Weeding out *striga* from African drylands

A *striga* workshop organised by the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) gathered experts from Europe, USA, Africa and Asia for two days (28-29 November 2017) in Nairobi to discuss viable and scalable options for eradicating this weed that has plagued sub-Saharan African agriculture for decades. From soil fertility management, push-pull intercropping and seed treatment to crop improvement, solutions exist but progress on the ground has been modest so far. The *striga* specialists are calling to form an Alliance for *Striga* Control in Africa to reclaim the much-needed food potential of millions hectares of *striga*-infested fields.

Despite its striking purple flowers and potential medicinal uses, the parasitic nutrient sap-sucking *striga* weed or witchweed is no innocent pest. A lasting and very damaging weed for the major cereal crops in sub-Saharan Africa, it can cause up to 100% crop losses across millions of hectares of farmland and an annual loss of several billion dollars.

Once the field is infected with *striga*, farmers can’t get rid of this pest easily. Like black dust, these tiny seeds produced in large quantities – one spikelet can produce over 50,000 seeds – spread rapidly within the farming community. The seeds can remain viable for up to 20 years under the right conditions until a host plant, usually a cereal crop such as rice, maize, sorghum or millet, emits germination signal molecules called strigolactones at the root zone. The invisible pest develops underground, sucking life from the host root. After a month when it appears over ground, it is almost too late.

**Knowing your enemy**

Researchers and practitioners have been on the case for decades, yet paradoxically, we still don’t know enough about the extent and intensity of *striga* invasion, judging...
by the differences in the figures on damage impact circulated by different scientists during the workshop. And although *striga* biology is now understood up to the molecular level, some practical aspects are not necessarily grasped by smallholder farmers. A young farmer who had just inherited a pristine plot of land borrowed ploughing equipment used in his father’s *striga*-contaminated fields and ended up spreading the weed in one season.

Julie Scholes, a professor from Sheffield University in the UK, says there is still a lot to discover at molecular level on how *striga* and host plants interact. She uses rice as one of the host plants, which she inoculates with *striga* seeds under rhizotrons, large Perspex root chambers that facilitate easier observation of *striga* invasion of the host and its development. Her work shows that there are different *striga* ecotypes with varying levels of aggression depending on host plant and agroecologies.

It has been observed that poor soil fertility and drought are worsening *striga* infection. Harro Bouwmeester, a professor from the University of Amsterdam has researched how soil fertility could affect plant signalling during *striga’s* interaction with the host. He reports about 20 different types of strigolactones that may or may not be specific to the host. Experiments in West Africa showed that in phosphate-deprived soils, sorghum host plants were producing more strigolactones. On the contrary, phosphate fertilization could reduce *striga* occurrence by 40 to 80% and improve sorghum harvests by up to 142%.

However, similar experiments in maize fields in Eastern Africa showed less effect with nitrogen fertility levels. It shows that further soil and water management research is needed to better understand which soil qualities could block or slow *striga* infestation.

Prof Abdalla Mohammed who has been breeding *striga* tolerant sorghum varieties using molecular marker-assisted technologies calls for integrated *striga* management options combining soil fertility improvement, collective weeding, water conservation and use of improved seeds, as experienced by ICRISAT in Mali.

Many approaches have been tested to fight *striga* with varying levels of success. These range from low-tech solutions, like the use of trap crops like desmodium (a cover crop that induces ‘suicidal germination’ of *striga* seeds without allowing the *striga* plantlet to anchor to the roots) to more sophisticated practices like seed treatment (IR maize popularized by the African Agricultural Technology Foundation) or development of *striga*-resistant crops through plant breeding. Most experts admit that adoption of such innovations has not been high in many African countries although there are limited studies to explain the observed low adoption among farmers.

Build a global coalition against *Striga*, and a strong case for action

Jeff Ehlers, Senior Program Officer at the Bill & Melinda Gates Foundation recalled working in Western Kenya around Lake Victoria in the late 1980s with 6 million people affected by the weed at the time. Recent statistics provided by agricultural economist Hugo deGroote at CIMMYT, who has studied *striga* economics for years, shows that in this *striga* belt, as in many parts of Africa, the scenario unfortunately worsened with even more people affected.

There is an urgent need to work with farmers and social scientists to understand what would trigger adoption or rejection of some interventions. The push-pull approach, for instance, may be effective in pilot testing but farmers who practice intercropping may not want to replace an essential food crop like groundnut with desmodium intercrop. While breeding for resistance, plant scientists should consider that farmers may reject a new variety if the shape of the plant, taste and color of grain are far from their usual expectations.

We need to look at the practicalities, access and affordability of the solutions to fight *striga* and ensure that we use a multidisciplinary approach including microbiologists, breeders, agronomists, soil scientists, economists and sociologists.

Despite the recent discoveries, there are still many knowledge gaps about this versatile weed and it is not easy for decision makers to know where to start to eradicate *striga*. Dr Senait Senay, Research Associate on ecological informatics at International Science & Technology Practice & Policy (InSTePP), showed how mapping scenarios of pest invasions can help prioritize geography of interventions and evaluate costs and benefits of eradication programs. By modelling presence and absence of a pest – *striga* in this case – against layers of environmental data like climate, soils, etc., the GEMS platform (Genetics x Environment x Management x Socioeconomical data) can map the risks of *striga* infestation now and in the future.

The Economics of Land Degradation Initiative has recently built a case for more investments in land rejuvenation, assessing the global cost of inaction on soil health. Likewise, the *striga* expert community needs to build a comprehensive narrative on why the fight against *striga* is so important today in order to mobilize governments, donors, farmers, and the development and private sectors.

A first step forward would be to form an Alliance for *Striga* Control in Africa which could define a common research for fast action agenda to fight *striga* and reclaim the much-needed food potential of *striga*-infested lands.
Can developing market opportunities for dryland cereals and legumes support uptake of quality seed?

Crops such as millets, sorghum, groundnut, chickpea, pigeonpea and other grain legumes are important staple foods that are not only resilient to harsh weather conditions but are also healthy and packed with critical micronutrients required for our normal health and development. For example, gluten-free pearl millet is a good source of iron and zinc which help reduce anemia, a condition that is of high public health significance in most developing countries. Similarly, nitrogen-fixing legumes are not only excellent in improving soil fertility in a sustainable way and as sources of high-quality feed to livestock, but are also a major source of dietary protein in the diet of the poor in most parts of sub-Saharan Africa. They are considered the 'poor man's meat'.

These nutritious and climate-smart crops offer an alternative to the better-known (more popular) and supported staple crops like rice, maize and wheat, production of which has been declining as a result of pest attacks, diseases and changing weather patterns. If we are to meet the rising food demand due to population growth, it is necessary to increase the supply of diverse foods. Grain legumes and dryland cereals (GLDC) are critical to meeting this need.

So why is adoption of improved varieties of these crops still so low?

This is one of the key questions that experts from east Africa, west Africa, India and western countries deliberated on during a recent workshop in Nairobi. According to Dr Alastair Orr, a seed systems researcher, "One main reason for low adoption of these crops is the challenge of scaling up quality seed". His advice to the workshop attendees, who had met to develop a seed systems strategy for these important crops, was that they would need to address what he called four separate drivers of adoption – Awareness (creating demand for seed), Advantage (ensuring the seed meets farmers’ needs), Affordability (farmers ability to purchase seed) and Access (availability of seed when farmers need it).

Unprofitable business models for seed entrepreneurs and producers, poor policy support (low investment and complex regulations) and inconsistent demand for GLDC grain (weak markets for food and feed products) were identified as the main systemic bottlenecks blocking the scaling out of seeds of GLDC crops.
“The grain market will create a seed pull”, Dr Moses Siambi (ICRISAT Regional Director for Eastern and Southern Africa) argued in his remarks. “If we don’t find markets for the grain, the farmers will not invest in the seed. Grain markets will create the demand pull for improved seed by the smallholder farmer”.

What needs to be done?

There was a consensus that there is a need to redefine the seed systems business model and perhaps a lot more focus should be put on innovating around the markets for these crops.

Four strategic thrusts were identified as critical to unlock the bottlenecks hindering success of the GLDC value chains.

Enhancing market demand through diversified product development

With limited GLDC food and feed products in the markets globally, and the low global demand for the products due to low awareness (compared to wheat and maize products, for example), the market remains below the potential. There is a need to invest in R&D around food science and value addition to make a variety of products available for different market segments. Awareness creation and marketing of these products is key and will help stimulate a demand pull and open up markets for the GLDC grains, which will in turn provide a pull for quality seed. The Kenyan government has joined in the support of opening up markets for dryland cereals in the country. The Cabinet Secretary of Agriculture, Mr. Willy Bett, recently announced that the government would introduce a new policy to make it a requirement for millers to blend maize with millet, sorghum or cassava. “Through this initiative, we shall reduce the issue of malnutrition by two per cent annually and also give millet, sorghum or cassava farmers a chance to sell their produce,” he said.

Increasing access to dynamic market intelligence

There exist weak linkages between seed producers, marketers/distributors and users. This has led to lack of accurate data and information regarding seed and grain demand and supply making reliable forecasts for planning purposes difficult. There are now plans to establish structures for market intelligence to gather and share relevant information with all stakeholders. This will help increase efficiency in their business planning.

Enhancing market responsiveness through technology development.

To respond to the needs of the markets, it was agreed that it’s necessary to develop technologies that suit various needs. Market segmentation and targeting was the way to stimulate and enhance demand and supply of GLDC grain and seed. Development of hybrid materials was highlighted as crucial for both cereals and legumes. For cash crops like groundnuts, emphasis was laid on the need to segment markets not only into national, regional and international markets but also based on industry needs (oil, protein content) for confectionary, livestock feed, peanut butter, etc. uses. There is a need to document industry quality standards or industry needs and align variety release requirements.

To increase volumes of grain produced and reduce drudgery, it was suggested that variety attributes that also allow mechanization need to be developed. ICT was seen as crucial for structuring and optimizing the demand and supply chains, thus improving efficiency and compressing costs.

Lobbying and advocacy for systemic policy changes

Lack of support, low investment, complex regulations, lengthy processes and interference by governments were noted to considerably affect the success of the GLDC value chains. To unlock these bottlenecks, concerted efforts are needed to engage and seek support from various government institutions. Some of the suggested areas of intervention will include dealing with issues such as facilitation of seed trade, waiving registration fees for publicly developed varieties, introduction of quality assurance systems, use of TASAI (The African Seed Access Index) indicators for advocacy and monitoring progress, use of IT platforms for quality assurance, harmonization of regional seed policies and seed trade as well as pushing for policies to incentivize private sector investments.

The GLDC seed systems strategy development workshop which was organized by ICRISAT and its partners under the CRP GLDC program took place in Nairobi on November 30 and December 01, 2017. The workshop brought together more than 70 experts from 40 organizations representing farmers, private seed companies, governments, universities, NGOs, CGIAR, NARS and other research and development organizations.
Achieving better nutrition, one cookery class at a time

A recently published research paper reveals how technology, knowledge and effective communication can help to address dietary misconceptions and encourage better nutritional practices in rural settings. The paper reports on the success of the innovative methodology used for knowledge transfer (collective cooking) among women in rural communities in Mali during the An Be Jigi (‘Hope for All’ in Bambara) nutrition project. The intervention, driven primarily by women, resulted in a significant increase in adoption of the use of whole grain sorghum for food preparation, especially for young children.

When the An Be Jigi project began in 2006, women and children in the Koulikoro region of Mali suffered from malnutrition, low growth and anemia. Despite sorghum and millets – cereals rich in iron and zinc – being a significant component of the local diets, researchers found that uptake of these essential minerals was low because of the way the grains were cooked.

For example, to prepare a local dish Tô, women pounded the sorghum grains for decortication (removal of the seed coat). The women explained that decortication was considered essential as incompletely pounded grains were considered a sign of laziness on the part of the cook in their community. Decortication also imparted a wealthier status to the family. Unfortunately, the removal of bran also resulted in about 50% loss of iron and zinc.

To solve this issue, the project team developed alternative methods of cooking whole grain sorghum (without pounding out the bran): soaking and drying the grains before grinding in a mill. They also created new recipes that used the flour obtained by this method. For spreading these ideas among the main stakeholders of community nutrition – the women (especially young mothers) – the team conducted group cooking (cuisines collectives) sessions to teach women the recipes and discuss child nutrition and hygiene issues. Several remarkable women came forward to become nutrition leaders in their regions, conducting workshops and information sessions. They explained that using whole grain not only increased the nutritive value of their food, it also freed up the time that the women would otherwise spend pounding the grain in a mortar and pestle.

Aminata Sanogo and Assa Kayentoo are two such nutrition leaders who use the local idiom to explain the science behind nutrition, growth and health. To make an impact on a largely illiterate audience, they use pictures, drawings and examples drawn from day-to-day life (“Proteins are essential – like the bricks to build a house”).

During these sessions, apart from learning new, wholesome recipes, women could also discuss among themselves other problems and difficulties. This led to greater understanding of the workings of rural communities, the roles played by women in the family and the age-old perceptions associated with food. A post-project survey in 2015 revealed practical problems faced by the rural women in including whole grain in their diets,
such as not having a flour mill close by for grinding the whole grain sorghum into flour, and having to depend on men to drive them to the mill.

Nevertheless, the work done by An Be Jigi has resulted in a significant increase in the consumption of whole grain sorghum in the region, especially among young children. The above-mentioned paper about the study, conducted after conclusion of the project, revealed that over 71% of the women were feeding whole grain to their children at least every other day. About 56% of families were having whole grain diets every day.

By reaching out to the women in novel ways and digging deep to understand their motivations for adopting certain cooking practices, An Be Jigi researchers have broken new ground in social science research. They have shown that knowledge and technology sharing reaps richer rewards with a cultural understanding of the local milieu.

Mothers in the Koulikoro region of Mali are leading by example to create a more capable younger generation. While some challenges still exist – removing gender-based distinctions on activities (e.g. riding motorbikes) – women like Aminata, Assa and others have contributed immensely to changing the mindsets and practices of villagers in Mali, giving the children a solid base for a stronger, healthier adulthood.
Telangana tribal farmers learn new ways through exposure visits and study tours

Realizing the need for tribal farmers to adopt new technologies in agriculture and to improve their incomes, the Tribal Cooperative Finance Corporation Limited (TRICOR) of the Tribal Welfare Department, Government of Telangana, has joined hands with ICRISAT to organize exposure visits-cum-study tours for tribal farmers in Telangana.

The visits will give 500 farmers a chance to learn about innovative farming techniques, develop marketing strategies for their produce, and enhance their knowledge. To be held over a period of one year, the program will conduct training in 20 batches, with each farmer receiving training over six days. While batches will be organized along identified themes like agriculture, horticulture, floriculture, vegetable cultivation, livestock and poultry, fisheries, and dairy, the program’s focus will be on innovative and sustainable farming, training on marketing strategies, exchange of local farming concepts, and basic knowledge on harvest processing and preservation. Farmers will also be taught about drip irrigation techniques across the globe.

The first batch of the program was inaugurated on 4 December 2017 at ICRISAT, Patancheru, in the presence of Mr Thati Venkateshwarlu, MLA (Aswaraopet) and Chair of the Tribal Welfare Department, Telangana; Shri Shankara Rao, DGM (A&P), TRICOR; Shri Lakshmi Prasad, State Mission Manager, TRICOR; and Ms Sandhya Rani, Asst. Director (Horticulture), Tribal Welfare Department.

Dr Kiran K Sharma, CEO of the Agribusiness and Innovation Platform (AIP) of ICRISAT, and Mr S Aravazhi, COO of the Innovations and Partnership (INP) program at AIP-ICRISAT also welcomed the participants.

At the inauguration, Mr Venkateshwarlu spoke on the need to adopt new farming techniques, and the benefits of growing millets for farmers. He encouraged farmers in the first batch to use the program to learn new techniques and help build a better Telangana by educating other farmers on their return. He also mentioned the Telangana government’s efforts towards supporting farmers through various irrigation projects to facilitate cropping round the year.

Speaking at the event, Dr Sharma stressed the need to link farmers to markets to improve incomes. He encouraged farmers to adopt new technologies and inputs for better yields, and turn to entrepreneurship in agriculture by adopting effective post-harvest technologies. He also stressed the need for public and private entities to readily integrate other sectors like IT into agriculture for better results.

Mr Aravazhi said that through its Technical Support cell (TSC), AIP of ICRISAT would extend its support to the participating farmers for a year and a half after the duration of training. Participating farmers can return to ICRISAT for any queries or help towards the implementation of learnings from the program.
ICRISAT in the Media

ICRISAT’s collaboration with Microsoft in building the Sowing App, that helps farmers plan their sowing/harvesting activities easily and effectively, has been catching media attention worldwide.

Our cloud momentum faster than anticipated

Microsoft investing in hybrid, intelligent and trusted cloud

Microsoft is eyeing digital transformation opportunities worth $100 billion in India in the next few years said Anant Maheshwari, president, Microsoft Corp (India). The world’s largest software maker, which competes with Amazon and Google in the cloud services space, is driving this digital transformation using technologies like artificial intelligence and cloud computing for applications ranging from helping farmers to increase crop yields to supporting doctors provide better diagnosis and a cure for diseases, he said.

Microsoft builds AI-powered Sowing App to help farmers in India

Microsoft India recently showcased several projects that make use of the company’s cloud-based artificial intelligence, cognitive services and Internet of Things (IoT) technologies that can change the way citizens, enterprises and governments engage in healthcare services, agricultural practices, education and everyday work.

Here’s how Microsoft AI is helping Indian farmers increase crop yields

New technologies such as Artificial Intelligence (AI), Cloud Machine Learning, Satellite Imagery and advanced analytics are helping small farmers in India to increase their income through higher crop yield and greater price control, Microsoft India said.

In a few dozen villages in Telangana, Maharashtra and Madhya Pradesh, farmers are receiving automated voice calls that tell them whether their cotton crops are at risk of a pest attack, based on weather conditions and crop stage.

Farming goes hi-tech with Artificial Intelligence

Here’s how Artificial Intelligence is going to change the way farming is done in the country. Right from sowing to harvesting and then to post-harvest help, the AI solutions promise informed inputs to farmers and other stakeholders in the ecosystem.

The solutions are going to give them heads up on the likelihood of rain, outbreak of diseases or attack of pests and on soil health condition. The information gathered from the field using satellite images and sensors on balloons would be juxtaposed with historical weather and other agronomic data to generate customised data for a specific farmer on a specific crop.
100 Voices on seed systems
The time taken to develop improved crop varieties has almost halved with the rapid strides made in genomics research and the last decade has seen the genomes of eight crops sequenced. This includes pearl millet and groundnut which are important for the nutrition and livelihoods of smallholder farmers in the drylands of sub-Saharan Africa and India. These achievements have emerged from the advanced genomics research being carried out at the Center of Excellence in Genomics (CEG) at ICRISAT.

Established in 2007, CEG is celebrating a decade of using modern genome analysis methods with the goal of delivering crop varieties (better adapted to poor soils, low rainfall, high climate variability and pest and diseases) that will help improve the livelihoods of smallholder farmers. CEG was set up in collaboration with the Department of Biotechnology (DBT), Government of India.

CEG has been recognized both nationally and internationally for its work in high-throughput molecular genotyping and phenotyping technologies, which have been made available to a wide range of public and private research institutes in India. The decoding of genetic information of important dryland crops led to the discovery of many new crop breeding tools like single nucleotide polymorphism (SNP) genetic markers for faster and more targeted crop improvement programs. CEG’s work has helped development of drought-tolerant or disease-resistant varieties of groundnut and chickpea, key to improving Indian smallholder farmers’ productivity and climate resilience.

Speaking at the international conference ‘Crop Genomics: Present & Future,’ organized to celebrate the anniversary, Chief Guest Mr YS Chowdary, Minister of State for Science & Technology and Earth Sciences, Government of India, said, “The work being done at CEG in decoding the genome information of dryland crops like chickpea, groundnut and pigeonpea will serve the national mission of Doubling Farmers’ Incomes.” He added, “We need to upscale such science and their applications to improve profitability for farmers and improve nutrition for farmers and consumers.”

Elaborating on the need for capacity building, the Minister said, “We need to go from 300 to 3000 students as we scale up the application of genomics in modern crop improvement to double farmer incomes.”

Dr David Bergvinson, Director General ICRISAT, said, “We have decoded the genome sequences of our mandate crops and demonstrated the utility of sequence information in crop improvement. This is the way of the future as we bring diverse disciplines and leading institutions around the globe together to address food and nutritional security. ICRISAT can serve as a hub to integrate traditional Systems Biology with a holistic framing based on a global network of institutions, connecting plant science with microbiome (soil, gut), nutrition, health and education.”

“We started this journey in 2007 with a grant from the DBT, Government of India, with an objective to provide marker genotyping services and train scientists in the area of molecular breeding. Now CEG has emerged as center for high-quality science, translational genomics and training at the international level,” said Dr Rajeev Varshney, Director,
CEG, and Research Program Director, Genetic Gains, at ICRISAT.

Working in close collaboration with scientists from ICRISAT and 184 partner institutes from 35 countries, the CEG has published over 350 research articles in high-impact journals. Apart from sequencing important crops, another important dimension of CEG is building the capacity of national partners from across the world with over 300 scientists trained in state-of-the-art crop breeding techniques. Scientists at CEG have been honored with more than 42 awards and fellowships for their contributions to agricultural sciences. Over 370 delegates from 139 institutes and 34 countries attended the three-day conference.
Introducing groundnut varieties more tolerant to rosette disease in Tanzania

A farmer amazed to see yield of Pendo at ARI, Naliendele.

Groundnut researchers are striving to introduce superior options to a popular early-maturing groundnut variety, Pendo (ICGMS 33), in Tanzania. Although Pendo has many strengths compared to other varieties, it is highly susceptible to rosette disease. Efforts are on, under the Tropical Legumes III project, to develop and disseminate varieties that overcome this limitation of Pendo.

- In 2013, varieties ICGV-SM 90704 and ICGV 12991 were crossed to introgress rosette resistance.
- Three rosette-tolerant varieties with individual improved traits: Naliendele 2009 (ICGV-SM 99555), which is early-maturing; Mangaka 2009 (ICGV-SM 99557), which has three kernels per pod; and Masasi 2009 (ICGV-SM 01721), which is bold seeded; have been released.
- Three varieties, primarily for use in the confectionary market: Narinut 2015 (ICGV-SM 01731), Kuchele 2015 (ICG 8326) and Nachi 2015 (ICGV-SM 90704) have been released, and are currently being multiplied as breeder seeds.
- The project is also promoting the improved varieties released from 2009 so as to replace Pendo.

Under the Tropical Legumes III project, several efforts have been made to improve existing popular varieties and introduce improved varieties suited to new threats and changing agro-climatic conditions. These efforts have helped improve overall groundnut production in Tanzania, as Figure 1 shows.

Pendo, released in 1998, was adopted in large numbers by Tanzanian farmers, outdoing other varieties such as Sawia, Red Mwitunde, Nyota and Johari. This popularity was owing to the fact that it was high-yielding (1.2-1.5 t/ha), early-maturing (90-100 days), easy to shell by hand, had large kernels, and adapted well to a wide range of groundnut-growing areas, including low-rainfall regions. Despite these, susceptibility to the rosette virus (known to cause up to 100% yield loss), and zero seed dormancy (causing yield loss if not harvested on time) were major limitations of the Pendo variety.

From the experience with Pendo over two phases of the Tropical Legumes project (II and III), it is easy to see how adoption of new technology is dependent on farmer preference in conjunction with market availability and communication. Keeping this in mind, researchers can gain important insights not only into adoption of new varieties, but also into the development of market linkages for both seed multiplication and production, and for increasing incomes for smallholder farmers.
Figure 1: Groundnut production in Tanzania (1998-2014).

Farmers at Lukuledi village, Masasi district, explain why they prefer Pendo.

This work contributes to UN Sustainable Development Goals.
Strengthening synergies between groundnut projects in Nigeria

Groundnut is acknowledged to be important to Nigeria’s economy – both commercially and nutritionally. The most commonly grown crop in Nigeria, the legume is an affordable source of protein, edible oil, and micronutrients to millions of small-scale farmers and farm families on the African continent. As a result, there are a number of development projects aimed at promoting the legume. In development landscapes, crowded with numerous actors, creating and strengthening synergies is a difficult but core requirement of project implementation. If well articulated, synergies can result in more efficient and effective program delivery.

While driving to further develop improved groundnut cultivars, researchers involved in the USAID-funded Groundnut Upscaling, and the Bill & Melinda Gates Foundation-funded Tropical Legumes – Phase 3 (TL III) projects are building on the momentum created by the Groundnut Value Chain project, in addition to earlier versions of the Tropical Legumes project in Nigeria.

Both projects are promoting the adoption of released groundnut varieties to a wide range of value chain actors, and putting in place sustainable seed systems, while contributing to the development of institutional and human capacities in the national agricultural research systems (NARS) of Nigeria.

While the TL III project is being implemented by plant breeders and cropping systems agronomists, the execution of the USAID Groundnut Upscaling project is led by a socio-economist and technology uptake specialist with skills in gender mainstreaming and project planning. On the ground, both projects benefit from the recurrent services of Focal Persons of the State Agricultural and Rural Development Authorities, who coordinate the efforts of farmer-contact agents in local government bodies of each state.

In this scenario, skills and experiences drive reciprocal dealings between the USAID Groundnut Upscaling and TL III projects. Since the main cropping season of 2016, concerted efforts between both projects are visible through a number of action points, notably:

- organization of two pre-season planning meetings with partners
- organization of three training workshops to close skill gaps identified during pre-season trainings
- establishment of 974 varietal demonstration plots for awareness (emphasis of TL III), and adoption (emphasis of USAID Groundnut Upscaling), including over 20 multi-location trials and nine technology validation trials
- preparation of a comprehensive variety release technical proposal
- facilitation of the production of all seed classes leading to 24 tons of breeder seeds, 80 tons of foundation seeds and 1,749 tons of certified seeds
- several planned and unplanned field visits/monitoring of the evolution of demonstration
- participation in numerous field days
- unrestricted exchange of information and discussions on the implications of the interventions of the two projects.
On each of these counts, experts from both projects have brought irreplaceable knowledge and skills on board. Their combined skill set and experiences are enhancing impacts beyond the institutional prescriptions of the two projects. Overall, awareness on all classes of improved groundnut varieties, the extent of their use (adoption), abilities of the actors engaged and sustainability of the seed system have all seen marked improvement. In other words, leveraging the skills, expertise and resources of both projects to work towards common goals is giving rise to enhanced project delivery – helping achieve better outcomes than if each of the projects worked independently.

Click here to read about similar work being done in Nigeria by ICRISAT.

**Project:** Increasing Groundnut Productivity of Smallholder farmers in Ghana, Mali and Nigeria (2015-2018); Tropical Legumes (TL III)

**Partners:** Institute for Agricultural Research/Ahmadu Bello University, Zaria (IAR/ABU), Centre for Dryland Agriculture/ Bayero University of Kano (CDA/BUK), National Agricultural Seeds Council (NASC), Federal University of Agriculture, Markudi (FUAM), Green Sahel Agricultural and Rural Development Initiative (GSARDI), Catholic Relief Service (CRS), Women Farmers Advancement Network (WOFAN), Agricultural Development Authorities/Projects of Jigawa, Kano, Katsina, Kebbi and Sokoto States.

**Funding:** United States Agency for International Development (USAID); Bill & Melinda Gates Foundation

**CRP:** Grain Legumes

This work contributes to UN Sustainable Development Goals
Science-policy dialog around future farming ‘scenarios’ for climate smart agriculture

Food on our plates, be it meat or pulses, rice or millets, and how and where it is produced can be a major driver of climate change adaptation. This is especially true in highly vulnerable farming systems in the rainfed drylands. Climate Smart Agriculture (CSA) aims at a ‘triple win’ from the transformation of agricultural and food systems: a more productive and profitable agriculture that ensures national and local food security, keeps adapting to a changing climate, and reduces its carbon footprint.

Designing climate smart agriculture at scale remains a challenge for both scientists and policy makers and there is often not enough convergence between CSA programs and large initiatives in natural resource management and food security. The 4th Global Science Conference on Climate Smart Agriculture, organized by the New Partnership for African Development (NEPAD), from the 28th to 30th November 2017 in Johannesburg, South Africa, looked at how interaction between scientists and policy makers can accelerate CSA uptake from local to national stage. As part of the international Agricultural Model Intercomparison and Improvement Project, the Crop Livestock Intensification Project (AgMIP CLIP) in Zimbabwe illustrated how researchers, decision makers, and practitioners could use ‘scenarios’ to trigger changes towards more sustainable farming.

Lessons learned from the Crop Livestock Intensification Project

Tool to upscale climate smart policies: How can decision makers be certain that investing in a certain sustainability pathway – for example, expanding food and feed legumes – is more worthwhile in the long run, as compared to business-as-usual or fast economic growth pathways such as high input and carbon footprint farming systems?

Investing in CSA can quickly improve the lives of the poorest while building a more food secure future: Evaluated integrated interventions (technologies, institutions, policies) were able to double groundnut yields and triple net returns of the poorest farms in a few years (Figure 1), making them less vulnerable to climate variability and shocks.
In the long term, investments in sustainability pathways can reduce vulnerability and halve poverty by 2050 (Figure 2). Research showed that sustainability pathways support both poverty reduction and positive outcomes in gender, food security and nutrition. Greater impacts are observed for the extremely poor; adoption of forage legume crops helped small herders compensate for the negative effects of climate change on rangeland production but were often not enough for those with large herds who experienced higher feed gap risks, thus requiring supplementary feeding practices.

![Figure 1: Short-term gains from improving practices today](Source: AgMIP information brief).

Science and policy dialog for faster and effective development outcome using tools and approaches from a global climate science initiative (AgMIP), and the co-design of future scenarios by researchers, local experts (including farmers and practitioners) and policy makers, brings both credibility and local ownership. The project was able to simulate out-of-the-box but feasible transformative interventions across diverse farming systems, and looked at various cross-cutting issues like gender or conflict prevention over common resources.

This participatory scenario development approach can help not only agricultural production but also present a broader perspective on food systems and social issues, and provide clues to greater carbon sequestration. It can illustrate trade-offs between biodiversity, farm revenues and off-farm employment, and set priorities for changes that favor diversity, community wellbeing and poverty reduction. Not only can scenario development help create important linkages between diverse insights, the approach also reinforces the dialog between scientists, policy makers and stakeholders, providing valuable feedback also to understand why some CSA interventions, promising when modelled, do not take off. Thus, a new way of bridging science and policy should focus on joint and collaborative work to design, analyze and implement interventions and not only on relaying information.

**Legumes innovations in Zimbabwe pave the way towards climate smart farming.**

The case from Zimbabwe showed how discussion around desirable trajectories and impact assessments of different scenarios helps encourage participation of all key stakeholders and initiate necessary policy changes to upscale chosen interventions.

Through innovation platforms and climate modelling work, ICRISAT researchers have convinced partners and decision-makers that investing in tropical legumes is climate smart. Groundnuts, being more climate resilient than cereals, have been identified as a key CSA crop. A profitable and ‘women’s crop’, groundnuts improve family nutrition and food security. ICRISAT has since launched a groundnut...
The incorporation of legume forages like mucuna not only reduce the feed gap under climate change, but also provides vulnerable farmers high-quality feed for livestock, thereby enhancing the profitability of livestock value chains. Furthermore, these forages enrich soil with organic matter and reduce crop pests, enabling more stable crop yields and higher carbon sequestration. Enhancing on-farm feed production also reduces conflicts over rangeland(s) as animals graze closer to home. While three years back, promoting mucuna was seen with skepticism, the technology has now been scaled out to more than 90,000 farmers, with private sector actors promoting seed multiplication.

The use of scenarios in building sustainability pathways goes beyond agriculture to answer bigger questions; what food systems do we want now and in 50 years, and what is the role of agriculture in our society? Working on sustainability pathways is not to turn farming more profitable by any means, but to create sustainable grounds that can nourish and provide wellbeing to our grandchildren.

Such debate could take place in a national conference to be organized in Zimbabwe, that will present a case for sustainability transitions, and how these may be embedded in national and local decision-making processes more effectively.

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Breathing life into dying soils in harsh landscapes of the Ethiopian Highlands

As the Global Landscapes Forum – the world’s largest science-led platform on sustainable land use – begins on December 19 in Bonn, Germany, ICRISAT research in Ethiopia shows how crop yields can be doubled in degraded soils while reducing fertilizer wastage through precision soil fertilization.

Ethiopia, a land of farming contrasts, exports high quality coffee beans from its highlands but has millions of small drylands farmers in regions like Afar or Tigray with meagre crop harvests as they suffer recurrent droughts and widespread soil degradation. In sub-Saharan Africa, agronomists blame poor soil fertility as one (if not the first) limiting factor of farming. Yet, the use of fertilizer is sparse with less than 10 kg fertilizer per hectare compared to 200 to 300 kg in Europe. This decline of soil fertility costs Ethiopia 3% of its GDP (Bojo & Cossells, 1995). For years, crop scientists have been underlining the need to replenish soils to improve Ethiopian food potential.

Low crop response to fertilizers prompts the studies

Since the 1970s, the Ethiopian government has invested in fighting against soil erosion through community-based watershed programs and restoring soil health. Recently, they undertook a very ambitious soil fertility program, with nation-wide soil testing and mapping, producing district-level soil maps showing essential soil nutrient deficiencies. With this soil fertility atlas, Ethiopian agricultural services produced district-level soil fertility recommendations while five fertilizer blending factories across the country could supply specific fertilization packages according to the recommendations. Despite this massive public support, crop yield gains have been modest. As landscape and farming systems could vary a lot across each district, the need for fine tuning recommendations was identified following feedback from farmers and regional governments. Research organizations and development NGOs were consulted. In this context ICRISAT conducted two studies in two wheat-based farming systems in the highlands of Lemo and Endamohoni districts with the support of the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), the German development agency and Africa Rising.

Based on the results of more than 600 farmers’ field experiments, ICRISAT scientist Dr Tilahun Amede says that there is potential for doubling crop yields if location-specific nutrient management is practiced depending on the landscape position of farms and the cropping system.

Fine tuning fertilization recommendations

Studies show that precision fertilization improves on-farm productivity and resilience. Crop yields increased by 45-200% with targeted fertilizer use and the right agronomic practices while fertilizer wastage was reduced by 20-80%. Soil health was improved through water conservation efforts, organic amendments and the right dosage of fertilizer. Research shows also that grain quality improved with the application of micronutrients like Sulfur and Zinc.

Site-specific nutrient management is important in the Ethiopian Highlands as the terrain and soil fertility varies widely within and between farms.
These results were obtained in regions where centuries of nutrient mining had resulted in severe and eroded soils that produce 40% less than the global average. Yields in farmers’ fields in Lemo and Endamohoni are three times lesser than what is recorded in research fields.

**Approach adopted to fine tune recommendations for farmers**

More than 600 on-farm and on-station field experiments, testing on different landscapes various fertilizer combinations of Nitrogen (N), Phosphorus (P), Potassium (K), Sulfur (S) and Zinc (Zn) with different ratios were conducted in six wheat belts. ICRISAT capitalized on earlier attempts by Agricultural Transformation Agency (ATA-Ethiopia) and other stakeholders.

Homogeneous cropping management zones were identified and categorized as hillslopes, midslopes and footslopes based on the degree of slope, soil fertility, water-holding capacity and other parameters.

**Development of ‘Decision Support Tools’**

**GIS-based analysis** was used to interpolate potential niches of the respective response level.

**Agronomic practices recommended for both sites included:**

**Soil and water conservation structures:** Building soil bund/terrace to ensure that the soil, seed and fertilizer are not washed away.

**Integrated soil fertility management:** Application of chemical fertilizers with organic amendments and other technologies.

**Split application of urea:** To minimize nitrogen loss and increase fertilizer use efficiency, about one-third of urea should be applied at planting; the remaining two-thirds should be applied at 40-45 days after planting.

**Weeding:** At least twice per cropping season. It could be done first at the time of split application of urea at 40-45 days after sowing and second a week before flowering.

**Sowing in a row:** For proper input placement and weeding.

**Use of high-yielding and adapting wheat varieties:** To facilitate increased yields.

**Soil amendment to decrease acidity:** Application of lime was advised.

The above recommendations are also suitable for barley, sorghum and millets.

**Decision guide for fertilizer application**

In general, fertilizer response was higher in the footslopes and midslopes hence greater fertilizer requirement. Expected yields were in the range of 8.0-4.5 t/ha and 4.5-2.5t/ha for footslopes and midslopes respectively. The hillslopes had an expected yield of 2.5-1.5 t/ha and were advised lesser fertilizer. In areas that had yields less the 1.5 t/ha fertilizer application was not recommended and advised lesser fertilizer. In areas that had yields less the 1.5 t/ha fertilizer application was not recommended and application of organic amendments was encouraged. Legumes as precursor crops were recommended for better yield of succeeding crops.

The above recommendations of right fertilizer dosage combined with good agronomic practices gave farmers a yield increment that was more than double.

For further information:

*Photo: T. Amede, ICRISAT*

A test farm situated on a midslope in Endamohoni district, Ethiopia.

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