HARC Update

Chifumi Nagai, PhD
  cnagai@harc-hspa.com

Hawaii Agriculture Research Center (HARC)
  http://www.harc-hspa.com

July 21, 2017
HCA Conference
Maui, Hawaii
Origin and variety/ cultivar of coffee

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Origin</th>
<th>Cultivar</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blue Mountain</td>
<td>Jamaica</td>
<td>Typica, Blue Mountain</td>
</tr>
<tr>
<td>Sumatra Mandhaling</td>
<td>Indonesia</td>
<td>SL28, Lintong</td>
</tr>
<tr>
<td>Kenya AA</td>
<td>Kenya</td>
<td>SL28, Ruiru11</td>
</tr>
<tr>
<td>Ethiopia</td>
<td>Harrar, Yelgacheffe</td>
<td>Arabica mix varirties</td>
</tr>
<tr>
<td>Kona</td>
<td>Kona</td>
<td>Typica</td>
</tr>
<tr>
<td>Costa Rica</td>
<td>Tarazu</td>
<td>Catuai, CostaRica95</td>
</tr>
<tr>
<td>Guatemala Antigua</td>
<td>Antigua</td>
<td>Caturra, Bourbon</td>
</tr>
</tbody>
</table>
Cultivars of arabica coffee

- Botanical varieties: Typica, Bourbon

- Mutants: Caturra (Ct), Maragogipe (Mg), mokka (molr), laurina (lr), San Ramon (SR)

- Semi Wild arabica accessions: Geisha

- Hybrids among arabica coffee:
  - Mundo Novo: High yield selection of Bourbon types
  - Red and Yellow Catuai (Mundo Novo x Caturra)
  - SL28
  - Pacamara: Maragogipe x Pacas select

- Hybrids with Timor Hybrid (natural cross of Arabica x Robusta) = CLR resistant
  - Catimor - Central America
  - Icatu – Brazil
  - Tupi, Obata (Sachimore) - Brazil
  - Ruiru 11 - Kenia
Steps for Cultivar Development by Plant Breeding

1. Understanding of the nature of the genetics and reproductive system of plants
2. Select the parents based on the traits to combine
3. Hybridization
4. Selection
5. Propagation
Milestones of Coffee Cultivar Development in Hawaii

1. 1950s: Imported over 30 varieties of arabica and wild species of Coffea to Hawaii. (Dr. Hamilton, UH)
2. 1980s: Field trials of 20+ arabica varieties at 10+ locations on 5 islands. (Cavaletto and Bittenbender, UH)
3. 1997: Dr. Medina consulted by HCGA for cultivar development
4. 1998: Established a field of cultivars of Hawaii at HARC Kunia for the breeding project (Nagai and Osgood, HARC, and HCGA)
5. 1999: 1st Hybridization of arabica varieties (Nagai, HARC)
6. 2000-2007: Selection of superior trees at HARC and Growers fields (HARC, Kauai Coffee, HCGA)
7. 2012-13: Distribution of Tissue cultured plants of 3 selected hybrids
8. 2017: 1st Commercial product of an unique Hawaiian cultivar (Tom Greenwell)
Genetic Resources (Parents)
Kauai
yellow Catuai
red Catuai

Oahu
mokka hyb.
Promecafe

Molokai
red Catuai
red Caturra

Maui
mokka
red Catuai

Kona
‘Guatemalan’
typica
‘Old Hawaiian’
Hawaiian

37 family total

Common Field
Kunia, HARC
planted April, 1998

Crosses (spring 1999)

<table>
<thead>
<tr>
<th>Group</th>
<th># of crosses</th>
</tr>
</thead>
<tbody>
<tr>
<td>mokka and other arabica varieties</td>
<td>66</td>
</tr>
<tr>
<td>with Promecafe (Catimor)</td>
<td>53</td>
</tr>
<tr>
<td>with Icatu</td>
<td>8</td>
</tr>
<tr>
<td>mokka and other selfs</td>
<td>40</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>167</strong></td>
</tr>
</tbody>
</table>

• H99 - series
Progeny (1,500)
• H00- series
(400)
<table>
<thead>
<tr>
<th>Group</th>
<th>Description</th>
<th>Genotype</th>
<th>Source</th>
<th>Tree #</th>
<th>Owner</th>
</tr>
</thead>
<tbody>
<tr>
<td>HI commercial</td>
<td>Typica</td>
<td>4</td>
<td>Kona</td>
<td>72</td>
<td>HARC/ public</td>
</tr>
<tr>
<td></td>
<td>Catuai</td>
<td>10</td>
<td>Maui, Kauai, Molokai</td>
<td>150</td>
<td>HARC/ public</td>
</tr>
<tr>
<td></td>
<td>Caturra</td>
<td>2</td>
<td>Molokai, UH</td>
<td>35</td>
<td>HARC/ public</td>
</tr>
<tr>
<td></td>
<td>Yellow Catuai</td>
<td>2</td>
<td>Kauai</td>
<td>40</td>
<td>HARC/ public</td>
</tr>
<tr>
<td></td>
<td>Mokka</td>
<td>4</td>
<td>Maui</td>
<td>80</td>
<td>HARC/ public</td>
</tr>
<tr>
<td></td>
<td>Mokka hybrid</td>
<td>5</td>
<td>Oahu</td>
<td>100</td>
<td>HARC/ public</td>
</tr>
<tr>
<td></td>
<td>Catuai odd type</td>
<td>1</td>
<td>Molokai</td>
<td>15</td>
<td>HARC/ public</td>
</tr>
<tr>
<td>Other commercial</td>
<td>P502</td>
<td>1</td>
<td>UH HSPA trial1988</td>
<td>10</td>
<td>HARC/ public</td>
</tr>
<tr>
<td></td>
<td>Maragogipe</td>
<td>1</td>
<td>UH HSPA trial1988</td>
<td>11</td>
<td>HARC/ public</td>
</tr>
<tr>
<td></td>
<td>6549</td>
<td>1</td>
<td>UH HSPA trial1988</td>
<td>12</td>
<td>HARC/ public</td>
</tr>
<tr>
<td></td>
<td>6661</td>
<td>1</td>
<td>UH HSPA trial1988</td>
<td>12</td>
<td>HARC/ public</td>
</tr>
<tr>
<td></td>
<td>San Ramon</td>
<td>1</td>
<td>UH HSPA trial1988</td>
<td>12</td>
<td>HARC/ public</td>
</tr>
<tr>
<td></td>
<td>Pacas</td>
<td>1</td>
<td>UH HSPA trial1988</td>
<td>11</td>
<td>HARC/ public</td>
</tr>
<tr>
<td></td>
<td>Yellow bourbon</td>
<td>1</td>
<td>UH HSPA trial1988</td>
<td>12</td>
<td>HARC/ public</td>
</tr>
<tr>
<td></td>
<td>Kents</td>
<td>1</td>
<td>UH HSPA trial1988</td>
<td>9</td>
<td>HARC/ public</td>
</tr>
<tr>
<td></td>
<td>Blue mountain</td>
<td>1</td>
<td>UH HSPA trial1988</td>
<td>12</td>
<td>HARC/ public</td>
</tr>
<tr>
<td></td>
<td>Preger</td>
<td>1</td>
<td>UH HSPA trial1988</td>
<td>11</td>
<td>HARC/ public</td>
</tr>
<tr>
<td></td>
<td>Guadalupe</td>
<td>1</td>
<td>UH HSPA trial1988</td>
<td>12</td>
<td>HARC/ public</td>
</tr>
<tr>
<td></td>
<td>SL28</td>
<td>1</td>
<td>Kauai Coffee</td>
<td>6</td>
<td>HARC/ public</td>
</tr>
<tr>
<td></td>
<td>Catimor</td>
<td>8667-6,5775-7-1</td>
<td>2</td>
<td>Promecafe (1)</td>
<td>45</td>
</tr>
<tr>
<td></td>
<td>Canephora</td>
<td>C. canephora</td>
<td>1</td>
<td>UH HSPA trial1988</td>
<td>7</td>
</tr>
</tbody>
</table>
Use of mokka germplasm as parents

**Goal:**
The introgression of Mokka flavor traits into high yielding and larger bean size cultivars

- Mokka is an arabica coffee variety (*C. arabica*) originating in Ethiopia. Historically Mokka coffee was exported from Mokka port in Yemen.

- Mokka was introduced to the Univ. of Hawaii coffee germplasm collection in the mid 1950s

- The original Mokka is considered as a mutant of Bourbon (C alvalho et al 1965)

- Commercially cultivated on Maui (Kaanapali Coffee Co). The accession is considered to be a Mokka hybrid. (by Medina)

- The cupping quality of Mokka hybrid was evaluated excellent by coffee cuppers in US but bean size is very small (about 30-40% of Red Catuai beans).
Mokka germplasm at HARC Kunia Station

The original mokka (short mokka)
From Dr. Medina, Campinas

Mokka hybrid ‘Ibaiiri’

Mokka:MA2-7

Field of various Mokka hybrids
Examples of genetic traits for arabica coffee breeding

- Pest and Disease Resistance
  CLR (Coffee Leaf Rust), CBD (Coffee Berry Disease)

- Unique Cupping Quality and other components
  non-caffeine coffee

- Beans and tree characters:
  bean size, shape, tree height

- Advantage for cultivation:
  drought tolerance, mechanical harvestability
Typica vs. Catuai

Ripe Coffee Cherries

‘typica’

‘mokka’
Hybridization and Selection
Flowering of Arabica Coffee

Pollen of coffee (x 200)

https://www.pinterest.com
Hybridization of coffee

Pollination

Fruit/seed development

Harvest: 6-7 months from pollination
Fruits of Mokka and a Mokka Hybrid

Developing fruits

Ripe fruits

Ripe Fruit sizes

Typica

Mokka

H99-36:
MA1-12 x Margogipe
(mokka select)

- Increased bean Size
  - Yellow catuai x Margogipe
  - Mokka hyb. Self
  - Mokka x Red Catuai

- Tree height
  - Red Catuai x Mokka hyb
  - Red catuai dwarf x mokka hyb
  - Red Catuai x typica
  - SanRamon? x mokka

- Cupping Quality
  - Red Catuai x SL28
  - Mokka hyb self
  - Red Catuai x 6661

F2 Segregation of hybrid families
<table>
<thead>
<tr>
<th>Hybrid #</th>
<th>Parentage</th>
<th>Pedigree</th>
</tr>
</thead>
<tbody>
<tr>
<td>H99-54</td>
<td>OA13-5 self</td>
<td>Blue Mtn x Mokka Hyb self</td>
</tr>
<tr>
<td>H99-56</td>
<td>MA8-3x MA1-12</td>
<td>Red catuai x Mokka Hyb</td>
</tr>
<tr>
<td>H99-60</td>
<td>MA10-5 self</td>
<td>Mokka Hyb self</td>
</tr>
<tr>
<td>H99-74</td>
<td>#6661x Catuai</td>
<td>#6661x Catuai</td>
</tr>
<tr>
<td>H99-131</td>
<td>BMT1x 6661</td>
<td>Typica x 6661</td>
</tr>
<tr>
<td>H99-150</td>
<td>MA6-2x SL28</td>
<td>Red Catuai SL28</td>
</tr>
<tr>
<td>H99-153</td>
<td>MA7-1 x SL28</td>
<td>Red Catuai SL28</td>
</tr>
<tr>
<td>H99-160</td>
<td>MO24-8 x mocha2</td>
<td>Red Catual x mokka</td>
</tr>
<tr>
<td>H99-169</td>
<td>OA13-1 BMT-1</td>
<td>BMT Mokka x Typica</td>
</tr>
<tr>
<td>H99-22A</td>
<td>MA1-12 self</td>
<td>Mokka Hyb self</td>
</tr>
<tr>
<td>H99-36</td>
<td>MA1-12 x Maragogipe</td>
<td>Mokka Hyb x Maragogipe</td>
</tr>
<tr>
<td>H99-43</td>
<td>MA10-5 x Y. Bourbon</td>
<td>Red Catuai x Bourbon</td>
</tr>
<tr>
<td>KA17</td>
<td>Yellow Catuai</td>
<td></td>
</tr>
<tr>
<td>KO34</td>
<td>Typica</td>
<td></td>
</tr>
</tbody>
</table>
Field trial of selected F1 hybrid families at Kauai coffee (2004-2007)

Objective: Field evaluation of selected coffee hybrid families at a commercial coffee field

Experimental Design : RCB
14 Entries:12 new hybrid families
2 check varieties: Yellow catuai (KA17) and Kona typica (KO34)
2 Location with 4 reps
14 trees/plot
(14 x 3.75 ft spacing- Kauai Coffee Standard)
Kauai Coffee Field Trial

Field Planting 4/1/04
Propagation
Cloning/ Tissue Culture of Selected Hawaiian Arabica Hybrids

Sub-contracted from HCA/ HCGA for SCBGP-FB, 2010-2012
Acclimatization: Sterile environment to soil
Clones of New F1 and F2 Hybrids

Clones (via tissue culture) of top 3 F2s (H99-153, H99-150 and H99-160) were distributed to HCGA members and HARC Maunawili station in 2012.
H99-36 F1
H99-36 F5 Development and Selection
HARC/ HCGA/ Greenwell Farms

**F1: Original Hybrid H99-36 1999**
HARC Kunia
MA1-12 x Maragogipe
( mokka hybrid)

**F2: Kauai Coffee Trial 2004**
39 trees (seeds from 3 F1 trees)

**F3: Greenwell Farms, Kona 9 trees (seeds from 1 F2 tree)**
Planted 2007

Cupping at various times

**F4: Greenwell Farms, planted (seeds from selected 6 F3 trees) in 2011**

**F5: Greenwell Farms, Kona planted (seeds from selected F4 trees) in 2015**
F3 Planting at Greenwell Farms at Kona
F4 Trees planted in 2012
H99-36 F5 at Greenwell Farms
H99-36 F5 Flowering in 2017
HARC Coffee Research Team and Collaborators

HARC
Dr. Chifumi Nagai
Dr. Ming Li Wang
Nick Dudley
Tyler Jones
Lance Santo (Agronomy consultant)
Jayme Barton
Kyle Onaga, Emma Smith
Juli Burden

USDA-ARS PBARC
Dr. Tracie Matsumoto et.al
Suntory Global Innovation Center Limited, Japan
Dr. Koichi Nakahara et al.

World Coffee Research (WCR)

University of Illinois
Dr. Ray Ming

Texas A&M University, Dallas
Dr. Qing Yi Yu

Mi-Cafeto, Tokyo, Japan
Jose Kawashima

Hawaii Coffee Growers’ Association (HCGA)

UH- CTHAR
Andrea Kawabata

Research Funding: USDA-ARS, HDOA