

Pulp colour: orange

Fruits/tree: 55-60

Selected progenies under evaluation for PRSV tolerance coupled with fair fruit quality
Acid lime

Phule Sharbati

- High summer crop (25%)
- Round fruit, thin rind
- Less incidence of canker and tristeza
- Yield (180 kg/tree)
Balaji acid lime

- High yielding (115 – 120 kg/tree)
- Canker tolerant
- Large and round fruit
H-531

- Resistant to nematode & *Fusarium* wilt
- Resembles Poovan
- Yield 13-15 kg/bunch
Kovvur Bontha Selection

- High yielding cooking type
- 35 kg / bunch
Clonal Selection of Nendran (Manjeri Nendran II)

- Higher bunch weight (14-15kg-potential even up to 25kg as against local Nendra 10 kg)
- Suitable for annual cropping
- Tolerant to Sigatoka leaf Spot & pseudostem borer
Jackfruit

Promising type

Selection G-11a

- Medium latex exudation
- Coppery red flakes of 44g/flake
- Medium sized fruits (9.5-10 kg)
- Thick flakes (1.1 cm)
- Fake to Fruit ratio of 0.48
- High TSS (23°B)
- Acidity of 0.4%
- High carotenoids (3.5 mg/100g)
Jackfruit

Selection G-65

- Low latex exudation
- Medium sized fruits (8.65 - 13.2 kg)
- Good crispy flakes
- TSS of 24 – 29 °B
Osmo-dried jackfruit slices of different types
- Dwarf statured
- Fruits are oval in shape
- High yield (65-75 kg/tree/year)
- Medium size fruits

- Compact tree canopy
- Suitable for high density planting
- High yielder (100.4 Kg/tree/year; 20.08 t/ha)
- Spindle shaped fruits in clusters
- Attractive pulp with honey brown colour

Sapota
Rootstock research

- Root which impart better vigour and productivity of soil even under adverse situation and provides required architecture
- Used in most of the perennial fruit trees
- Use of rootstock is success story
  - Grape: Dogridge and 110R (drought and salinity tolerance)
  - Citrus: Alemow
  - Mango: 13-1
  - Guava: Interspecific wilt resistant rootstock (*Psidium guajava* x *P. molle*)
Rootstock, plant architecture management & use of hormones made grape successful in tropics with highest global yield.

Root stock technology alone revolutionized grape cultivation with 10 % yield and quality advantage fetched additional revenue of 129 Million USD.
Citrus rootstock Alemow: Resistant to *Phytophthora* (root rot & gummosis)

Two times increased yield

Nagpur mandarin (>21 t/ha)  Acid lime (> 13t/ha)
Cluster analysis of RAPD markers generated for 36 mango cultivars grown in different regions of India
High Density Planting in banana

- Paired row system at 1.2x1.2x2.0m
- 5208 plants/ha

- 3 plants/ Hill at 1.8 x 3.6m
- 4630 plants/ha
## Nutrient requirement under HDP in banana

<table>
<thead>
<tr>
<th>Density</th>
<th>RDF (%)</th>
<th>Centre/variety</th>
</tr>
</thead>
<tbody>
<tr>
<td>4650 to 5000 plants/ha</td>
<td>50</td>
<td>Rajapuri at Arabhavi</td>
</tr>
<tr>
<td>75</td>
<td>Alpan (Pusa), Robusta (Kovvur), Martaman (Mohanpur) and Grand Naine (Gandevi)</td>
<td></td>
</tr>
<tr>
<td>100</td>
<td>Borjahji (Jorhat) and Nendran (Kannara)</td>
<td></td>
</tr>
</tbody>
</table>

3 suckers /hill 1.8x 3.6m = 4600 plants/ha

3 suckers /hill 2x3m = 5000 plants/ha
HDP in guava
HDP and canopy management in guava

Early shoot management for better canopy and production

Enhancement of flowering through shoot pruning
HDP and canopy management in guava Contd...

Heavy fruiting after 7 years of planting

Initial canopy management to maximize fruiting under high density planting
High density orcharding in mango

- 400 trees/ha in case of Alphonso facilitated through vigour regulating practices - enhancing productivity in early years of mango orchard
PRUNING AND TRAINING
Stems must be in rest for sufficient time

generally about four to five months to induce the flower in the absence of chilling temperatures

Rhizosphere of mango plants

• Microbial inoculum (Trichoderma and Pseudomonas) +

• Ethylene precursors - Methionine + FeSO$_4$

highest ethylene levels in leaves during flowering and highest percentage of shoots flowered

(Reddy and Singh, 2010; Pulla Reddy et al., 2010)
Micro-propagation techniques for various fruits

- Success story in banana

Cleaning of infected materials

- Shoot tip grafting in Citrus

In vitro propagation for Quality assurance

Quality seed and planting material-health management
New propagation techniques

- wedge/ softwood/epicotyle grafting in mango
- wedge grafting in guava, jackfruit, aonla & jamun
- shoot tip and mini-crown grafting in citrus

Wedge grafting in guava
Why micro-propagation?

- Development of disease-free planting material
- Development of micro-propagation protocols for recalcitrant crops
- Mass multiplication of vegetatively propagated plants
- Safe exchange for disease safety
Micro-propagation success story in banana

Revolutionized the banana production

The graph shows the trend in production (in m ton), productivity (in Mt/ha), and area (in m ha) from 1991-92 to 2010-11. The productivity and production have increased steadily over the years, while the area has remained relatively consistent.
Diagnostics development

- **ELISA Kit** - Banana bunchy top
  - Banana mosaic
  - Citrus tristeza virus

- **PCR based** - Banana bunchy top
  - Banana streak virus

- **NASH based detection** - Banana bunchy top/streak

- **RT - PCR based detection** - Banana bract mosaic
  - Banana mosaic caused by CMV

Diagnostics developed for banana and citrus
Crop Protection Technologies

Standardised the region-specific control measures for the management of insect pests, nematodes and diseases using chemicals, botanicals and bio-agents.

Bio-agents

- *Mallada boninensis* (4-6 eggs per shoot) for black fly in citrus
- *Paecilomyces lilacinus* and *Pseudomonas fluorescens* for nematodes in banana
- *Trichoderma viride, T. harzianum, Pseudomonas fluorescens* for *Phytophthora* in citrus.
- *Pseudomonas fluorescens* for nematodes/Sigatoka leaf spot in banana.
- Bt for citrus butterfly

Botanicals

- Neem oil for leaf folder and fruit sucking moth in citrus.
- NSKE for citrus leaf miner & canker.
- Neemazal for pseudostem borer of banana
- Neem cake for nematodes of banana and citrus
- Pongamia oil for blackfly
Biological Control of Papaya Mealy Bug using Exotic Parasitoid Acerophagus papayae

*Paracoccus marginatus*, an invasive mealy bug, which cannot be controlled by insecticides.

Release of parasitoid results in complete control of mealy bug in 3-4 months.

Healthy plant after release of parasitoid.
IPM & CBC

Complete suppression of papaya mealy bug through, deploying three exotic insect parasitoids, in seven states, saving 245 m USD worth of starch, papain and silk in cassava, papaya and mulberry crops.
Management of Mango Stem Borer using Sealer-cum-Healer

- Neglected orchards more prone to stem borer attack to the tune of 15-20% of trees
- Application of sealer-cum-healer will control the borer infestation and rejuvenate the affected trees
Important Protection Technologies

IPM in mango
Integrated Diseases Management in Mango
Management of fruit rots in mango

Pre-harvest application - Azoxystrobin (0.1%) +

Post-harvest application - Neem leaf extract (5%) or Azoxystrobin (0.1%) or Chitosan (0.1%) or hot water treatment (10 minutes 52°C)
Hot water treatment plant

- Capacity: 1 ton/hour
- Anthracnose control: 52°C for 5 minutes
- Fruit fly control: 46°C for 65 minutes
Biological control of guava wilt was achieved with *Aspergillus niger* and *Trichoderma* sp. Technique for its multiplication in FYM was developed.
Pre as well as Post NAIP Value Chain Scenario for Kesar Mango and Ahllabad Safeda guava

Production system of mango and guava

Harvesting, post harvest handling and management

Consumption

Marketing of fresh fruits or value added products

Processing of fruits

Consumer Satisfaction and Benefit to Growers

Intervention of NAU
What we have Achieved?

- Enriched Genetic Resources: 2300 (total: 79600) accessions
- New Varieties/hybrids: 240 (total 1870)
- Plant architectural engineering and management for enhancing efficiency
- Crop management system - water & nutrients
- Plant health management - IPM & Bio-control
- Technology for reducing losses
- Post harvest technology & value addition
Research priorities

- Development of hybrids - genes for higher yield and resistance to biotic and abiotic stress which respond to climate change
- Improved production technology for mitigating problematic soil
- Enabling efficient use of water, nutrients and solar energy
- Technology for safe management of insect pests and diseases
- Reduction in post-harvest losses and value addition
- New areas
  - organic farming
  - precision farming
  - protected cultivation
  - biotechnology