World Agroforestry

CGIAR RESEARCH PROGRAM ON Forests, Trees and Agroforestry

AOCC

African Orphan Crops and Trees - Delivering More Nutritious Food

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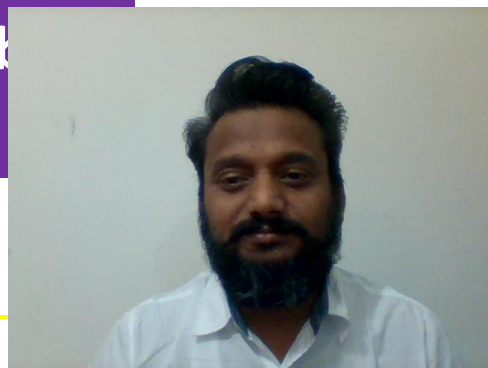
African Orphan Crops Genomics Lab

Theme TREEs, CIFOR-ICRAF HQ, Nairobi

Kenya



African orphan crops consortium: AOCC

Conceptualization: 2011 during Clinton Global Initiative (Howard Yana- Shapiro, dignitaries from African Union and a few governments)
Formal opening of genomics lab in Dec 2014 located at CIFOR-ICRAF, Nairobi

Neglected/Orphan Crops as Solution to Nutrient Deficiency in African Population

- **African Orphan Crops**: Under-researched, under-invested and under-represented in scientific and donor community, often neglected by policy makers but are important at local and regional level. They are not the top 8-10 usual suspects.
- **AOCC Vision:** To provide localized solutions to address stunting, hunger and chronic malnutrition of African population through improvement in the African farming systems (resilient food production systems, markets & value chains, policy etc.)

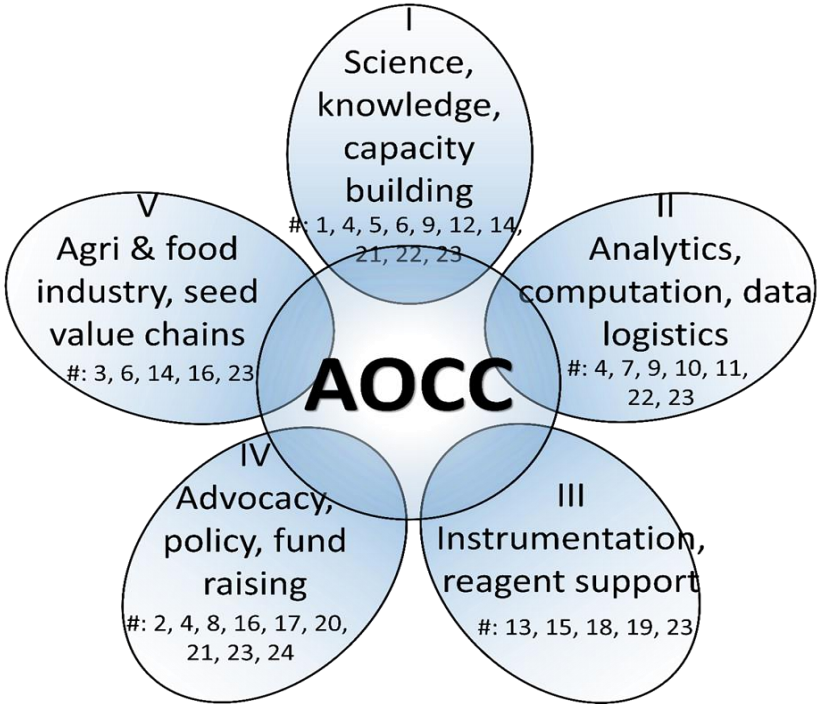
Immediate Objectives

- **To develop next generation genomics resources (***whole genome sequence, transcriptome sequence, SNP marker arrays/panels***) for 101 African Orphan crops including ~50 trees**
- **To train 150 African plant breeders by 2020 to employ genomics-driven breeding programs**

AOCC: Uncommon Public-Private Partnership

Partnership philosophy: Seek specialists on board in a de-centralized approach, International organizations, govt bodies, NGOs, research institutes, universities, and private concerns (agric., food processing, breeding companies, data companies etc.) etc. which bring substantial investments

Partnership: Five founding members- AUDA- the then NEPAD, WWF, UC Davis, Mars Incorporated, ICRAF (now CIFOR-ICRAF); now the partnership has increased to 28.



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AUDA-NEPAD AFRICAN UNION DEVELOPMENT AGENCY
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MARS incorporated
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syngenta
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Oxford NANOPORE Technologies
The James Hutton Institute
UNICEF
VIB
WWF
SRUC

Meet the Crops

Tree species				Annuals		
	Scientific name	Common name	Tree/Annual/Lianas		Scientific name	Common name	
1	*Adansonia digitata*	Baobab	T	52	*Abelmoschus caillei*	Okra	A
2	*Adansonia kilima*	Baobab	T	53	*Allium cepa*	Onion	A
3	*Allanblackia floribunda*	veg tallow tree	T	54	*Amaranthus blitum*	Amaranth	A
4	*Anacardium occidentale*	Cashew	T	55	*Amaranthus cruentus*	Grain amaranth	A
5	*Annona senegalensis.*	Wild Custard Apple	T	56	*Amaranthus tricolor*	Vegetable amaranth,	A
6	*Annona reticulata*	Custard Apple	T	57	*Basella alba*	Vine spinach	A
7	*Artocarpus heterophyllus*	Jack Tree	T	58	*Brassica carinata*	Ethiopia Mustard	A
8	*Artocarpus altilis*	Breadfruit	T	59	*Cassia obtusifolia*	Sickle Senna	A
9	*Balanites aegyptiaca*	Balanites	T	60	*Celosia argentea*	Celosia	A
10	*Boscia senagalensis*	Aizen, Nabedega	T	61	*Citrullus lanatus*	Watermelon	A
11	*Canarium madagascariense*	Canarium nut, Ramy nut	T	62	*Cleome gynandra*	Spiderplant	A
12	*Carica papaya*	Papaya	Non-Tree Fruit (NtF)	63	*Colocasia esculenta*	Taro	A
13	*Carissa spinarum*	Carissa	T	64	*Corchorus olitorius*	Jute mallow	A
14	*Casimiroa edulis*	White sapote	T	65	*Crassocephalum rubens*	Yoruban bologi	A
15	*Chrysophyllum*	Star apple	T	66	*Crotalaria juncea*	Sunn hemp	A
16	*Cocos nucifera*	Coconut	Palm (P)	67	*Crotalaria ochroleuca*	Rattlebox	A
17	*Dacryodes edulis*	African Plum	T	68	*Cucumis metuliferus*	Horned Melon	A
18	*Detarium senegalense*	Sweet detar	T	69	*Cucurbita maxima*	Pumpkin	A
19	*Diospyros mespiliformis*	African persimmon	T	70	*Cyphomandra betacea*	Cape tomato. Tree tomato	T
20	*Dovyalis caffra*	Kei Apple	T	71	*Digitaria exilis*	Fonio	A
21	*Elaeis guineensis*	Oil Palm	Palm (P)	72	*Dioscorea alata*	Yams	Perennial tuber (PT)
22	*Faidherbia albida*	Acacia (Apple-ring)	T	73	*Dioscorea dume torum*	Bitter yam	Perennial tuber (PT)
23	*Garcinia livingstonei*	African Mangosteen	T	74	*Dioscorea rotundata*	Yams	Perennial tuber (PT)
24	*Garcinia mangostana*	Mangosteen	T	75	*Eleusine coracana*	Finger Millet	A
25	*Gnetum africanum*	African Gnetum	T	76	*Ensete ventricosum*	Enset	A
26	*Hibiscus sabdariffa*	Roselle	T	77	*Ipomoea batatas*	Sweet Potato Leaves	Perennial root (PR)
27	*Icacina oliviformis*	False yam	T	78	*Lablab purpureus*	Lab lab Bean	A
28	*Irvingia gabonensis*	Sweet bush mango	T	79	*Lens culinaris*	Lentils	A
29	*Landolphia spp*	Gumvines	Woody Fruit Climber (WFC)	80	*Macrotyloma geocarpum*	Geocarpa groundnut	A
30	*Lannea microcarpa*	Tree grapes	T	81	*Momordica charantia*	Bittergourd	A
31	*Macadamia ternifolia*	Macadamia	T	82	*Musa acuminata AAA Group*	Bananas	Non-woody fruit (NwpF)
32	*Mangifera indica*	Mango	T	83	*Musa balbisiana*	Bananas	Non-woody fruit (NwpF)
33	*Moringa oleifera*	Drumstick tree,	T	84	*Musa x paradisica AAB Group*	Plantains	Non-woody fruit (NwpF)
34	*Morus alba*	Mulberry	T	85	*Passiflora edulis*	Passion Fruit	Woody Climber Fruit (WFC)
35	*Opuntia monacantha*	Prickly pear	Perennial Succulent (PS)	86	*Phaseolus vulgaris*	Green Bean	A
36	*Parinari curatellifolia*	Mobola plum	T	87	*Plectranthus esculentus*	African Potato	A
37	*Parkia biglobosa*	African Locust	T	88	*Plectranthus rotundifolius*	African Potato	A
38	*Persea americana*	Avocado	T	89	*Solanum aethiopicum*	African Eggplant	A
39	*Pistacia vera*	Pistachio	T	90	*Solanum nigrum*	African Nightshade	A
40	*Psidium guajava*	Guava	T	91	*Sphenostylis stenocarpa*	Yambean	Perennial tuber (PT)
41	*Ricinodendron heudelotii*	Ground Nut Tree	T	92	*Talinum fruticosum*	Ceylon spinach	Perennial vegetable (PV)
42	*Saba comorensis*	Rubber vines	T	93	*Telfairia occidentalis*	Fluted gourd	Perennial vegetable (PV)
43	*Sclerocarya birrea*	Marula	T	94	*Tylosema esculentum*	Marama bean	Perennial tuber (PT)
44	*Strychnos spinosa*	African Orange	T	95	*Vangueria madagascariensis*	African Medlars	T
45	*Syzygium guineense*	Water berry	T	96	*Vangueria infausta*	African Medlars	T
46	*Tamarindus indica*	Tamarind	T	97	*Vicia faba*	Favabean	A
47	*Uapaca kirkiana*	Wild loquat	T	98	*Vigna radiata*	Mungbean	A
48	*Vitellaria paradoxa*	Shea Butter	T	99	*Vigna subterranea*	Bambara groundnut	A
49	*Vitex doniana*	Chocolate berries	T	100	*Xanthosoma sagittifolium*	Elephant ears	Perennial rhizome (PR)
50	*Ximenia caffra*	Sour plum	T	101	*Xanthosoma spp*	Cocoyams, Arrowroots	Perennial rhizome (PR)
51	*Ziziphus*	Jujube	T				

The 101 species are the crops grown or maintained in rural Africa primarily as part of mixed or back-yard farming and akready a part of Africa's agro-forestry systems

Distribution of species:

1. **Perennial woody trees: 48**
2. **Annuals: 35**
3. **Perennial tubers: 5**
4. **Non-woody fruits: 3**
5. **Palms: 1**
6. **Woody fruit climbers: 2**
7. **Perennial vegetables: 2**
8. **Perennial rhizomes: 2**
9. **Non-tree fruits: 1**
10. **Perennial succulents: 1**
11. **Perennial roots: 1**

TOTAL: 101

Orphan Crops: Inherently Nutrient Rich but Low yielding

Sl No.	Species	Nutritional importance
1	African eggplant (*Solanum aethiopicum*)	Fruits rich in **carotenoids**, **antioxidants** with moderate quantity of **K, P**
2	African mangosteen (*Garcinia livingstonei*)	Fruits rich source of ***carbohydrates***, minerals- **P, K, Ca, Mg, Fe, Zn, S, Mn, S, Cu antioxidants, and vitamin C**
3	African nightshade (*Solanum nigrum*)	Leaves rich source of **vitamins A, B, C, minerals- Ca, Fe, Zn**
4	African orange (*Strychnos spinosa*)	Fruit pulp rich in **carbohydrates**, **vitamin C**, and minerals- **P, Ca, Mg, Na, traces of Zn, Mg, Fe**
5	African perssimon (*Diospyros mespiliformis*)	Fruit pulp rich in **carbohydrates**, **vitamin C**, and minerals- **P, Na, Mg, Ca and trace amounts of Zn, Mn, Fe, Cu**
6	African Plum (*Dacryodes edulis*)	Fruits rich in proteins **with essential amino acids**, minerals- **Ca, K, Zn, Na, Mg, Fe, P, vitamin C**
7	African star apple (*Chrysophylum albidum*)	Fruit pulp contains moderate amounts of **carbohydrates**, **proteins** and minerals **K, Ca, P, Zn, and ascorbic acid, beta-carotene**.
8	African yam bean (*Sphenostylis stenocarpa*)	Protein rich legume with high quality **proteins** and **carbohydrates,** minerals- **Fe, Se, Zn**
9	Amaranth (*Amaranth cruentus*)	Grains rich source of **Fe, Ca, Mg, P, K, Zn, Fe and riboflavin**. Contains essential **AA methionine and lysine**. Leaves rich in **Ca, Mg, K, P, Mg, Fe, Zn**
10	Amaranth (*Amaranthus tricolor*)	Leaves rich in **Ca, Na, K, Fe, and beta-carotene**.
11	Bambara nut (*Vigna subterranea*)	Seeds high in protein contents **Fe, Zn, Ca**
12	Baobab (*Adansonia digitata*)	Fruit rich source of **vitamin C** and contains high amounts of **antioxidants**, and minerals- **Ca, Cu, Mg, K, Zn**
13	Bitter gourd (*Momordica charantia*)	Fruits rich in **carotene, ascorbic acid, vitamin C, folic acid**, and minerals **Mg, Ca, S, Cu, Fe, P**
14	Breadfruit (*Artocarpus altilis*)	Fruits rich in **polyphenols, antioxidants and vitamin C**, also rich in **Ca, P, Mg, Na, Fe, K, and chlorides**.
15	Desert date (*Balanites aegyptiaca*)	Fruit rich in **Ca, P, K, Na, Mg**, and trace amounts of **Fe, Zn, and vitamins B1, E**.

Role of these crops in the changing world:

1. **Dietary diversification and human health**: to address malnutrition, hidden hunger, and stunting; tackling life style diseases like diabetes, hypertension
2. **Develop resilient and sustainable farming systems** diversification and resilient landscapes
3. **Climate change mitigation**- droughts, floods, temperature variations
4. **Planetary health**- lowering GHG emissions, local production & consumption

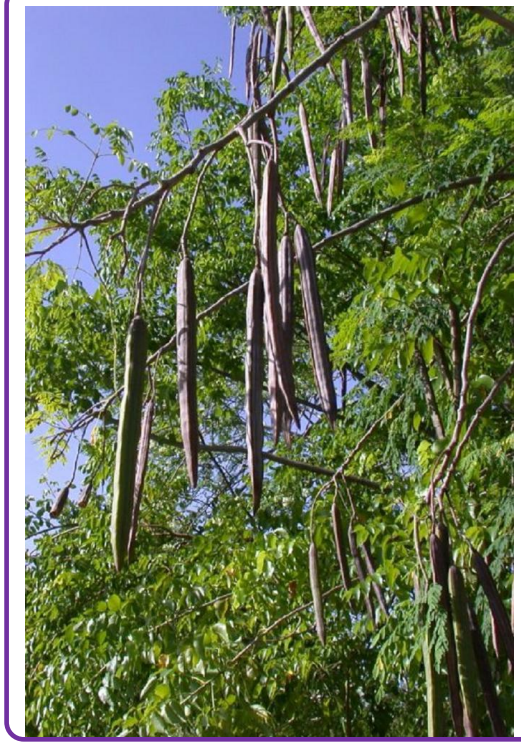
Some AOCC Trees

***Allanblackia* spp**:
Seeds used to extract oil used in culinary and cosmetics industry, found in humid tropics of Africa in Western-Central Africa and in Tanzania

Marula tree *(Sclerocarya birea)*:
Fruits are rich in carbohydrates, vitamins and minerals used for fresh consumption as well as in local brewery industry. Wine is called as Amarula.

Baobab (Adansonia digitata) :
Omnipresent in Africa, multiple uses specifically the fruit pulp and powder rich in vitamin C and antioxidents

Shea tree *(Vitellaria paradoxa)* :
Seeds used to extract oil used in culinary and cosmetic industry, found in sub-Saharan Africa from Western Africa till some parts of Ethiopia



Moringa *(Moringa oleifera)*:
A naturalized African tree found all across Africa. Leaves and fruits are consumed as vegetable. Rich in vitamin A, and anti-diabetic and other health promoting substances.

Meet the Crops

High quality fats, anti-oxidants, medicinal and industrial use

Miracle tree, Oleic acid, calcium, potassium, iron, copper, Vit A, C

Low in fats, potassium, Vit C, high fiber, high energy (sugar)

High fiber, iron, copper, magnesium, potassium, Vit C, A

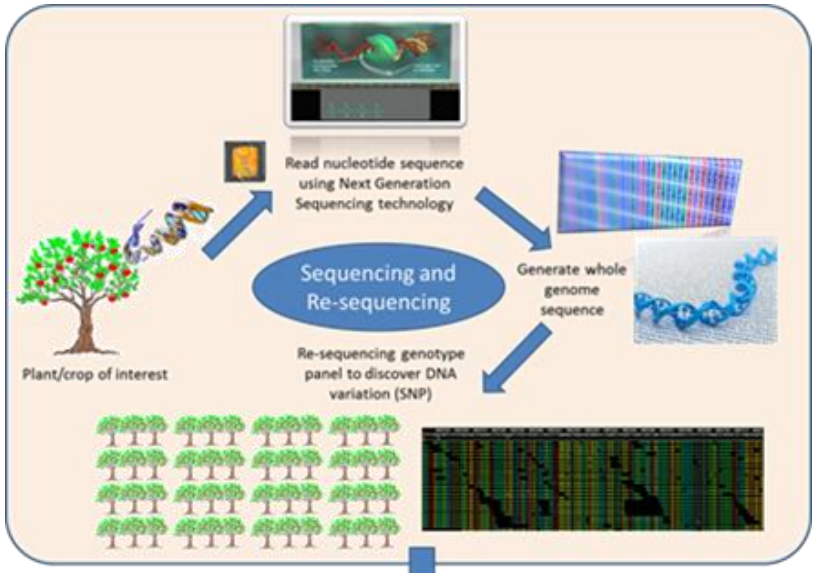
High quality protein, iron, calcium, potassium

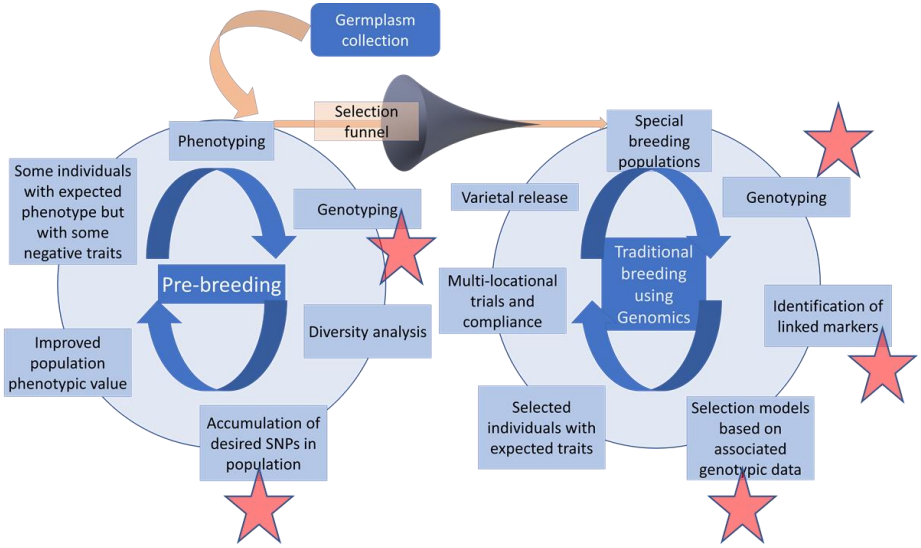
High quality protein, micronutrients, iron, zinc , Vit A

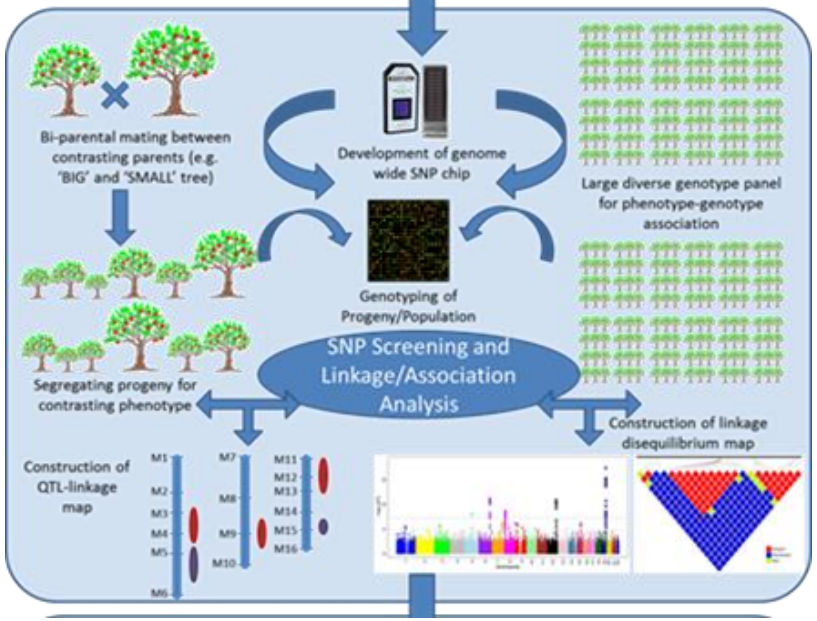
High quality protein, methionine, calcium, Vit A, B1, B2

Anti-oxidants, Beta carotene, calcium, iron, Vit C

Genomics for Trait Enhancement

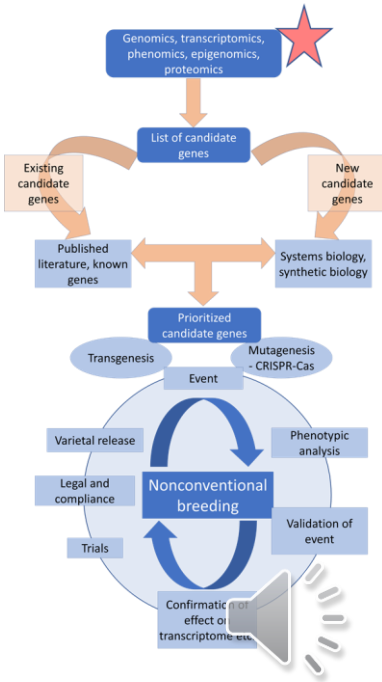






Genomics: To understand genetic basis of a phenotypic trait using genome
Breeding: Improving traits

Genomics assisted breeding: Looking at the traits using genomic landmarks as an indirect tool for trait selection, accumulation and incorporation into varieties



Nutrient as Traits

Visual/perceptive traits	Indicator of	Traditional assay	Genes/pathways
A. Skin/pulp color			
Red	Lycopene, ellagic acid, quercetin, hesperidin	Biochemical	Known in model plant and some fruit species
Orange and yellow	Pro-Vit A, zeaxanthin, flavonoids, lycopene, potassium, vitamin C		
Green	Chlorophyll, lutein, zeaxanthin,		
Blue/purple	Flavonoids, Vit C, resveretrol, lutein, zeaxanthin,		
White	Beta glucans, lignans		
B. Taste			
Sour	Vitamin C	Biochemical	Known in model plant and some fruit species

Genomics of Yield and Nutrients

Intrinsic yield genes (IYG)- *Eg. ANT, ARF, GRF, EBP, EXP* etc.

Shelf life- Polygalacturonase, ACC synthase

Genes involved in **nutrient storage** proteins- *Eg. Ferritin*

Genes involved in **nutrient transport/translocation** in plant body- *Eg. NAS, IRT, YSL, VIT*

Genes involved in **nutrient uptake/translocation**- *Eg.* Mugineic acid phytosiderophores, *IRO*

Systems biology- GO/Pathway/Regulatory network mapping and candidate gene discovery

Genomics tools and methods- GWAS studies (phenotype, eQTL, metabolic profiling etc.)

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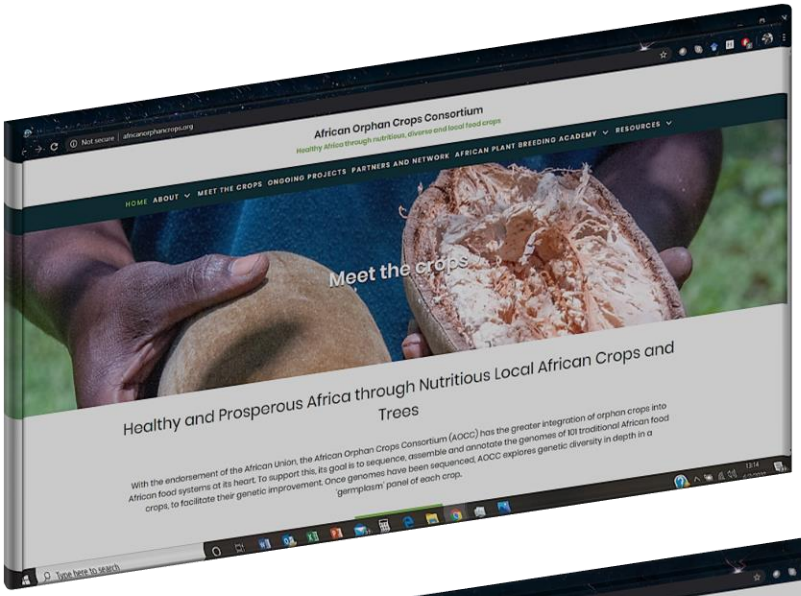

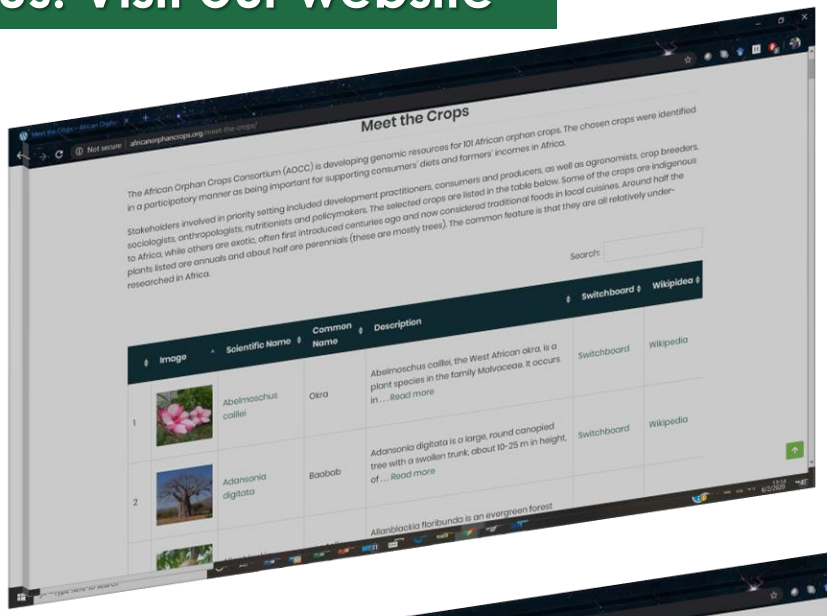

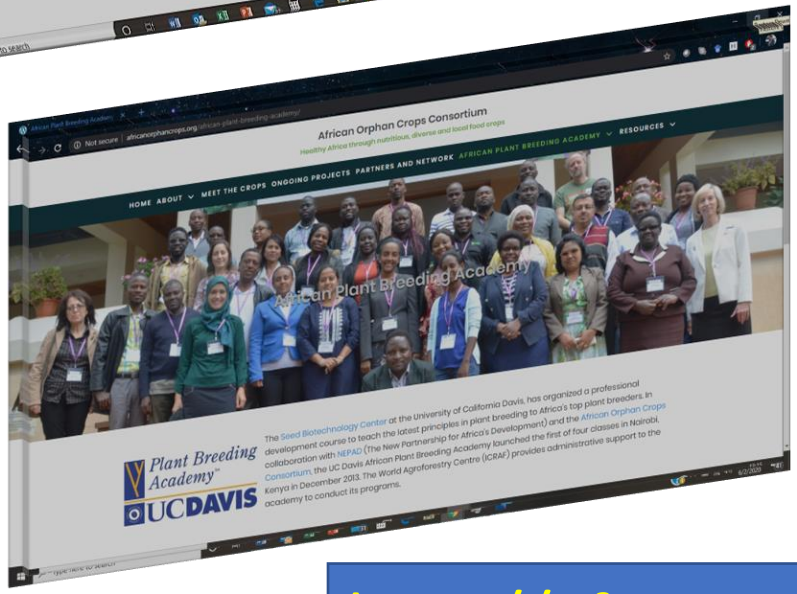

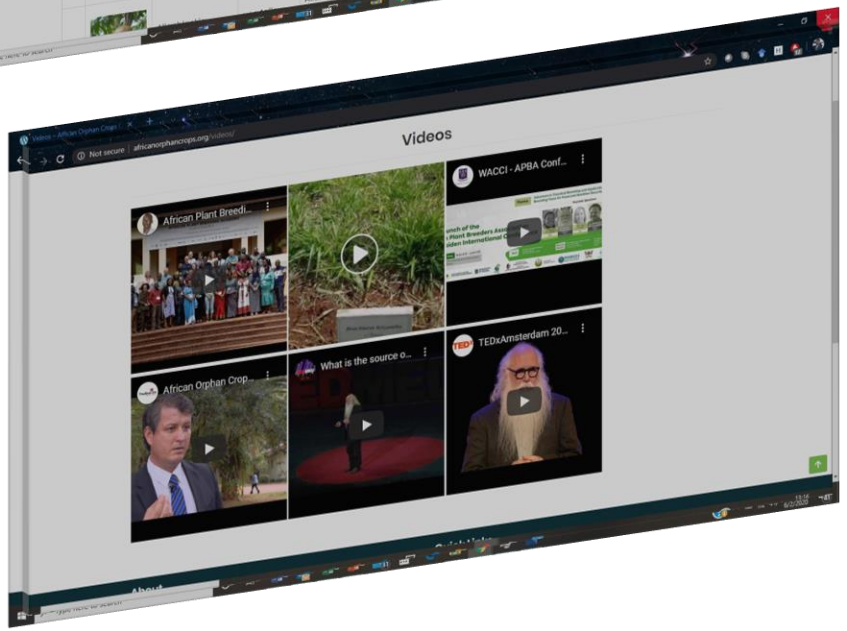

http://africanorphancrops.org/