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

Major cowpea production regions

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

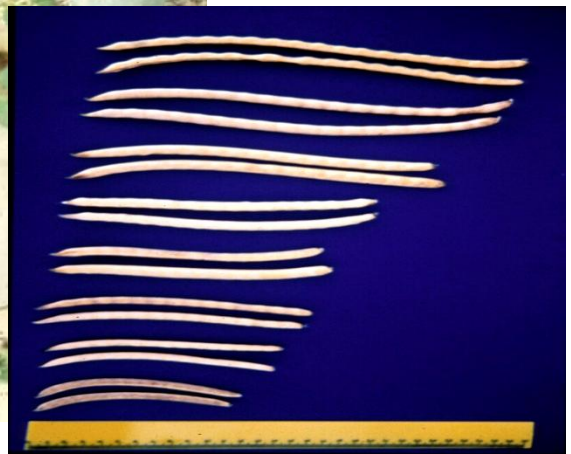
Seed quality = Viability, seed size, seed color, hilum color, seed coat texture, seed coat thickness, seed hardness, water absorption and swelling volume, density and cooking time

Nutritional quality = carbohydrate, protein, minerals, and vitamins

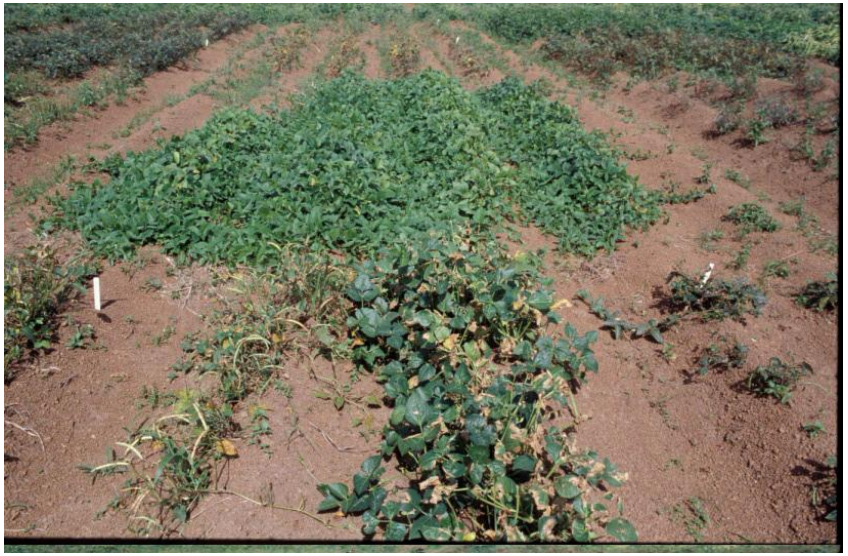
Health factors = antioxidants, complex carbohydrates

Fodder Quality = protein, fiber and digestibility

High Yield: Improving plant type



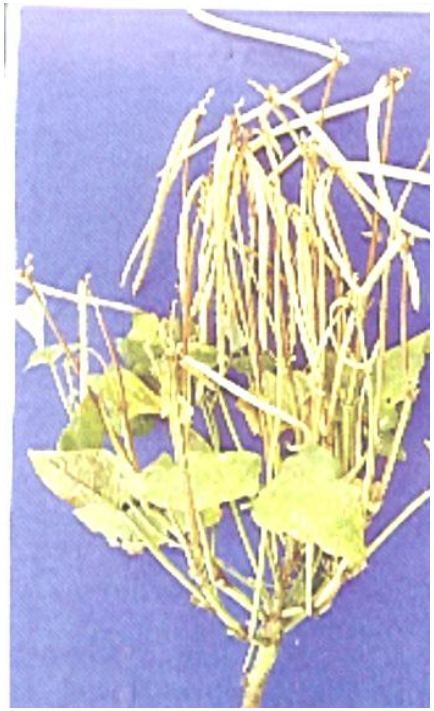
High Yield: Resistance to major diseases



High Yield: Resistance to major insects

High yield : breeding for drought tolerance and low fertility

High Yield: Diverse maturity and plant type

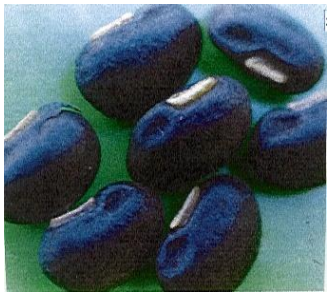


High Yield: grain type and dual purpose cowpea varieties

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

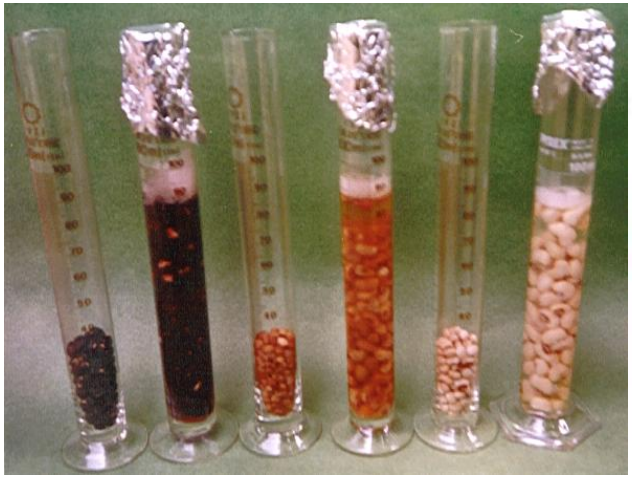
Dry seed volume - 20 g seeds in 50 ml water. Measure the rise in water level.

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.

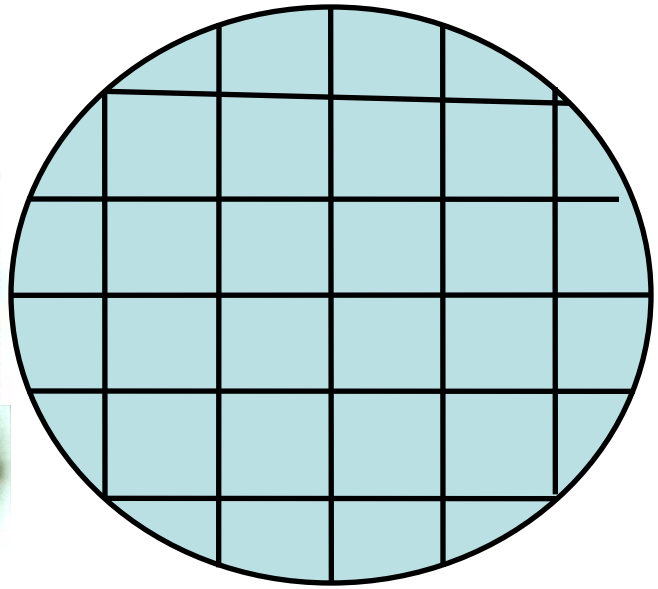
Swelling ratio - The wet seed volume divided by dry seed volume equals swelling ratio.

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

Variety	Testa %	Hardness	D. seed vol.	Density	Water abs.	Wet seed vol.	Swelling Ratio	Cook time	Seed size
IT90K-277-2	6.8	4.4	17.6	1.14	22.7	40.2	2.3	27.5	17.0
Dan Ila	6.4	5.1	16.4	1.22	24.5	40.2	2.5	32.5	17.0
Aloka	8.4	9.0	17.5	1.14	23.5	41.1	2.3	57.5	15.6
IT93K-452-1	6.7	4.0	18.2	1.10	24.0	42.2	2.3	32.5	15.0
IT98K-813-21	8.7	4.4	16.5	1.11	26.2	42.8	2.6	32.5	14.3
IT95K-1113-3	9.3	6.7	15.5	1.21	23.3	40.3	2.6	37.5	17.8
TVU 12349	13.8	3.7	15.9	1.21	25.0	40.3	2.6	32.5	11.8
Kanannado	6.1	5.1	17.2	1.16	26.5	43.7	2.5	37.5	24.7
IT97K-1105-5	11.6	4.8	17.5	1.14	23.5	43.3	2.5	32.5	21.1
Mean	8.3	5.1	16.9	1.15	24.2	41.5	2.5	35.5	16.9
Heritability	0.66	0.92	0.55	0.72	0.70	0.46	0.62	0.71	0.90

Smooth coat

Seed coat %

10.5

11.5

13.5

Rough coat

Seed coat %

6.8

6.5

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

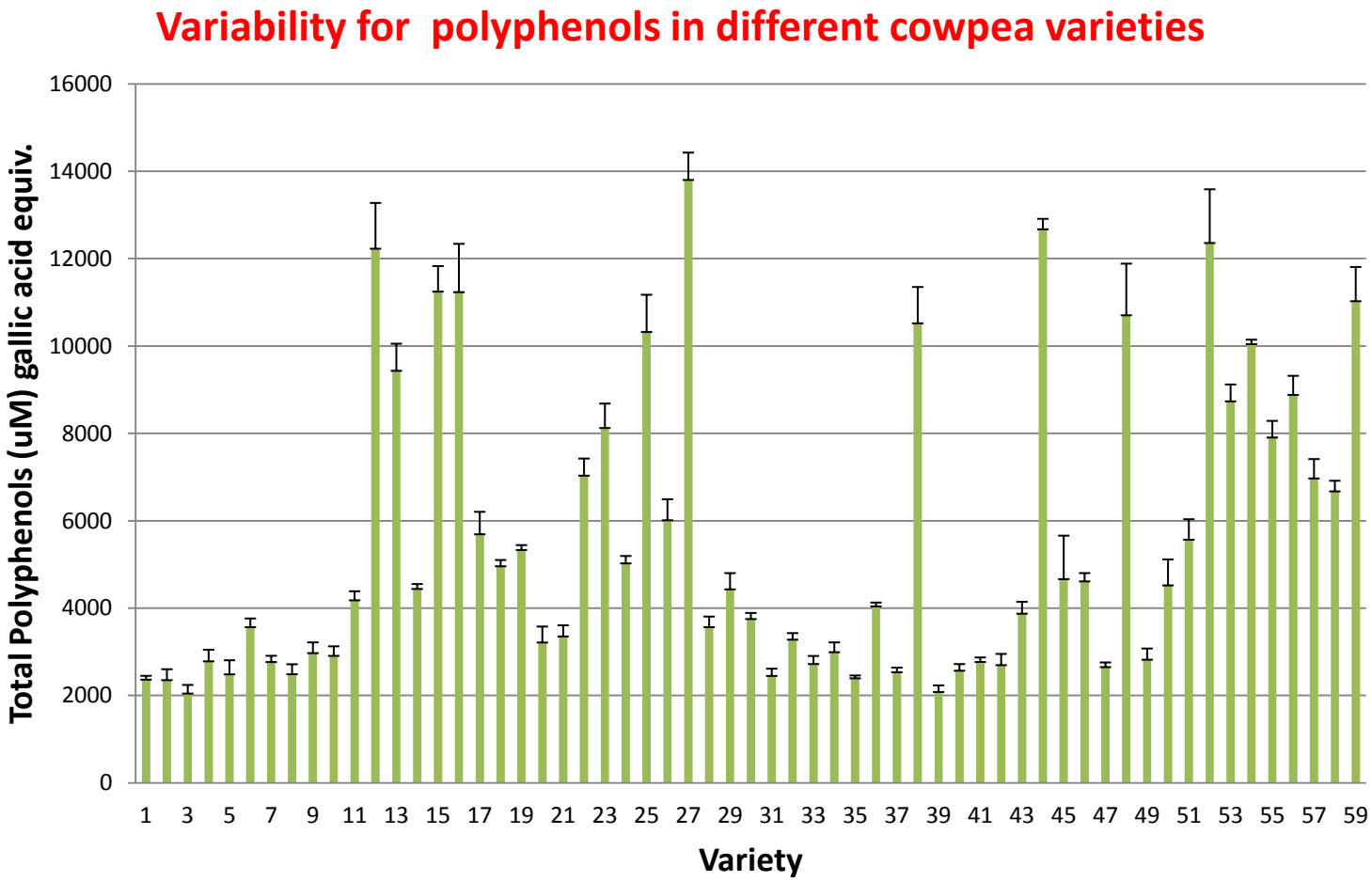
Magnesium - 1611 to 2052 ppm

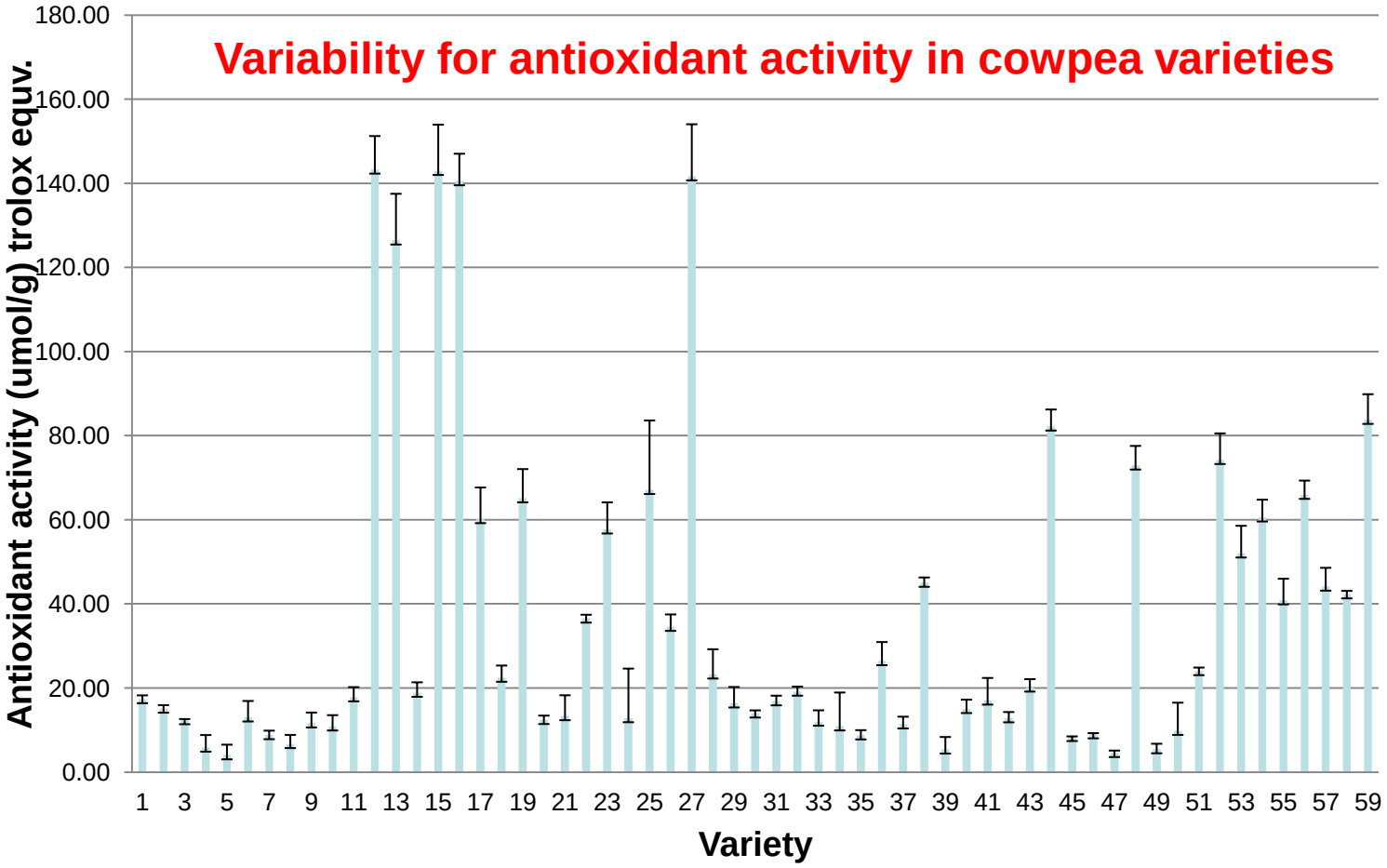
Phosphorus - 3867 to 4922 ppm

Sulfur - 1880 to 2354 ppm

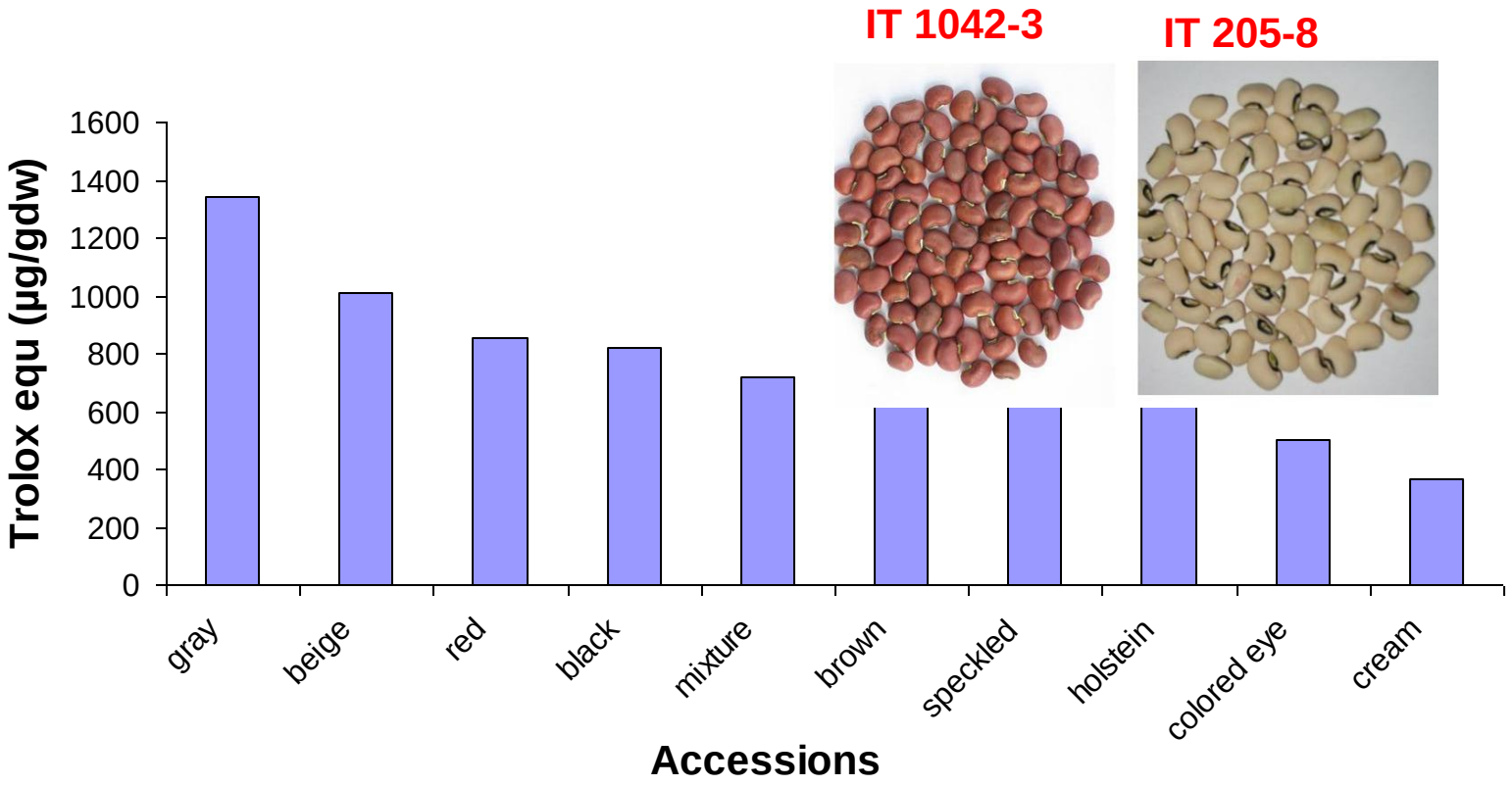
Breeding for health factors in cowpea

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.



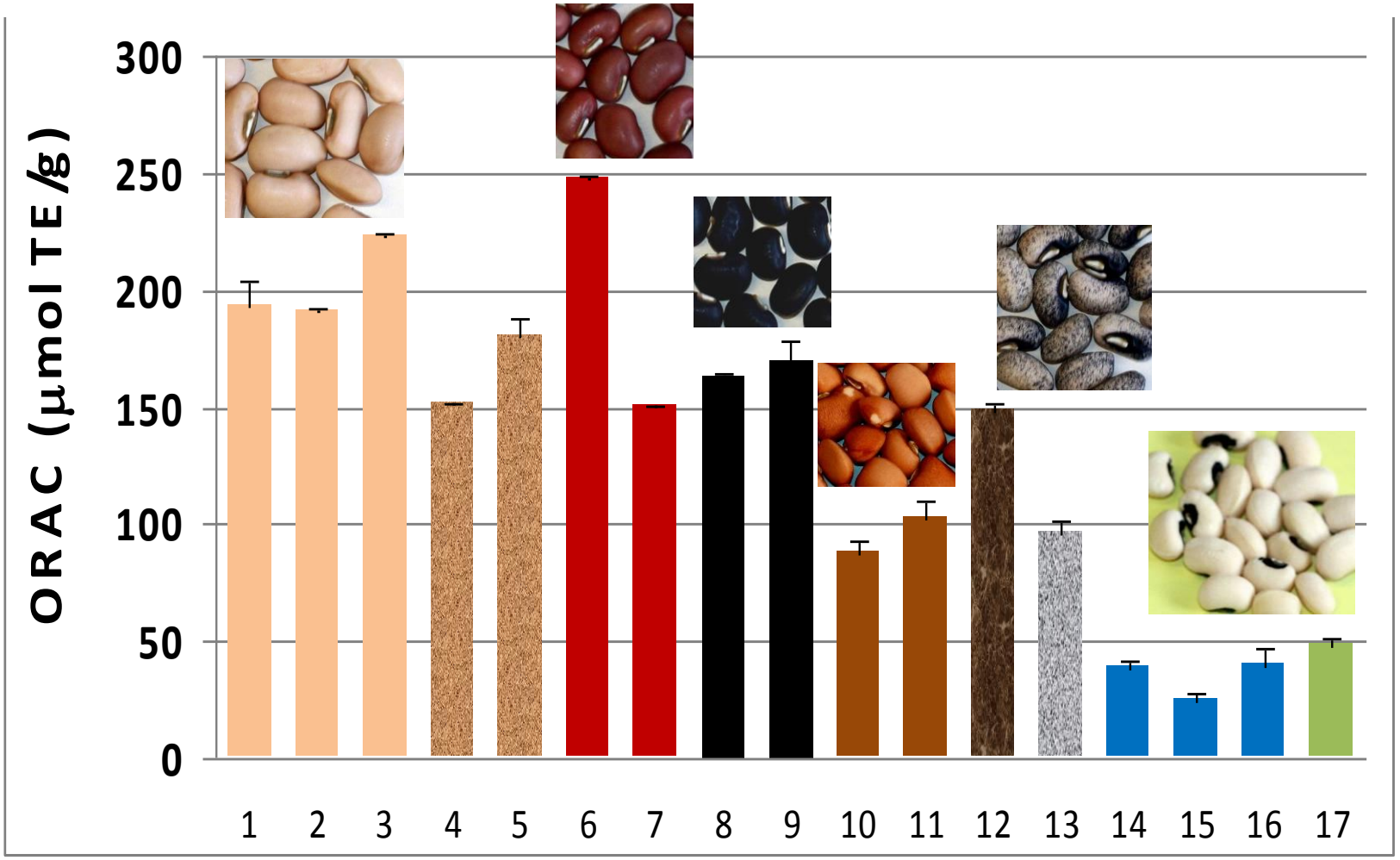

Variability for antioxidant activity in cowpea varieties
Antioxidant activity (umol/g) trolox equv.
180.00
160.00
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39 41 43 45 47 49 51 53 55 57 59
Variety

Breeding cowpea varieties for health factors



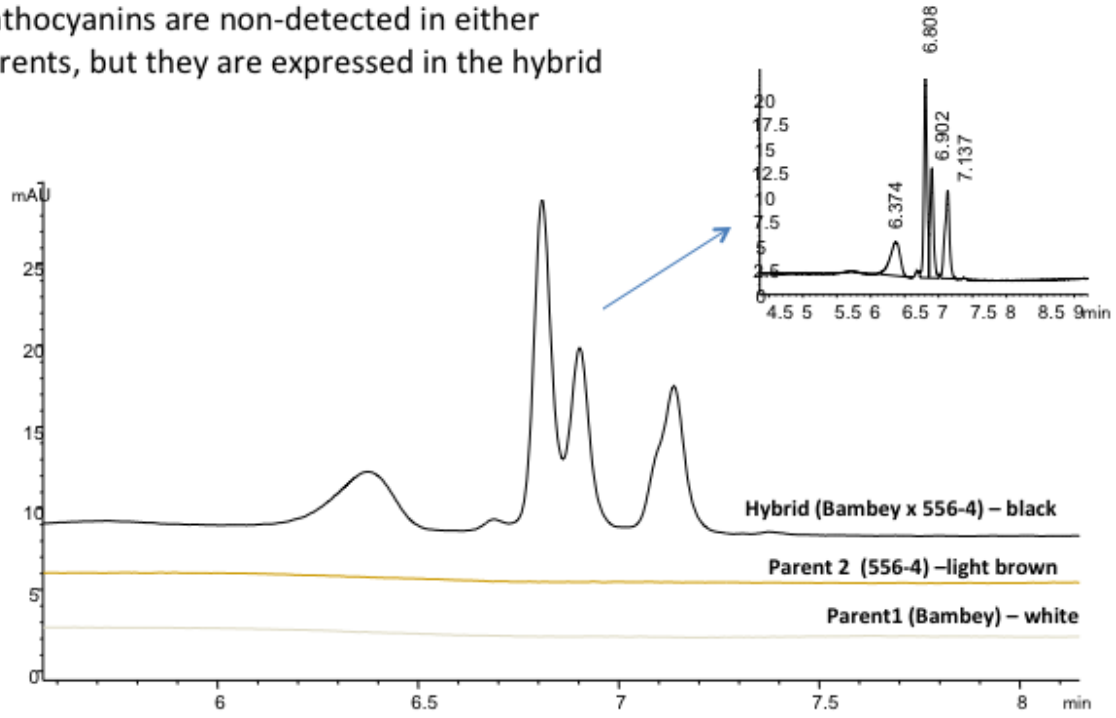
Variety	CP	Fe	Zn	Ca	K	Mg	P	S
IT97K-1042-3	30	69	45	858	14378	1987	5139	2361
IT98K-205-8	27	60	42	994	13672	1952	4922	2109

Antioxidant activity (ORAC)



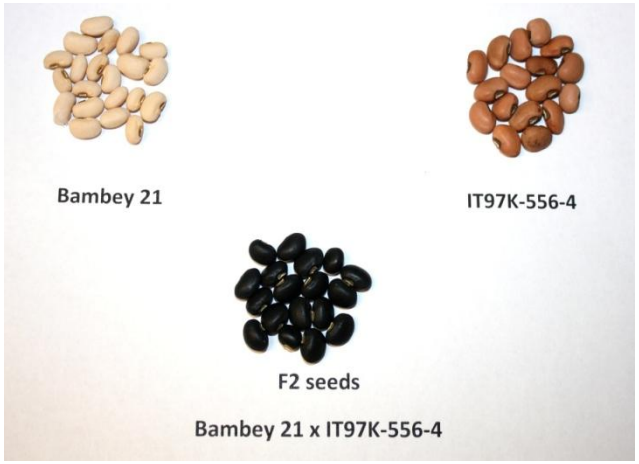
Gene complementation phenomenon

Anthocyanins are non-detected in either parents, but they are expressed in the hybrid



3-D overlay of signals at 520 nm of parents and hybrid

HPLC graphs of white parent (Bambey 21), light brown parent (556-4) and F_1 hybrid detected at 520 nm showing anthocyanins.



Mean antioxidants in different colors

87.539 ± 7.00	Light brown^{a}
83.793 ± 3.49	Black^{ab}
64.230 ± 1.38	Red^{bc}
46.161 ± 1.97	Mixed^{cd}
32.538 ± 3.43	Dark brown^{de}
12.919 ± 0.59	White^{e}

New cowpea varieties with high yield and quality

Improved Cowpea Varieties with High yield and quality

Variety	Protein	Fe	Ca	Zn	K
IT97K-1042-3	30.7	77	980	46	16,000
IT98K-205-8	27.1	65	885	45	14,500
IT99K-216-48-1	27.5	65	780	39	15,650
IT97K-556-4	27.4	63	660	38	15,750
IT98K-205-8	27.1	65	885	45	14,500
Aloka local	23.1	49	1,070	40	15,900
IT93K-452-1	24.0	63	885	40	15,150
IT98D-1399	24.1	61	1,300	27	16,000

Recently released varieties of cowpea in India

Varieties	Seed color	Yield Kg/ha	% Protein	Iron ppm	Zinc ppm	Mn ppm
Pant Lobia-1	White	1969	28	89	45	14
Pant Lobia-2	Red	1845	31	90	45	31
Pant Lobia-3	Brown	2072	27	97	51	34
Pant Lobia-4	White	1794	25	109	51	12
Pant Lobia-5	Tan	2161	24	66	36	13

Pant Lobia-1

Pant Lobia-2

Pant Lobia-3

Pant Lobia-3

Pant Lobia-4

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

Wheat

Cowpea

Rice

Nov. Dec. Jan. Feb. Mar. Apr. May Jun. Jul. Aug. Sep. Oct. N

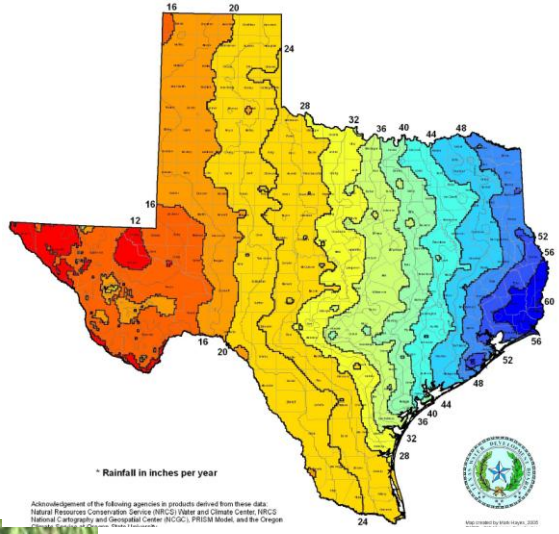
60-day cowpea varieties tolerant to heat and drought and resistant to viruses with acceptable seed type tested

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.

Year	Area (ha)	Production (ton)	yield (kg/ha)
1960	955746	249959	261.5
1980	1168837	267260	228.6
2006	1553643	466347	300.2
2009	1352923	711186	525.6

21 improved varieties released

Double cropping after soybean

Mechanized cultivation of cowpeas in Brazil

Cowpeas 55 Days after planting

World production of food legumes (x10^6 tons)

Crop	1961	1981	2001	2009	% +61	% +01
Beans	11.2	15.3	18.2	19.7	75	8.0
Broad Bn	4.8	4.1	4.1	4.1	-14	0.0
Chick pea	7.7	5.8	6.9	9.7	25	40
Cowpea	0.87	1.3	3.7	6.4	635	73
Lentils	0.85	1.4	3.3	3.6	323	9.0
Pea	7.3	7.7	10.3	10.3	41	0.0
Pignpea	2.2	2.1	2.9	3.5	59	21
Pulses ttl	40.8	41.6	55.8	61.5	51	10
Cereals ttl	876	1632	2108	2489	184	18

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

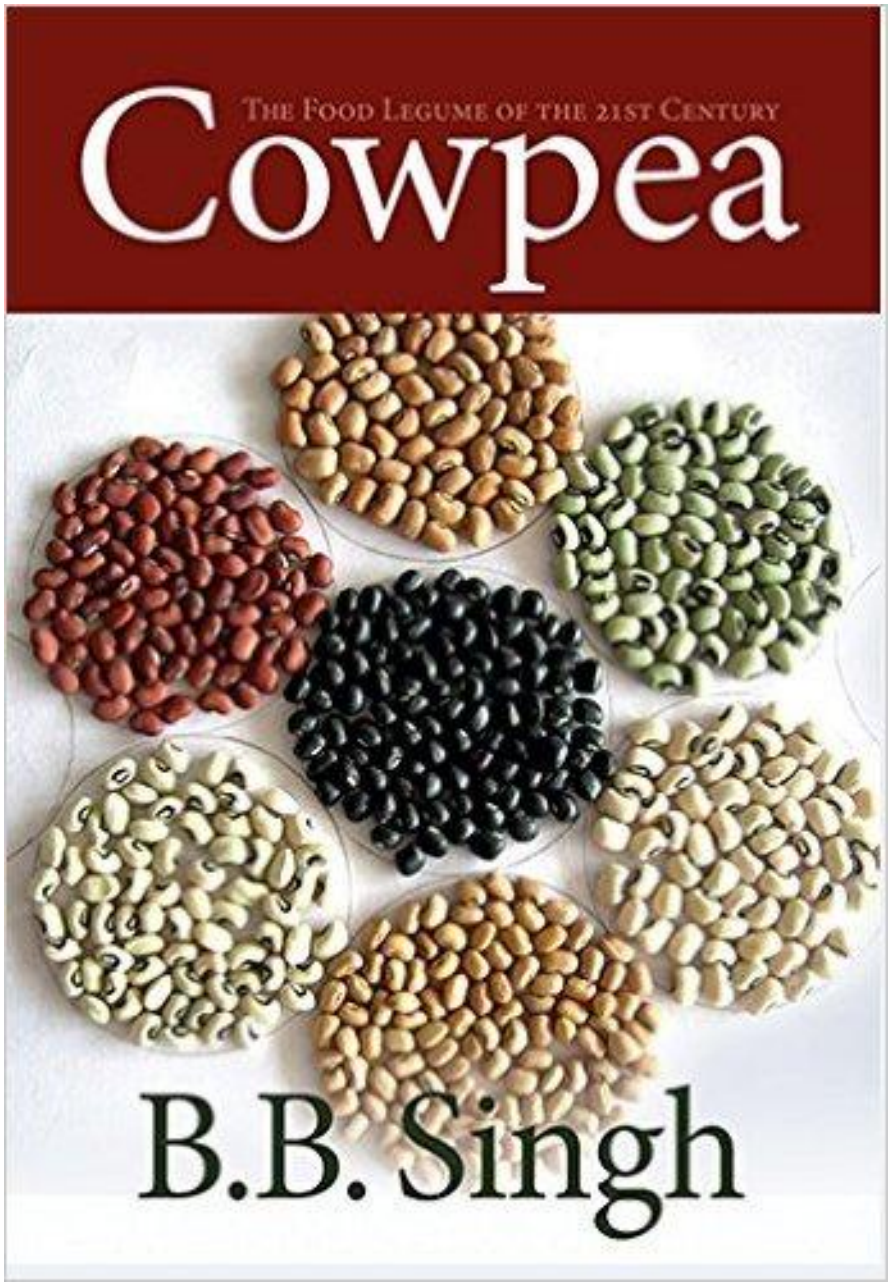
Calcium – 71.3mg
Iron – 8.3 mg
Magnesium – 278mg
Phosphorus – 366mg
Potassium – 1148mg
Sodium – 48mg
Zinc – 5.1mg
Vitamin C – 1.3mg
Thiamine – 0.568mg
Riboflavin – 0.142mg
Niacin – 2.443mg
Pantothenic acid – 1.3mg
Vitamin B6 – 0.301mg
Folate – 534 mcg
Vitamin A -28 IU

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.




Cowpea in all continents


Thank you for your kind attention