Breeding High Yielding Cowpea Varieties with Improved Seed Quality and Enhanced Nutritional and Health Factors.

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2016 –The International year of Pulses

Pulses are a gift from nature: rich in protein, minerals, vitamins and other health factors, pulses evolved in tandem with carbohydrate rich cereals and root crops at different geographical locations and they together ensured a nutritionally balanced food for the early human settlers in these locations.

1. Wheat, barley, pea, chick pea, lentil evolved in the West Asia
2. Rice, pigeon pea, mung bean in India
3. Rice and soybean in China
4. Sorghum and cowpea in Africa
5. Maize and beans in Mexico
6. Potato, sweet potato, cassava and peanut in South America
Cowpea is a major food legume in the tropics covering over 65 countries.

14 million ha
7 million tons
Diversified uses of cowpea:

Food – green pods, green leaves, fresh and dry grains

Fodder and green manure and pastures
Cowpea breeding programs

- **IITA – Global mandate in CG system**
  (Intl. Inst. Of Tropical Agriculture)
  - over 15,000 cultivated lines from 100 countries and 560 wild types
  - most of these evaluated and screened for biotic and abiotic stresses
  - Sources of resistance identified.

* **Other major breeding programs**
  - Brazil, Nigeria, Burkina Faso, Senegal, USA, India,

* **Breeding Objectives**
  - High yield, diverse maturity, plant type, grain type, vegetable type, dual-purpose
  - Resistance to biotic and abiotic stresses
  - Physical and nutritional qualities of seed and fodder
Breeding for high yield and quality

High yield = plant type, maturity, resistance to pests, drought tolerance, efficient BNF and use of phosphorus

Seed quality = Viability, seed size, seed color, hilum color, seed coat texture, seed coat thickness, seed hardness, water absorption and swelling volume, density and cooking time

Nutritional quality = carbohydrate, protein, minerals, and vitamins

Health factors = antioxidants, complex carbohydrates

Fodder Quality = protein, fiber and digestibility
High Yield: Improving plant type
High Yield: Resistance to major diseases
High Yield: Resistance to major insects
High yield: breeding for drought tolerance and low fertility
High Yield: Diverse maturity and plant type
High Yield: grain type and dual purpose cowpea varieties
Cowpea breeding for nutritional quality and health factors

- Acceptable seed size, color and texture
- High protein, minerals and vitamins
- High antioxidants, complex carbohydrates and fibres
- Fast cooking time
- Versatility for use in diverse foods and local dishes
- Specialty products – home and industrial scale
- Fresh snack foods
- Extruded snack foods
- Diverse products from cowpea leaves and fresh pods
Breeding for seed types

**Seed color** – Black, red, brown, white, green

**Seed texture** – Smooth, rough

**Seed size** - 100 seed weight in grams

**Seed density** - Seed weight in grams divided by volume in ml

**Dry seed volume** - 20 g seeds in 50 ml water. Measure the rise in water level.

**Wet seed volume** - 20g seeds overnight in cylinder with 50 ml water. The water level in the morning recorded as total volume of the wet seeds and unabsorbed water. Excess water removed in another measuring cylinder: The difference between the total volume and excess water was recorded as the wet seed volume.

**Swelling ratio** - The wet seed volume divided by dry seed volume equals swelling ratio.

**Water absorbed** - The excess water removed after overnight soaking was subtracted from 50 ml and the difference was recorded as water absorbed.
Seed hardness

Swelling properties

Cooking time
## Genetic variability for seed characteristics

<table>
<thead>
<tr>
<th>Variety</th>
<th>Testa %</th>
<th>Hardness</th>
<th>D. seed vol.</th>
<th>Density</th>
<th>Water abs.</th>
<th>Wet seed vol.</th>
<th>Swelling Ratio</th>
<th>Cook time</th>
<th>Seed size</th>
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<td>4.4</td>
<td>17.6</td>
<td>1.14</td>
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<td>40.2</td>
<td>2.3</td>
<td>27.5</td>
<td>17.0</td>
</tr>
<tr>
<td>Dan Ila</td>
<td>6.4</td>
<td>5.1</td>
<td>16.4</td>
<td>1.22</td>
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<td>9.0</td>
<td>17.5</td>
<td>1.14</td>
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<td>42.2</td>
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<td>32.5</td>
<td>15.0</td>
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<td>16.5</td>
<td>1.11</td>
<td>26.2</td>
<td>42.8</td>
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<td>2.6</td>
<td>37.5</td>
<td>17.8</td>
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<tr>
<td>TVU 12349</td>
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<td>3.7</td>
<td>15.9</td>
<td>1.21</td>
<td>25.0</td>
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<td>2.6</td>
<td>32.5</td>
<td>11.8</td>
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<td>Kanannado</td>
<td>6.1</td>
<td>5.1</td>
<td>17.2</td>
<td>1.16</td>
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<td>Mean</td>
<td>8.3</td>
<td>5.1</td>
<td>16.9</td>
<td>1.15</td>
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<td>41.5</td>
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<td>16.9</td>
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<tr>
<td>Heritability</td>
<td>0.66</td>
<td>0.55</td>
<td>0.72</td>
<td>0.70</td>
<td>0.46</td>
<td>0.62</td>
<td>0.71</td>
<td>0.90</td>
<td></td>
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</tbody>
</table>
Smooth coat

Seed coat %

1108-4: 10.5
453-3: 11.5
12349: 13.5

Rough coat

Seed coat %

1696: 6.8
350-4: 6.5
207-15: 5.7
Breeding for nutritional traits in cowpea
(Supported by Harvest Plus project of CGIAR)

Genetic variability for major nutritional traits from 2000 lines screened

Seed size - 9 to 27g /100 seeds
Protein - 22.9 to 32.5%
Ash - 2.9 to 3.9%
Fat - 1.4 to 2.7%
Carbohydrate - 59.7 to 71.6%
Cooking time - 21.1 to 61.9 min

Iron - 51 to 109 ppm
Zinc - 33 to 51 ppm
Calcium - 581 to 1252 ppm
Potassium - 12084 to 15133 ppm
Magnesium - 1611 to 2052 ppm
Phosphorus - 3867 to 4922 ppm
Sulfur - 1880 to 2354 ppm
Breeding for health factors in cowpea

A total of 64 cowpea varieties collected from Africa, Asia and USA were analyzed for several health factors and a great deal of variability was observed.
Variability for antioxidant activity in cowpea varieties

Antioxidant activity (umol/g) trolox equiv.

Variety
Breeding cowpea varieties for health factors

![Graph showing Trolox equ (µg/gdw) for different varieties.]

<table>
<thead>
<tr>
<th>Variety</th>
<th>CP</th>
<th>Fe</th>
<th>Zn</th>
<th>Ca</th>
<th>K</th>
<th>Mg</th>
<th>P</th>
<th>S</th>
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<tbody>
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<td>69</td>
<td>45</td>
<td>858</td>
<td>14378</td>
<td>1987</td>
<td>5139</td>
<td>2361</td>
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<tr>
<td>IT98K-205-8</td>
<td>27</td>
<td>60</td>
<td>42</td>
<td>994</td>
<td>13672</td>
<td>1952</td>
<td>4922</td>
<td>2109</td>
</tr>
</tbody>
</table>
Antioxidant activity (ORAC)
Gene complementation phenomenon
Anthocyanins are non-detected in either parents, but they are expressed in the hybrid

HPLC graphs of white parent (Bambey 21), light brown parent (556-4) and F₁ hybrid detected at 520 nm showing anthocyanins.

Mean antioxidants in different colors

<table>
<thead>
<tr>
<th>Color</th>
<th>Mean ± SD</th>
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<tbody>
<tr>
<td>Light brown</td>
<td>87.539 ± 7.00</td>
</tr>
<tr>
<td>Black</td>
<td>83.793 ± 3.49</td>
</tr>
<tr>
<td>Red</td>
<td>64.230 ± 1.38</td>
</tr>
<tr>
<td>Mixed</td>
<td>46.161 ± 1.97</td>
</tr>
<tr>
<td>Dark brown</td>
<td>32.538 ± 3.43</td>
</tr>
<tr>
<td>White</td>
<td>12.919 ± 0.59</td>
</tr>
</tbody>
</table>
New cowpea varieties with high yield and quality
### Improved Cowpea Varieties with High yield and quality

<table>
<thead>
<tr>
<th>Variety</th>
<th>Protein</th>
<th>Fe</th>
<th>Ca</th>
<th>Zn</th>
<th>K</th>
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</thead>
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<tr>
<td>IT97K-1042-3</td>
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<td>77</td>
<td>980</td>
<td>46</td>
<td>16,000</td>
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<tr>
<td>IT98K-205-8</td>
<td>27.1</td>
<td>65</td>
<td>885</td>
<td>45</td>
<td>14,500</td>
</tr>
<tr>
<td>IT99K-216-48-1</td>
<td>27.5</td>
<td>65</td>
<td>780</td>
<td>39</td>
<td>15,650</td>
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<tr>
<td>IT97K-556-4</td>
<td>27.4</td>
<td>63</td>
<td>660</td>
<td>38</td>
<td>15,750</td>
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<tr>
<td>IT98K-205-8</td>
<td>27.1</td>
<td>65</td>
<td>885</td>
<td>45</td>
<td>14,500</td>
</tr>
<tr>
<td>Aloka local</td>
<td>23.1</td>
<td>49</td>
<td>1,070</td>
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<td>885</td>
<td>40</td>
<td>15,150</td>
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<tr>
<td>IT98D-1399</td>
<td>24.1</td>
<td>61</td>
<td>1,300</td>
<td>27</td>
<td>16,000</td>
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</tbody>
</table>
Recently released varieties of cowpea in India

<table>
<thead>
<tr>
<th>Varieties</th>
<th>Seed color</th>
<th>Yield Kg/ha</th>
<th>% Protein</th>
<th>Iron ppm</th>
<th>Zinc ppm</th>
<th>Mn ppm</th>
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</thead>
<tbody>
<tr>
<td>Pant Lobia-1</td>
<td>White</td>
<td>1969</td>
<td>28</td>
<td>89</td>
<td>45</td>
<td>14</td>
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<tr>
<td>Pant Lobia-2</td>
<td>Red</td>
<td>1845</td>
<td>31</td>
<td>90</td>
<td>45</td>
<td>31</td>
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<tr>
<td>Pant Lobia-3</td>
<td>Brown</td>
<td>2072</td>
<td>27</td>
<td>97</td>
<td>51</td>
<td>34</td>
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<tr>
<td>Pant Lobia-4</td>
<td>White</td>
<td>1794</td>
<td>25</td>
<td>109</td>
<td>51</td>
<td>12</td>
</tr>
<tr>
<td>Pant Lobia-5</td>
<td>Tan</td>
<td>2161</td>
<td>24</td>
<td>66</td>
<td>36</td>
<td>13</td>
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</tbody>
</table>
Improved cowpea varieties in improved strip cropping system in Africa
Improved cowpea – cereals strip cropping in Nigeria
Introduction of cowpea in wheat-rice system in northern India
60-day cowpea varieties tolerant to heat and drought and resistant to viruses with acceptable seed type tested
Opportunity for expanding cowpea cultivation in the USA

1. As a multi-purpose crop from June to September
   - Green manure, fodder, grain plus fodder and pasture crop from mid-west to southern USA

2. Selected grain type cowpeas (beyond black eye) for export to Asia and Africa
## Cowpeas in new lands & double cropping in Brazil

### Estimated area, production and yield of cowpea dry grain in Brazil.

<table>
<thead>
<tr>
<th>Year</th>
<th>Area (ha)</th>
<th>Production (ton)</th>
<th>Yield (kg/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1960</td>
<td>955746</td>
<td>249959</td>
<td>261.5</td>
</tr>
<tr>
<td>1980</td>
<td>1168837</td>
<td>267260</td>
<td>228.6</td>
</tr>
<tr>
<td>2006</td>
<td>1553643</td>
<td>466347</td>
<td>300.2</td>
</tr>
<tr>
<td>2009</td>
<td>1352923</td>
<td>711186</td>
<td>525.6</td>
</tr>
</tbody>
</table>

21 improved varieties released
Double cropping after soybean
Mechanized cultivation of cowpeas in Brazil
Cowpeas 55 Days after planting
<table>
<thead>
<tr>
<th>Crop</th>
<th>1961</th>
<th>1981</th>
<th>2001</th>
<th>2009</th>
<th>% +61</th>
<th>% +01</th>
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</thead>
<tbody>
<tr>
<td>Beans</td>
<td>11.2</td>
<td>15.3</td>
<td>18.2</td>
<td>19.7</td>
<td>75</td>
<td>8.0</td>
</tr>
<tr>
<td>Broad Bn</td>
<td>4.8</td>
<td>4.1</td>
<td>4.1</td>
<td>4.1</td>
<td>-14</td>
<td>0.0</td>
</tr>
<tr>
<td>Chick pea</td>
<td>7.7</td>
<td>5.8</td>
<td>6.9</td>
<td>9.7</td>
<td>25</td>
<td>40</td>
</tr>
<tr>
<td>Cowpea</td>
<td>0.87</td>
<td>1.3</td>
<td>3.7</td>
<td>6.4</td>
<td>635</td>
<td>73</td>
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<tr>
<td>Lentils</td>
<td>0.85</td>
<td>1.4</td>
<td>3.3</td>
<td>3.6</td>
<td>323</td>
<td>9.0</td>
</tr>
<tr>
<td>Pea</td>
<td>7.3</td>
<td>7.7</td>
<td>10.3</td>
<td>10.3</td>
<td>41</td>
<td>0.0</td>
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<tr>
<td>Pignpea</td>
<td>2.2</td>
<td>2.1</td>
<td>2.9</td>
<td>3.5</td>
<td>59</td>
<td>21</td>
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<tr>
<td>Pulses ttl</td>
<td>40.8</td>
<td>41.6</td>
<td>55.8</td>
<td>61.5</td>
<td>51</td>
<td>10</td>
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<tr>
<td>Cereals ttl</td>
<td>876</td>
<td>1632</td>
<td>2108</td>
<td>2489</td>
<td>184</td>
<td>18</td>
</tr>
</tbody>
</table>

World cowpea production is now over 7.3 million tons
Cowpea is a complete food minus fat
Half a cup of cowpea, (83.5 grams) provides:

Macronutrients:
Water-9.23g
Calories- 286
Protein-20.0 g
Carbohydrate-50.0
Fiber- 8.9g
Fat – 1.7g
(no cholesterol)

Micronutrients
Calcium – 71.3mg
Iron – 8.3 mg
Magnesium – 278mg
Phosphorus – 366mg
Potassium – 1148mg
Sodium – 48mg
Zinc – 5.1mg
Vitamin C – 1.3mg
Thiamine – 0.568mg
Riboflavin – 0.142mg
Niacin – 2.443mg
Pantothenic acid – 1.3mg
Vitamin B6 – 0.301mg
Folate – 534 mcg
Vitamin A -28 IU
Substitute part of the meat with cowpea for good health
Cowpea as poor man’s meat and rich man’s a health food

New cowpea varieties have up to 30% protein, and rich in calcium, iron, zinc, complex carbohydrates, soluble fibers and full of antioxidants:
good for health and heart
Cowpea as the pulse crop of 21st century

1. Production of food legumes in the world has reached a plateau at about 73 million tons.
2. This is because most of the good lands have gone to the green revolution led cropping systems involving wheat, rice and maize and food legumes have been pushed to marginal lands where pulses are grown with little or no inputs.
3. Also, all pulses mature between 90-130 days and compete for land with cereals
4. How can pulses production be increased in the 21st century?
5. The only answer is to cultivate ‘60-day’ cowpeas in the existing niches between cereal-based systems and drought and low fertility tolerant cowpeas in the marginal lands.
6. The cowpea production has increased from 0.8 ml.t in 1961 to 7.3 ml.t in 2013.
Thank you for your kind attention

Cowpea in all continents