Sustainable African Indigenous Vegetable Production and Market-Chain Development for Improved Health and Nutrition and Income Generation by Smallholder Farmers in Kenya, Tanzania and Zambia

PURDUE UNIVERSITY

RUTGERS UNIVERSITY

Collaborators:

U.S. - Purdue University, PI - Stephen Weller,
Rutgers University, PI – James Simon
Kenya - AMPATH, University of Eldoret, KARI,
Tanzania - AVRDC, Horticulture Research Institute,
Sokoine University, St. John's University
Zambia - ASNAPP

USAID FROM THE AMERICAN PEOPLE

HORTICULTURE INNOVATION LAB

UCDAVIS UNIVERSITY OF CALIFORNIA

African Indigenous Vegetables

African Nightshade

Amaranthus

Spider plant

Two Goals: Build Local Scientific and Farmer Capacity For Increased Small Producers' Participation in African Indigenous Vegetable Markets

Objective 1.

Evaluate the status of the Growers, AIV Market Chain and Identify the Needs for Improvement of the Chain and Program Impacts

Objective 2:

Evaluate Agronomic Potential of Improved AIV Germplasm and Develop Improved Production Techniques

Objective 3:

Evaluate Best Preparation and Preservation Techniques that will Enhance Micro-nutrient Composition and Retention

Objective 4:

Build Capacity of Stakeholders (Farmers, Marketers, Scientists and Graduate students) in the AIV Market Chain

Major Problems in Developing World Poverty Hunger & Food Insecurity

- 7 billion people on earth, and 1 in 7 suffer from hunger
  - 37% live on less than $2 per day
- Hunger is due mainly to poverty
  - No one in rich countries go hungry except in times of war, natural disaster or politically-imposed famine
  - 70% of the extreme poor live in rural areas, and most are farmers
  - Poverty, hunger and malnutrition are integrally linked
  - Stunts the mental and physical development of the next generation
  - Horticulture provides an opportunity to increase incomes and diversify diets
- To solve the world's hunger problem, the world poverty problem must be solved

Robert L. Thompson

Projected Population Growth

Region	2011	2050	Change	Percent
World	6,987	9,587	+2,600	+ 38
High Income	1,242	1,333	+ 91	+ 7
Low Income	5,745	8,254	+2,509	+ 44
East & S.E. Asia	2,183	2,308	+ 125	+ 6
South Central Asia	1,795	2,574	+ 779	+ 43
Sub-Saharan Africa	883	2,069	+1,186	+134
Lat. America/Carib	596	746	+ 150	+ 25
N. Africa & W. Asia	451	725	+ 274	+ 61

Source: Population Reference Bureau. 2011 World Population Data Sheet.

Micronutrient Diet Deficiency in Kenya

Source: Micronutrient Initiative – Canadian Cooperation Office

Population:	36,553,490
Children-under-5 mortality rate:	121 per 1,000
Vitamin A deficiency, in children 6 to 59 months old:	84.4%
Children Iodine deficiency:	36.8%
Prevalence of anemia, in children 6 to 59 months old:	69%
Prevalence of anemia, in women:	55.5%

AIVs – African Indigenous Vegetables

- Mainstay in traditional diets and consumed in a wide range of traditional meals
- Neglected crop ~ 400 species, locally adapted and easy to grow
- Not normally planted as cash crop – a bit on the side for home consumption
- Periods of abundance and periods of scarcity
- Rich sources of protein, minerals and vitamins
- Health, Nutrition and Medicinal value – natural bridge linking agriculture and nutrition
- Tremendous market potential
- Consumer preferences vary from place to place
- Lack of seed availability
- Poor knowledge of agronomic practices
- Unfamiliar with post-harvest management to keep “market fresh”
- Marketing networks unclear

Why Horticulture?

- High value crops – income generation and diversification
- Intensive farming on small plots possible
- Nutritional benefits of diet diversification
- Women are heavily engaged in horticulture crop production and marketing
- Use income for benefit of children

AIV Project Areas

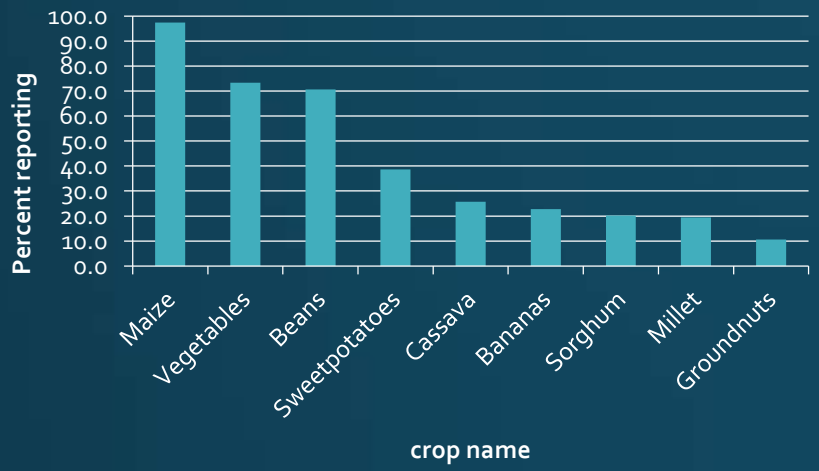
Objective 1. Evaluate Status of AIV Market Chain, Identify the Needs for Improvement of the Chain and Program Impacts

Household survey- basic demographic data, current knowledge and challenges of AIV production, postharvest handling, household consumption, preparation methods, and market accessibility. Done in Kenya, Tanzania and Zambia

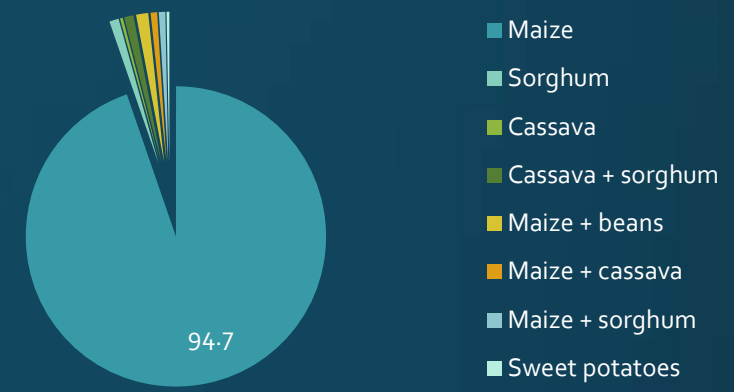
Market survey to understand existing linkages between AIV producers and market chain actors

Follow-up survey to assess the outcomes of project interventions along AIV value chain

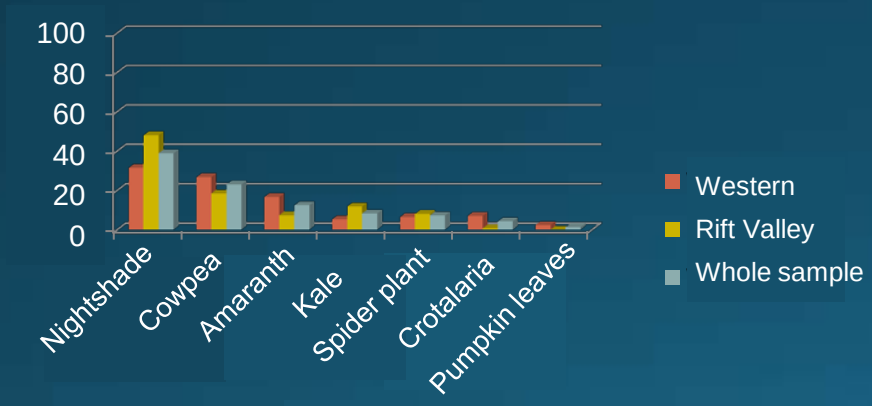
Objective 1. Household Survey Results*



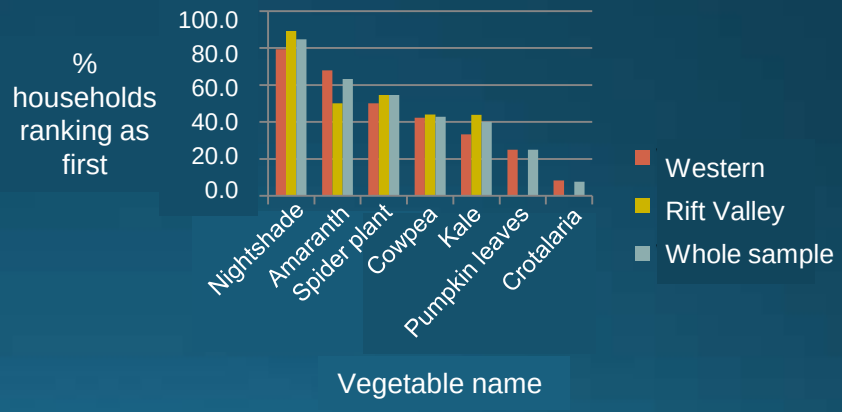
Major crops grown by households in Western Kenya



Major staple food in Western Kenya



Adoption of AIVs in Western Kenya

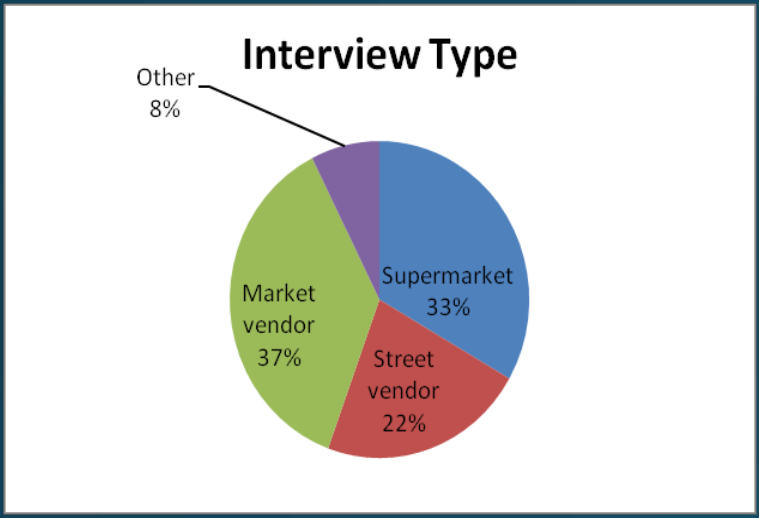


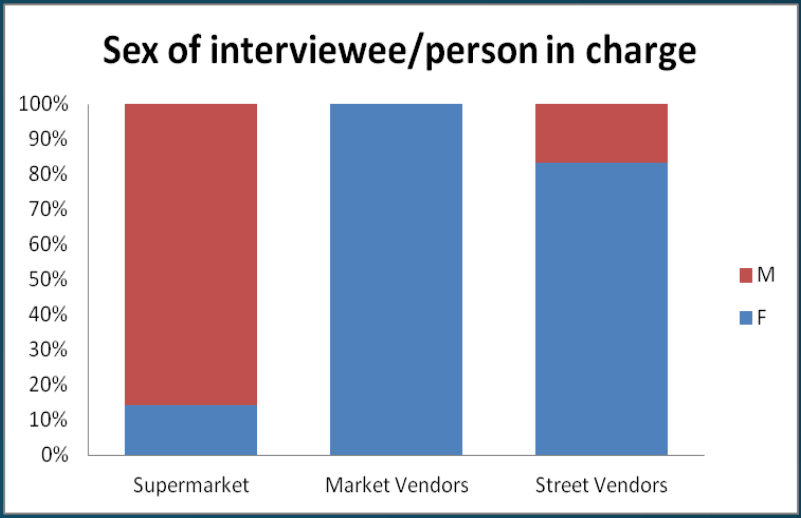
Ranking of AIVs in Western Kenya

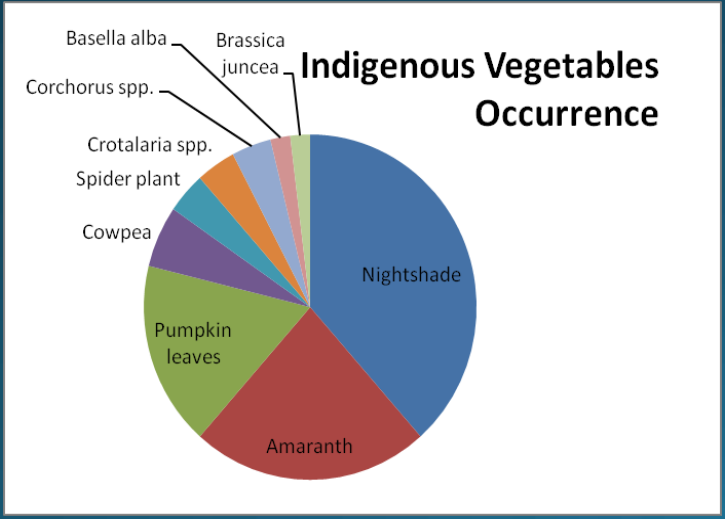
Key Findings of Household Survey in Kenya

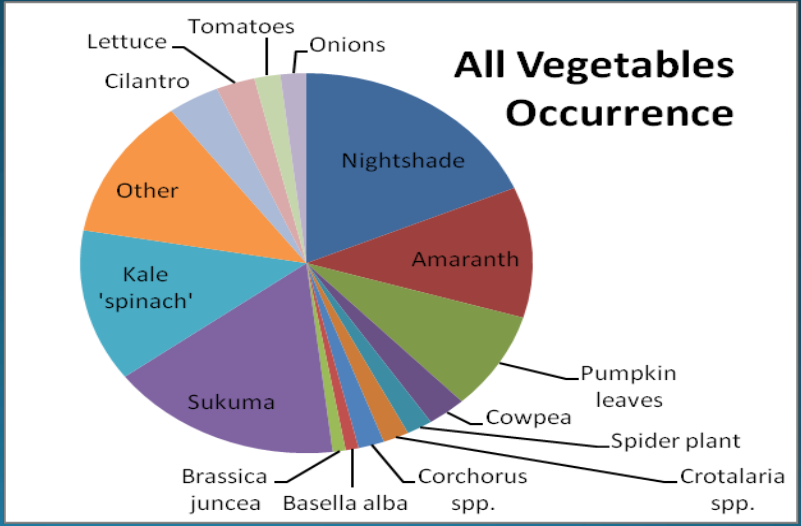
- AIV preferences vary across regions. Nightshade was most preferred AIV in Rift valley; Amaranth and Spider plant most preferred in western regions
- Key socioeconomic constraints in AIV value chain were high fertilizer price, poor quality seed, lack of money to buy fertilizers and major biophysical constraints were drought, pests and low soil fertility
- Households headed by people of about 49 years of age
- 59% of households were male headed of whom 53% were primary school level
- A majority of the household heads were married, living with their spouses
- Average household size was 6
- Landholdings small averaging 2 acres per household
- Women are the main contributor of household labor to AIV production
- 71 % of households sold some AIVs
- Most sales were to other farmers rather than large commercial enterprises
- Most households (92%) obtained AIVs consumed from their own-farms
- Limited processing of AIV was done and boiling was the common processing and consumption method

Market Survey Results



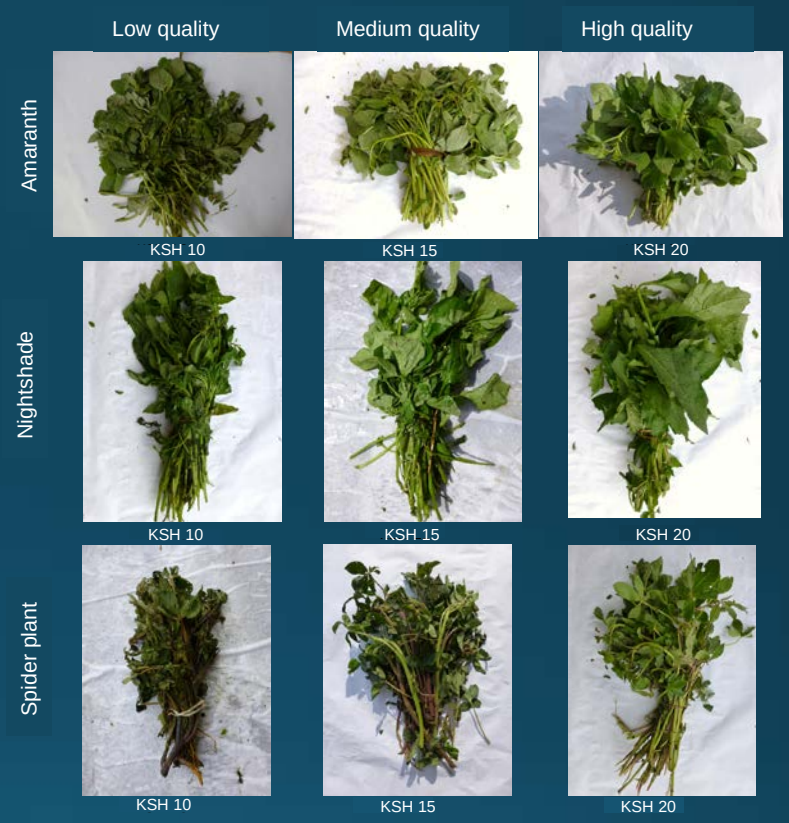


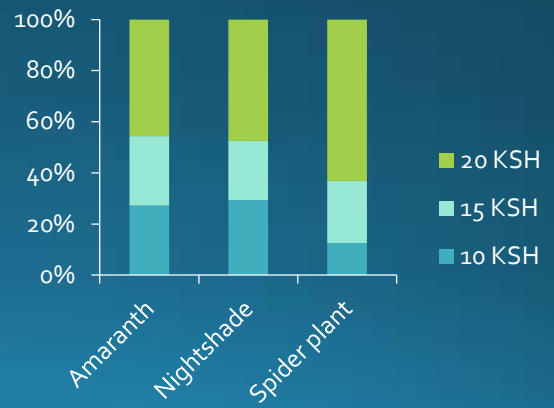




Consumer Survey

- Consumers asked to choose between very wilted, slightly wilted, and fresh AIVs at different prices
  - Significantly more chose spider plant at the highest price and quality (about 23 cents) than either of the other two AIVs
  - Strong regional preferences (Busia customers prefer spider plant the most while Eldoret customers buy more nightshade)
  - Women more likely to spend more for higher quality
  - Supermarket vs. open air market makes no difference in consumer preference for quality
  - Quality is key










Market prices for AIV compared to other popular leafy vegetable

Type of vegetable	Price per unit (Bunch or head for cabbage) (KES) (1USD = 100KES TODAY)		
	Dry season	Wet season	Average cost
African Nightshade	12.38	7.19	9.78
Amaranth	12.38	7.19	9.78
Spider plant	12.38	7.19	9.18
Kales	10.48	6.43	8.45
Cabbage	16.67	4.29	9.28
Spinach	14.05	11.19	7.38
Cow pea	9.64	18.1	5.71
Pumpkin leaves	8.81	10.95	7.14
Mito	9.05	11.43	7.85

Men Dominated Focus Group Session & Women's Focus Group Sessions - Busia

Men's Perspectives

- Land scarcity
  - Lack of titles
  - Fragmentation
  - Land disputes – land inheritance goes to sons
- Low maize productivity
  - Lack of access to inputs: fertilizer, improved seed, credit, pesticides
  - Inadequate technical assistance
  - Poor rainfall exasperated by climate change
  - Labor constraints exasperated by HIV/AIDS
- Maize mentality – maize is for food, although some intercropping with cassava, millet, sorghum
- Migrate for work in years of bad harvests
- Potable water – scarce and need to walk far
- Trees are important on agricultural landscape

Women's Perspectives

- Forced to marry – Dowry
- Traditions – second wives complicates family/community
- Women raise children, responsible for schooling
- Responsible for putting food on the table
- No access to land but do all the farming
- Carry potable water long distances
- Do all the domestic chores, lack of labor for ag
- Men control the household finances
- Men do all the marketing
- Tribal Elders – all men, reinforce dominant position of men
- Highest priority – daughter's education

Objective 2: Evaluate Agronomic Potential of Improved AIV Germplasm and Develop Improved Production Techniques

- Germplasm evaluation trials and production studies
- Evaluate nutrient composition of leaves of AIVs.
- Evaluate best harvest and postharvest storage practices for maintaining nutritional composition of AIVs
- Two lines of each of amaranth, African nightshade, and spider plant from the immediate impact project will be submitted for national performance trials (NPT) and Distinctness, Uniformity and Stability (DUS) trials for release and registration as commercial varieties
- Determine best harvest and processing techniques for optimum AIV seed, yield, quality and storage

Common Production Constraints

- Ignorance of commercial value
- Limited quality seed and germplasm
- Consumer taste preferences
- Poor production practices, seed acquisition and markets
- Post harvest handling, seed preservation

Common Pest Constraints

- Often overlooked, but a regular production issue
- Cutworms, white grubs, crickets aphids, bollworms, leafminers, root-knot nematodes, spider mites
- Also plant diseases

Evaluate Agronomic Potential of Improved AIV Germplasm and Improved Production Techniques

Impact of Fertilization on AIVs

- 3 varieties of each AIV species (2 improved varieties from AVRDC and a local variety)
- Fertilizers: farm yard manures (chicken and cattle), rate of 20 t/ha, three inorganic fertilizers included Urea (200kg/ha), Minjingu Mazao and NPK and a control (0 MT /ha Kenya and Tanzania tested farm yard manure, commercial fertilizer vs. 0 fertilizer
- Data - mature leaf harvest (fresh weight) every 2 weeks for 3 harvests and cumulative yield
- AIVs had increased quality and yield in response to all organic and inorganic fertilizers compared

  to 0 fertilizer

Key goal is to provide for year-round supply of AIVs with grower groups accessing water tanks, drip irrigation, peddle pumps

Household Pesticide Survey

- Two thirds (68%) of respondents reported pests
  - Aphids 55% of households
  - Caterpillars (cutworms and bollworms) at 11.3%
  - Ants 6.9%, spider mites 6.6%
  - Birds 4.9%
  - No plant diseases were reported

42.7% of households used pesticides

- Adults apply most treatments (99.5%)
- More women only (53.1%) than men only (9.3%) treat
- However both treat in a third (34%) of the households

More households treat nightshade (99.3%), than spider plant (81.2%) or amaranth (36.0%)

Common AIV Pests & Diseases

Insects	Diseases
Early stages of crop growth	
Cutworms (*Agrotis* spp) A, N, S	Damping off (*Pythium* spp) A, N, S
White grubs	
Crickets	
[Birds]	
Vegetative to flowering stages	
Aphids (*Aphis fabae, Myzus* sp) A, N, S	Leaf spots (*Alternaria & Septoria* spp) A, N
Flea beetle (*Phyllotreta mashonana)* A, N, S	Late blight (*Phytophthora* spp) A, N
Leafminer (*Liriomyza* sp) A	
Whiteflies (*Bemisa* sp) A, N, S	
Thrips (*Frankliniella sp)* S	
Flowering to senescence	
African bollworm (*Helicoverpa armigera*)	
Flower bugs (*Bagrada* spp) S	
[Birds] A, N, S	

A = Amaranths, N = Nightshade, S = Spider Plant

Germplasm Evaluations – Seed Production and Agronomics

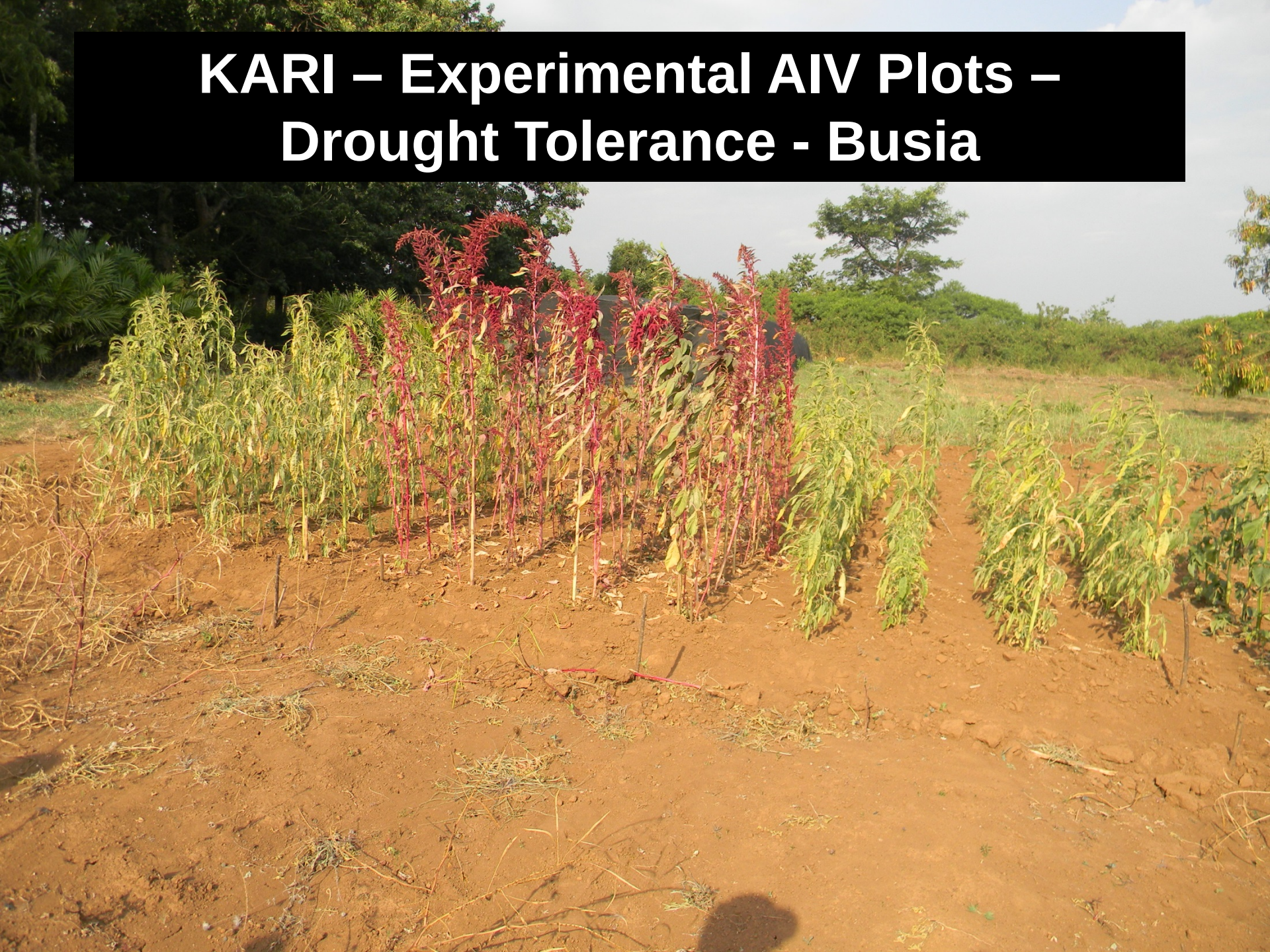
AIV Seed Evaluation Trials

- 3 species of AIVs: African nightshade, Spider plant and Amaranth tested
- Days to flowering - Days to 50 % flowering: Spider plant 28 to 35 , amaranth 35 days to 98 days and nightshade 48 to 52 days
- Seeds of *Solanaceae* contain germination inhibitors in seed coat which contribute to lower germination in freshly harvested seeds
- Nightshade, amaranth and spider plant require after-ripening to break dormancy and ensure proper germination and embryo development
- Fertilizer resulted in increased seed size and germination %
- 2 varieties each of African nightshade (BG16 and Ex-Hai), Amaranth (AC-38 and Ex- Zim) and spider plant (PS and ML-SF-29 have been submitted for Kenyan DUS tests for eventual commercial release
- 2 trainings for farmers and staff on AIV seed storage using neolite drying beads (collaboration with UCD seed storage project) held at KARI-Kakamega with 20 participants - 7 farmers and 13 staff from AMPATH and KARI

Seed Storage Training

- Composition, characteristics, source and cost of the drying beads
- Advantages of using drying beads verses other drying substances like silica gels
- How to dry beads to required moisture contents
- How to measure moisture absorption capacity of the beads
- How to determine the weight of seeds and beads using the drying bead calculator
- Trials of seed storage using drying beads being implemented by KARI

KARI – Experimental AIV Plots – Drought Tolerance - Busia



Drought Tolerance

- Evaluating improved germplasm for drought tolerance
  - Water stress experiment
    - Test 22 total varieties of amaranth, nightshade, and spider plant for water stress response
  - Phenology characterization
    - Measure stages of development for each variety
  - Transpiration
    - Evaluate differences between varieties in rates of transpiration to help identify different water stress response strategies

Objective 3: Evaluate Best Preparation and Preservation Techniques that will Enhance Micro-nutrient Composition and Retention

- Characterize the nutritional composition and benefits of AIVs, identify any anti-nutritive factors
- Evaluate best leaf drying methods to preserve nutritional composition of AIV leaves
- Evaluate vitamin retention and micronutrient bioavailability in improved AIV recipes developed in earlier projects
- Conduct organoleptic evaluation to determine consumer acceptability of improved recipes.
  - Delayed due to Passing of Mama Guga, we do have a draft cookbook with nutritional information included - under review

Quality Assessment & Essential Nutrient Preservation of Dried AIVs

- Samples from Mace Foods, Eldoret, Kenya for Spider Plant (Saga), Black Nightshade (Managu), Amaranth (Dodo) *and* Cowpea Leaves (Kunde)
- Total moisture, ash and acid insoluble ash and elemental analysis
- Work parallels nutritional proximate analysis, antioxidant screens, total phenols, total carotenoids, and tocopherols
- Results positive for quality and nutrient content compared to exotic vegetables
- Data assists developing nutrition labels for packaging of dried vegetables for nutritional information and facilitating entrance into export markets. increase in market reach will support more local production of the AIVs in our targeted communities

Nutrient Composition of Dried AIVs from Kenya and Tanzania (Mace Foods and Sylva's Foods)

Species	Ca (g/100g)	Mg (g/100g)	K (g/100g)	Fe (ppm)	P (g/100g)	Zn (ppm)	Mn (ppm)	Vitamin A (IU via β-carotene)
Amaranth	2.79	1.23	1.99	32.30	0.41	6.70	15.50	4855 ± 3.1%
Nightshade	1.02	0.31	1.86	35.70	1.86	3.70	8.75	5842 ± 8.9%
Spiderplant	1.52	0.43	0.94	58.80	0.94	4.60	9.98	7300 ± 39%
Spinach*	0.99	0.79	5.58	27.1	0.49	5.3	10.2	9377
Kale*	2.63	0.82	8.59	25.7	1.61	0.98	9.08	9990

*Data for spinach and kale from USDA nutrient database not from comparative field-grown varieties in Africa

Samples from Mace Foods, Eldoret, Kenya for Spider Plant (Saga), Black Nightshade (Managu), Amaranth (Dodo) *and* Cowpea Leaves (Kunde). Measured for total moisture, ash and acid insoluble ash and elemental analysis. Results were positive for quality and nutrient content compared to exotic vegetables.

Alkaloid Analysis of *Solanum nigrum* Indigenous in Kenya

- **Black Nightshade (Managu) *Solanum nigrum* leaf (AIV 12060) and Black Nightshade (Managu) *Solanum nigrum* leaf (AIV 12061) provided by Mace Foods, Eldoret, Kenya. Our role is to assist in developing nutritional labels for their AIV products and science to support market expansion.**
- **TLC and HPLC used for analysis of tissue for alkaloids**
- **The *Solanum nigrum* samples had alkaloid levels in the lower range as reported in the literature and an unusually low amount of α-solanine, previously reported as a major alkaloid in nightshade. Guidelines for potatoes recommend limiting glycoalkaloid content to 200 mg/kg fresh weight, which is well above the levels found in *S. nigrum* species analyzed.**

Measurements of AIV Nutrient Levels in Tanzania AIV samples

Nightshade Nutrient Levels – Example - Leaves sampled at various days after seedling emergence & analyzed for phytate, NO3, Vitamin C, Fe, Zn and Se. Similar measures for Amaranthus and Spider plant.

		21 Days		28 Days		35 Days
Nutrient mg/100g	BG-16	SS-49	BG-16	SS-49	BG-16	SS-49
Phytate	.03	.15	.2	.3	.3	.43
NO3	66	85	64	80	63	75
Vitamin C	49	27	49	66	115	107
Oxalate mg/Kg	28	42	38	55	59	60
Fe	273	230	345	411	845	850
Zn	71	57	54	51	43	43
Se	420	405	2190	720	285	1500

***Similar measurements have been conducted in Kenya in the agronomic studies with all AIV lines and species**

Zambian Field Grown & US Field Grown AIVs

Field grown vs. USA grown variety by variety	Variety, Location	Fe ppm	Ca %	Mg %	N%	K%
Amaranthus spp. (Amaranth)	Ex-Zim Lusaka	138.5	1.78	0.91		5.27
Amaranthus spp.	Ex-Zim Livingstone	160	3.52	2.15	4.23	2.32
Amaranthus spp.	Ez-Zim RU	460.7	3.56	1.49	5.08	5.51
Amaranthus spp.	UNZA A1 Lusaka	130.93	1.95	0.9	3.96	5.62
Amaranthus spp.	UNZA A1 RU	419.18	4.39	1.12	4.75	5.73
Amaranthus spp.	AM38 Lusaka	101	2.91	1.9	4.35	3.26
Amaranthus spp.	AM38 Livingstone	164.62	1.73	0.91	3.37	6.55
Amaranthus spp.	AM38 RU	783.04	3.81	1.48	4.65	7.7
Amaranthus spp.	AC-45 Livingstone	402.84	2.75	1.62	4.9	4.87
Amaranthus spp.	AC-45 RU	508.35	4.32	1.56	4.94	4.99
Amaranthus spp.	UGAM40 Lusaka	185.97	1.77	0.77	4.06	6.73
Amaranthus spp.	UGAM40 Livingstone	139.04	2.8	1.43	3.85	3.18
Amaranthus spp.	Ex Mwanga Livingston	366.04	2.64	2.3	4.82	5.01
		Fe ppm	Ca %	Mg %	N%	K%
Solanum spp. (Nightshade)	SS49 Lusaka	189.83	1.6	0.56	6.16	3.15
Solanum spp.	SS49 NS5 RU	103.95	2.97	0.57	6.02	3.78
Solanum spp.	SS52 Lusaka	193	1.78	3.58	5.43	3.58
Solanum spp.	SS52 NS 3	135.84	2.8	0.63	5.9	3.78
Solanum spp.	BG-16 Lusaka	207.11	1.41	0.56	5.49	4.08
Solanum spp.	BG-16 NS7	106.27	2.69	0.57	6.17	3.78
		Fe ppm	Ca %	Mg %	N%	K%
Cleome gyndandra (Spiderplant)	SP Lusaka	182.89	2.06	0.53		2.3
Cleome gyndandra	UG-SF-23 Lusaka	248.72	2.6	0.48	5.58	2.87
Cleome gyndandra	UG-SF-23 sp3	156.58	2.93	0.64		3.13
Cleome gyndandra	PS Lusaka	184.17	2.4	0.48	5.21	2.81
Cleome gyndandra	PS SP5	273.1	3.24	0.76		2.95

Objective 3. Value Addition - Drying Vegetables and Nutrient Composition and Quality of Dried AIVs

Solar Dryer – modified UCD design – dries AIVs in 3 hours vs 24+ hours in Mace GH, functional and ready for replication

Moisture content of dried vegetables derived from the tunnel solar dryer ranged from 4.5% to 8.2% compared to Mace foods dried leaves of 9.2% to 12.8 %. Will analyze leaves for N, Ca, Fe, Mg and Vitamin C

Chemical analysis and assistance to Mace Foods, Kenya and Sylva's Catering, Zambia for nutrient content and antioxidant activity for each of their packaged AIVs

Evaluate Oganoleptic, Vitamin Retention and Micronutrient Bioavailability in Improved AIV Recipes

- Recipe Cookbook in review from AVRDC for publication in 2014
- Sensory evaluations conducted in Kenya and Tanzania (pictures at KARI in Kenya)

- Cooking and consumption and evaluation
- Vitamin retention and nutrient levels in progress in Kenya - vitamin A and C and N, Ca, Fe and Mg in cooked AIV recipes

Farmer Taste Testing AIVs and Recipe Development

Objective 4. AIV Outreach,Training and Capacity Building

Training - germplasm, agronomics, seed collection and storage, field demonstrations, seed fairs

Capacity building – graduate students Kenya, Tanzania, US-Purdue and Rutgers, host country collaborators, private sector - Mace Foods, Sylva Foods, Sun International Hotels

Steps in AIV Harvest and Handling

- Training on harvest during the cooler times of day (in the early morning or even at night if possible)
- Use of shade after harvest
- Cool AIVs after harvest whenever possible
- Coolbot demonstrations and experiments in Zambia

Shadebot

Shadebot & Coolbot storage

Evaporative cool

Training Courses in Tanzania*

- Vegetables and seed production
  - Arusha trainings – 149 farmers, 74 female, 75 male
  - Seed Fair - 269 farmers, 104 female, 165 male, 6 seed companies
- Production practices (amaranths, nightshade and spider plant)
  - Nursery management
  - Plant protection (safe use of pesticides)
  - Preservation of vegetable by drying, postharvest practices
  - Nutritional value of vegetables for balanced diet
  - Recipe preparation and utilization of AIVs
  - Safety and hygiene
- Training Materials Provided
  - Production leaflets for amaranth, nightshade and spider plant
  - Recipe leaflets
  - Garden Seed Packets

*Similar trainings done in Zambia and Kenya with 1000 total farmers trained (~60% women)


Vegetable recipe exercise, 2013


Seed Fair

Farmers Field Days - Evaluating AIVs

Kenyan Farmer Collaborators

Zambia Collaborators and Training

AIV Seed Training

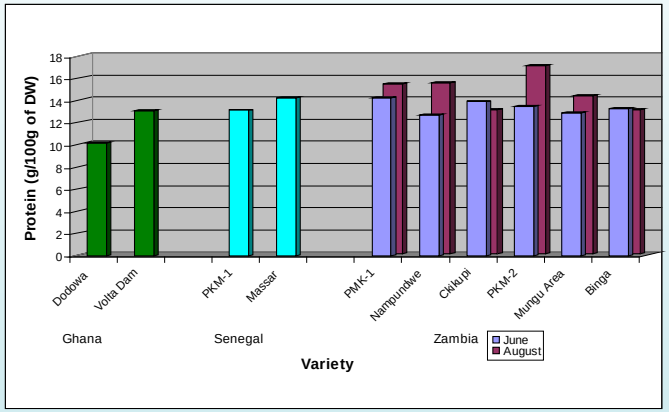
- A field day was held to train farmers in proper seed collection, processing and storage

Many AIVs can serve as Delivery Systems to Improve Human Nutrition, Health & Reduce Disease: Moringa

- Moringa, an endemic tree found across sub-Sahara Africa with 13 species, *M. oleifera*, the main spp. of interest.

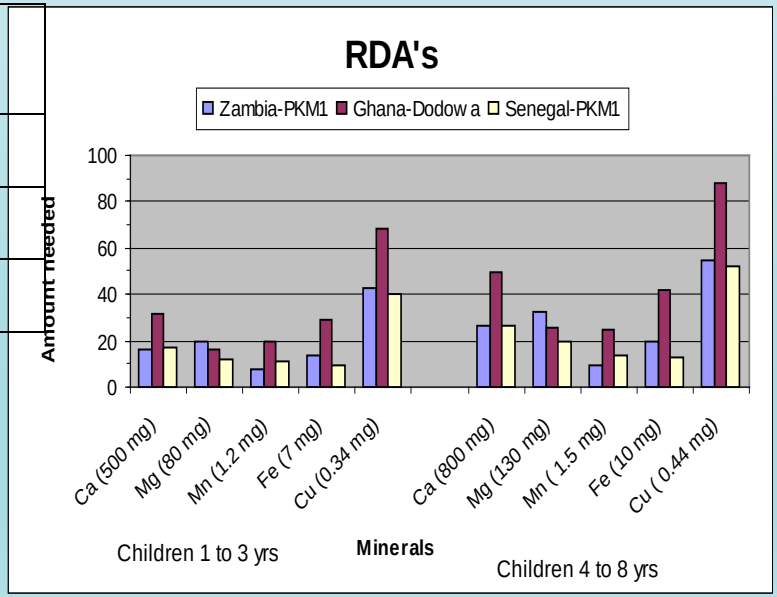
- Very rich in vitamins A and E, iron, zinc, selenium (same vitamins and minerals that have been identified as the major limiting nutritional factors in the same region particularly for vulnerable populations)
- Leaves, pods and seeds rich in glucosinolates and flavonoids

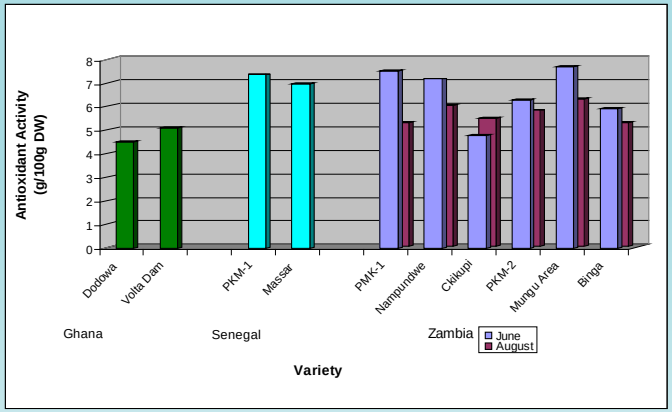
Total Protein



Child between 1 to 3 years old is 13 grams/day
Child between 4 to 8 years old is 19 grams/day

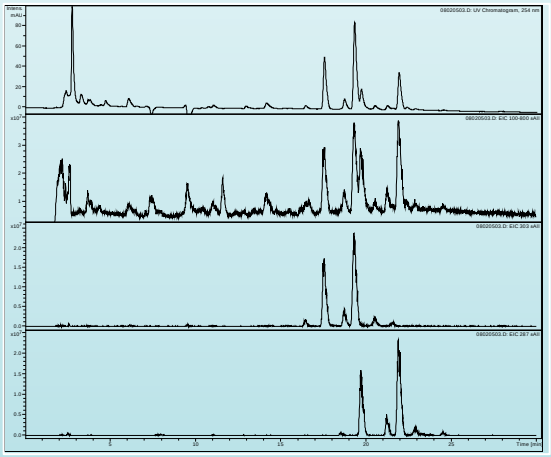
Location	Ascorbic Acid mg/100g	Total tocopherols (mg)	Total Carotenoids (mg/100g)
Gasabo	0.36	36.93	23.02
Kibungo	0.35	49.52	45.94
Kicukiro	0.44	43.08	29.44

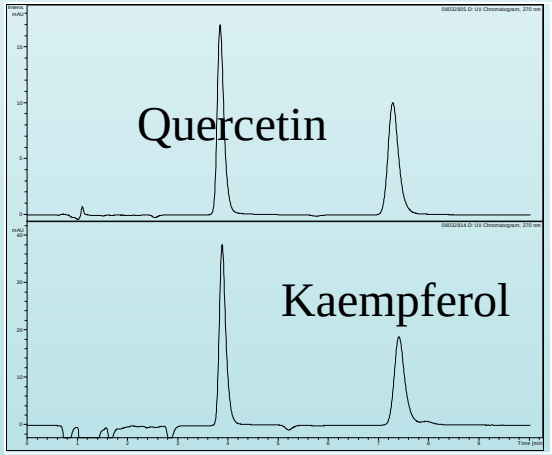




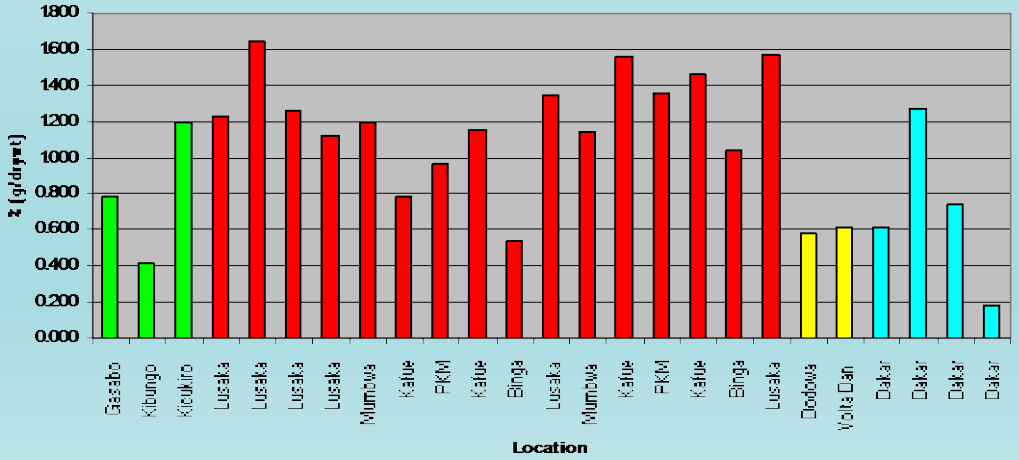
Antioxidant Activity

Moringa: Also a Rich Source of Health-Beneficial Bioactive Flavonoids*





Total Flavonoids (Quercetin and Kaempferol)



***Samples from Ghana, Rwanda, Senegal, and Zambia, analyzed using our HPLC/UV/MS**

Potential for value adding

- Fresh vegetable
- Juices, beverages
- Dry ground vegetable (powder form)
- Dried vegetable
  - In powder form
  - Whole leaves or in chopped form
- Other products
  - Oil from some vegetable seeds

Collaborative Agreements

Partnered with 4 farmer groups in western Kenya associated with the USAID-KHCP by introducing AIVs and training on agronomic practices, harvesting, postharvest, seed saving and market connections.

Kakamega-Blessed Development Youth Group;

Bungoma- Muanda Support Group;

Bungoma- Tunapo Self Help Group;

BUSIA-Budinyu Bwe Dala

Amaranth- Budinyu Bwe Dala

- **All groups grew, harvested and marketed AIVs locally.**
- **USAID Mission highlighted work in November 2013 newsletter.**

- **Fintrac in Kenya –AIV to KHCP smallholder collaborators**
- **Seed Storage UCD project – Kent Bradford**
- **CASH Project in Zambia- A GDA including AIVs**

Build stakeholder capacity through participatory research & outreach activities

Outcomes

Increase AIV productivity, marketability and utilization and understand nutritional composition of fresh, dried and cooked AIVs for improved health and nutrition

More opportunities for small-holder farmers, particularly women to participate in AIV

Acknowledgements

CRSP: Purdue:
Maria Marshall
Steve Yaninek
Betty Bugusu
Fernanda San Martin-Gonzalez
Pam Obura
Lonni Kucik
Marcia Croft

Rutgers:
James Simon
Ramu Govindasamy
David Byrnes

Kenya AMPATH:
Naman Nyabinda

University of Eldoret:
Elizabeth Omami
Julius Ochuogho
Linnet Gohole
Violet Mugalavai
Wilson Ng'etich

KARI:
Christine Nyabinda
Martins Odendo

Tzanzania: AVRDC:
Chris Ojiewo
Fekadu Dinssa
Hassan Mndiga
Mama Guga

Hort Research Institute:
Nancy Kaaya
Emmanuel Vicent
Grace Kindimba
Samali Njau

Sokoine University:
John Msuya

St. Johns University:
Don Lotter

Zambia
ASNAPP
Petrus Langenhoven
Emil Van Wyk
Lupiya Sakala

USAID
FROM THE AMERICAN PEOPLE

HORTICULTURE INNOVATION LAB

UCDAVIS
UNIVERSITY OF CALIFORNIA