NARO

NATIONAL AGRICULTURAL RESEARCH ORGANISATION

2016/17

Annual Report



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Cover Photo: The Cassava Regional Center of Excellence building at National Crops Resources Research Institute (NaCRRI).

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Overview

The primary role of NARO in agriculture is to improve livelihood of more than 68% of the resource poor subsistence farmers operating in very militating environments. NARO implements a research agenda with the aim of solving food and nutrition insecurity; unlocking employment opportunities and wealth creation; increasing production and productivity; value addition, market access and institutional capacity development.

To achieve this, NARO generates and promotes Technologies Innovations and Management Practices (TIMPS) in crops, livestock, forestry and fisheries as well as integration of Indigenous Knowledge with modern scientific methods in the research agenda such as biodiversity conservation, characterisation, bio-prospecting.

In achieving its vision, mission and goal, NARO implements a client and impact oriented, market responsive research agenda through its 16 Public Agricultural Research Institutes (PARIs) (7 National Agricultural Research Institutes, 9 Zonal Agricultural Research Institutes) with 893 Staff representing 89.7% of the total establishment (646 male and 247 female) of which 293 Scientists; 97 PhD, 171 MSc, 25 BSc. In the 2016/17 budget, NARO was allocated UGX 114.13B, of which released UGX95.55B was released and 93.10% of the released funds were spent.

The Mandate, Vision, the Mission, the Goal and the Values that guide the National Agricultural Research Organisation are derived from the National Agricultural Research Policy.

Mandate

"Coordinating, overseeing and guiding agricultural research in Uganda".

Vision

"A market responsive, client oriented and demand driven national agricultural research system".

Mission

"To generate and disseminate appropriate, safe and cost effective technologies".

Goal

"To enhance the contribution of agricultural research to sustainable agricultural productivity, sustained competitiveness, economic growth, food security and poverty eradication."

Core Values

Inclusivity, Transparency, Integrity, Accountability and Excellence.

For more information visit; **www.naro.go.ug**

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Location of the Public Agricultural Research Institutes (PARIs)



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NARO Governing Council

Members of the NARO Governing Council in a group photo with the then Minister of Agriculture, Animal Industry and Fisheries, Hon. Tress Bucyanayandi (3rd from left) and the Council Chairman, Prof. Joseph Obua (4th from left), shortly after taking their official oath.

NARO Top Management



Dr. Ambrose Agona,
Director General, National Agricultural Research Organisation



Dr. Yona Baguma,
Deputy Director General - Research Coordination



Dr. Imelda N. Kashaija,
Deputy Director General - Agricultural Technology Promotion



Prof. Justus Rutaisire,
Director Corporate Services



CPA Mary Kigunddu,
Director Finance



Mr. Robert Bagonza,
Director Human Resource



CPA Denis Owor,
Head Internal Audit

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Word from the Chairman, NARO governing Council

Prof. Joseph Obua

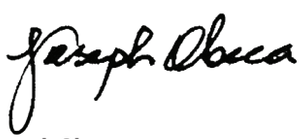
The overarching agricultural challenge in Uganda today is low productivity across all the farming systems. Growth in agricultural Total Factor Productivity (TFP) - a broad index that compares the total output of crops and livestock commodities to the total inputs of agricultural land, labour, capital and material resources, has been estimated at about 2% per year for developing countries as a whole, twice the rate of agricultural TFP growth in sub-Saharan Africa (Fuglie and Rada, 2013).



This underscores the need for new and innovative approaches to accelerate agricultural productivity growth not limited to food security alone but also income security. Transforming agriculture from livelihood activity into a profitable business provides the fastest options for feeding, employing and lifting millions of people out of poverty.

Addressing poverty and the risk of food insecurity is an unavoidable moral and development imperative that requires a concerted effort of all sectors of society. Therefore, NARO innovates for agricultural transformation through technology research to ensure food security, wealth creation, employment and job creation among others. Such research initiatives are guided by various policy frameworks and the NARO Governing Council in FY 2016/17 approved the following Policies and Frameworks:

- Communication and Knowledge Management Strategy, 2016-2021;
- Levy policy for off-budget research projects;
- Criteria for staff promotion;
- Internal Audit Manual;
- Internal Audit Charter;
- Audit Committee Charter;
- Performance management policy and appraisal guidelines;
- ZARDI Research and Development Programmes.



Prof. Joseph Obua,
Chairman, NARO governing Council

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Overview by the Director General, National Agricultural Research Organisation

Dr. Ambrose Agona

Today, one in nine of the world's 7.3 billion people- more than 800 million men, women and children- do not get enough to eat. They are undernourished, including 90 million children under the age of five. One (1) billion people worldwide suffer from insufficient calories and nutrients; 2 billion have sufficient calories but insufficient nutrients and 2.5 billion consume excess calories, but with insufficient nutrients. Therefore only about 3 billion people have sufficient calories and sufficient nutrients.



Over the years, the challenges of meeting global food demands in terms of requisite calories, proteins, vitamins and minerals have necessitated application of Science Technology and Innovations (STI) that increase labour productivity, availability, access and sustainability.

The four main drivers of agriculture in meeting global food demand include: Food availability, Food access, Food utilisation and use, and Food stability.

New and existing technologies to combat biotic and a biotic stresses, raise crop and livestock productivity, improve soil fertility and make water available, can potentially increase the amount of food produced. Storage, refrigeration, transport and agro-processing can address the dimension of food accessibility. Using science we can produce high-nutrient staple crops to combat malnutrition, improving food utilisation and use. STI for climate change mitigation and adaptation- precision agriculture, index-based insurance and EWS can address food stability.

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And God said on the 3rd day of creation "Let the earth bring forth vegetation, the plant yielding seeds and the fruit tree yielding fruits after its kind, whose seed is in itself upon the Earth, and it was so"

The science of agriculture has been refined and perfected over time to accommodate for the ever-increasing human population, especially, the demand for food, feed and fibre. Techniques such as irrigation (e.g. the shadoof), intercropping and crop rotation increased efficiency in agriculture.

Four generally agreed-upon goals that define a sustainable agriculture: Satisfy human food, feed, fibre needs; Enhance environmental quality and the resource base; Sustain the economic viability of agriculture; and Enhance the quality of life for farmers, farm workers and society as a whole.

Based on empirical evidence, STI have the potential to increase efficiency, effectiveness and impact of our efforts to meet the ambition of SDG 2030 agenda and create benefits for society, the economy and the environment

NARO through development, release, and promotion of high-quality crop varieties have enhanced the supply capacity of major agricultural products. Breakthroughs in developing varieties that are high-yielding, nutrient-dense, disease resistant/tolerant, pest tolerant and moisture-stress/drought/heat tolerant has successfully contributed to food/nutrition security, job creation and wealth creation.



Dr. Ambrose Agona
Director General, National Agricultural Research Organisation

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Key Achievements, FY 2016 - 2017

66
Production technologies generated and disseminated to uptake pathways



36
New crop varieties/ prototypes generated



2
Efficacious anti-tick candidate vaccines developed



70
Papers published in peer reviewed journals



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2
Bio-acaricides developed



7
PhD, 5 MSc students completed



12
Products identified for patenting, licensing, direct sale and commercialization



13
Buildings completed and handed over



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NATIONAL AGRICULTURAL RESEARCH ORGANISATION

CHAPTER 1

GENERATION OF AGRICULTURAL TECHNOLOGIES



Crop sub-sector

In an effort to contribute to food and nutrition security, NARO has developed technologies that respond to emerging threats and opportunities thus contributing to increased factor productivity and food security. Among such technologies include improved crop varieties and corresponding management packages/practices.

Three Bio-fortified Bean Varieties Released

Lack of iron can impair mental and physical development. Severe anemia often caused by iron deficiency, increases risks to women during childbirth and can cause death.

Despite efforts to curb iron deficiency through supplements and fortified foods, iron deficiency remains the most widespread nutrition deficiency, affecting an estimated 1.6 billion people worldwide. The Biofortified Iron and Zinc enriched bean varieties have been deployed in Uganda and several other countries to alleviate VAD; and an estimated total of 528,000 households had been reached with these varieties. Consumption of such bio-fortified commodities will generate measurable improvements in human health and nutrition. Such efforts have led to NARO's recognition as the Centre of Excellence (CoE) for Bio-fortification research in Africa.

Beans are further a source of income for female and male farmers contributing about 9% to GDP. Farmers have bean able to reap from sale beans as seed under the local seed business model where they supplement the formal seed sector. Over 24,000 farmers and over 1 million households are engaged in commercial bean production. Today, vendors on the Kampala streets are satisfied with the demand and income obtained from NABE 12C fresh beans. NABE 14 bean grain is also being exported to Asia earning farmers' involved substantial income.

Bio-fortified bean varieties with enhanced levels of Iron and Zinc

NAROBEAN 1



- Bush
- Large seeded
- Iron: 65.8-72 ppm
- Zinc: 31.4-34.2ppm
- Yield :1500-2000 kg/ha
- Maturity: 60-68 days

NAROBEAN2



- Bush
- Medium seeded
- Iron: 66.1-72 ppm
- Zinc: 32.5-36.2ppm
- Yield : 1600-2200 kg/ha
- Maturity: 58-68 days

NARO BEAN 3



- Bush
- Medium seeded
- Iron: 65.4-69ppm
- Zinc: 35-38ppm
- Yield : 1500-2000 kg/ha
- Maturity: 58-68 days

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Promoting Improved Cassava Varieties

Following the outbreak of cassava mosaic disease, NARO bred mosaic resistant cassava varieties that averted famine especially in northern and eastern Uganda, saving the national economy an estimated US$ 60 million per annum.

By 2017, 77% of farmers were growing improved cassava varieties; compared to the national average of 30%. The average yield of improved varieties ranges between 20-45 t/ha, compared to 9.5 t/ha of most landraces. Currently, a cassava rich in Vitamin A is being developed.

Many farmers have taken up high quality cassava planting material production of NARO's improved varieties as a business. Potential domestic and regional demand is over 150,000 bags of stem cuttings. From 2015 to February 2017, estimated 300,000 bags of cassava stems for mainly NASE 14, NAROCASS 1 and NASE 19 were sold, generating about UGX 5 billion for farmer seed producers.

NASE 14, NAROCASS 1









Case 1: The Contribution of Cassava to Livelihoods

The remarkable breakthrough in cassava research has led to 21 cassava varieties released. The improved varieties are superior in terms of yield (20-45 t/ha), disease resistance and consumer-tagged storage root qualities.

These varieties have been widely disseminated, with high adoption rate of 77% by 2014. This has resulted in increased average yields from 9.7t/ha (2010) to 15.6t/ha (2015), reduction in national cassava brown streak disease (CBSD) incidence 27.3% in 2011 to 20.4% in 2017 and controlling cassava mosaic disease (CMD) occurrence below 20%.

These outputs and gains have directly contributed to food and nutrition security of major cassava growing areas. Consequently, there is very high demand for planting material of improved cassava varieties, which calls for increased production through a clean seed system.

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Five Early Maturing and Drought Tolerant Rice Varieties Released and promoted

In FY 2015/16, Uganda produced up to 320,000MT of rice (FAO, 2015). This is equivalent to an import substitution of about US$ 104 million per year. In the same year up to 33,000 tonnes milled rice was imported.

As a check for import substitution, Five (5) improved rice varieties (NaMCHE 1 – 5) that mature in 110 days after planting with an average yield of 4.0 ton per ha have been developed. Over 40,000 ha of these varieties are being grown by commercial farmers and 10 MT of foundation seed is available for use by seed multipliers



A farmer celebrating a bountiful rice harvest in Bungatira, Gulu District.

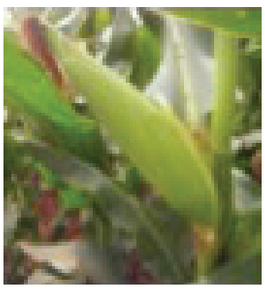
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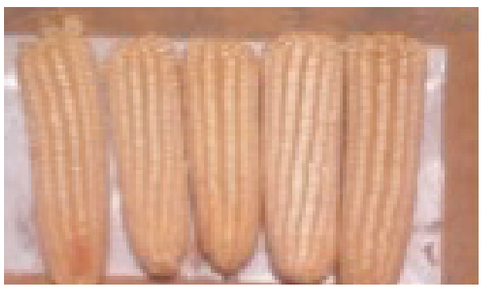
Three Stress Tolerant Maize Varieties Released

Introduced into Africa by the Portuguese in the 16th century, maize has become Africa's most important staple food crop with the total production surpassing that of wheat or rice. Maize can be grown all year round therefore making it a food security crop. Maize meal is also used as a replacement for wheat flour, to make cornbread and other baked products.

Maize in Uganda is grown mainly for consumption however this is changing as more farmers are growing it commercially now due to the increase in demand for not only consumption but also as feed for livestock and poultry. Low production brought about by stress due to prolonged drought is affecting maize yields and to address this, NARO has been able to release three stress tolerant maize varieties; NARO Maize03 (UH5503), NARO Maize56 (UH5556) and NARO Maize57 (UH5557). National average maize yield has shifted from 1.8 to 2.7 Mt in the last five years.

NARO Maize03 (UH5503)

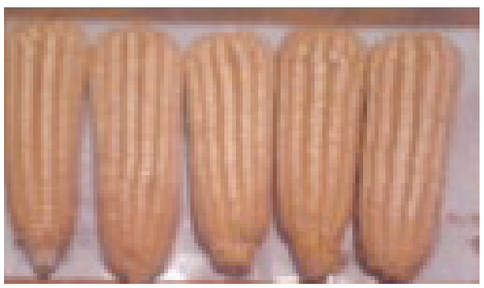




- Yield potential of 6-7 T/ha
- Resistant to common foliar diseases
- Matures in 120-126 days

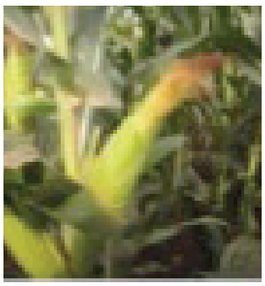
NARO Maize56 (UH5556)

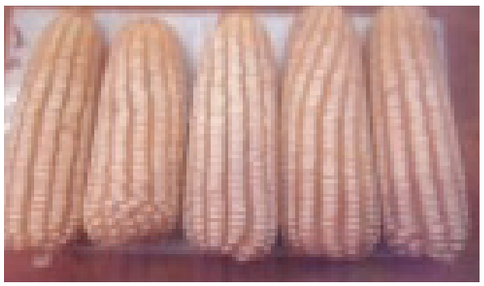




- Tolerant to MLN
- Yield potential of 8-9 T/ha
- Stay-green characteristics
- Matures in 135-140 days

NARO Maize57 (UH5557)





- Very stable in drought and low soil fertility
- Yield potential of 6-7T/ha
- Matures in 125-130 days

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Six multi-stress Tolerant Cowpea Varieties Released

Six cowpea varieties NAROCOWPEA 1- 6 have been released and are high yielding between 2100 to 2200 kg/ha, drought tolerant and resistant to virus, scab, yellow blister and bacterial blight

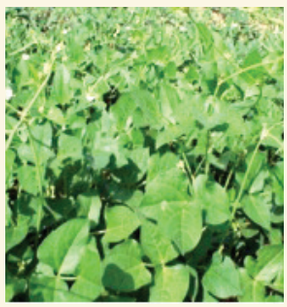
NAROCOWPEA1




Alegi x ACC12-36 NewName: NAROCOWPEA4)




NAROCOWPEA2




NAROCOWPEA




NAROCOWPEA3




NAROCOWPEA6




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Two High Yielding and Drought Tolerant Greengram Varieties Released

Two Greengram varieties NAROGRAM 1 and NAROGRAM 2 were released this year. The varieties have desirable characteristics and are adaptable to the eastern and northern regions of Uganda.

They mature very early in only 65 days making them suitable to grow during short rainy seasons. They cook fast, high yielding and resistant to common greengram pests and diseases. NAROGRAN 1, with large green seeds and dull luster is tolerant to cercospora leaf spot, moderately resistant to powdery mildew and tan spot diseases.

NAROGRAM 2 has greenish –yellow seeds and shinny luster and moderately resistant to tan spot disease. The latter is highly tolerant to drought and so is highly recommended for Eastern and Northern Uganda where temperatures are high and Dry spells are longer.

These new varieties can be grown both as single (mono-cropping) or mixed (intercropped) with other. They are also rich in proteins (crude protein content of 23%) and dietary fibre (14%) and low in fat (0.41%) and anti-nutritional factors that cause flatulence. The varieties have yield potential of between 1200-1400 kilograms per hectare compared to local varieties which stand at 300kgs and are resistant to pod shuttering.

Greengram also known as Mungbean or locally called Choroko is increasingly becoming an important crop to farmers in these regions. Seed of these two improved varieties can be obtained from the National Semi-Arid Resources Research Institute, NaSARRI.





Dr. Ambrose Agona tours a demo field of released greengram varieties during the 24th Source of the Nile Agricultural and Trade Show in Jinja. Right: a heavily podded greengram plant.

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Four Hybrid Banana Varieties in the Offing

Four hybrid banana varieties;M19, M20, M25 and M27 resistant to blacksigatoka weevils and nematodes have been identified. These varieties taste as good as landraces, are soft in texture and rich in Pro-vit A with an average yield 35 t/ha, compared to 10 t/ha for the landraces.

The first multi-location field trial for transgenic Banana Bacterial Wilt (BBW) resistant lines have also been planted. The trial was planted at the National Agricultural Research laboratories - Kawanda. This was the first one in the product development phase. When put in M9 (hybrid) and Nakitembe (local variety) the genes provided BBW resistance of 100%.

The purpose of this trial is to see how resistant varieties perform in terms of BBW resistance, yield and vigor. Of the 60 lines that were planted, 10 will be selected. It is from these 10 that the final line to take to the farmers will come from. More field trials will be planted in Bulindi and Mbarara agricultural research stations.

This year (2017) NARO embarked on a new project on banana agronomy. Supported by the Bill and Melinda Gates Foundations, the 4-year project, Improving scalable banana agronomy for small scale farmers in highland banana cropping systems in East Africa, seeks to increase banana productivity from 10 to 25ton/ha. The project will develop and deliver necessary knowledge and information products, and tools for availing this knowledge to banana scaling partners and through them to farmers in Uganda and Tanzania.

In Uganda, project sites are in central (Nakaseke), midwest (Kabarole) and western (Isingiro). At the end of 4 years, through scaling and partners, the project will reach over 25,000 households in Uganda and Tanzania thus creating a value of over US$ 14.3 million and provide a prototype for increasing banana productivity in all major banana growing areas at national and regional levels.







L-R: M19, M25 and M27

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Four High Yielding, Drought and Disease Tolerant Sorghum Varieties Released

This year NARO through the Serere based Institute NaSARRI released four Sorghum Varieties. The varieties NAROSORG 1, NAROSORG 2, NAROSORG 3 and NAROSORG 4, have been bred with critical traits such as resistance to drought, diseases and pests. All the four releases showed resistance to covered smut, which was as well a big menace to the commercial sorghum production with a yield high up to 2800 kilograms per hectare compared to local varieties



NAROSORG 1; Excellent brewing quality, is of medium maturity, has grey seed color, and is drought tolerant and midge resistant. It is an open pollinated pure line variety developed through pedigree selection and it's a replacement to SESO 1 that had succumbed to striga.



NAROSORG 2; A red-seeded, Drought tolerant with minimal or no bird damage on the grain, its release was partially informed by being highly desired for food and brew in Karamoja and West Nile.



NAROSORG 3; Chalky white Tolerant to sorghum midge pest good for forage as the stalk due to its stay green trait.



NAROSORG4; Highly Striga-tolerant a weed that has constrained sorghum farmers in Uganda and most conducive for food

Case 2: Contribution of sorghum research to household income and wealth creation

Traditionally, sorghum (food variety) was least price commodity and grown on small scale for home consumption, it is now largely grown for export to neighboring countries. However, due to changing weather patterns many farmers in Acholi have also taken extensive commercial sorghum farming.

Iren Jovia Atek is one of such a farmer in Bobi sub county, Omoro District. She took SESO3 improved sorghum variety tolerant to harsh weather conditions and matures early within 90 days and yields 2500kg/ha. She harvested 11 tonnes of sorghum grain planted on 25 hectares of land and sold at UGX 2,000/=@kg and she got UGX 20million following the current famine. The variety has high demand locally and in South Sudan for food. She intends to increase area production and use appropriate agronomic practices in to order to maximize yields. Hence NARO is contributing towards creation of wealth through improved varieties that respond to demand, market opportunities and promote smallholder investment ***(Market watch, pull out from Saturday Monitor March 4, 2017)***

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Three Advanced Drought tolerant and high yielding candidate pigeonpea Varieties in offing

Legumes provide multiple benefits to millions of smallholder farmers in Uganda. It is a cheaper source of protein compared to expensive animal-based diets. Also pigeon pea is a deep rooted crop making it tolerant to drought. The crop has the ability to fix atmospheric nitrogen hence improvement of soil fertility.

The high consumption and demand both locally, regionally and internationally makes pigeon pea a high income generating crop.

The bulk of pigeonpea production in Uganda is in the Northern Region (88%) followed by Eastern region (9%) and the remaining (3%) is by other parts. Uganda was traditionally a large exporter of pigeonpea but civil strife (1985 – 2007) reduced production and export capacity. By 2009, production had dropped to around 11,300 Mt from an area of 29,800 Hectares. Of this, Northern Region accounted for 11,000 Mt (97.4%) and Eastern Region 219 Mt (1.9%).

The crop is mostly it grown as inter-crop with finger millet, groundnut, and cassava or in rotation. It is in this direction that there is exerted efforts to revitalize pigeonpea production in Northern and Uganda at large and hence DUS trials were conducted at Ngetta ZARDI and Zombo for Varieties; ICEAP 00557, 00554, ICEAP 540, SEPI 1 (control) and have been submitted for release.



A heavily podded drought tolerant pigeonpea plant.



Ratoon crop ready for harvest in Lira district, January 2017.

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New High Yielding, Malting Barley Varieties for Uganda

Barley, (*Hordium vulgare L*) is the fourth most important cereal globally after maize, rice and wheat (FAOSTAT, 2015). A significantly high value use of barley in Uganda is for malting to produce malt as a raw material for the production of beer. Nile Breweries Limited (NBL) one of the leading brewing companies in Uganda produces specialty beer whose quality is dependent on specialty malt.

NBL's current barley requirement is 12,000 MT per annum and the market is growing year-on-year at double digit growth. However, NBL has peaked at being able to produce 6,000 MT per cropping year in Uganda which accounts for 50% of their required tonnage.

NBL under the new management "ABInBev" is emphatic about Uganda becoming 100% locally self-sufficient in barley for malt. The biggest challenge has been use of the low yielding barley varieties.

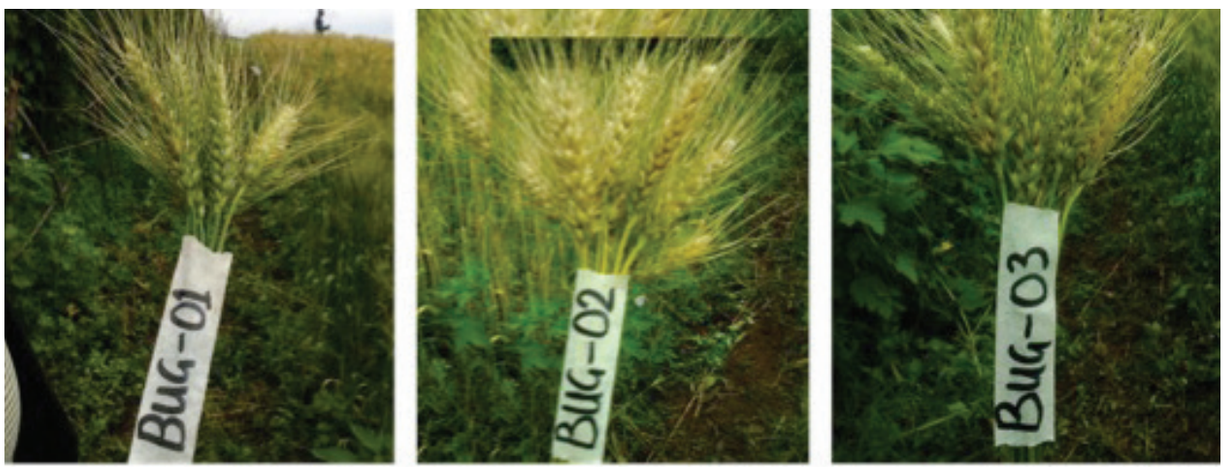
The National Agricultural Research Organization has released two new barley varieties for use by the public. The new barley varieties have been rigorously tested in different barley growing areas in Uganda by NARO researchers at the Buginyanya Zonal Agricultural Research and Development Institute (BugiZARDI).

They were evaluated for adaptability, disease response, yield and malting quality. They were also assessed for distinctiveness, uniformity and stability (DUS) by the Crop Protection Department of the Ministry of Agriculture, Animal Industry, and Fisheries (MAAIF).

The malting attributes of the barley grains were analysed by the "end-user" Nile breweries and the two varieties were found to be of high grade malting quality than the local check. The two new high yielding malting barley varieties are Narobar1 formally Hessekwa and Narobar 2 formally designated as T279.

Narobar1 (Hessekwa) is a medium height (61.5 cm) vari-

Developed High Yielding and Excellent Brewing Barley Varieties



- Takes 110 days to mature
- Average yield of 2.5t/ha, compared to 0.8t/ha of the other varieties.

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ety which takes 65 days to flower, 109 days to mature and yields 2.5-3 t/ha. Narobar2 (T279) is tall (68 cm) and also yields 2.5-3 t/ha. It takes 56 days to flower and 103 days to mature.

The two varieties are highly resistant to the common barley diseases (stem rust and leaf rust). On the other hand the local check variety SSG 564 (control) is low yielding producing upto 1.5-2.0 t/ha. It takes 57 days to flower and 102 days to mature. It has medium height (61.0 cm) with a goose neck posture at maturity. The descriptors of these varieties are summarized in the table below;

Parameter	Narobar1 (Hessekwa)	Narobar2 (T279)	Local check (SSG564)
Yield (t/ha)	2.5-3.0	2.5-3.0	1.5-2.0
Days to flowering	65 days	56 days	57 days
Days to maturity	109 days	103 days	102 days
Plant height	Medium (61.5 cm)	Tall (68.0 cm)	Medium (61.0 cm)
Stem rust response	Resistant	Resistant	Resistant
Leaf rust response	Resistant	Resistant	Moderately resistant
Ear attitude	Erect	Semi-erect	Goose neck

New and Improved Potato Varieties Introduced

During 2016/17 period, 7 varieties with resistance to major diseases and good processing qualities targeting the export markets were released. This has led to increase in farmers' incomes.

The new and improved varieties, especially Kachpot 1, with good processing qualities has further led to the development of small cottage industries in the Kigezi region operated by over 150 women with an average earning of UGX 600,000 per month.

This has contributed to income as well as jobs for the youth and women as we move towards achieving vision 2040. New horizons in potato processing are yet to be exploited by new institutional innovations such as the Kisoro Potato Processing industries supported through the public-private partnerships.

However, availability of sufficient quantities of high quality seed potato remains the main challenge to commercialization of the potato. It is anticipated that the newly trained 156 (80 males and 76 females) seed producers will contribute to ensuring supply of high quality seed as a business venture.







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Three Wilt Disease Resistant Coffee Varieties Released

In 2009, 7 Coffee Wilt Disease (CWD) resistant lines with yield potential of up to 1.5T/Ha were released and these have been promoted. In 2016/17, NARO released three (3) CWD resistant varieties that yield up to 3.9T/Ha. Coffee farmers will now be able to get up to US$ 6,500/Ha/year as a result of the incremental yields from the new varieties as compared to the old seven (7) CWD varieties that give US$ 4,000 Ha/yr.



The director of National Coffee Research Institute (NaCORI), Dr. William Wagoire, (left), looking at one of the CWD resistant varieties at Mr. Sam Mabingo's farm in Mityana district.

This will significantly increase income of over 8 million Ugandans, mostly smallholder producers that depend on coffee for their livelihoods (UBOS, 2007). NARO has also developed management strategies for the Black Coffee Twig Borer (BCTB) which causes the country an annual loss of US$ 40Million per annum. The management strategies will reduce this loss by up to 35% saving the country US$ 26 million (Kagezi *et al.,* 2017).

Further, CWD management practices have been developed and promoted. This has reduced CWD damage from 50% in 2004 to less than 10% to date. The promotion of management practices for CWD and BCTB is estimated to have shifted coffee exports from 3.6m bags in 2015 to 4.2m bags in 2016 in an effort to meet the government target of 20m - 60kg bags by 2025. This is a great milestone towards achieving the middle income status by 2020, with per capita income of US$ 1,039 as specified in the National Development Plan II (NDPII).

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Boosting tea productivity in Uganda

The agricultural sector is expanding the tea sub sector as a result of the NARO research efforts especially in the development and dissemination of clean materials.

The tea expansion strategy aims to increase tea acreage from the current estimated 20,000 Ha by planting at least 3,000 Ha per year (15% annual increase) for a period of five (5) years (2015/16 – 2019/20). NARO has strengthened tea research facilities at Rwebitaba ZARDI, mapped and identified all the 276 clones available, and established a tea nursery that produces 40,000 seedlings.

In FY 2015/2016, a total of 520,000 high yielding clonal plantlets were supplied to tea farmers. A total of 146,629,506 plantlets were distributed in the last 5 years (2010-2015) giving an acreage of 13,210ha. This has increased acreage under tea to 41,210ha throughout the country. NARO has developed a commercial product that is being sold under the name of Rwebitaba Tea.



Scientists from Rwebitaba ZARDI collecting data from a tea plantation



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Livestock sub-sector

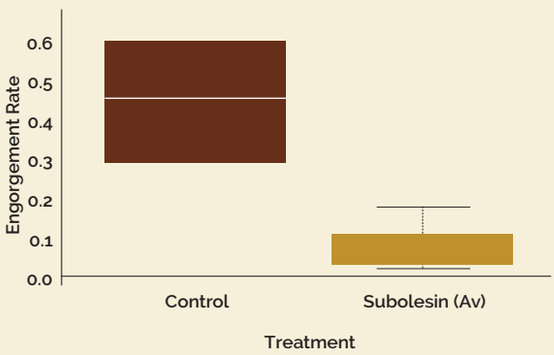
Breakthrough in tick vaccines

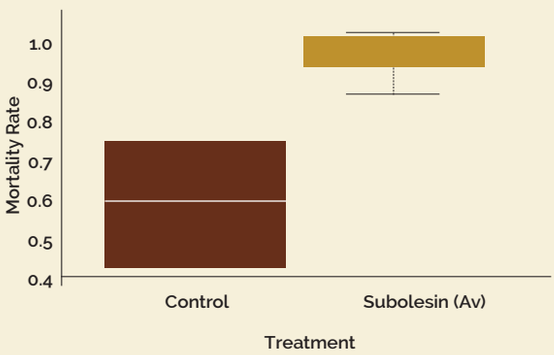
NARO has 3 candidate tick vaccines that have proved to be effective against Bont-legged ticks and Brown ear ticks. The Bont legged tick vaccine is 100% effective, that is, kills 100% of the ticks and reduces blood sucking by 100%. The Brown ear tick vaccine kills 80% of the ticks and reduces blood sucking by 80%.

The third vaccine controls the blue tick (*B. decoloratus)* which transmits *Babesiosis* (Redwater disease). It Kills 80% of the Blue tick and reduces blood sucking by 80%. NARO is in talks with BRENTEC Vaccines Ltd to constitute the vaccines. Other than vaccines, NARO has developed a bioacaricide and a drug that are also candidates for release. The Acaricide is effective for controlling the ticks that transmit ECF and the drug, a de-wormer is effective against *Haemonchus contortus*.

Efficacious anti-tick vaccine against *variegatum*



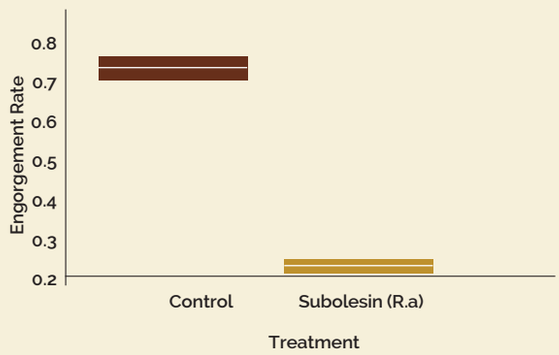


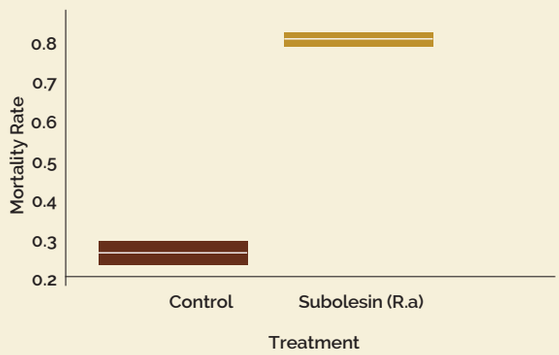


- Kills 100% of the Bont legged tick
- Reduces blood sucking by 100%

Efficacious anti-tick vaccine against *R. appendiculatus*







- Kills 80% of the Brown ear tick
- Reduces blood sucking by 80%

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- Controls the blue tick (B. decoloratus) which transmits *Babesiosis* (Redwater disease)
- Kills 80% of the Blue tick (B. decoloratus)
- Reduces blood sucking by 80%
- NARO is discussing with BRENTEC Vaccines Ltd to constitute the vaccines

NARO Candidate Bioacaricide and Drug

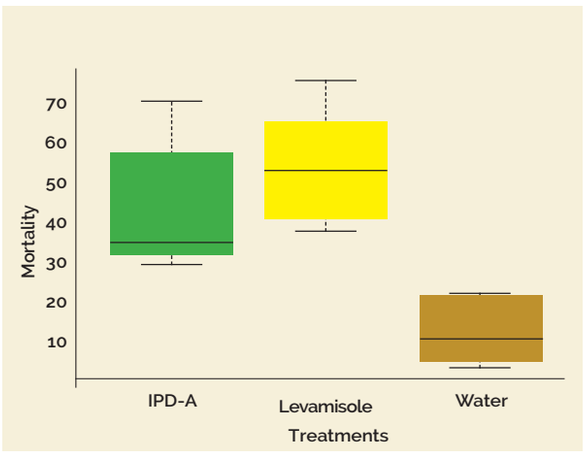


Acaricide



Dewormer

Effects of IPDA-A on *Haemonchus*

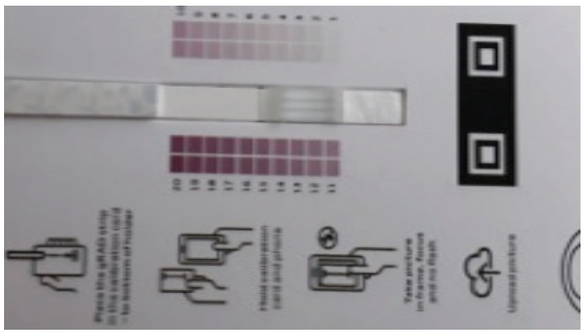


- Acaricide: Effective control for ticks that transmit ECF
- Dewormer: Effective against Haemonchus Contortus

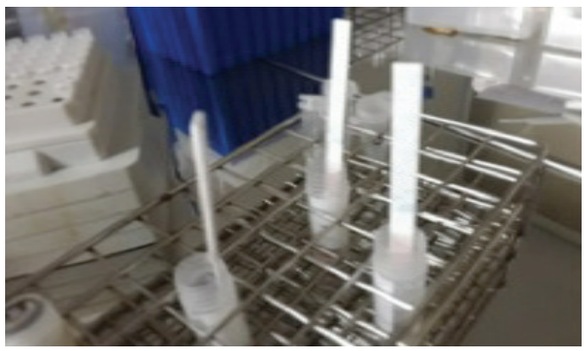
NARO African Swine Fever Diagnostic Kit

Two diagnostic kits for detection of Foot and Mouth Disease (FMD) and African Swine Fever (ASF) were developed. Two bio-acaricide formulations were developed and evaluated to manage the emerging challenge of tick resistance to available acaricides. A national tick distribution map, to guide tick control programs and initiatives was produced.

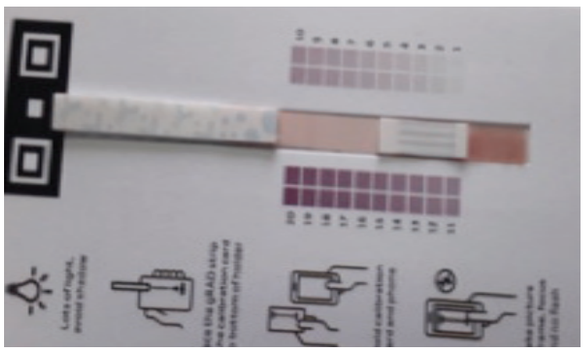
Before testing



Testing



Diagnosis



P=Penside strip; R-Card reader; X-Test region

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NARO has further conducted initiatives to increase the availability of forages and feed.

NARO Forage Seed Stocks to Enhance Feed Production

NARO has developed, evaluated and availed to farmers a milk enhancing ration, with the potential to increase milk production from local animals by 30%. One (1) milk enhancing ration is based on sorghum stover and *Tithonia*.

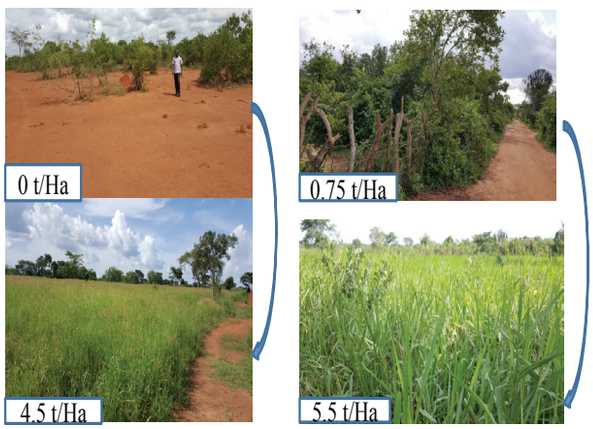






Improved Pastures on Degraded Grazing Lands

NARO piloted the rehabilitation and restoration of at least 42 ha of unproductive and degraded grazing land to enhance nutritive and palatable pastures in the central cattle corridor. This has contributed to increased pasture availability from 0 – 4t/ha.



- Milk production increased from 2.6 to 6.7 L /day
- Daily weight gain improved from to 160 to 283 g/day
- Reduced time taken to achieve market weight (400kg) from 7 to 4 years

Fodder conservation techniques

Two (2) management techniques for optimal biomass production and conservation for four (4) fodder species *(Calliandra calothyrsus, Morus alba, Vernonia amygdalina* and *Brachiaria spp)* were developed.

NGU-B2 trap and Biconical trap for control of tsetse flies

Trapping to control tsetse is a critical means for management of tsetse population densities and the diseases they transmit in both humans and livestock. Designing an appropriate trap for the control and monitoring of the tsetse fly apparent densities is on demand.

The choice of trap designs currently used in small tsetse control operations in Karamoja is based on their ease of availability from other parts of the country without consideration for efficiency. NARO has therefore developed the Biconical and NGU-B2 traps as the most appropriate traps for control and monitoring of *Glossina morsitans* in Karamoja sub-region.



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Forestry sub-sector

Deforestation rate in Uganda is currently estimated at 200,000 hectares per annum (NFA, 2015). As a result, there is a shortage of wood products (timber, building and fencing poles and fuel wood. To combat this trend, plantation forestry is deemed the best option but choice of appropriate tree species for plantation establishment is key.

NARO through the National Forestry Resources Research Institute (NaFORRI) and in collaboration with International Service for the Acquisition of Agri-biotech Applications (ISAAA), Gatsby Charitable Foundation (GCF) of UK and Mondi Forests Limited of South Africa, introduced eleven Eucalyptus hybrid clones and one pure clone in Uganda.

This was motivated by the need to bridge the timber and other wood products supply gap and to improve the living standards of the rural communities in Uganda, particularly of the resource poor segment of the population by enhancing forestry production. Performance trials were established in different Agro Ecological Zones (AEZ) of Uganda, evaluated performance and recommended appropriate clones for the different AEZs of Uganda. NaFORRI also established the profitability of clonal Eucalypts.

To date, growth and profitability parameters of clonal eucalyptus indicate that most clonal hybrids grow faster and are more profitable than the land races. The merchantable wood volume of *Eucalyptus grandis* at 7 years is estimated at 130m^3ha^{-1} compared to 184m^3ha^{-1} for GC 550 (a clonal eucalypt hybrid from grandis and camaldulensis) at the same age. This volume increment improves the net present value (NPV) from US$ 1372 ha^{-1} to US$ 2164 ha^{-1}, representing a significant increase in profitability.

Over 50 private nursery operators spread across the country have adopted the clonal eucalyptus technology, and are currently generating significant income, as well as contributing to provision of the much needed planting material for plantation forest establishment. Production from the private nursery operators range between

Promoted Melia volkensii Tree for Dryland Rehabilitation

Melia volkensii wood vs Mvule wood



- Fast tree; 10 yrs cf. 30 yrs in other mahoganies
- Drought tolerant
- Termite resistant
- High quality timber
- High coppicing

Melia volkensii is compatible with most intercrops



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100,000 and 500,000 per annum. At a conservative annual average production of 300,000 seedlings per private nursery, a total of 15,000,000 seedlings each at a cost of 500 shillings provides income of 7.5 billion shillings per annum.

This total number of seedlings translates to establishment of 13,500 hectares of clonal eucalyptus plantations across the country in the last financial year. Not only will the established plantations contribute to meeting the increasing demand for timber and other wood products but will also improve household income as well as providing domestic energy needs.

Unfortunately three exotic pests have attacked Eucalyptus including the clones. These insect pests include; Blue gum Chalcid (*Leptocybe invasa*), Bronze bug (*Thaumisticoris perigrinus)* and Red gum Pysillid (*Glycaspis brimblecombei*). NARO in partnership with the Forestry and Biotechnology Institute (FABI) of S. Africa have identified biological control agents (*Selitrichodes neseri*, *Cleruchoides noackae, and Psyllaephagus bliteus)* against the above pests and 6000 *S. neseri* were reared and released in 3 agro ecological zones.

A protocol for rearing, evaluation and release of *Selitrichodes neseri* (a parasitoid for control of Blue gum Chalcid) was developed and optimized; and 6000 *Selitrichodes neseri* were reared and released in 3 agro ecological zones.

Fruit trees

NARO during FY 2016/17 developed an innovative protocol, referred to as the backhorning technology, to control citrus canker. A broad spectrum preventive and curative fungicide for managing citrus leaf spot disease was identified and promoted alongside the backhorning technology.

The protocol has been adopted by 30 model farmers to rehabilitate their devastated citrus orchards. The rehabilitated fields are now used as demonstration and training sites in Amolatar, Gulu, Oyam, Lira, Dokolo and Kitgum. This initiative has greatly contributed to restoration of citrus production in the Northern sub-region thus contributing to food and income security.

Other improved management and production practices generated for the improvement of productivity and production of fruit tree resources during the year included; one (1) shea grafting method for early fruiting of shea tree that reduces time to fruiting from 15 to 5 years or less. In addition, 80kg of Calliandra seed; 501 grafted shea butter tree wildlings, 90, 000 seedlings of assorted tree species (Eucalyptus, Avocado, Albizia, pine, Melia, Terminalia) were produced.

Back-horning technology: A protocol to control citrus canker developed



Diseased tree | Bark-horned | Management for canopy recovery

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Fisheries sub-sector

Fast Growing strain of Nile Tilapia

In the 2016/17 financial year NARO has developed faster growing strain of Nile tilapia (that grows from 0.52g/day to 2.47g/day) and distributed to farmers in 10 districts. Further studies have yielded an F3 strain that is expected to perform better but is under on-station performance evaluation. Reports further indicate increased farm yields by five (5) folds since the onset of ATAAS project. Farmers have reported better incomes and generated more interest in fish farming in the country.

Improved solar light attraction technology for harvesting Silver cyprinid (Mukene)

NaFIRRI through NARO CGS support, established the most efficient light source, colour for harvesting Mukene and method of operation. The green and white colours were established as most efficient and appropriate for sustainable harvest of Mukene on Lake Victoria. Solar as a clean source of light was established to be more efficient than the kerosene lamps and generators.

The technologies have been widely disseminated among fishers particularly on Lake Victoria through field visits, National Agricultural and Trade shows, World Fisheries day and if existing policy challenges are addressed, will contribute to increased sustained harvest of Mukene on Lake Victoria using solar light.

Appropriate gill net mesh size for harvesting Silversides (Alestesbaramose), and Elongate tigerfish (*Hydrocynusforskalii)* in L. Albert established

The Silversides (Angara) and *Elongatetiger* fish (Ngassia) are key commercial fish species on lake Albert which have been suffering illegal fishing methods while the *haplochromines* have not been exploited optimally.

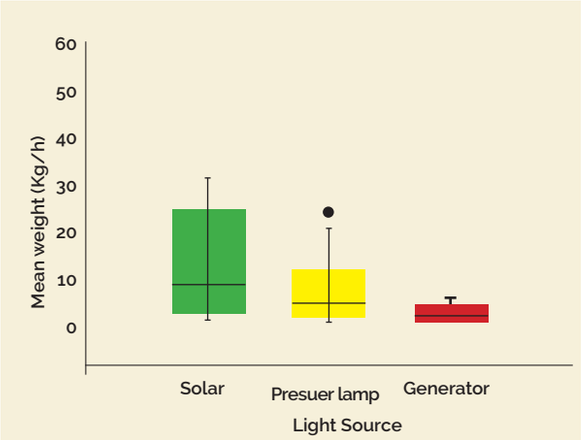
The appropriate gillnet mesh size for Silversides was established as 76.2mm (3 inches) when operated in waters of 20m or more. The appropriate gillnet mesh sizes will avoid losses due to illegal catch for Silversides and Elongate tigerfish fisheries.



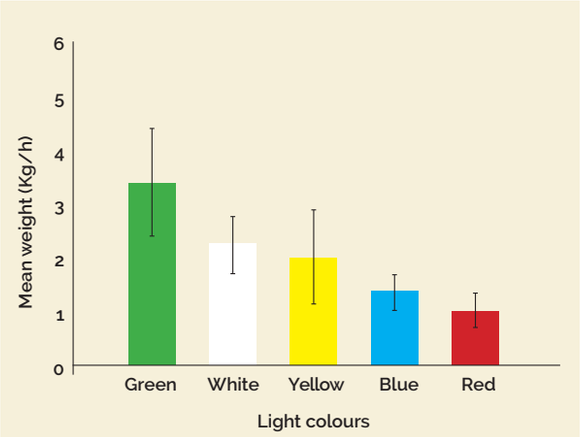


Fish breeding and juvenile set up at Aquaculture Research and Development Centre, Kajjansi

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Mean catch (Kg/h ± SE) of Mukene harvested by different light sources on Lake Victoria.



Mean catch rate (Kg/h ± SE) of Mukene harvested by light of different colours on Lake Victoria.

Forty-six (46) Fish breeding areas of key fish species identified, characterised and mapped

46 sites with high scores based on indicators of breeding intensity for fish and fish biodiversity that can be considered as fish breeding sites have been identified for Lake Victoria. These include major river mouths such as the Kagera and Sio, with high species richness (>10 species) and highest breeding scores (>24). Of these, twenty-five were near shore sites where tilapiines (*Oreochromis niloticus, Coptodon zillii, Oreochromis leucostictus*) with a mean gonad state >5 were retrieved. Ten sites of these sites are where more than 70% of Nile perch were less than 15 cm TL. The sites vary in size (0.1 – 6.0 km^2) depending on the location and other habitat features.

Zonal cage fish farming established

Guidelines for cage fish farming were completed and are being distributed to cage fish farmers, prospective farmers and other stakeholders. These guidelines are important for the fish farming sector so that fish production can increase with minimal negative impacts on other lake users and the environment. NaFIRRI has further setup an experimental cage fish farm in Napoleon Gulf for adaptive research to facilitate cage fish farming establishments, and operations. At the same time, the farm is acting as a site to demonstrate cage fish farming technologies that are relatively new to farmers and more productive compared to pond fish farming.

Inventory of haplochromine fish species occurring in the upper Victoria Nile

With support from the ministry of Energy and mineral development, an inventory of haplochromine fish species occurring in the upper Victoria Nile was established. A total of 62 species and other previously unknown species and seemingly endemic to the Victoria Nile, were observed in different habitats. This inventory has contributed to the proposed extension of Kalagala offset area for conservation of biological diversity in the upper Victoria Nile.

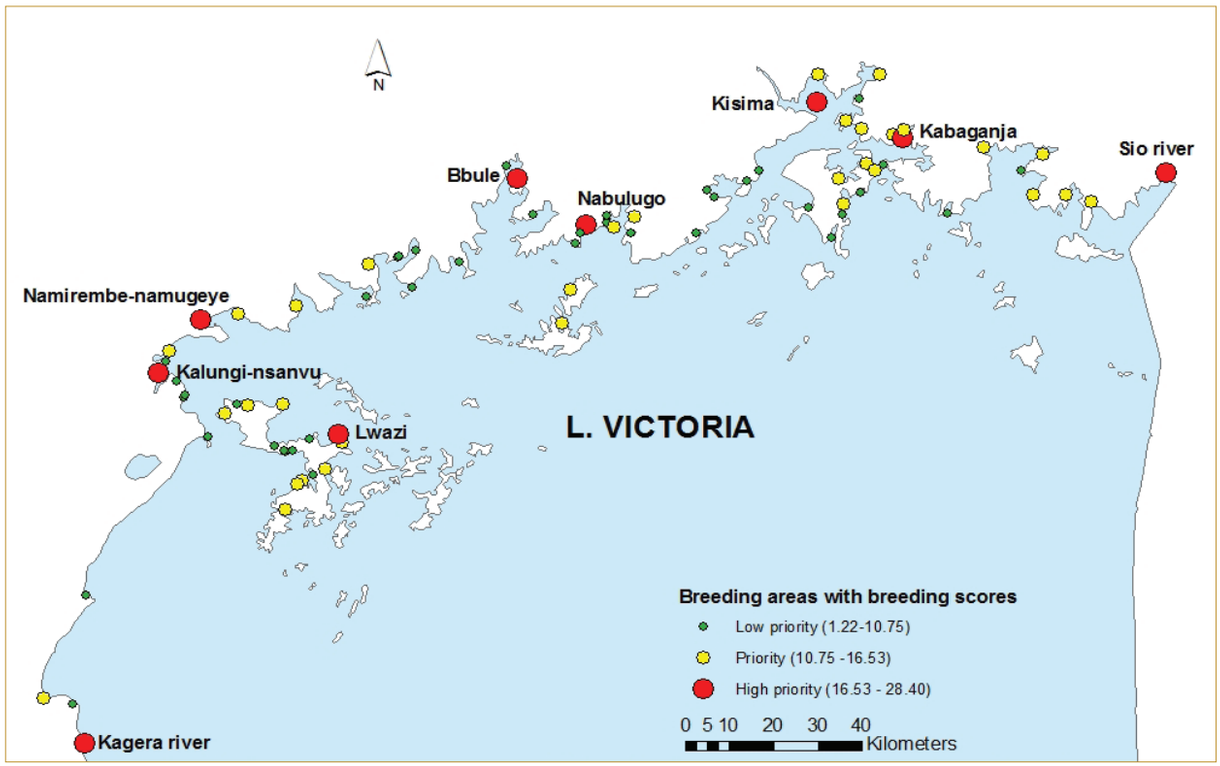
Technology for culture of live fish feed for African catfish developed

Established moina as a live feed organism to enhance growth and survival for African catfish. A technology for sustained mass production of the moina was developed. It can sustain reasonably pure culture of micro algae Chlorella (food for Moina) and sustaining high density cultures of Moina for more than 1 month

Two feed formulae developed for African catfish

Developed two most promising African catfish grower feeds, Cat 1 and Cat 2 producing 1kg of fish at UGX 1,959 and UGX 1,916 respectively. The difference in the prices is a result of partial replacements of the higher price fish meal (FM) with the lower price soybean meal (SBM). The crude protein, crude lipid and other contents are within the range suitable for African catfish.

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The location of fish breeding areas identified from the breeding intensities of various fish species taken in experimental gillnets in inshore areas between 2012 and 2016 on Lake Victoria, Uganda.

Major pathogens of Nile tilapia and African catfish identified in aquaculture systems

Major pathogens belonging to protozoa, bacteria, and *ecto-parasites* were identified from major aquaculture systems in Uganda. This is a substantial step towards developing strategies for prevention and treatment of the fish diseases that are devastating benefits from fish farming enterprises across the country.

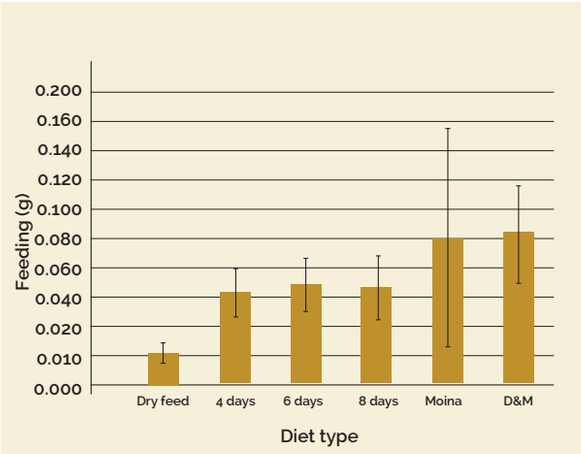
Three bio-control agents for bacterial and fungal infections in Nile tilapia and African catfish identified

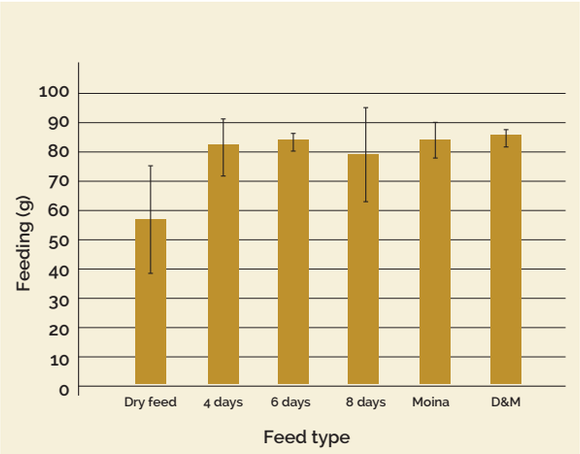
As means to control fish pathogens and diseases, four Plant extracts: *Ocimum sp.* (Basil); Musa sp. (banana); *Bidens pilosa* (Black jack) and Garlic were identified with high antibiotics and anti-oxidants properties. In-vitro efficacy of the selected plant extracts revealed that ethanol extracted Garlic, black jack banana and Basil are more effective against infectious bacteria *Aeromonas hydrophi-*

Protozoan pathogens of Nile tilapia & African catfish identified in aquaculture systems in Uganda

Species	Environment/Location	Host
Apiosoma sp.	Freshwater/Fish farms (North AEZ) ponds &cages	Clarias gariepinus (African catfish)
Chilodonella sp.	Freshwater/ (North AEZ) ponds	*Oreochromis niloticus (Nile tilapia)*
*Epistylis*sp.	Freshwater/Fish farms (North & East) Tanks	*C. gariepinus*
*Ichthyobodo*sp.	Freshwater/Fish farms (North & East) ponds & cages	*O. niloticus*
*Trichodina*sp.	Freshwater /Fish farms ponds & cages	*C. gariepinus, O. niloticus*
Ichthyopthiriusmultifillis	Freshwater/Fish farms, (North & East) ponds	*O. niloticus, C. gariepinus*

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Growth and survival of catfish fry weaned at different times from Moina to dry diet

Profitability measures per production cycle in Western Uganda

	Mixed Tilapia/catfish	Tilapia only	Catfish only
Gross profits (Shs mill)	1.7	(0.3)	(0.2)
Break-even point for tilapia (kg)	213	292	--
Break-even point for catfish (kg)	212	--	333
Pay-back period (production cycles)	2	--	--

la 001C, *Streptococcus Aureus* Nam and *Pseudomonas sp. 0103* that were isolated from infected farmed Nile tilapia and African catfish.

Increasing capacity of fishers on Lake Edward to adopt alternative livelihood options

Imparted knowledge and skills in hive products value addition (honey packaging, candle making and making propolis) to 49 members of the fisher communities at Kayanja, Kazinga and Kishenyi landing sites on Lake Edward.

Established 5.8 km² of degraded land within the buffer zone of L. Wamalathat should be rehabilitated.

Land degradation adjacent to lake Wamala was found to be associated with deterioration in water quality. Therefore, 5.8 km² that is currently under land uses prohibited in the buffer zone were identified for rehabilitation.

Land use within the 200m buffer zone of Lake Wamala. Negative land uses cover an area of 5.8km² which should be rehabilitated.

Enterprise budgets for fisheries and aquaculture investments determined

Profitability indices for aquaculture enterprises were determined for Western and South-WesternUganda In western Uganda, fish farmers make losses on tilapia only ponds of UGX 2,683,654 and African catfish only ponds of UGX 1,507,236, but make gross profit on mixed tilapia and catfish ponds of UGX 6,604,203 per production cycle.

The average break-even point per production cycle for a tilapia only pond was 3,855kg, for a catfish only pond 1,794kg and for a mixed tilapia/catfish pond, it was 1,112kg The payback period was one production cycle for mixed tilapia and catfish ponds.

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Value addition and Appropriate Engineering

Cassava

Private use of cassava by industries as raw materials for value added products in beverages, bakeries and starch production is gaining momentum.

East African Breweries uses 6,000 MT dry cassava chips per year to produce Ngule Beer. Similarly, Kamtech Logistics Ltd. (Lira) produces 4,000 litres of ethanol from 15 Metric Tons dried cassava per day, creating 75,000 jobs and plans to double the capacity.

Sorghum

To increase utilization and marketing of sorghum, NARO in collaboration with Serere Sorghum Producers and Processors Association (SOSPPA) and Vision Terudo, a non-governmental organization (NGO) operating in Eastern Uganda has developed value added sorghum food products. Through this partnership, SOSPPA is supported to produce a range of value added sorghum-based food products such as sorghum bread, popped sorghum, sorghum cake and composite flour. The target beneficiaries are: Expectant mothers, HIV/aids patients, school age going children, elderly people and diabetic patients.

Other innovations

1. Unlocking the potential of bamboo through product development and commercialization in Uganda.



2. Transforming traditional ghee processing into an economically viable business in Uganda.



3. Developing protein food bait for management of fruit flies (Family: *Tephritidae*) infesting fruits and vegetables in Uganda



4. Honey product development and commercialization for income and employment creation in Uganda



5. Angara Fish value-added products.



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CHAPTER 2

PARTNERSHIPS AND LINKAGES



Partnerships

NARO has overtime established strategic partnerships at local, national, regional and global levels that have facilitated implementation of interventions along the agricultural value chain. In line with the National Agricultural Extension Policy and Strategy 2016, NARO appreciates Public Private Partnerships (PPP) as one of the vehicles that has contributed to its achievements effectively and efficiently. Partnerships have also assisted in bridging the gap between Agricultural Research, Extension and farmers.

NARO has established partnerships with donors and other institutions and bodies outside the Organization, such as Universities, NAADS, Non-Governmental and Community Based Organizations (NGOs and CBOs respectively), farmer groups and federations, among others. Partnerships also exist across NARO's thematic areas and institutes as well as regional and international organisations dealing in agricultural research.

Earlier in the reporting year NARO conducted a baseline study on capacity of Multi-Stakeholder Innovation Platforms (MSIPs) in the country as vehicles to increasing collaboration, exchange of knowledge and influence mediation among farmers, researchers and other stakeholders.

A total of 78 MSIPS were documented from the different agro-ecological zones and 6 have been identified for further collaboration.

NARO intends to train them in the areas of Governance and Group Dynamics; Business Plan Development; Post-harvest handling and value addition; Marketing and Quality Assurance; Climate Change and Adaptation; Improved husbandry and Management practices.

Individual scientists in NARO have initiated partnerships at different levels targeting specific synergies in implementation of different interventions. Resources have been mobilized through donors and cost sharing arrangements on joint activities. NARO staff have also benefited from capacity building as a result of these partnerships.



However, there is still need for strong and plausible partnership/linkage between research - extension and farmers to enhance adoption of these technologies by more farmers for Ugandans to reap more from NARO research outputs.

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NARO Partners with Private Sector to Grow New Rice Varieties

A delegation comprising Dr. Ambrose Agona, Director General of the National Agricultural Research Organisation (NARO); Prof Joseph Obua, Chairman of NARO Council, together with other NARO staff and MAAIF seed inspection staff, attended the inaugural rice harvest ceremony in Vinayak Farm, Nwoya District in July 2016.

This was as a result of the success of an innovative public-private partnership to scale up new rice technologies in Uganda. NARO had identified big private players in Northern Uganda to grow different rice varieties as part of adoption of the technologies. NARO through research had released new high-yielding, climate-resilient upland rice varieties with high grain quality, namely ARICA4, ARICA5, NAMCHE II, NAMCHE III, NAMCHE IV and NAMCHE VI in 2013. However, there was focus on two rice varieties; NAMCHE I and NAMCHE III.

According to NARO's Principal Research Officer, Dr. Jimmy Lamo, the varieties that had been grown by Vinayak farm was NAMCHR I and NAMCHE III on about 3,000 acres and there is very high farmer preference for these varieties over other varieties like NERICA IV, NERICA VIII, and 'Nylon' (indigenous variety) because they are drought tolerant and high yielding. NAMCHE III, one of the six varieties released by NARO in 2013, gives up to 1 ton more yield advantage per hectare higher than the popular NERICA varieties. The production of rice in Uganda is estimated at 260,000 tons, leaving a gap of 40,000 tons, a gap the NARO is working on closing through release and availing drought tolerant and high yielding varieties to rice farmers. NARO provided technical expertise to the farmers on agronomic practices of rice growing.









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NARO participates in the inaugural World Bank Open Day

The World Bank Group and the Government of Uganda held the inaugural Open Day on May 30th, 2017, at Kololo Ceremonial grounds in Kampala. This event is designed to help the public learn more about the benefits and the positive impact of many Bank-financed projects and attracted over 50 exhibitions.

NARO was among the different government Ministries, Departments and agencies that participated, showcased new, high-yield crop varieties, and livestock breeding techniques under the theme, "Partnering for Development,"

Dr. Imelda Kashaija, the Deputy Director General - Agricultural Technology promotion NARO, decried the misguided information in circulation that the western world is running away from Genetically Modified Organisms (GMOs), while Uganda is embracing them. She confirmed that NARO was carrying out research on GMOs in the institutes but under tight restrictions and had not released any transgenic.

NARO awaits the enactment of the Biotechnology and Biosafety Bill, 2012 into law before any GMO derived from modern biotechnology is released.

NARO showcased a number of Technologies being funded by World Bank under ATAAS. An array of commodities were showcased to the general public from crops, to livestock, appropriate machinery alongside information materials for each displayed commodity. There was free coffee tasting to the show goers complete with a snack made from fish and cassava pastries using NARO products. This was such a crowd puller, drawing long queues around the NARO tent area.

Different NARO commodities displayed during the World Bank Open day

Item	Variety	Products Displayed
Cassava	NAROCASS1 and NAROCASS2	Roots, cake,
Beans	NAROBEAN 1, 2, 3 & 4C, 5C	Seeds
Rice	NERICA and NAMCHE	Rice seeds
Coffee		Coffee beans, coffee
Fish		Fish sausages, fish fillet
Shea Nut		
Banana		Banana bunches
Greens	*Nakati and Doodo*	
Pastures	*Bracharia mullato*	
Poultry		
Bambara Nuts		
Tree products		Ear rings, table lamps, stools,
Appropriate machinery		Maize Sheller, Rice hauler and hay baler.

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NARO and Makerere University Hold First Joint Agricultural Dissemination Conference

The National Agricultural Research Organisation together with Makerere University represented by the College of Agricultural and Environmental Sciences (MAK-CAES) organized the first biennial scientific conference from 21-24 November 2016, at the Speke Resort Munyonyo in Kampala. The thrust of the conference was on knowledge and technology dissemination and was guided by the theme "Agricultural Research and innovations for Social-Economic Transformation".

The main objective of the conference was to provide a platform to stakeholders in the agricultural sector for dialoguing on novel agricultural research findings and promoting modern technologies and other innovations targeting socio-economic transformation of Uganda and other developing countries.

The conference comprised of five subthemes; namely (a) Advances in agricultural innovations for increased competitiveness, (b) Partnerships for enhancing utilization of agricultural innovations, (c) Closing the gender gap in agricultural transformation, (d) Strengthening enabling environment for agricultural transformation, and (e) Mainstreaming evaluation research in agricultural initiatives. Two subthemes, "Partnerships for enhancing utilization of agricultural innovations, and Mainstreaming evaluation research in agricultural initiatives" failed to attract abstracts and manuscript submissions.

The conference was attended by 450 participants from the agricultural research and development fraternity of NARO, Makerere University, other public and private sector, and the civil society institutions.

A total of 450 participants drawn from NARO, Makerere University and other institutions of research and higher education in Uganda, Zambia and Ghana, policy makers, media, private sector practitioners such as farmers and agro-processors and development partners attended the four-day agricultural dissemination conference.

A total of 350 Abstracts were delivered as oral or poster presentations at the conference. In addition, there were six key note presentations as well as success stories from practicing farmers. The conference attracted over 25 exhibitors from the sector, who show-cased a wide range of products along the agricultural value chain. Awards were given to best presentations in the different categories.

The official opening was by the Minister of Agriculture, Animal Industry and Fisheries, Hon. Vincent Sempijja, who represented the Prime Minister, Dr. Ruhakana Rugunda.



Presenters posture for a group photo with officials from NARO and Makerere university after receiving awards for their presentations during the NARO-MAK first biennial scientific conference at Speke Resort Munyonyo.

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World Food Day 2016: Climate is Changing; Food and Agriculture must too

World Food Day is commemorated each year on October 16th. This was date set aside in 1979 by the Conference of the Food and Agriculture Organization (FAO) with the aim to heighten public awareness of the world food problem and strengthen solidarity in the struggle against hunger, malnutrition and poverty. In 1980, the General Assembly endorsed observance of the Day in consideration of the fact that "food is a requisite for human survival and well-being and a fundamental human necessity" (resolution 35/70) of 5 December 1980).

On 16th October 2016, National World Food day celebrations were held at Ngetta Zonal Agricultural Research and Development Institute (Ngetta ZARDI) in Lira district, Northern Uganda under the theme, "Climate is Changing, Food and Agriculture must too." The president who was represented by the prime minister of Uganda, Rt. Hon. Ruhankana Rugunda said," government was committed to ensuring that all Ugandans prosper through a number of mechanisms that have been put in place.

He pointed out that, to ensure food security in the current changing climate, there is need to change to the use of fertilizers and shift from depending on rains to irrigation.

In relation to theme, he mentioned that, "We must replenish the nutrients in the soil, and that is how the theme "Climate is changing food and agriculture must too," will be relevant to our citizens," He emphasised the need to commercialize agriculture and phase out subsistence farming in order to enhance both food and income security in Uganda. In regard to developing the agricultural sector, a number of issues had been identified; that include, converting 68% of the homesteads from subsistence farming to commercial agriculture, promoting linkages between the research institutes and the farmers and increasing the use of fertilizers among others.

The Minister of Agriculture, Hon. Vincent Ssempijja, reiterated that the World Food day presents an opportunity to the country to discuss salient issues such as the need to combat climate change as well as transform agriculture into a competitive sector of the economy by farmers being organized in associations in order to target and compete favorably in the external global markets.

He decried farmer losses during the first season of 2016 due to reliance on rain fed agriculture. He emphasized the need for better access to appropriate technologies, market information and investments to tackle the drastic climate changes affecting agricultural needs in the country.

The Director General National Agriculture Research Organisation, Dr. Ambrose Agona pledged NARO's commitment to *Kisanja Hakuna Mchezo* and also urged Ugandans to invest in other methods of agriculture such as irrigation and planting of pest and drought resistant crops in order to enable agriculture to thrive as well as increase household incomes. This event was also attended by a cross section of people, Politicians, Development Partners, Government officials, farmers and the general public.

This annual event witnessed the official opening of the new administrative block at Ngetta ZARDI, built with support from the World Bank by the Prime Minister, Hon. Ruhakana Rugunda.

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Food biosciences and agribusiness

NARO has developed one fish product (fish powder) formulated from fish wastes (skins and bone). It was characterized and culinary profiling successfully completed with an acceptability rate of 6.2. Its commercialization is ongoing.

Additionally, one (1) bean product, two (2) maize based products and two (2) cassava based products were developed. Cassava waxing proved to keep cassava fresh for a period of one month. For all these products, being developed as commercial products with private entrepreneurs, consumer profiling and market testing has been successfully completed. In product development, NARO has also developed two cost-effective fish feeds for farmed fish, and four different fish products developed.



A fish based product targeting the malnourished but also good for general population.

Compositional profile

Parameter	Level	Reference (WFP, WHO)
Moisture content (%)	5.95± 1.1	4.5
Energy (Kcal per 100gms)	295.7±8.7	400.0
Protein (g/100gms)	21.8±3.1	28.0
Fats (g/100gms)	10.7±1.4	15.0
Added sugar (g/100gms)	0.0	14.1
Crude fibre (g/100gms)	1.9±0.4	2.3
Peroxide value (meq/kgfat	14.1±3.2	10.0
Total ash (g/100gms)	6.1±2.6	3.5

The story of cassava value addition in pictures



Cassava uprooted from the garden.



Cassava processing at Arapia Innovation platform into HQCF.



Agro Transformation (U) Ltd produces pharmaceutical ethanol from cassava.







Some of the products from Cassava: cookies' crisps, Engule and biodegradable paper. In Uganda, cassava provides about 13 per cent of the total daily caloric intake.

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Contribution towards Wealth creation

NARO has contributed to efforts towards shifting 68% of agricultural households from subsistence to commercial production through various interventions that aim at wealth creation; For the rice sub-sector, between 2014 and 2017 a total of 6 major commercial farmers took upland rice as their major commercial enterprises.

These companies include; Omer Farm, (4,000 ha cropped rice each year), Vinayak Agro Farm Limited (7,000 ha cropped rice each year), Amatheon Limited (1,000 ha cropped rice each year), Victoria Farm (8,000 ha cropped rice a year), Panyimur Farm (1,000 ha cropped rice a year) and Lii Farmers group (600 ha cropped rice per year.

This Financial Year, 5 more commercial farmers went into commercial farming using the NARO released varieties, NAMCHE I, NAMCHE III, NAMCHE IV and NERICA 4. With 21,600 ha cropped with upland rice and average yield of 3.0t/ha a total gross revenue of US$ 21.6 million is got (Exchange rate: 1US$ = UGX 3,600). Profit is estimated to be US$ 10.8 million at production cost of 50% of total revenue.

NERICA has the potential to increase per capita income by US$ 16 (10 per cent of actual per capita income.

Together with Africa 2000 Network and Oxfam, NARO is working with cassava stakeholders Oyam and Pader districts, aiming to increase farmers' access to clean seed, knowledge on cassava disease management, good agronomic practices and improve the quality of their cassava products for better markets. Towards this, 353 (152 males and 201 females) farmers and other stakeholders were trained on cassava value addition and post-harvest management techniques in 2017.

Under coffee, NARO produced about 100,000 clean starter planting materials by conventional method for further multiplication by nursery operators. This is equated to 3 million seedlings, hence an income (wealth) creation of US$ 1.25 million pa to over 200 nursery operators spread across 35 Robusta coffee growing districts. Beginning with the coffee year 2017, research plans to produce 1.5-3M plantlets within a period of 3years using tissue culture are in place.

A regional potato Multi-Stakeholder Innovation Platform (MSIP) to foster development of the potato value chain in Eastern Uganda supported by different partners, including NARO, Districts, CIP and IFDC, has been formed. This platform was built on existing structures and initiatives such as the National Potato steering committee facilitated by International Fertilizer Development Corporation (IFDC).

The platform brings together 100 members with a 9 man executive committee composed of member representatives from producer groups, input dealers, research, international agencies and trade. Through this MSIP, seed quality standards and warehousing options to improve prices have been explored.

Today, the producers export potatoes to other neighboring countries including Rwanda. The MSIP has also greatly increased supply of improved seed potato from 25MT to 80MT within the region.

NARO introduced to the MSIP new potato varieties namely Rwangume and Kinigi which are currently the mostly grown and marketed varieties.

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Job creation through agribusiness incubation

Enhancing emergence and growth of agro-enterprises through incubation of proven technologies. Aware of the fact that the agricultural sector continues to be mired by low levels of value addition (about 20%), product diversification and lack of competitive agri-enterprises, NARO has supported agri-business development through a functional agri-business Incubator at NARL.

Through the agribusiness incubation approach, NARO facilitates commercialization technologies to foster a competitive agribusiness industry in Uganda leading to job and wealth creation.

To-date, NARO has supported four enterprises including 1.) AGRIBIZ Marketing 'U' Ltd; 2.) Masupa Enterprises 'U' Ltd (Briquettes from agricultural wastes); 3.) Biospore 'U' Ltd (Mushroom products); and 4.) JAY Life Centre (infant foods) and ten (10) companies are currently undergoing incubation for commercializing various NARO technologies.



Incubatees pack juice extracted from banana at Excel Hort Consult Ltd.

In line with the government policy towards achieving a transformed middle income status by 2020, NARO has supported formation of the Uganda Banana Producers Cooperative Union Ltd' (UBPCUL) that seeks to improve competitiveness and transform the banana industry (value chain).

The cooperative brings together seven primary cooperative societies and continues to register more primary societies to engaged in commercial production and marketing of bananas thus contributing to job creation.

For example, a nutritive beverage of sweet banana juice traditionally produced by artisan in Uganda is being marketed under the brand name Exelas Banana Nectar by Excel Hort Consult Ltd, an agribusiness incubation, innovation and development company that operates in the eastern and central African region.

The banana nectar is packed in 5 and 1 litre containers for institutions and in 300ml Polyethylene terephthalate (PET) bottles in order to cater for the different needs and capacity of customers.

All these efforts envision a Uganda which is free of chronic poverty as a result of better use of agricultural produce through value addition thus improving household incomes and creation of employment opportunities.

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Agro-machinery: Reducing drudgery through mechanization

Most agricultural operations are characterized by very low level of mechanization at all aspects of farm operations from production to agro-processing and storage. In an effort to addressing this challenge, NARO through the agricultural engineering arm has developed and introduced nine technologies in the last 10 years.

These technologies are power tiller moldboard plow, lowland rice weeder and treadle pump for selected production operations; NARO lightweight rice thresher, ASI thresher, paddy cleaner and maize sheller to reduce threshing losses and improve grain quality of strategic cereals; food grade cassava chipper for processing quality cassava chips and forage chopper to improve feed intake of dairy cattle.

The introduction of these technologies to farming communities have already shown good and promising results. For instance, in addition to over 30 units of NARO lightweight rice thresher been used by farmers, the Chairperson NARO Governing Council launched promotion of the NARO lightweight and ASI rice threshers as grain hire service scheme business being operated by six (6) entrepreneurial farmers of whom 50% (n=3) are female in northern Uganda.

The farmers using these threshers have ably reduced their grain loss during threshing from 4.8 to 0.1%. In the event that these threshers will be used by all rice farmers, the country will be able to save US$ 5.92 million (17,760 tons of paddy). In addition to the benefits obtained from their own farms, the farmers operating these threshers as business earn net profit of US$ 180 – 835 per month during harvest period from the hire service scheme. Similarly the youth recruited as thresher operators earn US$ 170 – 200/person and per month as additional income during the rice harvest period.



Chairperson NARO Council, Prof. Joseph Obua (left), with Dr. Ambrose Agona (right), testing and inspecting threshers during promotion event.

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Climate change resilience

About 80% of the population in Uganda depends on agriculture and a significant proportion, (around 25%), lives below the poverty line and suffers food insecurity (UBOS, 2006; 2010).Crop yields in the country have for along time not increased significantly while cereal yields and per capita food production have declined since the 1980's (Muchena *et al.,* 2005).

Among the main factors responsible for this bad situation are the poor inherent soil fertility particularly Nitrogen (N) and Phosphorus (P) deficiencies (Bekunda *et al.,* 1997), which is exacerbated by the rapid soil fertility depletion (Vlek, 1993; Sanchez *et al.,* 1997) and climate variability and change.

Climate variability and change, land degradation and rapid declining soil fertility have particularly affected the land on which the poor depend and threatens food security for many smallholder farmers (Sanchez, 2002). These three key factors are considered as the major threats to food security and natural resource management in the country.

Uganda is among the countries with the most severe soil nutrient depletion in Africa (Stoorvogel and Smaling, 1990; Wortmann and Kaizzi, 1998). The estimated average depletion rates for nitrogen (N), phosphorus (P) and potassium (K) in SSA are -22, -2.5 and -15kg ha-1 year-1, respectively, and the equivalent rates in Uganda are -21, -8 and -43kg ha-1 year-1 (Smaling *et al.,* 1997; Wortmann and Kaizzi, 1998; Nkonya *et al.,* 2005). Soil erosion and nutrient depletion is widespread (Nkonya *et al.,* 2004; Wortmann and Kaizzi, 1998). In addition, land degradation through water runoff and soil erosion is a major problem contributing immensely to nutrient depletion and declining agricultural productivity.

The extent of soil erosion in most areas has reached alarming levels. Recent studies have demonstrated that excessive soil and nutrient losses exist in major agro-ecological zones across the country (NEIC, 1994; NEMA, 2001; Kazoora, 2002; Majaliwa *et al.,* 2005; Bamutaze *et al.,* 2011). It is estimated that 4%-12% of Gross Domestic Product (GDP) is lost through environmental degradation (Slade and Weitz, 1991; NEMA, 2001), with 85% of this loss coming from soil erosion, nutrient loss and changes in crops (Olson and Berry, 2003).

Deforestation, cultivation of steep slopes and other agricultural activities have also induced severe soil erosion (Gafur *et al.,* 2003). The total monetary value of environmental degradation was estimated at US $170-460 million p.a. in 1991 and at $230-$600 million in 2003 (Kazoora, 2002). With arable land per capita expected to decline from 1.1 ha in 1991 to 0.6 ha in 2015 (NEMA 2001), it is critical to both reduce land degradation trends in areas already under cultivation, and ensure sustainable land management practices to prevent degradation in future cultivated areas.

Further, the level of understanding of the concept of climate change by policy makers, researchers, extension and the communities they serve needs to increase. The limited awareness of the pressing and changing nature of climate concerns is affecting the pace of understanding and analyzing climate change risks, and the development of climate change adaptation strategies.

Increasing awareness of climate change issues in the country will help in rapid appreciation of the problem. In turn, this will facilitate incorporation of adaptation concerns into policy documents, research budget allocations and the research agenda as a whole. Strategies to systematically mainstream climate change research into all the research subsystems have, therefore, been identified.

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Brief on Intellectual Property

The appreciation and value of Intellectual Property (IP) in NARO increased considerably and NARO has been making efforts towards having an effective IP management regime. This is because, knowledge and research findings have become the most important resources and the key elements in the current knowledge driven economy and the new business paradigm for economic growth and development.

IP Institutionalisation

Towards institutionalisation of IP, NARO established an Intellectual Property Office in January 2017, with core purpose to maximise the economic potential of NARO's generated intellectual property.

Key achievements to-date

1. An institutional Intellectual Property policy framework developed

The NARO IP policy framework has been developed as a set of principles that provides a conducive environment for stimulating creativity and guiding effective management of IP in NARO. It also provides a coordinated and balanced approach for effective protection and exploitation of IP and sharing of benefits thus striking a balance between the organisation, creators, users and partners in IP generation and utilisation.

2. IP awareness

Intellectual Property seminars have been conducted in all the 16 Public Agricultural Research Institutes (PARIs) of NARO. The purpose of these seminars was to create awareness about IP, promote identification and protection of IP amongst staff and linking IP information to research in NARO. About 627 NARO staff were engaged.

3. Linking Intellectual Property Information to Research in NARO

Technology Innovation Support Centres (TISCs) have been established in all NARO PARIs. TISC programme promotes access and effective use of valuable sources of technical and commercial information, such as patent information, scientific and technical journals, trademark and industrial design information to help researchers improve on the quality of their research and prevent reinventing-the-wheel and wasteful investment in research. Two TISC focal persons from each institute were identified and trained to coordinate TISC activities at PARIs.

4. Identification of technologies with IP and Commercial potential

Through regular IP scouting and Technology Disclosure Forms (TDF) initiative, a number of technologies with IP and commercial potential have been identified and assessed.

Three patent applications on Wound healing, tick vaccine and bio-acaricide technologies have been drafted and ready for filing with the National IP Office, Uganda Registrations Services Bureau (URSB) and the African Regional Intellectual Property Organisation (ARIPO).

Acknowledgements

We would like to acknowledge all our partners who at various times and in various places have supported the work on which this report is based. We may not name all of you in this report but we remain highly indebted. In a special way we recognise the World Bank (WB) and the government of the Republic of Uganda for all the support they have accorded us as a key impetus in doing our work. We thank you.

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NARO
NATIONAL AGRICULTURAL RESEARCH ORGANISATION

CHAPTER 3

AGRICULTURAL CAPACITY STRENGTHENING



Over the years, NARO has built capacity in scientific research and established strategic partnerships that has enabled delivery of science and technology.

Human Resources

For the human component, a four-year moving average for the annual total number of NARO Staff was generated from 1994 when NARO came into existence to 2016. It can be seen that the staff numbers from 1999 2003 kept reducing because the staff that exited were not replaced because of the ban on recruitment imposed by Government. However, from 2007 the ban was lifted and the staff numbers have steadily been increasing which has positively contributed to NARO successes.

Staff categorisation

Staff Category	Required Establishment	Filled positions 30th June 2017	Gaps
Directors	22	22	0
Scientists	283	276	7
Technicians	256	195	61
Support Staff	437	400	37
Total	998	893	105

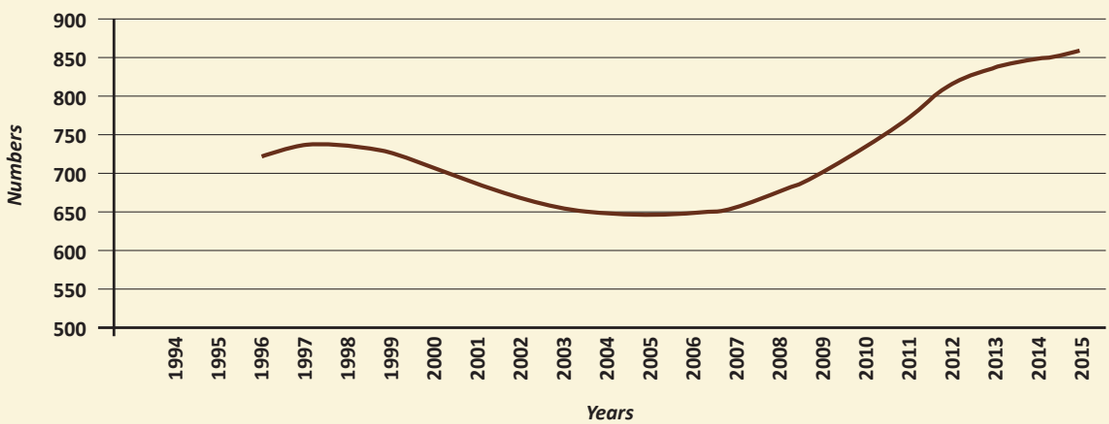
Source: NARO 2017

Appointments (As of March 2017)

Category	Male	Female	Total
Scientists	31	07	38
Technicians	13	02	15
Support Staff	07	00	07
Senior Support Staff NAROSEC	02	02	04
Total	53	11	64

Source: NARO 2017

Moving Averages for the Total Number of Staff from 1994 to 2016



Moving averages for the total number of staff and annual staffing by categories from 1994 to 2016

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Wage enhancement

During the FY 2016/17, NARO received a total of UGX 3.5 billion for staff salaries: The funds were utilized as follows; 2.1bn for salary enhancement, 938 million for recruitment of the 60 staff and 384 million for promotions. Salary enhancement was effected in July 2016; (Directors & Scientists received 14% increase; Technicians and Middle Level Support Staff 10% increase and General Support Staff 10% increase)

Promotions

Effective 1st March 2017 NARO promoted a total of 132 members of staff. Staff who had been promoted in the last four years were considered ineligible for promotion.

Summary of staff promotions 2017

Category	Number
Scientists	25
Technicians	62
Support Staff	45
Total	132

Employee Separation

During FY 2016/17, NARO registered the following numbers from staff employee separation;

Capacity building

In the year under review, NARO continued with the training of 31 staff on PhD and eight (8) on Masters. Out of the 31PhD students, 12 are female and 19 are male, while out of eight (8) Masters Students, two (2) are female and six (6) are male.

Some PhD programmes were scheduled to run for four years, while others were to last three years. Five (5) students completed their PhDs. 4 students defended their theses. Three (3) students submitted their theses. Fifteen 15 students were in final stages of completion. Two (2) students started late and expected to complete in 2018 Eight (8) staff enrolled and got supported for MSc. Five (5) finished and graduated. Three (3) submitted their theses.

NARO has empowered staff through short courses as follows; 37 scientists trained in data analysis and reporting; 46 staff trained in Monitoring & Evaluation at UMI; 20 Directors and Senior Staff trained in Leadership and Change Management at CSC Uganda; 41 staff trained in communication and dissemination of research results; 8 staff have were facilitated to attend international conferences and annual subscription was paid for 40 staff who subscribe to different professional bodies including ICPAU, ACCA, Institute of Internal Auditors, Human Resource Managers' of Uganda, Institute of Professional Engineers and Uganda Veterinary Association.

Reason	Scientists	Technicians	Support Staff	Total
Resigned	5	0	9	14
End of contract	0	0	1	1
Retired	3	2	9	14
Death	1	2	1	4
Contract Terminated	1	0	1	2
Absconded	1	0	1	2
Total	11	4	22	37

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Infrastructure Development

Over the years, NARO's infrastructure has developed giving a competitive edge to conduct novel research. NARO is regional Centre of excellence in rice, cassava and bio-fortification research.

The breakthrough in rice research efforts have been facilitated through development of two rice breeding equipment's by NARO. The first was a prototype of a cheap and efficient single-grain shatter tester for use in rice breeding (Lamo *et al*. 2010) and the second one was flower emasculation machine developed for conducting breeding (Lamo *et al*. 2010).

IPR Stimulates technology access and technology transfer through facilitating the public accesses and commercial routes to the NARO technologies. IP policy will be in place to provide an environment for promoting and generation of technologies. The money/revenue received through in form of royalties will be put back into the agricultural research fund to ensure research sustainability and continuity. The royalties through the benefit sharing arrangement will improve welfare of the researchers and motivate. Through the commercialization and public access, the NARO technologies will be moved out of the shelves

NARO has also made progress in other infrastructure development. Twenty two (22) civil works structures were completed in the various PARIs. These include renovations and construction of new structures.



The Cassava Regional Center of Excellence building at National Crops Resources Research Institute (NaCRRI).



Rice Research and Training Center at NaCRRI.



Food nutritional laboratory at NaCRRI.



Newly renovated staff house.

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Gender and ESS interventions by NARO

Through its institutionalized programs, NARO is now able to address gender, Environmental and Social Safeguard (ESS) concerns and has made considerable progress towards the institutionalization of these concerns for effective ESS management, and conducting gender responsive research and dissemination.

With regard to the above, NARO now has an Environmental and social safeguard management system (ESSMS) in place that's guided by an ESS policy. In addition, ESSM guidelines and plans for operationalizing the system were developed including; the ESSMS Manual, Environmental and Social Risk Management Procedure (ESRMP) including the Environmental and Social Grant screening checklist Risk Register template, and management plans for Biodiversity, waste/ hazardous waste, pests natural resources and stakeholders.

In line with performance enhancement of the ESSMS including gender mainstreaming, the organization has trained a total of 130 (41% female and 59% male) key NARO and MAAIF technical staff and has established gender; environmental and social safeguards focal points at ZARDI level providing them with clear terms of reference to operate.

These focal points are not only responsible for coordinating the implementation of the Environmental and Social Safeguards plans in all routine operations but also, monitoring for compliance and regular reporting. However, NARO still needs to provide additional tailored training, mentorship and funding for them to effectively execute their work including building strategic partnerships with the Local Government who are key in social risk management at community level.

Still in a bid to strengthen the response to social risks, NARO established partnerships with the International Labor Organization (ILO) and Ministry of Gender, Labor and Social development (MGLSD) and conducted a training workshop for NARO board members, Directors and technical staff from MAAIF and NARO on social risk management including HIV prevention and response, bridging gender gaps in agriculture, prevention of child labor including prevention and response to sexual harassment in the workplace. Through MAAIF the organization is planning to cascade this training to the district and district and community based staff to ensure skills transfer and capacity enhancement on social risk management across the sector. This however will require appropriate monitoring and financial support to ensure proper outcomes.

In an effort to address Environmental concerns, NARO has embarked on integrating sustainable land management (SLM) practices in its research interventions. To date, It has noted good progress overall in the implementation of SLM activities in the its ZARDIs.

Communities have adopted several SLM practices including, but not limited to: establishment of stabilization bands/trenches with tie bands, planting of elephant grass on "Fany Juu / Fanyachini" soil bands, minimum tillage and agroforestry practices. Positive outcomes have already been registered including reduced rate of soil erosion, availability of fodder of animals (Caliandra tree and spear grass), availability of manure from on farm animals under zero grazing, there are no cases of landsides hence no loss of life and property.

In relation to gender, the organization has a gender and diversity strategy 2017-2027 including an action plan to operationalize its various commitments towards integrating gender. These key achievements provide a foundation for reaching the most vulnerable and marginalized groups including fostering social sustainability. Regarding gender integration, in some

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cases NARO has surpassed the targets for inclusion of women, youth and vulnerable groups in terms of numbers. Available data on project beneficiaries reached indicates 52% women and 48% men (mainly youth). This also indicates that collection of gender-disaggregated data has been institutionalized in NARO.

However, to ensure that all gender categories of persons including; children, women, youth, elderly and persons with disabilities benefit from research and technology development and dissemination initiatives, NARO has developed different technologies in crop and livestock to that cater for food insecurity, nutritional and health needs, in engineering to address the lack of skills, lack of labour, workload burden and technologies to address issues of household welfare and lack of income concerns.

At production level, easy to use equipment such as oxploughs, inter-row animal drawn and manually operated planters, manually operated paddy rice planters and weeders have been developed. They require less technical skill and are light in weight. At post-harvest handling level, technologies such as potable forage and cereal stove choppers, feed mixers, oil pressers, Sheller's and hullers for crops like ground nuts, maize and rice respectively have been developed. These technologies are easy to operate manually, cheap to access, by small-scale farmers both crop and livestock, and commercial seed exporters.

NARO has also come up with a treadle for lifting water and a wind powered water acquisition system for livestock watering. The fact that the technology can be built within a community or homestead to make water easily accessible, addresses the concern of women having to move long distances in search of water. The institute also came up with renewable farm energy sources such as a biogas cook stove, a floating and fixed dome biogas digester.

These technologies are easy to operate, and are potable; they can easily be handled and moved about by the sick, elderly and disabled persons including the crippled and blind who find it hard to lift heavy technologies, they are cheap; made from locally available materials and hence easily accessible in terms of costs. The overall gender concerns addressed by these technologies include; lack of labour, labour intensity, time poverty (heavy workload), lack of access to and control over resources (equipment) as well as support to women's engagement in accessing markets and meeting market depend for commodity value chain development.



A man and woman decapitating African catfish (*Clarias gariepinus*) to extract the pituitary gland for inducing the female brood stock. Such innovations in NARO cut across the social gender divide.

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CHAPTER 4

MANAGING INVASIVE SPECIES



Combating the Kariba weed nuisance on Ugandan waters

The Kariba Weed *(Salvinia molesta)* is the latest water weed to invade aquatic systems in Uganda having been first noticed in 2013 on Lake Kyoga. The weed has now reached Lake Albert and the Albert Nile and reported in the greater Lake Victoria vicinity (Lake Kimira - Bugiri district). The weed is also commonly called African payal, African pyle, Aquarium water moss, Giant salvinia, Water fern or Water spangles depending on the country where it exists.

The invasion by Kariba has come about 11years after the water hyacinth menace was put under control. The weed is regarded as one of the world's worst invasive waterweeds. Under ideal conditions of nutrients, temperature and absence of grazers, Kariba weed can double its coverage and biomass in just 4 to 10 days. The rotting weed biomass, once it sinks to the lake bottom, rots and therefore consumes dissolved oxygen thereby rendering such areas unfit for survival of most fish. Extensive cover by Kariba weed interferes with water abstraction, watering of livestock, interferes with fishing activities, and water transport. A lake-wide survey by the National Fisheries Resources Research Institute (NaFIRRI) in January – March 2014 indicated that the weed was widespread on Lake Kyoga with an estimated infestation width of between 1.5 to 2 meters along the entire shoreline and totalling to 661 hectares.

The rapid proliferation of Kariba weed in the Kyoga Basin is believed to be aided in part by the connectivity of the various aquatic systems that include lakes Kwania and Opeta that are surrounded by extensive swamps. Additionally, the Victoria Nile that flushes Lake Victoria flows through the central and western zone of Lake Kyoga on its way to Lake Albert. This flow-through aids dispersal of weeds to the lower Victoria Nile and Lake Albert. Nutrient enrichment of the water bodies from un-regulated point sources (e.g. wastewater effluents discharged from industries and sewerage plants) and non-point sources (wastewater from human activities like agriculture, waste dumping sites, open defecation from communities that live in and around the water bodies). These wastes are washed into the water bodies by rainfall.

In February 2017, NARO imported the initial batch of Salvinia weevils that are specific biological control agents for Kariba weed. These, though few, are under quarantine and undergoing host-specificity tests on a range of crops and other plants. If proven specific to Kariba weed, they will be piloted on Lake Kyoga before being rolled out to other affected water bodies.



Kariba weed infestation interferes with water abstraction by local communities.



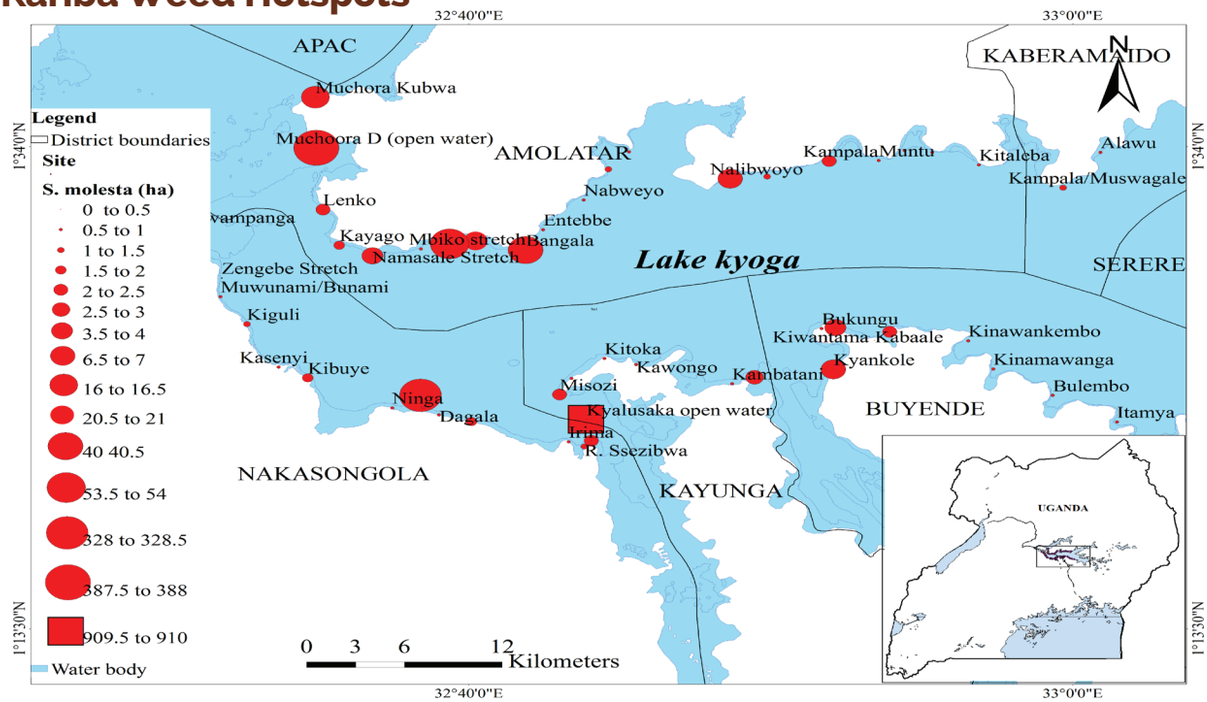
Thick Kariba mats impeding cows from drinking water on Lake Kyoga.



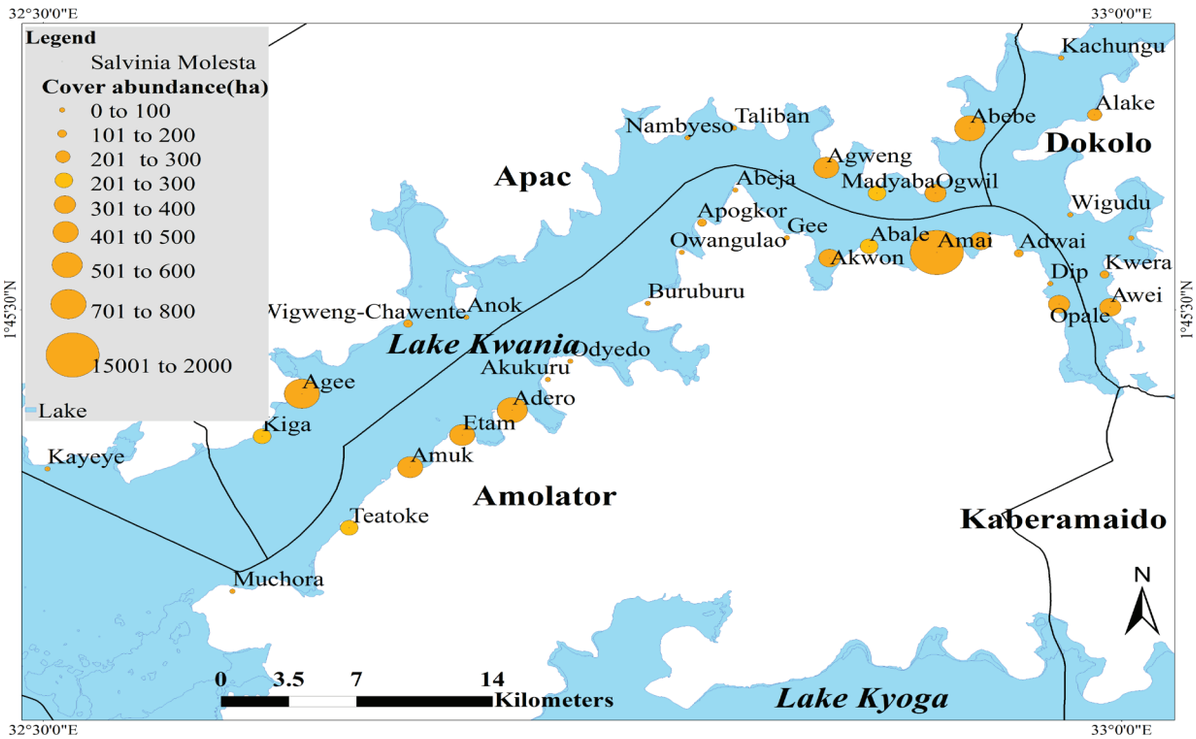
Kariba weed infestation interferes with fishing and transport operations on lakes.

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Kariba Weed Hotspots



Kariba weed has spread to most Kyoga basin lakes and Lake Kimira in Bugiri district and control interventions are targeting all these water bodies



Kariba weed hotspots on Lake Kwania: the infestation increases in the NE to SW direction

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Fall Army Worm

And a breakthrough has been registered where screening of maize lines for resistance to FAW under natural infestation has shown positive results. Assessment of Socio-economic impact of FAW has been initiated. This will document losses associated with FAW. Distribution and genetic diversity of FAW in Uganda is also in progress.



FAW caterpillar

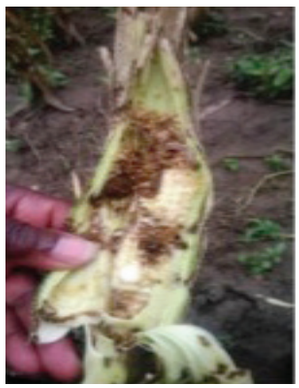


FAW adult moth





FAW damaged maize leaf



FAW damaged maize cob



Susceptible

Resistant



Susceptible

Resistant



Susceptible (CML 444)

Resistant



Susceptible

Resistant

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CHAPTER 5

LESSONS LEARNT AND FUTURE PROSPECTS



As a way of concluding this report, this chapter highlights lessons learnt based on practical understanding of doing agricultural research in Uganda including key challenges as well as the common aspirations to help meet these challenges. It also highlights deeply thought prospects for future Research Agenda.

Lessons learnt

- Broaden partnerships to accelerate generation of technologies and innovations for agricultural transformation
- Provide enabling environment and operational modalities to hasten delivery of research products for inclusive growth
- Swiftly integrate ICT applications in the research process as a decision support tool in REAL Time
- Build critical capacity to support World Class research in the 21st Century
- Enhance capacity for effective M&E

Gaps and Challenges

- Underfunding for agricultural research
- Weak promotion of research findings
- Slow migration to ICT support services
- Delay in enactment of essential policies and laws
- Inadequate preparedness to manage pest outbreaks
- Untamed impacts of prolonged drought
- Inadequate M&E framework
- Uncoordinated efforts within the sector

Future Research Agenda

1. Improved Food and Nutrition Security for Health

- Increased Yields/Genetics/Game Changing Traits
- Increased nutrient density
- Increased Dietary Quality
- Improved Food Safety
- Increased Early Seed Generation

2. Reduced Poverty

- Improved Human Health -- drudgery, pesticide use
- Improved Animal Health – vaccine and drug development
- Increased Profitability --- value addition
- Increased Resilience – coping capacity, insurance regimes

3. Improved Natural Resources Systems and Ecosystems Services

- Improved sustainability of agricultural and aquatic production system
- Enhanced conservation of water, soils, forests crops, livestock, and other biodiversity
- Enhanced resilience of vulnerable areas and restoration of degraded land

Ahead of 2025: Essentials For Research For Impact (R4I)

- A national discovery and innovation fund
- Strong Public Private Partnership for Entrepreneurship development
- Clusters of applied technology and business incubators
- Partnerships for technology prospecting, selection, access transfer, innovation and business development
- Enabling policies and regulatory mechanisms for agricultural research to deliver impactful results
- A comprehensive and fully functional M&E system
- A reference National Agricultural Knowledge Hub

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CHAPTER 6

REPORT AND AUDITED ACCOUNTS



This chapter outlines the internal audit work carried out for the year ending 30th June 2017 as well as the overall performance assessment based on the Key Performance Indicators (KPIs). The chapter also outlines the audit report of Office of the Auditor General which is mandated to Audit the Financial statements of NARO and to issue an opinion. A total of UGX 114.13B was approved for the FY 2016/17; out of which UGX83.70B was released and 93.10% of the released was effectively spent. The Auditor General (AG) issued non-qualified opinion on the Financial Statements.

NARO Internal Audit Charter and the Public Finance and Management Act of 2015, provide for the Internal Audit function to provide assurance and consultancy services on the overall adequacy and effectiveness of the NARO's framework of controls, risk management and governance processes (i.e. NARO's system of internal control).

This was achieved through a risk-based audit work plan, agreed with management and approved by the Audit and Risk Committee. Internal Audit provided a reasonable level of assurance on controls, risk management and governance processes in NARO, subject to the inherent limitations described below.

- The observation does not imply that Internal Audit reviewed all risks relating to NARO.
- The Audit and Risk Committee approved the internal audit budget of UGX 485,141,000.
- Internal audit work was performed in accordance with NARO Internal Audit Manual which is in conformance with the Public Finance and Management Act, 2015.

Internal Audit Observation

We are satisfied that sufficient internal audit work was undertaken to allow a conclusion to be given as to the adequacy and effectiveness of controls, risk management and governance processes. In giving this conclusion, it should be noted that assurance may not be absolute. In Internal Audit's opinion, there were no major weaknesses in the system of internal control.

Our conclusion was as of: Medium to High risk rated weaknesses were identified in individual activities.

Consequences of conclusion: Control, risk management and governance processes in relation to the business critical areas were generally satisfactory. However, there are some areas of weakness and non-compliance in the framework of controls, risk management and governance which may potentially put the achievement of NARO objectives at risk.

Improvements are required in those areas to enhance the adequacy and effectiveness of the framework of control, risk management and governance. A summary of key findings from our programme of internal audit work for the year work is recorded in the table below:

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Budget performance of FY 2016/17

Source of Funding	Approved Budget (UGX Billions)	Budget Released (%)	Budget Spent (%)	Releases Spent
GOU Funding				
Recurrent Wage	22.472	100.00	100.00	100.00
Recurrent Non-Wage	8.523	81.20	81.20	100.00
GOU - Development	9.13	65.50	65.50	100.00
External Donor Funding (IDA + GEF)	67.739	84.40	74.70	88.50
Total (GoU + Ext Fin.)	107.865	85.80	79.70	92.90
A.I.A Total	6.272	47.80	47.80	100.00
Total Vote Budget	114.137	83.70	77.90	93.10

Budget performance FY 2016/17; approved UGX 114.13B, released UGX83.70B, releases spent 93.10%

Overall Performance Assessment of FY 2016/17 (KPIs)

Key Strategic Areas of Focus in the Medium Term	MDA Strategic Area of Focus in the Medium Term	Planned Target	Actual Achieved	Variance Analysis	Reasons for the Variations in 2016/17
Increased Productivity: Generation of agricultural technologies Key Strategic Areas of Focus in the Medium Term Increased Productivity and Income: Research extension interface promoted and strengthened	New varieties submitted to Variety Release Committee	20	36	+16	Completed near ready technologies and support from off-budget grants
	Production technologies generated	60	64	+04	
	Research studies under CGS	45	46	+01	
	MDA Strategic Area of Focus in the Medium Term	Planned Target	Actual Achieved	Variance Analysis	Reasons for the Variations in 2016/17
	Technological innovation platforms established/supported	7	8	+01	Improved engagement with the District Local Government, OWC, NAADS, NGOs, CBOs, etc.
	Technological innovations delivered to uptake pathways	5	15	+10	

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Opinion of the Auditor General

REPORT OF THE A UDITOR GENERAL ON THE SPECIAL ACCOUNT OPERATIONS OF AGRICULTURAL TECHNOLOGY AND AGRIBUSINESS ADVISORY SERVICES (ATAAS) NARO COMPONENT PROJECT FOR THE YEAR ENDED 30TH JUNE, 2017

Opinion

I have audited the special account statement of the Agricultural Technology and Agribusiness Advisory Services (ATAAS) NARO component project for the year ended 30th June, 2017 which is set out on page 7 of the financial statements.

In my opinion, Project management complied in all material respects with IDA rules and procedures and that the Special Account Statement for the Agricultural Technology and Agribusiness Advisory Services (ATAAS) NARO component project for the year ended 30th June, 2017 presents fairly in all material respects the account transactions and the closing balance as at 30th June 2017.

Management Responsibility for the Special Account Statement

Project management is responsible for preparation of the special account statement and its fair presentation in accordance with the requirements of the Government of Uganda regulations and IDA guidelines. Management is also responsible for designing and implementing internal controls relevant to the preparation of the special account statement that is free from material misrepresentation, whether due to fraud or error and selecting and applying appropriate accounting policies and making accounting estimates that are reasonable in the circumstances.

Auditor's Responsibility

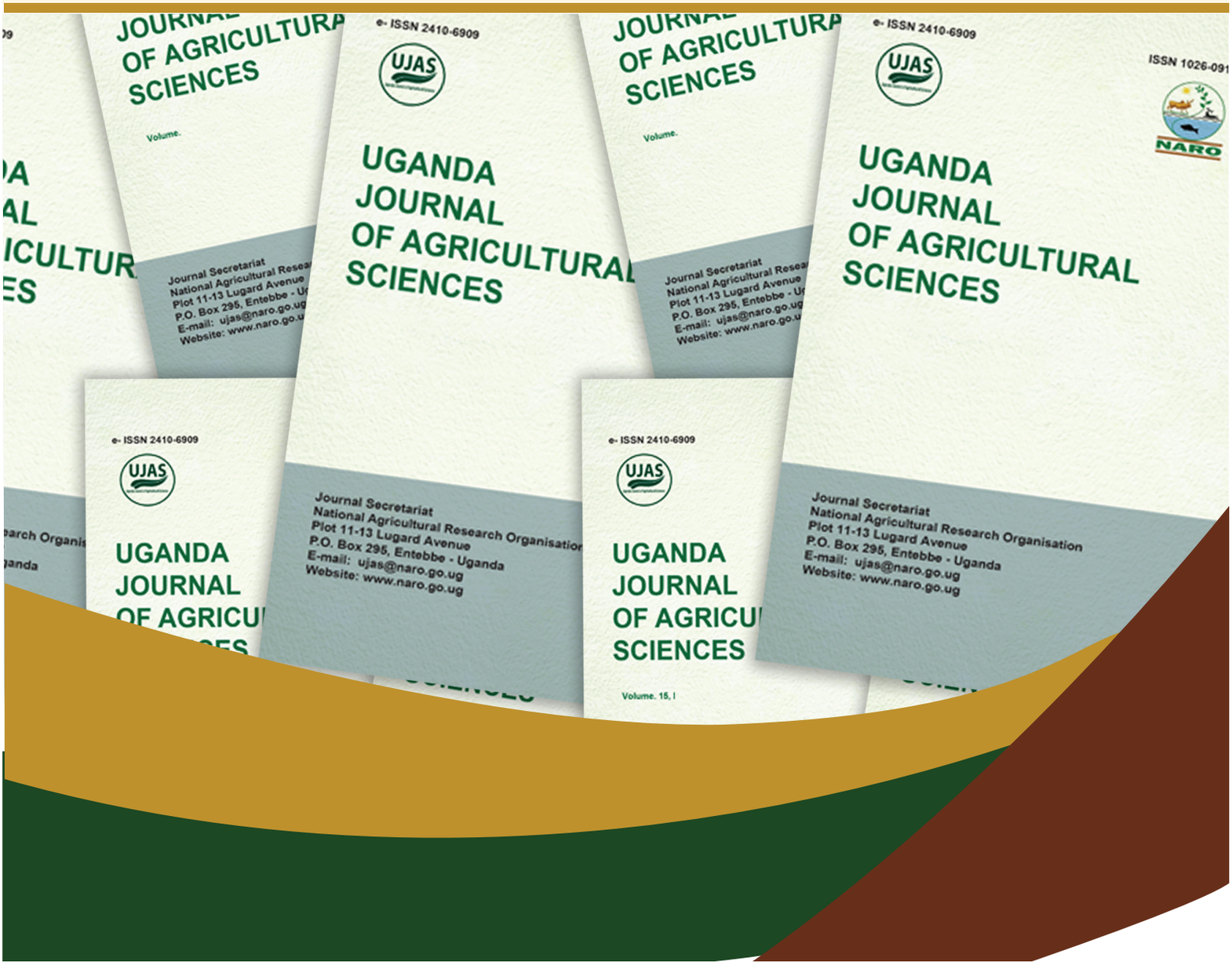
My responsibility is to express an opinion on the Special Account Statement based on my audit. I conducted the audit in accordance with International Standards on Auditing and the IDA guidelines on auditing. Those standards and guidelines require that I plan and perform the audit to obtain reasonable assurance about whether the Special Account statement is free from material misstatements. I believe that the audit provides a reasonable basis for my opinion.

John F. S. Muwanga
AUDITOR GENERAL
KAMPALA
14th December, 2017

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CHAPTER 6

PUBLICATIONS AND INFORMATION RESOURCES 2016/17



In this chapter we present to you the various publications and information resources generated by the respective institutes in the 2016-17 financial year

A. Scientific Journals

Crops, SLM and Climate change

1. Achola, E., Tukamuhabwa, P., Adriko, J., Edema, R., Mwale, S.E., Gibson, P., Naveen, P., Okul, V., Michael, D. and Okello, D.K. 2017. Composition and variation of fatty acids among groundnut cultivars in Uganda. *African Crop Science Journal*, 25 (3): 291 – 299.

2. Afutu, E., Mohammed, K.E., Odong, T.L., Biruma, M. and Rubaihayo, P.R. 2016. Evaluation of Ugandan cowpea germplasm for yield and resistance to scab disease. *American Journal of Experimental Agriculture*, 12:1-18.

3. Ahesibwe, A.R., Etiang, J., Ashaba, D., Kwikiriza, G., Mwesigye, R., Muhereze, R., Barekye A. 2017. Profitability of apple enterprise among small holder farmers in South Western Highland Agro-Ecological Zone (SWHAEZ) of Uganda. *Journal of development and agricultural economics*, 9 (7):190-199

4. Akankwasa K., Tushemereirwe W. and Ragama P. (2009). Urban consumer willingness to pay for introduced dessert bananas in Uganda. *African Crop Science Journal*, 16 (4):251-258.

5. Akankwasa, K., Ortmann, G. F., Tushemereirwe, W.K., and Wale E. 2016 . Early-Stage Adoption of Improved Banana Matooke: Hybrids in Uganda: A Count Data Analysis Based on Farmers' Perceptions. *International Journal of Innovation and Technology Management,* 13 (1).

6. Akodi, D., Komutunga, E., Agaba, C., Oratungye, J. K. and Ahumuza, E. 2016. The effect of land use on soil organic carbon stocks in Lake Victoria Crescent Agro-Ecological Zone, Uganda. *Journal of Agricultural Science and Technology,* A. 6 (3):154-160

7. Akwango,D.A., Obaa,B.B., Turyahabwe,N., Baguma, Y., Egeru,A. 2016. Agro-pastoral choice of coping strategies and response to drought in the semi-arid areas of Uganda. *African Journal of Rural Development,* 1 (3): 281 – 291.

8. Akwango,D.A., Obaa,B.B., Turyahabwe,N., Baguma, Y., Egeru,A. 2017. Effect of drought early warning system on household food security in Karamoja subregion, Uganda.*Journal of Agriculture and Food Security*, 6:43.

9. Akwango,D.A., Obaa,B.B., Turyahabwe,N., Baguma, Y., Egeru,A. 2017. Quality and dissemination of information from a drought early warning system in Karamoja sub-region, Uganda. *Journal of Arid Environments,* 145:69-80.

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10. Alicai, T., Ndunguru, J., Sseruwagi, P., Tairo, F., Okao-Okuja, G., Nanvubya, R., Kiiza, L., Kubatko, L., Kehoe, M.A., Boykin,L.M. 2016. Cassava brown streak virus has a rapidly evolving genome: implications for virus speciation, variability, diagnosis and host resistance. 6:36164. DOI: 10.1038/srep36164. Scientific Reports, 6:36164. doi: 10.1038/srep36164.

11. Anguria, P., Chemining'wa, G.N., Onwonga, R.N. And Ugen, M.A. 2017. Effect of organic manures on nutrient uptake and seed quality of sesame. *Journal of Agricultural Science*, 9 (7).

12. Anguria, P., Chemining'wa, G.N., Onwonga, R.N., and Ugen, M.A. 2017. Effects of organic residues on soil properties and sesame water use efficiency. *Journal of Agricultural Science*, 9 (6).

13. Anguria, P., Chemining'wa, G.N., Onwonga, R.N., and Ugen, M.A. 2017. Decomposition and nutrient release of selected cereal and legume crop residues. *Journal of Agricultural Science*, 9 (6): 108-119.

14. Anyanga, M.O., Yada, B., Yencho, G.C., Ssemakula, G.N., Alajo, A., Farman, D.I., Mwanga, R.O.M., and Stevenson P.C., 2017. Segregation of hydroxycinnamic acid esters mediating sweet potato weevil resistance in storage roots of sweet potato. *Frontiers in Plant Science,* 8:1011.

15. Arinaitwe, A.B, Kyooma, J., Rwaheru, A.A, Tibanyedera, D. and Barekye, A. 2017. Bridging the gap in quality and quantity of seed potatoes through farmer managed screen houses in Uganda. African Journal of plant science, 11 (2): 30-37.

16. Asekenye, C., Boris, E., Bravo-Ureta, B., Deom, M., Kidula, N., Okello, D.K., Okoko, N., Puppala, N. 2016. Productivity gaps among groundnut farmers in Kenya and Uganda: A stochastic production frontier analysis. *African Journal of Agricultural and Resource Economics*, 11 (2): 85-100.

17. Asekenye, C., Bravo-Ureta, B.E., Deom, M., Kidula, N., Okello, D.K., Okoko, N. and Puppala, N. 2016. Productivity gaps among groundnut farmers in Kenya and Uganda: a stochastic production frontier analysis. *African Journal of Agricultural and Resource Economics,* 11 (2): 85-100.

18. Ateka, E., Alicai, T., Ndunguru, J., Tairo, F., Sseruwagi, P., Kiarie, S., Makori, T., Kehoe, M.A., Boykin, L.M. 2017. Unusual occurrence of a DAG motif in the Ipomovirus Cassava brown streak virus and implications for its vector transmission. *PLoS ONE,* 12 (11): e0187883.

19. Awio, B., Mukankusi, M.C., Nkalubo, T.S., Gibson, P., Malinga, G.M., Rubaihayo, P. and Edema, R., 2017. Variety × Environment × Management Interaction of Diseases and Yield in Selected Common Bean Varieties. *Agronomy Journal,* 109 (5): 24-29.

20. Awio, T., Karungi, J., Bua, B., and Lamo, J. 2016. Relating water management regimes and rice genotypes with occurrence of insect pests and diseases of rice in Uganda. *Journal of Global Agriculture and Ecology*, 4 (1): 12-20.

21. Beyene, G., Chauhan, R.D., Ilyas, M., Wagaba, H., Fauquet, C.M. Miano, D., Alicai, T., Taylor, N.J. 2017. A Virus-Derived Stacked RNAi Construct Confers Robust Resistance to Cassava Brown Streak Disease. *Frontiers in Plant Science*, DOI: 10.3389/fpls.2016.02052.

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22. Blessing A.O., Nkalubo, S.T.,Mukankusi, C., Odong, T., Awale, H.E., Rubaihayo, P. and Kelly, J.D. 2017. Phenotypic and genotypic screening of rust resistance in common bean germplasm in Uganda. *Euphytica,* 213:49.

23. Blessing, A.O., Nkalubo, S.T., Clare, M., Pamela, P., Rubaihayo, P., James, K. and James, S. 2016. Prevalence and variability of the common bean rust in Uganda. *African Journal of Agricultural Research,* 11 (49): 4990-4999.

24. Boris M. E. Alladassi, Stanley T. Nkalubo, Clare Mukankusi, Eric S.Mwale, Paul Gibson, Richard Edema, Carlos A. Urrea, James D. Kelly and Patrick R. Rubaihayo. 2017. Inheritance of resistance to common bacterial blight in four selected common bean (*Phaseolus vulgaris L.)* genotypes. *Journal of Plant Breeding and Crop Science.* 9 (6), 71-78.

25. Deborah Karamura, D., Tumuhimbise,R., Muhangi, S., Nyine, M., Pillay, M., Tendo, S.R., Talengera, D., Namanya, P., Kubiriba, J. and Karamura, E. (2016. Ploidy level of the banana (*Musa* spp.) accessions at the germplasm collection centre for the East and Central Africa. *African Journal of Biotechnology*, 15 (31): 1692-1698.

26. Dennis O., Mukankusi C., Sebuliba S., Tukamuhabwa P., Tusiime G., Talwana H., Odong T. Namayanja A., Paparu P., Nkalubo S., Otim M., Ugen M., Buah S. and Gepts,P. 2017. Genetic variation, Heritability estimates and GXE effects on yield traits of Mesoamerican common bean (Phaseolus vulgaris L) germplasm in Uganda. *Plant Genetic Resources,* 1-12.

27. Ebinu, J.A., Nsabiyera, V., Otim, M., Nkalubo, S.T., Ugen, M., Agona, A.J., and Talwana, H.L. 2016. Susceptibility to bruchids among common beans in Uganda. *African Crop Science Journal*, 23 (3): 289 – 303.

28. Esuma, W., Kawuki, R.S., Herselman, L. and Labuschagne, M.T. 2016. Diallel analysis of provitamin A carotenoid and dry matter content in cassava (*Manihot esculenta Crantz*). *Breeding Science*, 66: 627-635.

29. Esuma, W., Kawuki, R.S., Herselman, L. and Labuschagne, M.T. 2016. Stability and genotype by environment interaction of provitamin A carotenoid and dry matter content in cassava in Uganda. *Breeding Science*, 66: 434-443.

30. Esuma,W., Herselman, L., Labuschagne,M.T., Ramu,P., Lu,F., Baguma, Y., Buckler, E.S. and Kawuki, R.S. 2016. Genome-wide association mapping of provitamin A carotenoid content in cassava. *Euphytica*, 212 (1): 97-110.

31. Gayi, D., Ocen, D., Lubadde, G., Serunjogi, L. 2016. Efficacy of bio and synthetic pesticides against the american bollworm and their natural enemies on cotton. *Uganda Journal of Agricultural Sciences*, 17 (1): 55-69.

32. Gayi, D., Lubadde, G., Biruma, M., Echaku, S., Ejiet, E. and Oxen, D. 2017. Distribution and seasonal occurrence of major insect pests of cotton in Uganda. *International Journal of Environment, Agriculture and Biotechnology,* 2 (5).

33. Gayi, D., Oce, D., Lubadde, G. and Serunjogi, L. 2017. Efficacy of bio and synthetic pesticides against the American bollworm and their natural enemies on cotton. 2016. *Uganda Journal of Agricultural Sciences,* 17 (1):55-69.

34. Goettsch, L. H., Lenssen, A. W., Yost, R. S., Luvaga, E. S., Semalulu, O., Tenywa, M., and Mazur, R. E. 2016. Improved production systems for common bean on Phaeozem soil in South-Central Uganda. *African Journal of Agricultural Research*, 11 (46), 4796-4809.

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35. Goettsch, L.H., Lenssen, A.W., Yost, R.S., Luvaga, E.S., Semalulu, O., Tenywa, M., Miiro R. and Mazur, R.E. 2017. Improved production systems for common bean on Ferralsol soil in south-central Uganda. African Journal of Agricultural Research, 12 (23), 1959-1969.

36. Goettsch, L.H., Lenssen, A.W., Yost,R. S., Luvaga,E. S., Semalulu,O. Tenywa,M. Miiro,R. and Mazur, R.E. 2017a. Improved production systems for common bean on Ferralsol soil in south-central Uganda. *African Journal of Agricultural Research*, 12 (23):1959-1969.

37. Goettsch, L.H., Lenssen, A.W., Yost,R.S., Luvaga, E.S., Semalulu, O., Tenywa, M. and Mazur, R.E., 2016. Improved production systems for common bean on Phaeozem soil in South-Central Uganda. *African Journal of Agricultural Research*, 11 (46). 4796-4809.

38. Kabiri, S., Rodenburg, J., Van Ast, A., Bastiaans, L. 2017. Slavery in plants: how the facultative hemi-parasitic plant *Rhamphicarpa fistulosa* can completely dominate its host. *Annals of Applied Biology*, 171 (3):53–363.

39. Kaizzi, C.K., Nansamba, A., Kabanyoro, R., Lammo, J. and Rware, H. 2017. Upland rice response to fertilizer in three agro ecological zones of Uganda. [in press].

40. Kaweesi, T., Kyaligonza, V., Baguma, Y., Kawuki, R. and Morag, F. 2016. Inbreeding enhances field resistance to cassava brown streak viruses. *Journal of Plant Breeding and Crop Science*, 8 (8): 138-149.

41. Kawuki, R.S., Kaweesi, T., Esuma, W., Pariyo, A., Kayondo, I.S., Ozimati, A., Kyaligonza, V., Abaca, A., Orone, J., Tumuhimbise, R., Nuwamanya, E., Abidrabo, P., Amuge, T., Ogwok, E., Okao-Okuja, G., Wagaba, H., Adiga, G., Alicai, T., Omongo, C.A., Bua, A., Ferguson, M., Kanju, E. and Baguma, Y. 2016. Eleven years of breeding efforts to combat cassava brown streak disease. *Breeding Science,* 66: 560–571.

42. Kiryowa, M., Ebinu, A., Kyaligonza, V., Nkalubo, S.T., Paparu, P., Mukankusi, C., Tukamuhabwa, P. 2016. Pathogenic variation of Colletotrichum lindemuthianum causing anthracnose of beans (*Phaseolus vulgaris*) in Uganda. *International Journal of Phytopathology*, 5 (3): 89-98.

43. Kizza, T., Sekhar, M., Rao, S.M., and Ruiz, L. (2016). Model based estimation of turmeric yield response to saline groundwater irrigation. *International Journal of Scientific Research and Engineering Studies*, 3 (10): 2349-8862.

44. Komutunga, E., Oratungye, J.K., Ahumuza, E., Akodi, D., Agaba, C. and Katambira, M.N. 2017. Adapting to rainfall variability in Uganda: seasonal characteristics tool for improved agronomic decision making. [in press].

45. Kubiriba J., Ssali, R.T. , Barekye, A., Akankwasa, K., Tushemereirwe, W.K., Batte, M., Karamura, E.B. and Karamura, D. 2016. The performance of East African highland bananas released in farmers' fields and the need for their further improvement. *Journal of Agricultural Sciences*, 13 (2):39-45.

46. Lubadde, G., Ebiyau, J., Akello, B.O. and Ugen, M.A. 2017. Comparison of GxE analysis methods for yield-related traits: a case of pearl millet in Uganda. *Uganda Journal of Agricultural Sciences*, 17 (1):1-11.

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47. Lubadde, G., Tongoona, P., Derera, J. and Sibiya, J. 2016. Combining ability and heterosis for grain yield and rust resistance in pearl millet. *Journal of Agricultural Science,8* (7):80-96.

48. Lubadde, G., Tongoona, P., Derera, J. and Sibiya, J. 2016. Production determinants of the pearl millet cropping system in Uganda and implications to productivity. *Journal of Agricultural Science,* 8 (7):97-111.

49. Lubadde, G., Tongoona, P., Derera, J. and Sibiya, J. 2016. Response of locally adapted pearl millet populations to S_1 progeny recurrent selection for grain yield and resistance to rust. *African Crop Science Journal, 24* (3): 247-257.

50. Lubadde, G., Tongoona, P., Derera, J. and Sibiya, J. 2017. Analysis of genotype by environment interaction of improved pearl millet genotypes for yield and rust resistance. *Journal of Agricultural Science*, 9 (2): 188-195.

51. Magambo, B., Harjeet, K., Arinaitwe, G., Tendo, S., Arinaitwe, I.K., Kubiriba, J., Tushemereirwe, W.K. and Dale, J. 2016. Inhibition of cell death as an approach for development of transgenic resistance against Fusarium wilt disease. *African Journal of Biotechnology*, 15 (19): 786-797.

52. Masika, F.B., Kisekka, R., Alicai, T., and Tugume, A.K. 2017. Incidence of viruses and virus-like diseases of watermelons and pumpkins in Uganda, a hitherto none-investigated pathosystem. *African Journal of Agricultural Research*, 12 (3):177-191.

53. Matsumoto, S., Tsuboi, T., Asea, G., Miyamoto, K., Maruyama, A., Takagaki, M. and Kikuchi, M. 2017. Effects of plant density on the performance of selected African upland rice varieties. *African Journal of Agricultural Research,* 12 (26): 2262-2272.

54. Mbeyagala, E.K., Amayo, R. and Obuo, J.E.P. 2016. Adaptation of introduced mungbean genotypes in Uganda. *African Crop Science Journal*, 24 (2): 155–166.

55. Mbeyagala, E.K., Kwikiriza, N., Amayo, R., Omadi, J.R., Okwang, D. and Obuo, J.E.P. 2017. Participatory selection of mungbean genotypes in Uganda. *African Crop Science Journal,* 25 (2): 253-262.

56. McQuaid, C.F., Van den Bosch, F., Szyniszewska, A., Alicai, T., Pariyo, A., Chikoti, P.C., Gilligan, C.A. 2017. Spatial dynamics and control of a crop pathogen with mixed-mode transmission. *PLoS Computational Biology*,13 (7): e1005654.

57. McQuaid, C.F., Sseruwagi, P. Pariyo, A. and Boscha, F.2016. Cassava brown streak disease and the sustainability of a clean seed system. *Plant Pathology*, 65: 299-309.

58. Mollel, H.G., Ndunguru, J., Sseruwagi, P., Alicai, T., Colvin, J., Navas-Castillo, J., Fiallo-Olivé, E. 2017. Desmodium mottle virus, the first legumovirus (genus Begomovirus) from East Africa. *Archives of Virology,* 162: 1799-1803.

59. Mollel, H.G., Sseruwagi, P., Ndunguru, J., Alicai, T., Colvin, J., Navas-Castillo, J., Fiallo-Olivé, E. 2017. Novel East African monopartite begomovirus-betasatellite complex that infects *Vernonia amygdalina*. *Archives of Virology,* 162: 1079-1082.

NARO 8/01/2018 redesign.indd 68 22/02/2018 09:43

60. Momolu, E., Lamo, J. and Katuromunda, S. 2017. Effect of soil moisture stress duration on the growth characteristics and yield of rice cultivars. *International Journal of Plant and Soil,* 15 (5): 1-10.

61. Monir, I.Y.A., Sserumaga, J.P., Ayesiga, S.B., Katuromunda, S., and Asea, G. 2016. Application of morpho-anatomical traits of maize plant to quality control and quality assurance in maize seed system. *African Crop Science Journal,* 24 (4): 361-375.

62. Mudde, B., M'mogi, F.O., Miano, D.W., Asea, G., Kilalo, D.C., Adriko, J., and Kiggundu, A. 2017. Farmer knowledge, perceptions and management of maize lethal necrosis disease in selected agro-ecological zones of Uganda. *African Journal of Rural Development*, 2 (2): 247-261.

63. Mugisa, I. O., Fungo, B., Adur, S.O., Ssemalulu, O., Molly, A., Atim, J., Nakyagaba, W., Kizza, T., Kabanyoro, R., Sseruwu, G. and Akello, B.O. 2017. Urban and peri-urban crop farming in Central Uganda: Characteristics, constraints and opportunities for household food security and income. *African Journal of Plant Science,* 11 (7):264-275.

64. Mugisa, I.O., Karungi, J., Akello, B., Ochwo-Ssemakula, M.K.N., Biruma, M., Okello, D.K. and Otim, G. 2016. Determinants of groundnut rosette virus disease occurrence in Uganda. *Crop Protection*, 79: 117-123.

65. Mutonyi, S., Beukel, K., Gyau, A. and Hjortsø, N.C. 2016. Price satisfaction and producer loyalty: The role of mediators in business to business relationships in Kenyan mango supply chain. *British Food Journal,* 118 (5): 1067-1084.

66. Mwanjalolo, J.G.M., Muwanika, V., Tabuti, J.R.S. , Kizza Luswata, C.K., Nampiija, J., Sebuliba, E., Mpiira, S. and Nyamukuru, A. 2016. Farmers' preferred trees carbon sequestration capacity in lake victoria's rural landscapes. *African Journal of Rural Development*, 1 (3): 305-315.

67. Nakato, G.V., Beed, F., Bouwmeester, H., Ramathani, I., Mpiira, S., Kubiriba, J. and Nanavati, S. 2016. Building agricultural networks of farmers and scientists via mobile phones: case study of banana disease surveillance in Uganda. *Canadian Journal of Plant Pathology,* 38 (3): 307-316.

68. Nakazi, F., Aseete,P., Katungi, E., Ugen, M.A. and Aye, G. 2017. The potential and limits of farmers' groups as catalysts of women leaders. *Cogent Economics and Finance,* 5 (1).

69. Nakazi,F., Njuki, J., Ugen, M.A., Aseete, P., Katungi, E., Birachi, E., Kabanyoro, R., Mugagga I.J. and Nanyonjo, G. 2017. Is bean really a women's crop? Men and women's participation in bean production in Uganda. *Agriculture and Food Security,* 6 (1).

70. Nalugo, R.G., Wambi, W., Ssebuliba, J.M., Okello, D.K. and Puppala, N. 2016. Gene effects for resistance to groundnut rosette disease in exotic valencia groundnuts. *African Crop Science Journal*, 24 (1): 89 – 95.

71. Namasaka, R.W., Tusiime, G., Orawu, M., Gibson, P., Nyiramugisha, J. and Edema, R. 2017. Evaluation of cowpea genotypes for resistance to *Fusarium redolens* in Uganda. *American Journal of Plant Sciences,* 8:2296-2314.

72. Namasaka, R.W., Tusiime, G., Orawu, M., Gibson, P., Agbahoungba, S., Mahule, A., Elyse Boris, E. and Edema, R. 2017. Genetic inheritance of resistance to *Fusarium redolens* in cowpea. *Journal of Plant Breeding and Crop Science,* 9:165-174.

NARO 8/01/2018 redesign.indd 69 22/02/2018 09:43

73. Namugga, P., Sibiya, J., Melis,R., Barekye,A. 2017. Genetic characterization and diversity assessment of potato genotypes using ssr markers. *Journal of Agricultural Science*, 9 (8).

74. Nansamba, A., Kaizzi, C.K., Twaha, A.B., Ebanyat, P., and Wortmann, C.S. 2016. Grain sorghum response to reduced tillage, rotation, and soil fertility management in Uganda. *Agronomy Journal*. 108:1–10.

75. Ndungu-Magiroi, K.W., Nansamba, A., Kaizzi, C.K., Mwangi, T., Koech, M., Kibunja, C.N., Wamae, D., Wortmann, C.S. 2017. Finger millet response to nitrogen, phosphorus and potassium in Kenya and Uganda. *Nutrient Cycling in Agroecosystems,*108:297–308.

76. Nsabiyera, V., Qureshi, N., Bariana, H.S., Wong, D., Forrest, K.L., Hayden, M.J. and Bansal, U.K. 2016. Molecular markers for adult plant leaf rust resistance gene Lr48 in wheat. *Molecular Breeding,* 36:1-9.

77. Nuwamanya, E., Baguma, Y., Atwijukire, E., Achieng, S., Abidrabo, P., Omongo, C.A. and Alicai, T. 2017. Cassava brown streak disease effects on leaf metabolites and pigment accumulation. *African Crop Science Journal*, 25:33-45.

78. Odipio, J., Alicai, T., Ingelbrecht, I., Nusinow, D.A., Bart, R., and Taylor, N.J. 2017. Efficient CRISPR/Cas9 Genome editing of phytoene desaturase in Cassava. *Frontiers in Plant Science.* DOI: 10.3389/fpls.2017.01780.

79. Odogwu, B.A., Nkalubo, S., Mukankusi, C., McCoy, S., Paparu, P., Rubaihayo, P., Kelly, J.D. and Sadman, J. 2016. Prevalence and variability of the common bean rust in Uganda. *African Journal of Agricultural Research, 11* (49): 4990- 4999.

80. Okello, D.K., Deom, C.M. Puppala, N., Monyo, E. and Bravo-Ureta, B. 2016. Registration of 'Serenut 5R' Groundnut. *Journal of Plant Registrations.* doi:10.3198/jpr2015.07.0041crc. Crop Science Society of America.

81. Okello, D.K., Deom, C.M., Puppala, N., Monyo, E. and Bravo-Ureta, B. 2017. Registration of 'Serenut 6T' Groundnut. *Journal of Plant Registrations.* doi:10.3198/jpr2017.03.0016crc.

82. Okello, D.K., Ugen, M.A., Tukamuhabwa, P., Ochwo-Ssemakula, M., Odong, T.L., Adriko, J., Kiconco, F., Male, A. and Deom, C.M. 2017. Molecular diagnostics of groundnut rosette disease agents in Uganda: Implications on epidemiology and management of groundnut rosette disease. *Journal of Plant Breeding and Crop Science,* 9 (5): 63-70.

83. Olango, N., Tusiime, G., Mulumba, J.W., Nankya, R., Fadda, C., Jarvis, D.I. and Paparu, P. 2016. Response of Ugandan common bean varieties to *Pseudocercospora griseola* and Angular leaf spot disease development in varietal mixtures. *International Journal of Pest Management*, 63 (2):119-127.

84. Oratungye, J.K., Oludhe, C., Manene, M.M. and Komutunga, E. 2016. A multivariate analysis approach in determining potential hotspots of seasonal rainfall change over Uganda. *International Journal for Research in Mathematics and Mathematical Sciences.* 1 (12):1-17.

85. Owere, L., Tongoona, P., Derera, J. and Wanyera, N. 2017. Genotype X Environment Interaction effects on grain yield, blast disease reaction and adaptability of finger millet genotypes in Uganda. *International Journal of Agriculture, Environment and Bio research*, 2 (4): 241–266.

NARO 8/01/2018 redesign.indd 70 22/02/2018 09:43

86. Owere,L., Tongoona,P., Derera,J. and Wanyera, N. 2016. Combining ability analysis of blast disease and agronomic traits in finger millet [*Eleusine coracana* (L.) Gaertn.]. *Journal of Agricultural Science*, 8 (11): 138–146.

87. Paparu, P., Acur, A., Kato, F., Acam, C., Nakibuule, J., Musoke, S., Nkalubo, S.T. and Mukankusi, C. 2017. Prevalence and incidence of four common bean root rots in Uganda. *Experimental Agriculture:* 1-13.

88. Ramu, P., Esuma, W., Kawuki, R., Rabbi, I.Y., Egesi, C., Bredeson, J.V., Bart, R.S., Verma, J., Buckler, E.S., and Lu, F. 2016. Cassava HapMap: Masking deleterious mutations in a clonal crop species. doi: https://doi.org/10.1101/077123

89. Semalulu O., Elobu, P., Namazzi, S., Kyebogola, S. and Mubiru, D.N. 2017. Higher cereal and legume yields using ca-bentonite on sandy soils in the dry eastern Uganda: increased productivity versus profitability. *Universal Journal of Agricultural Research*, 5 (2):140-147.

90. Ssebulime, G., Kagezi, G.H., Nyombi, K. Y., Mpiira, S., Tushemereirwe, W.K., Karamura, E.B., and Staver, C. 2017. Termite assemblages in the banana agroforestry systems of Kiboga District, Central Uganda. *International Journal of Agroforestry and Silviculture,* 4 (3): 267-277.

91. Ssebulime, G., Kagezi, H.G., Nyombi, K., Mpiira, S., Kucel, P., Byabagambi, S., Tushemereirwe, W.K., Kubiriba, J., Karamura, B.E. and Stave, C. 2017. Farmers' knowledge of the banana (musa sp.) Agroforestry systems in Kiboga district, central Uganda. *African Journal of Food, Agriculture, Nutrition and Development,* 17 (4): 12557-12573.

92. Sserumaga, J.P., Oikeh, S.O., Mugo, S., Asea, G., Otim, M., Beyene, Y., Abalo, G., and Kikafunda, J. 2016. Genotype by environment interactions and agronomic performance of doubled haploids testcross maize (Zea mays L.) hybrids. *Euphytica,* 207: 353-365.

93. Tomlinson, K.R., Bailey, A.M., Alicai, T., Seal, S., and Foster, G.D. 2017. Cassava brown streak disease: historical timeline, current knowledge and future prospects. *Molecular Plant Pathology,* DOI: 10.1111/mpp.12613.

94. Tumwesigye, K.S., Montañez, J.C., Oliveira, J.C. and Sousa-Gallagher, M.J. 2016. Novel intact bitter cassava: sustainable development and desirability optimization of packaging films. *Food and Bioprocess Technology*, 9 (5):801-812.

95. Tumwesigye, K.S., Morales-Oyervides, L., Oliveira, J.C. and Sousa-Gallagher, M.J. 2016. Effective utilisation of cassava bio-wastes through integrated process design: A sustainable approach to indirect waste management. *Process Safety and Environmental Protection,* 102:159–167.

96. Tumwesigye, K.S., Oliveira, J.C. and Sousa-Gallagher, M.J. 2016. New sustainable approach to reduce cassava borne environmental waste and develop biodegradable materials for food packaging applications. *Food Packaging and Shelf Life,* 7:8–19.

97. Tumwesigye, K.S., Oliveira, J. C. and Sousa-Gallagher, M.J. 2016. Integrated sustainable process design framework for cassava biobased packaging materials: Critical review of current challenges, emerging trends and prospects. *Trends in Food Science and Technology,* 56:103-114.

NARO 8/01/2018 redesign.indd 71 22/02/2018 09:43

98. Tumwesigye, K.S., Peddapatla, R.V.G., Crean, A., Oliveira, J.C. and Sousa-Gallagher, M.J. 2016. Integrated process standardisation as zero-based approach to bitter cassava waste elimination and widely-applicable industrial bio-material derivatives. *Chemical Engineering and Processing: Process Intensification*, 108, 139-150.

99. Tumwesigye, K.S., Oliveiraa, J.C. and Sousa-Gallagher, M.J. 2017. Quantitative and mechanistic analysis of impact of novel cassava-assisted improved processing on fluid transport phenomenon in humidity-temperature-stressed bio-derived films. *European Polymer Journal,* 91, 436–451.

100. Tumwesigye, K.S., Sousa, A.R., Oliveira, J.C., and Sousa-Gallagher, M.J. 2017. Evaluation of novel bitter cassava film for equilibrium modified atmosphere packaging of cherry tomatoes. *Food Packaging and Shelf Life*, 13:1–14.

101. Uke, A., Asea, G. and Natsuaki, K.T. 2016. Phylogenic analysis and serotyping of rice yellow mottle virus strains in Uganda. *Tropical Agriculture and Development,* 60 (2): 81-88.

102. Wagaba, H., Beyene, G., Aleu, J., Odipio, J., Okao-Okuja, G., Chauhan, R.D., Munga, T., Obiero, H., Halsey, M.E., Ilyas, M., Raymond, P., Bua, A., Taylor, N.J., Miano, D., Alicai, T. 2017. Field Level RNAi-mediated Resistance to Cassava Brown Streak Disease across Multiple Cropping Cycles and Diverse East African Agro-Ecological Locations. *Frontiers in Plant Science,* 7: 2060.

103. Wamatsembe, I., Asea, G. and Haefele, S. 2017. A survey: potential impact of genetically modified maize tolerant to drought or resistant to stem borers in Uganda. *Agronomy,* 7 (1): 24.

104. Weelar, C.G., Lamo, J., Otim, M.H., Awio, B., and Ochwo-Ssemakula, M. Mode of inheritance of resistance to the stalk-eyed fly (*Diopsis longicornis*) in rice. 2017. *International Journal of Agronomic and Agricultural Research,* 10:9–20.

105. Weelar, C.G., Otim, M.H., Lamo, J., Awio, B., and Ochwo-Ssemakula, M. 2016. Evaluation of rice genotypes for resistance to the stalk-eyed fly (*Diopsis longicornis*) in rice in Uganda. *International Journal of Agronomy and Agricultural Research,* 9 (2): 9-21.

106. Wolfe, M.D., Del Carpio, D.P., Alabi, O., Egesi, C., Ezenwaka, L.C., Ikeogu, U.N., Kawuki, R.S., Kayondo, I.S., Kulakow, P., Lozano, R., Rabbi, I.Y., Esuma, W., Ozimati, A., and Jannink, J.L. 2017. Prospects for genomic selection in cassava breeding. *Plant Genome, doi : 10.3835/plantgenome2017.03.0015.*

107. Wolfe, M.D., Rabbi, I.Y., Egesi, C., Hamblin, M., Kawuki, R.S., Kulakow, P., Lozano, R., Del Carpio, D.P., Ramu, P. and Jannink, J.L. 2016. Genome-wide association and prediction reveals genetic architecture of cassava mosaic disease resistance and prospects for rapid genetic improvement. *Plant Genome,* 9 (2):1-13.

108. Worku, M., Makumbi, D., Beyene, Y., Das, B., Mugo, S., Pixley, K., Bänziger, M., Owino, F., Olsen, M., Asea, G. and Prasanna, B.M. 2016. Grain yield performance and flowering synchrony of CIMMYT's tropical maize (*Zea mays L.)* parental inbred lines and single crosses. *Euphytica*, 211 (3): 395-409.

109. Wortmann, C.S. Milner,M., Kaizzi, C.K., Nouri, M., Athanase, R., Cyamweshi, A.R., Mohammed, K.D., Kibunja, C.N., Macharia, M., Ricardo, M., Nalivata, P.C., Negash, D., Nkonde, D., Ouattara K., Senkoro, C.J., Tarfa, B.D., and Tetteh, F.M. 2017. Maize-nutrient response information applied across sub-saharan Africa. *Nutrient Cycling in Agroecosystems*, 107:175–186.

NARO 8/01/2018 redesign.indd 72 22/02/2018 09:43

110. Yada, B., A. Alajo, G.N. Ssemakula, R.O.M. Mwanga, G. Brown-Guedira, and G.C. Yencho. 2017. Selection of simple sequence repeat markers associated with inheritance of sweetpotato virus disease resistance in sweetpotato. *Crop Science*. 57:1421-1430.

111. Yada, B., Alajo, A., Ssemakula, G.N., Brown-Guedira, G., Otema, M.A., Stevenson, P.C., Mwanga, R.O.M. and Yencho, G.C. 2017. Identification of simple sequence repeat markers for sweetpotato weevil resistance. *Euphytica,* 213:129

112. Yada, B., Brown-Guedira, G., Alajo, A., Ssemakula, G.N., Owusu-Mensa, E., Carey, E.E., Mwanga, R.O.M. and Yencho, G.C. 2017. Genetic analysis and association of simple sequence repeat markers with storage root yield, dry matter, starch and □-carotene content in sweet potato. *Breeding Science,* 67: 140-150.

113. Zewdu, Z., Gibson, P., Lamo, J. and Edema, R. 2017. Reaction of introduced Korean rice genotypes for resistance to rice blast in Uganda. *Journal of Plant Breeding and Crop Science,* 9 (7): 98-105.

Forestry

1. Akello, S., Turyahabwe, N., Okullo, P. and Agea, J.G. 2016. Land use/cover change and perceived watershed status in Eastern Uganda. *African Journal of Environmental Science and Technology*, 10:406-414.

2. Epila, J., H. Verbeeck, T. Otim□Epila, P. Okullo, E. Kearsley, and K. Steppe. 2016. The ecology of Maesopsis eminii Engl. in tropical Africa. *African Journal of Ecology,* 55 (4):679–692.

3. Moe, S.R., Eldegard, K., Rannestad, O.T., Okullo, P., Lindtjørn, O., Støen, O.G. and Dale, S. 2017. Strong positive effects of termites on savanna bird abundance and diversity are amplified by large herbivore exclusion. *Ecology and Evolution,* 7 (23):10079-10088.

4. Moe, S.R., Loe, L.E., Jessen, M. and Okullo, P. 2016. Effects of mammalian herbivores and termites on the performance of native and exotic plantation tree seedlings. *Journal of Applied Ecology*, 53:323-331.

5. Okello, J., Okullo, J.B.L., Eilu, G., Nyeko, P. and Obua, J. 2017. Mineral composition of Tamarindus indica LINN (tamarind) pulp and seeds from different agro-ecological zones of Uganda. *Journal of Food Science and Nutrition,* 5:959-966.

6. Otuba, M. and Johansson, K. 2016. Understorey plant diversity under seven tropical and subtropical plantation species. *Journal of Tropical Forest Science*, 28:107.

7. Shaban, K.S., Okumu, J.O., Okullo, P. and Obua, J. 2016. Assessing community-based organizations' influence on trees and grass planting for forest, soil and water management around Mt. Elgon National Park in Uganda. *Forests, Trees and Livelihoods*, 25:161-172.

8. Van Ittersuma, M.K., Van Bussela, L.G.J., Wolfa, J., Grassinib, P., Van Wartb, J., Nicolas Guilpartb, N., Claessensc, L., De Grootd, H., Wiebee, K., Mason-D'Croz, D., Yangb, H., Boogaardd, H., Van Oortf, P.A.J.,g, Van Loona, M.P., Saitof,K., Adimoh, O., Adjei-Nsiahi,S., Agalij, A. Balak, A., Chikowol, R., Kaizzi, C.K.,Kouressyn, M., Makoio, J.H.J.R., Ouattarap, K., Tesfayeq, K., and Cassman, K.G. 2016. Can sub-Saharan Africa feed itself? [*PNAS*, 113 (52): 14964-14969].

NARO 8/01/2018 redesign.indd 73 22/02/2018 09:43

Livestock

1. Bugeza, J., Kankya, C., Muleme, J., Akandinda, A., Sserugga, J., Nantima, N. 2017. Participatory evaluation of delivery of animal health care services by community animal health workers in Karamoja region of Uganda. *PLoS ONE* 12 (6): e0179110. https://doi.org/10.1371/journal.pone.0179110.

2. Byaruhanga, C., Collins, N.E., Knobel, D., Chaisi, M.E., Vorster, I., Steyn, H.C., Oosthuizen, M.C. 2016. Molecular investigation of tick-borne haemoparasite infections among transhumant zebu cattle in Karamoja Region, Uganda. *Veterinary Parasitology: Regional Studies and Reports*, 3 (4): 27-35.

3. Hassim, A., Dekker, E.H., Byaruhanga, C., Reardon, T., Van Heerden, H., 2017. A retrospective study of anthrax on the Ghaap Plateau, Northern Cape province of South Africa, with special reference to the 2007-2008 outbreaks. *Onderstepoort Journal of Veterinary Research*, 84 (1): e1-e15. doi: 10.4102/ojvr.v84i1.1414.

4. Jonker, A., Hickey, S., Pinares-Patiño, C., McEwan, J., Olinga, S., Díaz, A., Molano, G., MacLean, S., Sandoval, E., Harland, R., Birch, D., Bryson, B., Knowler, K. and Rowe, S. 2017. Sheep from low-methane-yield selection lines created on alfalfa pellets also have lower methane yield under pastoral farming conditions. American Society of Animal Science.

5. Jonker, A., Molano, G., Sandoval, E., Taylor, P., Antwi, C., Olinga, S. and Cosgrove, G. 2016. Methane emissions differ between sheep offered a conventional diploid, a high-sugar diploid or a tetraploid perennial ryegrass cultivar at two allowances at three times of the year. *Animal Production Science. https://doi.org/10.1071/AN15597*

6. Kabirizi, J. Nviiri, G., Kayiwa, S., Mugerwa, S., Walamaku, R. (2016) Evaluation of Sugar graze and Nutri-feed sorghum forage varieties under different cutting and Nitrogen fertilizer regimes in northern Uganda. (in press)

7. Kajobe, R., Kato, E.K., Kasnagaki, P. and Abila, P.P., 2016. The status of honeybee pests in Uganda. *Bulletin of animal health and production in Africa*, 64 (1):105-117.

8. Kasangaki, P., Nyamasyo, G., Ndegwa, P., Kajobe, R., Angiro, C., Kato, A. and Masembe, C. 2017. Mitochondrial DNA (mtDNA) markers reveal low genetic variation and the presence of two honey bee races in Uganda's agro-ecological zones. *Journal of Apicultural Research,* 56:112–121.

9. Katongole, B.C., Kabirizi, M.J., Nanyeenya, N.W., Kigongo, J., and Nviiri, G. 2016. Milk yield response of cows supplemented with sorghum stover and Tithonia diversifolia leaf hay diets during the dry season in northern Uganda. *Tropical Animal Health and Production*, 48 (6).

10. Lita, E.P., Nasinyama, G.W., Ochi, E.B., Bugeza, J., Erume, J. 2016. Sero-prevalence and Risk Factors Associated with Bovine Brucellosis in Central Equatoria State, South Sudan. *Scholars Journal of Agriculture and Veterinary sciences*, 3 (7): 454-462.

11. Makuma-Massa, H., Bemigisha, J., Kyasimire, B., Nyiramahoro, E., Begumana, J., Mugerwa, S., Egeru, A., Cho, M., 2017. Mapping the potential for hay making in rangelands: A methodological proposition. *Rangelands,* 39 (5):152-162.

NARO 8/01/2018 redesign.indd 74 22/02/2018 09:43

12. Nakayima, J., Nanfuka, M. L., Aleper, D., Okidi, D. 2017. Serological prevalence of *Babesia caballi* and *Theileria equi* in camels and donkeys from Karamoja sub-region, North-eastern Uganda. *Journal of Veterinary Medicine and Animal Health,* 9: 137-142.

13. Nakayima, J., Nanfuka, M.L., Aleper, D., Okidi, D. 2017. Prevalence of endo-parasites in donkeys and camels in karamoja sub-region, North-eastern Uganda. *Journal of Veterinary Medicine and Animal Health,* 9:11-15.

14. Nakayima, J., Nerima, B., Sebikali, C., and Magona, J.W. 2016. An assessment of veterinary diagnostic services needs in Uganda. *Journal of Veterinary Medicine and Animal Health*, 8:50-55.

15. Nakiganda, A., Mohamed, A., Ojangole, S., Kaukha, R. 2017. Price incentives to milk producers: a case of Uganda. *Livestock Research for Rural Development,* 29 (76).

16. Namaalwa, J., Egeru, A., Aleper, D. and Ainembabazi, J.H. 2017. The potential of camel production in resilience building to climate variability in Karamoja, Uganda. *RUFORUM Working Document Series,* 14 (1):1027-1031.

17. Nanyeenya, W.N., Kabirizi, J., Taabu, L., Kasadha, M., Omaria, R. 2017. Animal feeds policy and legislation: Chicken value chain actors practices and predicaments in Uganda; *African Journal for Agricultural Research*. In press.

18. Nviiri, G., Okello, H., Mutoni, G., Nakyewa, P., Zziwa, and Mugerwa, E.S. 2017. Bridging the dry season dairy feeding gap using quality rice residue based Total Mixed Rations in Northern Uganda. *International Journal of Science and Research,* 6 (5):2319-7064.

19. Obba, P., Asizua, D., Komuntaro, G., Kasozi, N., Kalenzi, M., Mpamaku, M., Kateregga, J., Okwee-Acai, J., Ndukui, J. G., Kabasa, W. and Benda, K. K., 2016. In vivo efficacy of ethanolic extract of cassia nigricans (vahl) against gastro-intestinal nematodes (gin) of goats in West Nile Region, Uganda. *American Journal of Clinical and Experimental Medicine*, 4 (3): 43-49.

20. Wumbiya, S. D., Mutebi, F., Eneku, W., Nasinyama, G. W., Skjerve, E., Muwonge, A., Musso, M., Mugasa, C. I., Nabadda, D., Mirembe, B., Ambrose, J., Bugeza, J., Wizaso, M. and Kankya, C. 2017. Knowledge attitude and practices towards cystic echinococcosis among pastoral communities in greater kapoeta South Sudan. *Journal of Veterinary Medicine and Research,* 4 (5): 1086.

Fisheries

1. Aruho, C., Ddungu, R., Mwanja, M.T., Wadunde, A.O., Kamahooro, I., Nkambo, M. and Ondhoro, C.C. 2017. Growth performance and survival of African catfish (*Clarias gariepinus*) fed on different diets. *International Journal of Fisheries and Aquatic Studies*, 5 (3): 01-05.

2. Kwikiriza, G., Barekye, A., Muhereze, R., Tibihika, P.D.M., 2016. Growth performance of monosex nile tilapia (*Oreochromis niloticus*) juveniles at different stocking densities in cages at Lake Bunyonyi in south western highland agro-ecological zones. *International Journal of Fisheries and Aquatic Studies,* 4 (6): 42-48.

NARO 8/01/2018 redesign.indd 75 22/02/2018 09:43

3. Kwikiriza, G., Tibihika, P.D., Byakora, E., Aheisibwe, A. and Barekye, A. 2017. Comparative growth performance and proximate nutrient composition of three local strains of nile tilapia (*Oreochromis Niloticus* L.) collected from different locations in Uganda. *Fisheries and Aquaculture journal,* 6 (8):226-231.

4. Kwikiriza, G., Namulawa, V., Wadunde, O.A., Abaho, I. and Ondhoro, C.C., 2016. Proximate nutrient composition and cost of the selected potential fish feed ingredients in Lake Victoria basin, Uganda. *International Journal of Fisheries and Aquatic Studies*, 4 (3): 611-615.

5. Kwikiriza, G., Tibihika, P.D.M, Barekye, A., Beingana, A. and Orina P.S. 2016. Performance of african catfish (*Clarias gariepinus*) (Clarridae) fry fed on live rotifers (*Brachionus calyciflorus*), formulated diet and a mixture of rotifers and formulated diet. *International Journal of Fisheries and Aquatic Studies,* 4 (6): 11-15.

6. Musinguzi, L, Natugonza, V., Ogutu-Ohwayo, R., 2017. Paradigm shifts required to promote ecosystem modeling for ecosystem-based fishery management for African inland lakes. *Journal of Great Lakes Research*, 43 (1):1-8.

7. Mwanja, M.T., Ondhoro, C.C., Sserwada, M., Achieng, P., Ddungu, R. and Mwanja, W. 2016. Morphological variation of Nile tilapia (*Oreochromis niloticus*) populations from major water bodies of Uganda. *Uganda Journal of Agricultural Sciences* 17 (1); 21-32.

8. Natugonza, V., Ogutu-Ohwayo, R., Musinguzi, L., Kashindye, B., Jónssonc, S., ThorValtysson, H., 2017. Exploring the structural and functional properties of the Lake Victoria food web, and the role of fisheries, using a mass balance model. Ecological Modelling, 342, 161-174.

9. Natugonza, V., Ogutu-Ohwayo, R., Musinguzi, L., Olokotum, M., Naigaga, S., Kitabona, J. 2016. Implications of climate warming for hydrology and water balance of small shallow lakes: A case of Wamala and Kawi, Uganda. Journal Aquatic Ecosystem Health and Management, 19 (4), 327-335.

10. Ondhoro C. C., Masembe C., Maes G.E., Nkalubo N.W., Walakira J.K., Naluwairo J., Mwanja M.T., and Efitre J.M. 2017. Condition factor, Length – Weight relationship, and the fishery of *Barbus* altianalis (Boulenger 1900) in Lakes Victoria and Edward basins of Uganda. *Environmental Biology of Fishes*, 100:99–110.

1. Taabu-Munyaho, A., Marshall, B.E., Tomasson, T. and Marteinsdottir, G. 2016. Nile perch and the transformation of Lake Victoria. *African Journal of Aquatic Science*, 41 (2):127–142.

2. Tibihika,P.D.M., Okello,W., Barekye, A., Mbabazi, D., Omony, J., and Kiggundu, V. 2016. Status of kigezi minor lakes: a limnological survey in the lakes of Kisoro, Kabale and Rukungiri districts. *International Journal of Water Resources and Environmental Engineering*, 8 (5): 60-73.

NARO 8/01/2018 redesign.indd 76 22/02/2018 09:43

B. Special Publications

Policy Briefs, Thesis, Dissertations, Farming Information Resources

1. Akwango-Aliau,D. [2017. *Determinants for effective drought early warning systems in mitigation of drought effects in Karamoja sub-region, Uganda (Doctoral thesis).* Makerere University, Kampala].

2. Kabiri, S. [2017. *Ecology and biology of rhamphicarpa fistulosa, a new parasitic weed of rain-fed (Oryza sativa) in Sub-Saharan Africa (Doctoral thesis).* Aula of Wageningen University].

3. Mutonyi, S. [2016. *Value chain dynamics and impact of collective action on smallholder livelihood improvement in Kenya (Doctoral thesis).* Technical University of Madrid (UPM)].

4. Nakiyende, H. [2016. *Exploitation patterns and population structure of alestes baremose (JOANNIS, 1835) and hydrocynus forskahlii (CUVIER, 1819) on Lake Albert, Uganda.* (Masters thesis), Makerere University, Kampala].

5. Kagoya, E. [2017. *Visual sensitivity and behavioral analysis of nile tilapia (oreochromis niloticus). (Masters thesis).* Pukyong National University].

6. Tazibirwa, J. [2016. *Assessment of the influence of bujagali dam on the spatial and temporal fish assemblages of the Upper Victoria Nile River, Uganda, (Masters thesis).* University of Natural Resources and Life Sciences, Australia, UNESCO-IHE, Netherlands and Egerton University, Kenya].

C. Books and Book chapters

1. Akpo, E., Maereka, E.K., Okello, D.K., Mponda, O., Kilango, M., Nkalubo, S.T., Binagwa, P., Rubyogo, J.C., and Monyo, E.S. 2017. Seed business management in the context of smallholder farmers: training manual. http://tropicallegumes.icrisat.org/wp-content/uploads/2016/10/TL-III_Seed-Business-Management-in-the-Context-of-Smallholder-Farmers.pdf

2. Kaizzi, C.K., Mohammed, M.B., and Nouri,M. 2016. Fertilizer use optimization: principles and approach. In: Charles S. Wortmann and Keith Sones (Eds.), *Fertilizer Use Optimization in sub-Saharan Africa.* CABI. p11.

3. Kaizzi, C.K., Nansamba,A. and Kabuye, F.M. 2017. Optimizing fertilizer use within the context of integrated soil fertility in Uganda. In: Charles S. Wortmann and Keith Sones (Eds.), *Fertilizer Use Optimization in sub-Saharan Africa.* CABI. pp.193-209.

4. Lawrence, J.A., Byaruhanga, C., Oosthuizen, M., Mans, B.J., 2017. Non-pathogenic Theileria species in cattle. In: Coetzer, J.A.W., Thomson, G.R., Maclachlan, J., Michel, A., Botha, C. (Eds.), *Infectious Diseases of Livestock* (2nd ed.), Cape Town, South Africa: Oxford University Press, Southern Africa.

5. Lawrence, J.A., Byaruhanga, C., Oosthuizen, M., Mans, B.J., 2017. Theileriamutans infection. In: Coetzer, J.A.W.,

NARO 8/01/2018 redesign.indd 77 22/02/2018 09:43

Thomson, G.R., Maclachlan, J., Michel, A., Botha, C. (Eds.), I*nfectious diseases of livestock* (2nd ed.), Cape Town, South Africa: Oxford University Press, Southern Africa.

6. Lawrence, J.A., Byaruhanga, C., Oosthuizen, M., Mans, B.J., 2017. Theielriosis of sheep and goats. In: Coetzer, J.A.W., Thomson, G.R., Maclachlan, J., Michel, A., Botha, C. (Eds.), *Infectious diseases of livestock* (2nd ed.), Cape Town, South Africa: Oxford University Press, Southern Africa.

7. Okello, D.K., Okori, P., Emmanuel S Monyo, E.S. 2016. Integrated seed systems delivering on the promise: experiences from tropical legumes. Enhancing groundnut productivity and production in Eastern and Southern Africa. In: Monyo, E.S. and Varshney, R.K., (Eds). *Seven seasons of learning and engaging smallholder farmers in the drought-prone areas of sub-Saharan Africa and south Asia through tropical legumes, 2007–2014.* p11-27. ICRISAT, Patancheru, Telangana, India.

8. Okori, P., Monyo, E.S., Okello, D.K., Mponda, O.K., Chamango, A., Chintu, J., Amane, M. and Mausch, K.. 2016. Enhancing groundnut productivity and production in Eastern and Southern Africa. pp11-27. In: Monyo, E.S. and Varshney, R.K., [Eds.], 2016. *Seven seasons of learning and engaging smallholder farmers in the drought-prone areas of sub-Saharan Africa and South Asia through tropical legumes, 2007–2014.* 236p. ICRISAT, Patancheru, Telangana, India.

9. Rware, H., Kaizzi, C.K., Senkoro,C.J., Bayu,W. Oduor,G. and Watiti, J. 2016. Enabling fertilizer use optimization in Sub-Saharan Africa. In: Charles S. Wortmann and Keith Sones (Eds.), *Fertilizer use optimization in sub-saharan africa.* CABI. pp 220-240.

D. Farming and extension materials

1. Adopting improved dairy cattle breeds without significant milk yield enhancement frustrates farmers in Northern Uganda (May 2016)

2. Controlling Aflatoxin. [Fact sheet in in Ateso, Lugbara, Runyankole, and Luo].

3. D. Nabasumba, G. A. Beyihayo, R. Muzira, H. Kirunda. Diversity and biomass of pastures under selected tree species in open grazing systems in pastoral rangelands of South-Western Uganda - ICERAP, conference proceedings. Speke Resort Munyonyo, Kampala, Uganda 22nd - 23rd November, 2017.

4. Efitre, E., Natugonza, V., Musinguzi, L., Olokotum, M., Naigaga, S., Ogutu-Ohwayo, R. 2017Building Capacity for Climate Change Mitigation and Adaptation Through Mainstreaming Climate Change in Curricula of Tertiary Training Institutions in Africa. In: W. L. Filho (ed), Climate Change Research at Universities, Addressing the Mitigation and Adaptation Challenges, pp, 423-440

5. G. A. Beyihayo, D. Nabasumba, R. Muzira, H. Kirunda. Status of Sustainable Land Management in Pasture Production Systems in South Western Agro-Ecological zone of Uganda: Implications for Resilience of Livestock Production Systems - ICERAP, conference proceedings. Speke Resort Munyonyo, Kampala, Uganda 22nd - 23rd November, 2017.

NARO 8/01/2018 redesign.indd 78 22/02/2018 09:43

6. Groundnut Leafminer. [Brochure].
7. Groundnut production. [Brochure].
8. Groundnuts Postharvest Handling: Harvesting and drying. [Fact sheet in in Ateso, Lugbara, Runyankole, and Luo].

9. Groundnuts Postharvest Handling: Value addition and product development[Fact sheet in in Ateso, Lugbara, Runyankole, and Luo].

10. Groundnuts Postharvest Handling:Plucking, grading, storage and shelling. [Fact sheet in in Ateso, Lugbara, Runyankole, and Luo].

11. Mushroom growing as a livelihood option to fishing among Lake Edward fisher communities

12. Nanyeenya, W.N.; Kabirizi. J., Katongole. C., Nviiri.G, and Kigongo, J. and Mugerwa S (2016). Policy brief on prospects for improving dairy cattle performance by adopting feed supplements using locally available materials in Northern Uganda.

13. Nanyeenya, W.N.; Zziwa E., Mugerwa, S., Mubiru. D., Mwesigwa.M, Batanda, D and Sekandi. M (2017): Corrective Interventions to Manage Bare patch Effects on Pastures Denudation in Uganda's Cattle Corridor

14. Poor feeding frustrates dairy cattle performance improvement in Northern Uganda: prospects for adopting local feed supplements (May 2016)

15. Profitability of fish farming in, Western, Northern and Central Uganda.
16. Pumkins for food and nutritional security
17. Pumkins for food and nutritional security
18. Red Amaranthus (Amaranthus Blitum) Seed production guide
19. Red Amaranthus (Amaranthus Blitum) Seed production guide

20. Solar light technology for harvest of Mukene. NaFIRRI, 2017. A factsheet prepared by R. Mangeni-Sande, H. Nakiyende, W. Nkalubo, J, Wasukira, E. Kagoya, D. Mbabazi, J. Mulowoza, C. Nabwire, P. Mudondo, S. Bassa, R. Tumwebaze, Rukunya, G. Kubiriza, K. Neville, and A. Taabu-Munyaho, (July 2017).

21. Sorghum for food and fodder production
22. Spider Plant (Jjobyo) Seed Production Guide
23. Spider Plant (Jjobyo) Seed Production Guide

24. Status of Kariba weed (Salvinia molesta D.S. Mitchell) infestation, its impacts and management plan on Lake Kwania, Uganda – Annex H.

25. Sustainable land management manual for training of trainers. Volume 1. Soil and water management, forestry and energy conservation. 2017. NARO. ISBN:978-9970-9775-0-5.

26. Sustainable Land Management Manual for Training of Trainers. Volume 2. Improved livestock husbandry. 2017. NARO. ISBN:978-9970-9775-1-2.

NARO 8/01/2018 redesign.indd 79 22/02/2018 09:43

27. Sustainable Land Management Manual for Training of Trainers. Volume 1. Soil & water management, forestry & energy conservation. 2017. NARO. ISBN:978-9970-9775-0-5.

28. Sustainable Land Management Manual for Training of Trainers. Volume 2. Improved livestock husbandry. 2017. NARO. ISBN:978-9970-9775-1-2.
29. Tithonia diversfolia (Mexican sunflower) for smallholder crop-livestock farmers

E. Selected Technical Reports

1. A, Taabu-Munyaho, R. Mangeni-Sande, H. Nakiyende, W. Nkalubo, J. Wasukira, E. Kagoya, A. Mulowoza, C. Nabwire, P. Mudondo, S. Bassa1, R. Tumwebaze, E. Rukunya, G. Kubiriza,K. Naville (2016). A technical report of the CGS project "Improving Light Attraction Technologies for enhanced harvest of Mukene on Lake Victoria".

2. Afutu E,. Agoyi E.E., Amayo R., Biruma, M. and Rubaihayo, P.R. 2016. Cowpea scab disease (Sphaceloma sp.) in Uganda. http://dx.doi.org/10.1016/j.cropro.2016.06.024.

3. Akankwasa.K., Ortmann G.F., Tushemereirwe, W.K., Wale, E. 2016. Early-stage adoption of improved banana matooke" hybrids in Uganda: A Count Data Analysis Based on Farmers' Perceptions.

4. Perceptions.
5. Alternative livelihood options' adoption study draft technical report
6. Auma. L., Barwogeza M., Wambi, W., Abitegeka, J. and Ssekiwoko, F. 2017. Maize growers' guide; what you need to know.
7. Cost-benefit analysis of grow out cage fish farming enterprises in Uganda.
8. Cost-benefit analysis of grows out pond fish farming enterprises in Uganda.

9. D. Mbabazi, D., H. Nakiyende, A. M. Taabu, E. Rukuunya, J. Efitre, T. Hyuha, M. Nkambo, P. Tibihikwa, J. Twinamatsiko, S. Bassa, E. Muhumuza, J. Tazibirwa, A. Nankabirwa, V. Mpomwenda J. Twebaze, D. Birungi and J. S. Balirwa (2017). A suitability status report of the CGS project "Actualizing the potential for fish production in small water bodies in South Western Uganda, Project Number: CGS/4/30/14".

10. Deborah Karamura, Robooni Tumuhimbise, Sedrach Muhangi, Moses Nyine, Micheal Pillay, Reuben Ssali Tendo, David Talengera, Priver Namanya, Jerome Kubiriba and Eldad Karamura (2016) Ploidy level of the banana (Musa spp.) accessions at the germplasm collection centre for the East and Central Africa.

11. Kabasomi L., Abor, B., Mudde, B., Byenkya, G.S. and Hafashimana, D.L.N. 2017. Guidelines for harvesting, processing & packaging quality honey.

12. Kabirizi, J.M., Nviiri, G., Mugerwa, S., Mwesigwa, R. 2016. A Review of forage research and development in Uganda: A review of forage research and development in East and Central Africa". final report to ILRI is 25th January 2016

NARO 8/01/2018 redesign.indd 80 22/02/2018 09:43

13. Kubiriba J, Erima R. and Tushemereirwe W. K. (2016) Scaling out control of banana xanthomonas wilt from community to regional level: A case from Uganda's largest banana growing region

14. Kubiriba, J., Ssali, R.T, Barekye, A., Akankwasa, K., Tushemereirwe, W.K., Batte, M., Karamura, E.B. and Karamura, D. 2016. The performance of East African highland bananas released in farmers' fields and the need for their further improvement.

15. Lake Edward apiary pilot draft technical report

16. Magambo, B., Harjeet, K. Arinaitwe, G., Tendo, S., Arinaitwe, I.K., Kubiriba, J., Tushemereirwe, W. and Dale, J., 2016. Inhibition of cell death as an approach for development of transgenic resistance against Fusarium wilt disease.

17. Majaliwa Mwanjalolo, J.G., Muwanika, V., Tabuti, J.R.S., Kizza Luswata, C., Nampiija, J., Sebuliba, E., Mpiira, S. and Nyamukuru, A. 2016. Farmers' preferred trees carbon sequestration capacity in lake victoria's rural landscapes.

18. Mbabazi, B., Mulabuke, L, Abitegeka, J. and Byenkya, G.S. 2017. Forage conservation through silage making.

19. Mpiira, S., Kubiriba, J. and Nanavati, S. 2016. Building agricultural networks of farmers and scientists via mobile phones: case study of banana disease surveillance in Uganda.

20. Mubiru, D. N., Namakula, N., Lwasa, J., Otim, A. G., Kashagama, J., Nakafeero, M., Nanyeenya, W. N., Coyne, M. S. 2017. Conservation Farming and Changing Climate: More beneficial than conventional methods for degraded Ugandan soils. Sustainability, MDPI June 2017.

21. Mugabi .D, Abor. B & Masanyu. J (2017): Fruit flies management technologies for farmers in the Lake Albert Crescent Zone.

22. Mugisha, J., Akankwasa, K., Tushemereirwe, W. and Ragama, P. 2016. Urban consumer willingness to pay for introduced dessert bananas in Uganda.

23. NaFIRRI 2017, Characterization of Habitats and Haplochromine Diversity to Guide Conservation of Biodiversity amidst Hydropower Developments along the Upper Victoria Nile. A Report Prepared for the Ministry of Energy and Mineral Development

24. Nakato, G.V., Beed, F., Bouwmeester, H., Ramathani, I., Mpiira, S., Kubiriba, J. and Nanavati, S. 2016. Building agricultural networks of farmers and scientists via mobile phones: case study of banana disease surveillance in Uganda.

25. National Report of the Frame Survey 2016 on Lake Victoria, Uganda. Prepared by the Frame Survey National Working Group, December, 2016.

26. Report of the Lake-wide Hydro-Acoustic and Environmental Survey of Lake Victoria, September, 2016. LVFO, 2016.

27. Seasonal variation of the water quality and pollution status of the Kyoga basin lakes (Lake Kwania)

NARO 8/01/2018 redesign.indd 81 22/02/2018 09:43

28. Ssebulime, G., Kagezi, H.G., Nyombi, K., Mpiira, S, Tushemereirwe, K.W., Karamura, B.E., and Staver, C. 2017. Termite assemblages in the banana agroforestry systems of Kiboga district, central Uganda

29. Ssebulime, G., Kagezi, H.G., Nyombi, K., Mpiira, S., Kucel, P., Byabagambi, S., Tushemereirwe, K.W., Kubiriba, J. Karamura, B.E., Stave, C. and Kagezi, G. 2017. Farmers' knowledge of the banana (musa sp.) agroforestry systems In Kiboga district, central Uganda

30. Status of water quality variables that influence proliferation of Kariba weed in the Kyoga basin lakes (Lake Kwania)

31. Swaibu Mbowa, Tonny Odokonyero, Anthony T Munyaho (2016). Floating Fish Cage Farming a Solution to Uganda's Declining Fishery Stocks. Policy Brief, Issue No. 66 June, 2016. In Economic Policy Research Center, "Towards Sustainable Development".

32. echnical report of the 20th Aquatic Ecology Monitoring of the Upper Victoria Nile: Chapter on the Commercial Fisheries (Fishing effort, catch, beach revenue and socio-economic activities), May 2017. Prepared by Nakiyende Herbert, Bassa Samuel, Nduwayesu Everest, Muhumuza Elias, Balirwa John and Taabu Anthony Munyaho.

33. Technical Report of the Bottom Trawl (Fisheries and Water Environment Monitoring) Survey of Lake Victoria, Uganda (December 2016). Technical Document No. 2, 2017. Prepared by H. Nakiyende, S. Bassa, D. Mbabazi, E. Muhumuza, W., Nkalubo , S. Mageni, L Musinguzi., A. Nankabirwa, E. Ndiwayesu, R. Egesa, G Magezi, P. Ghandi, M. Nsega, J. Tazibirwa, E. Kagoya, P. Mudondo and A.M.Taabu National Fisheries Resources Research Institute, P.O.Box 343, Jinja, July 2017.

34. Tinzaara, W., Karamura, E.B., Kubiriba, J., Ochola, D., Ocimati, W., Blomme, G. and Ssekiwoko, F. 2016. The banana Xanthomonas wilt epidemic in east and central Africa: current research and development efforts.

35. Water quality status of minor lakes in the Kyoga Basin (Lake Kwania)

36. Zaabwe, T. and Abaho, I. 2017. Feeding and feed management in African fish catfish (Clarias gariepinus) and nile tilapia (Oreochromis niloticus).

NARO 8/01/2018 redesign.indd 82 22/02/2018 09:43

REFERENCES

1. FAO, IFAD & WFP, (2015). The State of Food Insecurity in the World 2015. Meeting the 2015 international hunger targets: taking stock of uneven progress. FAO, Rome.

2. Global Initiative for the United Nations (2015). Getting started with the Sustainable Development Goals. A guide for Stakeholders.

3. M.J. Haskell, K.M. Jamil, F. Hassan, and Kenneth H. Brown (2004). Daily consumption of Indian spinach (Basella alba) or sweet potatoes has a positive effect on total-body vitamin A stores in Bangladeshi men. Am. J. Clin. Nutr., 80 : (705-14)

4. Christine Hotz, Cornelia Loechl, Abdelrahman Lubowa, James K. Tumwine, Grace Ndeezi, Agnes Nandutu Masawi, Rhona Baingana, Alicia Carriquiry, Alan de Brauw, Jonnalagadda V. Meenakshi, and Daniel O. Gilligan (2012),. Introduction of B-carotene-rich orange sweet potato in rural Uganda results in increased vitamin A intakes among children and women and improved vitamin A status among children J. Nutr., 142:1871-1880

5. J.W. Low, M. Arimond, N. Osman, D. Tschirley A food-based approach introducing orange fleshed sweet potato increased vitamin A intake and serum retinol concentrations in young children in rural Mozambique J. Nutr., 137 (5):1320-7

6. P.J. van Jaarsveld, M. Faber, S.A. Tanumihardjo, Nestel P., Lombard C.J and Benadé (2005) A.J.ß-carotene rich orange-fleshed sweet potato improves the vitamin A status of primary school children assessed with the modified-relative-dose-response test. Am. J. Clin. Nutr., 81: 1080-1087

7. Jimmy Lamo, Pangirayi Tongoona, Moussa Sie, Mande Semon, Geoffrey Onaga and Patrick Okori (2017). Upland Rice Breeding in Uganda: Initiatives and Progress, Advances in International Rice Research, (Ed Jinquan Li.), InTech, DOI: 10.5772/66826. ISBN 978-953-51-3010-9, Print ISBN 978-953-51-3009-3, Published: March 15, 2017 under CC BY 3.0 license. Available from: http://www.intechopen.com/books/advances-in-international-rice-research/upland-rice-breeding-in-uganda-initiatives-and-progress

8. ASSP, 2016. Ministry of Agriculture, Animal Industry and Fishieries: Agriculture Sector Strategic Plan (Draft, 2015/16-19/20).

9. Sempiira, J. E., Katimbo, A., Mugisa, D. J., & Kisaalita, W. S. (2017). Ghee-making in the cattle corridor of Uganda. African Journal of Food, Agriculture, Nutrition and Development, 17 (1), 11771-11786. Available from: https://www.researchgate.net/publication/315535575_Ghee-making_in_the_cattle_corridor_of_Uganda [accessed Aug 31, 2017].

NARO 8/01/2018 redesign.indd 83 22/02/2018 09:43

10. Pre-Cooked Beans for Improving Food and Nutrition Security and Income Generation in Kenya and Uganda, Final Technical Report, (2017), National Agricultural Research Organization

11. Tharanathan R.N and S. Mahadevamma, (2003). Grain legumes— a boon to human nutrition

12. Uganda Bureau of Statistics 2016, The National Population and Housing Census 2014 – Main Report, Kampala, Uganda, pp 12

13. Uganda Bureau of Statistics (UBOS) and ICF, 2017, Uganda Demographic and health Survey 2016. Key indicators Report, Kampala, Uganda. UBOSand Rockville, Maryland, USA, UBOSand ICF.

14. National Food Security Assessment Report. 2017. National Food Security Assessment January 2017. Report published by the Department of Relief, Disaster Preparedness and Management. Office of the Prime Minister.

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