



The story of N2Africa

PUTTING NITROGEN FIXATION TO WORK
FOR SMALLHOLDER FARMERS IN AFRICA



A flavour of the excitement
and the richness of learning from N2Africa



**Nitrogen-fixing soybeans
and nitrogen-deficient
maize.** PHOTO: KEN GILLER

The core focus of N2Africa is

$$(G_L \times G_R) \times E \times M$$


Ken Giller in conversation with Peter Ebanyat in an N2Africa demonstration field, Zimbabwe. PHOTO: MINKE STADLER

N2Africa was launched ten years ago in 2009. It was the first project funded by the Bill & Melinda Gates Foundation that focused on crop management. Up to that date the Foundation's projects were largely based around crop breeding and biotechnology, or on markets and fertilizer supply.

To build on their earlier work, we started with the best grain legume varieties the breeders had available – but we needed to match these with the best rhizobium strains available. These needed to be tailored to the diversity of environments and farming systems across the countries where N2Africa would be working. All the earlier research indicated that good agronomic management was key to achieving good legume yields.

So we had the legume genotype (G_L) interacting with the rhizobium genotype (G_R), tailored to the environment (E) with a focus on best management (M). This became the core focus of N2Africa: $(G_L \times G_R) \times E \times M$.

Our vision from the very start was to *Put nitrogen fixation to work for smallholder farmers in Africa* – putting the very best technologies available into the hands of farmers and to learn by doing. The main research question was “What works where, when, why and for whom?” We addressed it by testing technologies, working with thousands of farmers. Closely monitoring and analysing outcomes, and

combining fundamental and applied research, allowed us to work along the technology pipeline. We were continuously looking to improve technologies and to refine our approach.

Along the way, we have collected a huge amount of information that is available in many forms of extension materials, newsletters, videos, radio programmes, project reports, and MSc and PhD theses. However, there was no one place where we had an overview of everything N2Africa has done. This collection of articles fills that void and gives a flavour of the excitement and the richness of learning from N2Africa.

Our funding from the Bill & Melinda Gates Foundation ended in June 2019, but much still remains to be done. We would like to thank the foundation for putting faith in us. N2Africa became a major part of the lives of many farmers, extension workers, scientists and others involved in rural development. We thank all of our partners for their collaboration and commitment that means that activities initiated through N2Africa continue in many forms.

Ken Giller

Wageningen University and Research

Bernard Vanlauwe & Fred Kanampiu

International Institute for Tropical Agriculture



PHOTO: KEN GILLER



1. INTRODUCTION

- 8 'In the end, it's all about the farmers' - Interview with Ken Giller
- 14 The N2Africa approach
- 16 Learning loops in practice - Interview with Theresa Ampadu-Boakye
- 18 Lessons learned: N2Africa is a cog in the wheel

2. PARTNERSHIPS AND ALLIANCES

- 22 The win-win-win of public-private partnerships - Interview with Edward Baars
- 28 The many shapes a PPP can take
- 32 The success of the Pawe PPP
- 34 The Legume Alliance
- 38 A fertile cooperation with Palladium
- 42 Personal story: A journey from unemployed to successful business owner
- 44 Lessons learned: Long-lasting PPPs



3. ADVANCES IN RESEARCH ON RHIZO BIOLOGY AND AGRONOMY

- 48 The effects of inoculants and nutrients
- 52 Understanding variability in yield
- 56 To grow beans, you have to own a cow
- 60 Personal story: Battling to form nodules
- 62 Lessons learned: The need for inoculation and nutrients

4. DISSEMINATION OF KNOWLEDGE

- 66 'Farmers believe it when they see it and understand it when they do it'
- 70 A wealth of information materials
- 74 Personal story: 'Everybody was looking for this new variety'
- 76 Lessons learned: Training and inspiration

5. ACCESS TO INPUTS

- 80 High-quality seed: diffusion at the grass roots level
- 84 Inoculants: a boost in awareness and availability
- 88 Fertilizers: a higher yield with the perfect blend

- 92 Running a farm with a mobile phone
- 96 Personal story: 'With the seed business I built a new house'
- 98 Lessons learned: Matching supply and demand

6. OUTPUT MARKET ACCESS

- 102 Challenges for soyabean farmers
- 106 Every legume its own approach
- 110 Personal story: 'The yields of soyabeans I get are extraordinary'
- 112 Lessons learned: Tailored approaches

7. EMPOWERING WOMEN TO INCREASE BENEFITS FROM LEGUME PRODUCTION

- 116 A nutrition boost thanks to soyabeans
- 120 Harvesting nutrition
- 124 Personal story: 'Agriculture has become a genuine business enterprise for women'
- 126 Lessons learned: Involving women is key
- 128 N2Africa partners
- 130 Acknowledgements



PHOTO: ISAAC CHABATA



INTERVIEW KEN GILLER

‘In the end, it’s all about the farmers’

Over the past ten years, N2Africa has helped smallholders in Africa towards a better future: higher yields, better access to quality seeds and a healthier diet. N2Africa has achieved a lot, but the work is far from done, says project leader Ken Giller. “All farmers deserve the opportunity to improve their food security and economic position.”

In 2007, Ken Giller, a professor of Plant Production Systems at Wageningen University & Research (WUR), was at a congress in Arusha (northern Tanzania) to give a lecture about soil fertility and the problems in the production of legumes.

For more than 35 years, the British professor has been fascinated by the problems faced by smallholders in developing countries. He worked earlier in Asia and Latin

‘Legumes can fix nitrogen from the air in symbiosis with rhizobial bacteria, truly one of the most amazing biological processes’

America before focusing for the past 30 years on Africa south of the Sahara. Before joining WUR, Giller spent several years as a professor at the University of Zimbabwe in Harare.

After his speech, a member of the audience approached him and asked if he remembered her.

“It turned out I had taught her during her MSc at the University of London some 20 years before,” says Giller. “She remembered me as a young teacher enthusiastically lecturing on nitrogen fixation in legumes.” Giller’s former student was working for the Bill & Melinda Gates Foundation as a senior project manager.

“We talked for a long time about what nitrogen fixation could do for smallholders in Africa.”

The conversation was the start of a two-year process in which Ken Giller worked with many researchers from Africa and elsewhere to identify

priorities. They wrote a plan together that eventually became N2Africa.

Over the past ten years N2Africa has received USD 52 million from the Bill & Melinda Gates Foundation, the largest grant ever for WUR. N2Africa ended in 2019 and several evaluation reports are currently underway.





Prof. Ken Giller at a climbing bean trial at Selian Research Station, northern Tanzania.

PHOTO: GLORIANA NDIBALEMA

Ken Giller photographing common bean plants in the West Usambara region, Tanzania.

PHOTO: RIK SCHUILING



KEN GILLER

1956 Born in Blaby, near Leicester, UK

1975-1978 BSc in Botany, Sheffield University

1978-1982 PhD in Plant Ecology, Sheffield University

1982-1986 Researcher at Rothamsted Experimental Station, working at the institutes ICRISAT

in India and CIAT in Colombia

1986 Lecturer in Tropical Soil Science at Wye College, University of London

1996 Personal Professor in Tropical Soil Fertility at Wye College

1998 Professor of Soil Science, University of Zimbabwe, Harare

2001 Professor of Plant Production Systems, Wageningen University & Research

What exactly is N2Africa all about?

"N2Africa is a long-term development and research project with the aim of improving the quality and yields of grain legume crops and thereby strengthening the economic position of smallholder farmers.

"The unique thing about legumes is that they can fix nitrogen from the air in symbiosis with rhizobial bacteria, truly one of the most amazing biological processes! Nitrogen is needed for the growth and development of all crops. More fixed nitrogen means better yields.

"We investigate how we can boost nitrogen fixation to improve the production and quality of grain legumes such as beans, groundnuts, soyabeans and chickpeas. Legumes are rich in protein, minerals and vitamins and are therefore an important food for human nutrition.

"Growing the legumes improves soil fertility and increases yields of crops grown after the legume such as maize. And as harvests improve, so does the economic situation of the small farmers, through sales in markets."

Was this a dream come true for you as a researcher?

"I've been intrigued by the ingenious biochemical system of the nitrogen-fixing symbiosis between legumes and rhizobia all my scientific life. I actually had the title of the project in my head for years: N2Africa - Putting nitrogen fixation to work for smallholder farmers in Africa.

"It's important for me that my work has added value. And I saw that my research on this subject could do so much for smallholders in Africa. And then this grant came along from the Bill & Melinda Gates Foundation. That was when I was able to give my



life's work that added value. It was truly a 'once in a lifetime' opportunity."

How did you proceed?

"We first carried out an intensive analysis of the eleven countries in sub-Saharan Africa in terms of the climate and soil conditions, in relation to the type of legumes to be cultivated, population density and infrastructure in rural areas. And, of course, we looked at whether markets were accessible for farmers.

"We sought cooperation with local partners and set up information campaigns, gave courses in rural areas on how inoculants work, how to use them and how to sow in the right way. And together with farmers, we created thousands of legume test plots so that we could work with them to find out which seed varieties – in combination with inoculants and sometimes specific fertilizers – gave the best results in terms of yield and quality.

"In each of the eleven countries, we worked



Women winnowing soya-beans in North Kivu, DRC.

PHOTO: KEN GILLER

with at least thirty organizations in public-private partnerships – researchers, government representatives, cooperatives, seed and inoculant producers, advisers and NGOs and national and international research institutions such as the International

‘The grant from the Bill & Melinda Gates Foundation was a ‘once in a lifetime’ opportunity’

Institute for Tropical Agriculture (IITA). In the end, it was (and still is) about the farmers. In total, we have now reached more than 660,000 farmers, and those partnerships have been crucial in achieving this.”

So not only farmers benefited from N2Africa. Supply companies such as seed breeders and inoculant developers also earned money from this project?

“Well, it was important for us not to give

everything away for free to farmers. They had to invest themselves, because that’s how you make lasting changes. In the first years we gave demonstrations to show what the effect of inoculants was when combined with good seeds. You have to remember that those farmers had never heard of inoculants before. We’re talking about poor farmers who in some countries had hardly any education. They also had little financial leeway. So you understand they’re not going to buy something they don’t know. We were able to use the demonstrations to show that inoculants generate higher yields.”

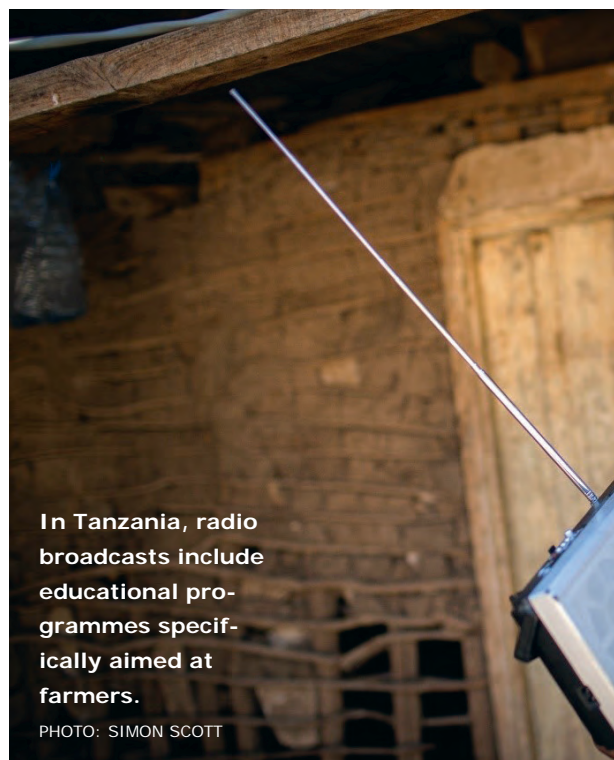
You’ve reached 660,000 farmers – that’s an impressive number. How do you reach the ones with small businesses in remote areas?

“In northern Ghana, for instance, we worked with people we refer to as ‘lead farmers’. These are farmers who we’ve trained in applying inoculants and good agricultural



Women carrying the bean harvest home, DRC.

PHOTO: KEN GILLER



In Tanzania, radio broadcasts include educational programmes specifically aimed at farmers.

PHOTO: SIMON SCOTT

practice. These lead farmers pass on their knowledge to other farmers.

“In Tanzania, we worked together with a consortium of partners such as Farm Radio International, which broadcasts educational programmes aimed specifically at farmers. In agro-dealer shops, we put up posters with information and we trained the shopkeepers so that they could advise farmers on the use of inoculants and fertilizers.

“In Ethiopia, smallholder farmers are often members of cooperatives. The farmers are well organized there. It is then easy to

farmers led to increases in legume consumption by the family – which did not happen through extension with the male family members. N2Africa received a prize for this work in 2013.”

Now, after ten years, the N2Africa project is coming to an end. Does it feel like all the work is done, too? Or is there still plenty to do?

“Yes, there are more than enough things that need to be improved. Two things come to mind immediately.

“We have shown that improving legume production and soil fertility results in higher yields for farmers. But the spread of that knowledge and the availability of inoculant, good seeds and specific fertilizers are not happening fast enough. We mustn’t underestimate how difficult it is to set up a functioning value chain.

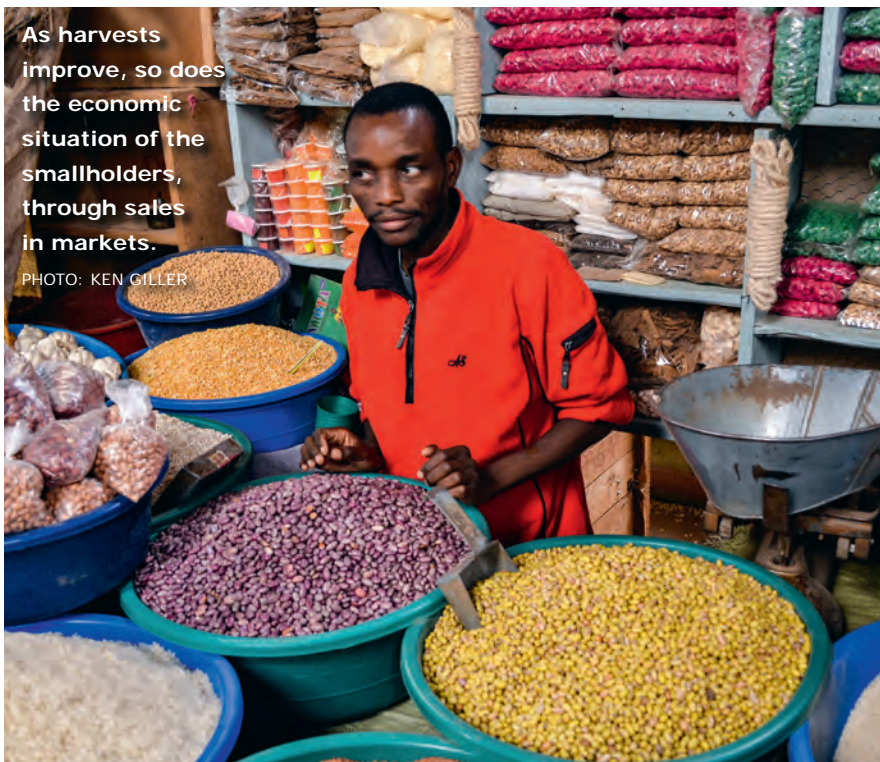
“In every rural district in Africa, there are some thirty or forty thousand farmers. So we’re talking about millions of farmers in total! You need information campaigns for the millions who are not well-educated, with few resources to invest. The roads are often bad and (as I said earlier) the availability of inputs hasn’t yet been sorted. That’s what we really need to focus on now, so that every farmer has the opportunity to improve their food security and economic position. “And I’m worried about the rate of devel-

‘We mustn’t underestimate how difficult it is to set up a functioning value chain’

reach a large group at once, since the farmers meet regularly.”

Women’s empowerment received special attention within N2Africa. Why?

“Women often do the heavy work, such as weeding by hand and grinding corn, as well as being responsible for the home. In addition they usually grow food on a piece of land for their own consumption and take care of the children. So relieving the burden on women by using herbicides and post-harvest mechanisation, for example, is also an important aspect of the project. “We found that direct extension with women



As harvests improve, so does the economic situation of the smallholders, through sales in markets.

PHOTO: KEN GILLER

opment in the rural areas. I see that governments are mainly investing in urban centres. So what we need to do is to convince governments of the importance of developing sound policies for small-scale agriculture in rural areas and assist them in doing so. This is important not only for these countries but (I would venture to say) also for the whole world.

"I work on the Sustainable Development Goals with the Sustainable Development

Solutions Network. One of the key goals is that there will be no more malnutrition and hunger by 2030. I know that 820 million people are still suffering from malnutrition at this moment. Zero hunger is an ambitious plan. With N2Africa, I believe we have made a small contribution to achieving this."



ABOUT RHIZOBIA AND NITROGEN FIXATION

Every organism needs nitrogen for growth and development. It is the basis of amino acids that in turn are the building blocks of proteins and it is also present in DNA. Nitrogen gas makes up 79 per cent of the air around us but cannot be used directly by most crops. There are nitrogen fertilizers made from nitrogen gas, but this is an energy-expensive chemical process.

Among our crops, only legumes are capable of converting nitrogen from the air into compounds that are useful for them. They do this in symbiosis with root-nodulating bacteria known as rhizobia (from rhizo = root + bio = living).

Roots form nodules that are full of rhizobia. The plant feeds the bacteria with energy in the form of organic acids; the bacteria convert nitrogen from the air into ammonium that the plants use to make amino acids in the root nodules.



Soyabean nodules.

PHOTO: KEN GILLER

Each legume crop needs a specific type of rhizobium and these are often not present or not abundant in the soil where the legume is to be grown. To help the legume crop grow, rhizobia are introduced or 'inoculated' onto the legume seeds. Rhizobial inoculants consist

of a carrier, usually peat, which protects the bacteria. Seeds of legumes are inoculated by gently turning them in the inoculum. The inoculated seeds are then planted, carrying the rhizobia with them into the soil.

The N2Africa approach

Successful legume yields and biological nitrogen fixation depend on the interaction between a legume, a rhizobium strain, the environment and farm management. That is the core concept of N2Africa. But how could this concept be put to work?

A lot of effort has been put into developing new legume varieties for African countries. However, smallholders are not always able to realize the full benefits of these new legume varieties because they are faced with nutrient deficiencies, drought, weeds or pests and diseases. Successful legume yields and biological nitrogen fixation require the right combination of a legume variety and rhizobium strain, with the right environmental and management factors. This concept became the core of N2Africa.

All N2Africa activities were embedded in an approach that embraces the wide diversity of farming systems

N2Africa worked in two phases. In the first phase of the project (2010-2014), the researchers provided a 'proof of concept' by showing significant legume yield increases and household benefits across all regions with many farmers. The results from this phase also showed that the management factor accounted for up to 90 per cent of the legume yield gap.

FARMING SYSTEMS ANALYSIS

Crop management cannot only be considered at the field level: it is related to decision-making and resource allocation

at the level of the whole farm. All N2Africa activities were therefore embedded in a (farming) systems approach. This approach recognizes and embraces the wide diversity of farms and farming systems. This diversity has implications for the different possibilities that farmers have for the cultivation of legumes on their farm.

For instance, farming households with sufficient land and labour benefit most from value-chain, market-led approaches that allow them to sell the extra produce resulting from yield increases. Poorer, often female-headed, households instead tend to benefit from the opportunities that grain legumes offer for intensifying production on small farms and processing legumes into nutritious food for the household. Different types of farmers may therefore be interested in different legumes or management practices.

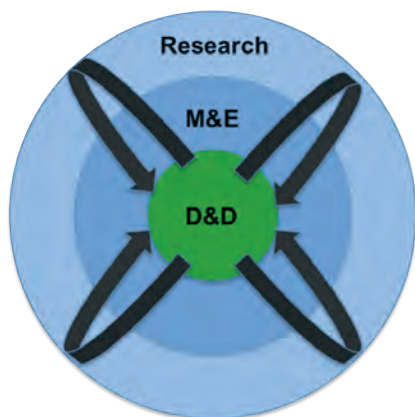
LEARNING LOOPS

N2Africa made use of an innovative 'Development to Research' model where the large-scale Delivery and Dissemination (D&D) campaigns of the improved legume techniques were combined with strong feedback from Monitoring and Evaluation (M&E), to provide the basis for 'feedback learning loops'. These learning loops drove the Research component of the project: how to

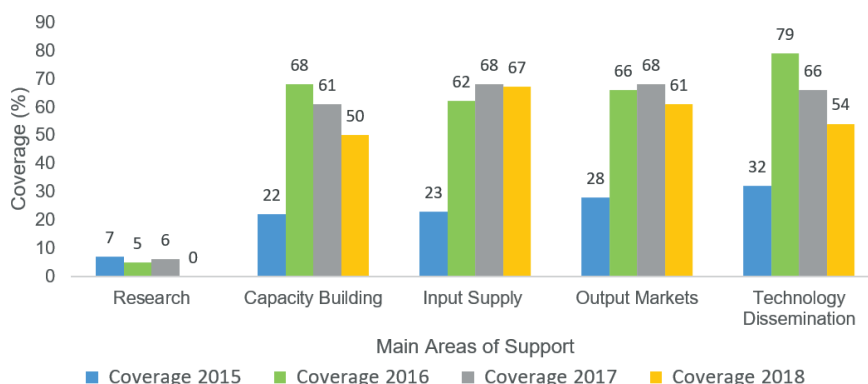


The farmer Peter Mukwenya showing off his common bean varieties in Zimbabwe.

PHOTO: ISAAC CHABATA



The 'Development to Research' model of N2Africa.



Over time the majority of partnerships supported capacity building, input and output markets and technology dissemination, with only few strategic research partners.

tailor the technologies that were disseminated to the needs of a diversity of farmers.

The 'learning pathways' led to best-fit recommendations. In most cases, recommendations were the result of the agronomic performance of varieties and technologies in demonstration trials, in combination with feedback from farmers. This feedback was either given on field days at demonstration trials and/or in survey evaluations.

Other information sources were results from agronomic trials to diagnose the response to different nutrients, adaptation trials in which farmers planted on their own fields, or government and private sector partners who had developed and introduced a new variety, fertilizer blend or inoculant. The best-fit recommendations for different legumes, countries and regions remain available for the use of future projects in a Recommendation Tool [see page 73].

Learning loops in practice

Theresa Ampadu-Boakye, Monitor & Evaluation (M&E) coordinator at N2Africa, tells how the learning pathways that were captured from the 'Development to Research model' functioned in practice.

The contributions of the M&E data and the learning loops to the dissemination and delivery (D&D) of technologies were based on three key questions: How will we ensure that the delivery and dissemination models worked at scale? Was the scaling up process on track? How will we use information to maintain support from partners?

"An important goal of the second phase of N2Africa was to increase the effectiveness and timeliness of the feedback mechanisms through enhanced use of innovative data collection tools," says Theresa Ampa-

Farming households with sufficient land and labour benefit most from market-led approaches

du-Boakye. "For instance, we used Open Data Kit software for collecting most of our data in the field. The M&E data collected was the basis for country-level planning on a yearly basis, ensuring targets were met and adjustments made where necessary.

Implementation strategies were revised when targets were not met."

Change of strategy

"An example of the use of M&E data and feedback was the change in strategy by most countries in 2015 on access to inputs. The data we had collected indicated that the project was far from achieving its targets for inputs being used by farmers. An outlook for the project during the 2016 planning was to ensure a change in strategy for the countries, namely to include more private-sector participation to drive the input models. This resulted in more focused strategies on access to inputs within most partnerships in 2016 and a resultant increase in use of inputs of between 10 per cent and 30 per cent in 2016.

"We also evaluated various dissemination approaches such as radio, demonstrations, leaflets and video. The number of farmers reached and the feedback from farmers on their preferences for approaches as learning platforms were then used for assessment. Country teams discussed the results as part of the planning process with partners, and



Women’s group providing feedback on how they share extension information in Ariziem village, northern Ghana.

PHOTO: EVA THUIJSMAN



Demonstration of the use of tablets in Nigeria.

PHOTO: N2AFRICA



Theresa Ampadu-Boakye, Monitor & Evaluation coordinator at N2Africa. PHOTO: DAVID NGOME, IITA

revisions were made to the dissemination approaches where necessary.”

A reflection platform and evaluation meetings

“The N2Africa project team also introduced biannual evaluation meetings and organized – at the country level – a reflection platform and annual planning meetings with partners. We reviewed and revised strategies every mid-year and this helped to adjust the initial targets and strategies before the end of the year.

“The M&E and the learning loops were therefore the driving forces behind D&D – so to say – and ensured constant feedback as well as addressing lapses in strategies and results. Though the design and implementation of such a system has its own challenges like partner commitments, capacity building and follow ups and a functional data collection system for timely feedback.”

Capacity building plan

“For projects using a similar learning approach, I would recommend an initial ‘partner readiness’ assessment in terms of checking that the partners’ monitoring, evaluation and learning system are in place, that they have sufficient implementation capacity, and that they are able to make use of feedback from such M&E systems. It is also important to ensure integration of such a system in the partners’ organization, so that the learning continues after the project exits. A capacity building plan, which will include constant follow-up, should be put in place to ensure alignment with what the project requires. Lastly, a focal person to champion monitoring, evaluation and learning within each partner organization is key to leading the process.”





Inoculated soyabean plus phosphorus fertilizer in northern Nigeria. PHOTO: KEN GILLER

LESSONS LEARNED

N2Africa is a cog in the wheel

Every project has its surprising twists and turns and unexpected outcomes as well as the expected ones. What have we learned from ten years of N2Africa?

1 A lot still needs to be done

Through many partnerships, N2Africa was able to reach more than half a million smallholders directly. Diffusion studies indicate we reached more than two million households through farmers passing on seed to their friends and neighbours. Yet in many ways this feels like just touching the tip of the iceberg, given the many millions of smallholder farms in Africa. A fledgling market is developing for rhizobium inoculants and other inputs, and rural supply chains and markets are growing stronger. N2Africa has worked to build independent national capacity for delivering improved legume technologies to smallholders. Learning from the experience of N2Africa, there are great opportunities to roll out legume-based intensification as the core of sustainable production systems. Our work is central to a vision of food and nutrition security for urban and rural Africa that is built on thriving smallholder farms.

2 A balancing act between bottom-up initiatives and top-down coordination

We call N2Africa a 'Development to Research' project. On the one hand, we aimed to reach large numbers of farmers with improved legume technologies. This requires partners taking over the dissemination of technology using their expertise and own approaches. On the other, we wanted to study the benefits of the technologies on farmers' fields, and compare the effectiveness of various dissemination approaches and business models. This requires a well-structured, coordinated research set-up. Working with so many farmers led to trade-offs in the quality of data or analyses. Large numbers of observations help to determine general trends, but more focused research is needed for detailed understanding.

3 Rhizobium inoculants are essential components of agronomic technologies for grain legumes

Rhizobium inoculants increased legume grain yields by 10 to 45 per cent on average. Since inoculants rarely cost more than USD 10 per ha in sub-Saharan Africa, they are a cheap way to increase legume yields with little financial risk. Over 90 per cent of the farmers achieve economic benefits from the application of inoculants. More importantly, inoculants help to make phosphorus fertilizers viable: P-fertilizer is much more expensive than inoculant, and the additional yield obtained due to inoculation when applied together with P-fertilizer more than covers the cost of the fertilizer! However, the handling requirements mean that delivering inoculants to smallholders is still a challenge.

4 A uniform approach lacks responsiveness to the institutional environment

The first phase of N2Africa focused on training farmers and demonstrating the benefits of improved legume varieties, P-fertilizer and inoculant. This led to market demand being created for legume inputs; the key challenge remained access to these inputs.

In time we shifted to a differentiated approach to dissemination, tailored to local circumstances, which allowed us to reach large numbers of farmers through strong involvement of business and development partners. Farmers will only invest in inputs that improve their yields when they are sure of a market with a good price for their produce. Moreover, farmers often lack capital to buy the inputs. Finding ways of pre-financing these inputs – whether through microloans, cooperatives or large buyers – is crucial.

A man is sitting on a large pile of hay inside a wooden structure. He is wearing a white t-shirt with a newspaper print pattern and green shorts. In the foreground, a black and white cow is visible, looking towards the camera. The background consists of green trees.

Partnerships and alliances

Farmers benefit from partnerships. PPPs can - for example - provide inputs and services so a successful value chain can be created. PHOTO: IITA



I Love My
Grandma &
Grandpa
Marino Island



INTERVIEW EDWARD BAARS

The win-win-win of public-private partnerships



How can you make sure that N2Africa's knowledge gets used by as many farmers as possible? An interview with Edward Baars, the business developer of N2Africa, whose role is to be the oil in the machine of public-private partnerships. "It takes a lot of understanding, negotiating and lobbying."

There were two important phases in N2Africa. The first investigated whether grain legume production could indeed be improved in volume and quality by using inoculants, good seeds and specific fertilizers. Once this had been demonstrated, the project progressed to its second phase.

Knowledge of inoculants and seeds and their availability then had to be spread further during the second phase. It wasn't only the 660,000 farmers taking part in

N2Africa who had to be able to benefit from the results, but all the millions of farmers in sub-Saharan Africa.

How can you achieve that? According to N2Africa, public-private partnerships (PPPs) were the key. In this type of long-term cooperation, national or local authorities worked together with non-governmental organizations (NGOs), the commercial sector, knowledge institutions and farmers' organizations. The important feature of public-private partnerships is that the parties work together using their own expertise.





Group assignments during the annual N2Africa overall strategic planning and review meeting with eleven N2Africa country teams, key partners, the project advisory board and donor organizations.

PHOTO: CHARLOTTE SCHILT

A wealth of experience

Edward Baars was appointed to flesh out and develop these PPPs in the second phase. He has a wealth of experience as a business development manager with various organizations in Africa. Over the last five years he has been based in Nigeria with the International Institute of Tropical Agriculture (IITA), coaching eleven N2Africa country teams. IITA's mission is to improve the yields and quality of crops with the aim of increasing incomes and reducing malnourishment among the poor.

"You could say that the second phase of N2Africa was above all a value chain project," says Baars. "That means that you don't only give out information about technologies but that you make sure the information spreads beyond the N2Africa project and that the inputs needed are available for purchase. In other words, the seeds, inoculants and legume-specific fertilizers are on the shelves in local stores and the farmers are able to sell their crops at a good price."

Business models are developed and progressively improved to get this process in motion and keep the wheels turning (see page 28 for the various business models). "In public-private partnerships, donor funds are used in combination with private funds to improve agriculture. That's good for the farmers and good for the population as a whole. Cooperating with the private sector also makes projects like N2Africa sustainable. It doesn't stop when the project ends: the work continues because it has been adopted by the private parties. And that's a win-win-win situation – for the farmers, the companies and the country as a whole."

Formalized partnerships with NGOs

Just like legumes and rhizobial bacteria live in symbiosis, Baars and the N2Africa country teams went looking for partnerships for N2Africa where there would be a win-win-win situation. Formal cooperative agreements were signed between the public and private organizations.

"That's unusual because companies and NGOs generally tend to operate independently."

'Public-private partnerships are good for the farmers and good for the population as a whole'

According to Baars, most of the projects of the NGOs have sufficient resources for supporting rural development and are keen to promote grain legumes, but they often fall short in the scientific and practical knowledge to provide the right information that farmers need.

"Take Catholic Relief Services, for instance, an international NGO with headquarters in Baltimore (USA) that works throughout Africa. They initiated a very strategic project to promote soybeans in Tanzania called *Soya ni Pesa* which means "soya is money" in Swahili. That was a huge value chain project with nearly eleven million dollars available and a network of local partners. But they initially lacked the detailed technical knowledge and the contacts with seed growers, inoculant producers and distribution networks."

N2Africa did have that knowledge and the contacts.

"So, together with the N2Africa team in Tanzania, we formed a close, fully-fledged partnership. With the combined resources of Catholic Relief Services and N2Africa, we were able to reach far more farmers than would ever have been possible for N2Africa alone."

Market forces and sustainability

According to Baars, NGOs are increasingly being required to cooperate with private parties in order to be funded.

"Donors think it is important that project descriptions also talk about market forces and sustainability," says Baars. "What that last point means is that the farmers must have a guarantee that they will be able to buy the inputs and then sell their crops after the project ends. NGOs write that down, but are often struggling to deliver." Baars says that this is because NGOs lack experience and affinity with working with the private sector. "They often see companies as exploitative, which is rarely true. It's entirely in the private parties' interests that the products farmers need are sold, so they listen carefully to what the farmers want."

According to Baars, the development landscape is changing. "In the past, NGOs would operate mainly through farmers' cooperatives and local authorities. They would often buy seed and give it away to farmers or sell it at half price. Then it turns out not to be seed that farmers want! That was hugely unhelpful."

Unfair competition

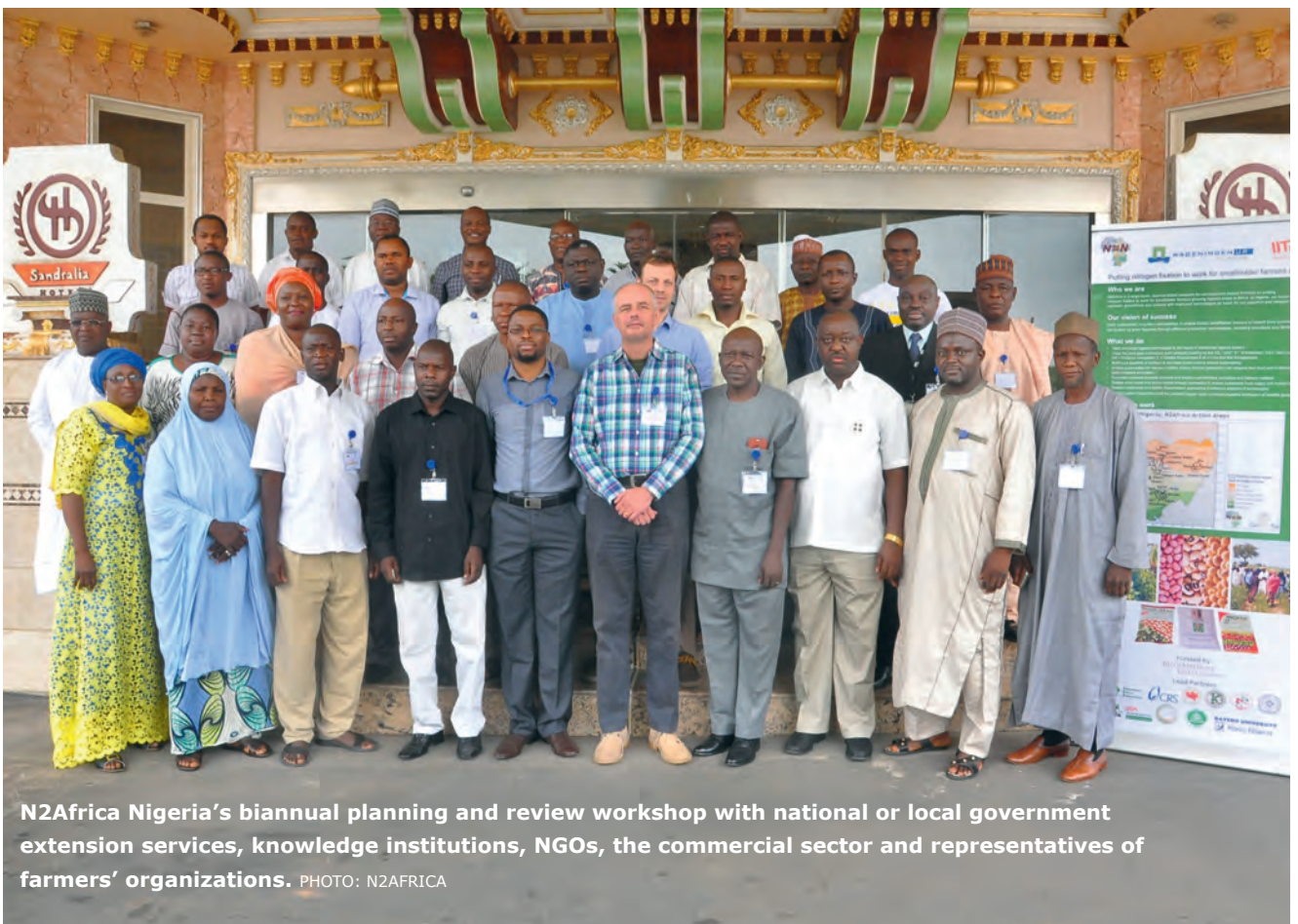
Similarly, private companies were resistant to working with NGOs. "The private sector – largely small and medium-sized enterprises – are first and foremost about selling products. They saw NGOs as unfair competition, because NGOs were able to offer seed or provide services for free."

Baars brings the two parties closer together, lubricating the wheels, as it were. That demands a great deal of understanding and negotiation, he says. And a lot of lobbying with both parties. "The mistrust generally fades away after a while, once they realise they have a common goal."

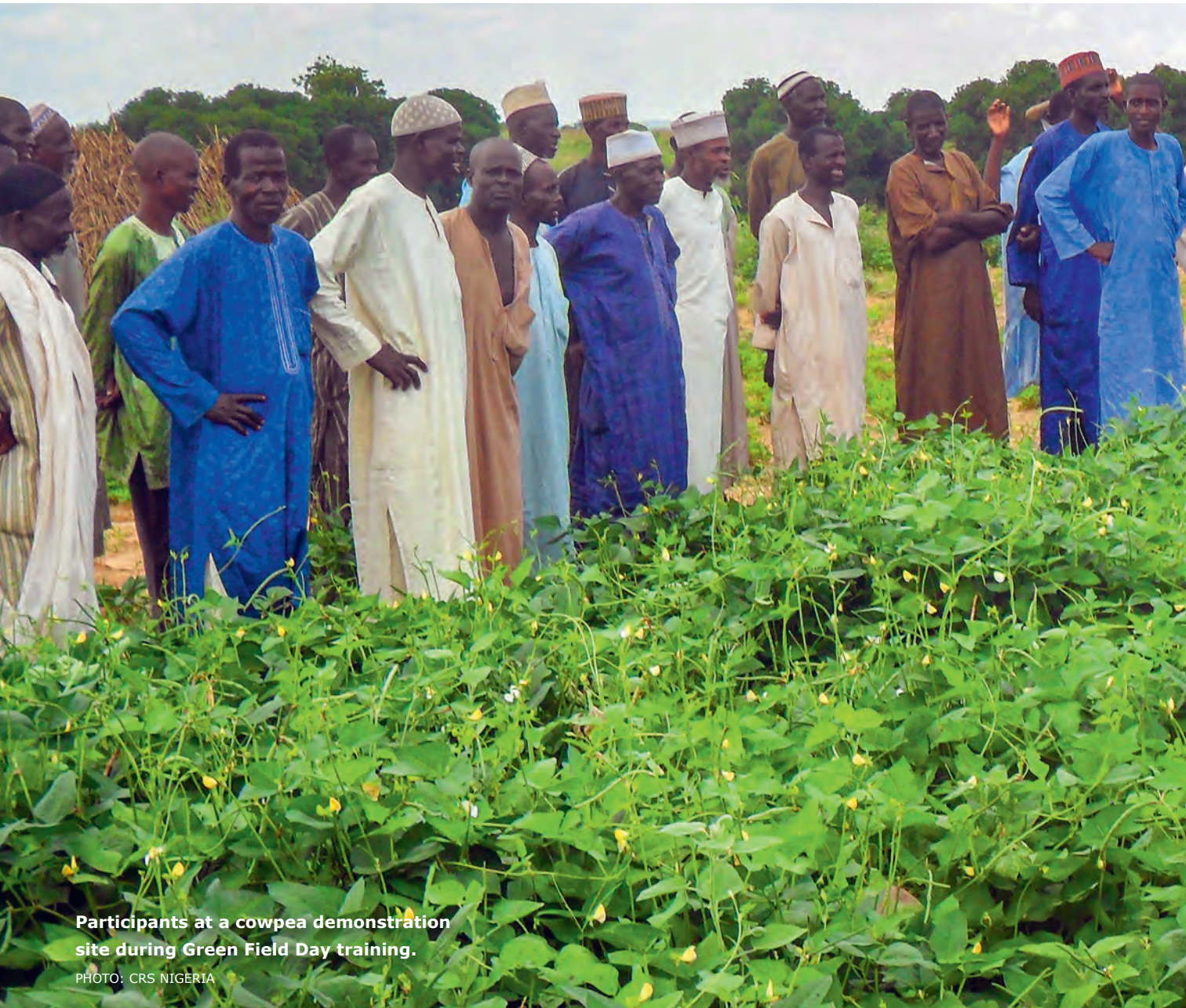


Training farmers and input suppliers in how to use the bundled input package scenarios, also linked to a cost-benefit analysis.

PHOTO: EDWARD BAARS



N2Africa Nigeria's biannual planning and review workshop with national or local government extension services, knowledge institutions, NGOs, the commercial sector and representatives of farmers' organizations. PHOTO: N2AFRICA



Participants at a cowpea demonstration site during Green Field Day training.

PHOTO: CRS NIGERIA

‘It’s entirely in the private parties’ interests that the products get sold, so they’ll listen carefully to the farmers’

Before Baars starts talking with private parties, he makes sure that he has a clear picture of the NGOs’ project proposals – what the NGOs’ mandate is. “The NGO has often received funding and promised to

cooperate with the private sector. I then ask people from the companies what they need from the NGO. That mostly boils down to them wanting information about the farmers’ needs and wishes, something that the NGO can easily invest in. Then I go to the NGO and explain the companies’ interests.

Finally, you hope that a workable win-win-win agreement will be signed. Which does happen in most cases, fortunately.”

Balegreen Spice and Grain

When asked about a PPP that is close to his heart, Baars names a PPP centred around Balegreen Spice and Grain Development plc in Ethiopia. “That is a really large nucleus farm that is involved in propagating not only seeds for itself but also for the community; they arrange the distribution of inoculants for the farmers in the surrounding area, they have room for storing the harvest and they supply mechanization services for a total of 90,000 smallholders who are members of various cooperatives. So they play an important



NGO

An NGO is a non-profit organization with a social or scientific objective. The majority of NGOs are involved in a single specific theme.

N2Africa has worked with various NGOs together with government services and private sector companies [see page 128]. These organizations work on themes such as combating poverty, rural development, entrepreneurship in the agricultural sector and agricultural innovations.

role in promoting new technologies within the community and buying and marketing the farmers' produce. The farm also works closely with a biotech company called Menagesha Biotech Industry plc, which sells the farmers inoculants for chickpeas." As far as Baars is concerned, business development had been the missing link while aiming to alleviate malnourishment

and poverty. "I see the smallholders as equals in the discussions, not as helpless victims. If there are disasters or refugees, business development isn't the answer – other forms of help are needed then. But I've been convinced since the eighties that business development, if setup ethically and responsibly, really helps to tackle poverty." ◇

The many shapes a PPP can take

To ensure that knowledge and improved legume techniques find their way to as many smallholders as possible, N2Africa entered partnerships with government organizations and the private sector. These public-private partnerships can take all kinds of forms.

Public-private partnerships (PPPs) are long-term partnerships between one or more private companies, farmers' organizations, NGOs and national or local bodies. In the case of N2Africa, the private partners were largely involved in providing inputs (certified seed, inoculants, fertilizers or machinery), providing services (such as tillage or disseminating information) or as the buyers and traders of farmers' produce.

Various business models for PPPs have been developed so that a successful value chain can be created. In particular, N2Africa used the following models to make sure that knowledge and equipment was disseminated and shared. N2Africa often collaborated with multiple stakeholders.



>



Farmers cultivating the field in West Usambara, Tanzania. PHOTO: RIK SCHÜLING



Tractor, transport and mechanization services offered to farmers in the surrounding area by a commercial nucleus farmer in Mozambique. PHOTO: EDWARD BAARS

1. DRIVEN BY INPUT SUPPLIERS

In this model, traders provide farmers with e.g. certified seeds, fertilizers and inoculants, as well as agricultural equipment for carrying out tasks such as ploughing or threshing the harvest. An agreement is made between the two parties about the remuneration, e.g. part of the harvest or cash.

2. DRIVEN BY PRODUCER COLLECTIVES

In this model, farmers' collectives or cooperatives regulate the availability of seed and other supplies for the affiliated farmers. In addition, it is possible for individual farmers

to make use of other services such as the storage and joint sale of harvests and the use of equipment, information about the market and information about the cultivation of crops.

3. DRIVEN BY BUYERS

This model is also called the out-grower model. A buyer such as an exporter of legumes makes agreements with the farmer about the amount of harvest to be delivered at a certain moment. The price is agreed in advance. This model offers the farmer a guaranteed income through the certainty of purchase, making it easier for the farmer to keep investing in seed, inoculants and fertilizer. In some cases, the buyer delivers all or part of the equipment needed for pro-



Agricultural fair organized by the N2Africa partner CRS Nigeria where farmers meet legume input suppliers, buyers of legumes, extension services and other stakeholders. PHOTO: N2AFRICA

duction on credit to the farmers, who then repay it with the harvest.

4. DRIVEN BY NUCLEUS FARMS

The starting point is a large farm. In addition to growing crops or keeping livestock, the company also sells high-quality seed to small farmers at a reasonable price. A nucleus farm usually has machinery too, so smallholders can make use of tractors or other small agricultural equipment. The nucleus farm can also have contracts with various small farmers in the area for the sale of the harvest at a predetermined minimum price.

5. DRIVEN BY MICRO-BUSINESSES

Small independent entrepreneurs play a key role in this model. They play a role between the supply chain (wholesalers and producers) on the one hand and the small farmers on the other. It is important that this entrepreneur, who has a linking function and often works in a cluster of villages, knows what the farmers need in terms of resources and information. At the same time, the producers and wholesalers inform the micro-business entrepreneur about their product range. The entrepreneur therefore plays a crucial role in making sure this information is exchanged rapidly in both directions. The entrepreneur receives a commission for every deal he makes. ◇

The success of the Pawe PPP



The Ethiopian government and development organizations have made huge investments to create long-lasting access to agricultural technology. However, access to agricultural inputs is a real challenge. The public-private partnership that N2Africa established in the Pawe district helped to tackle this challenge.

Agriculture plays a crucial role in Ethiopia's economic development and in achieving food security. As a result, the Ethiopian government and many development organizations and projects made huge investments to enhance the productivity of the agricultural sector, such as creating durable access to agricultural technology. However, access to agricultural inputs using such technology is a real development challenge for many reasons, including institutional bottlenecks. In Ethiopia, N2Africa set up seven PPPs to

(BoA) and the Ethiopian Institute of Agricultural Research (EIAR). The private sector comprised the animal feed processing company AKF, a commercial inoculant producer called Menagesha Biotech Industry (MBI) and a commercial farm, Tesfa Farm, that provided high-quality seed.

A cooperative union was the heart of the PPP: the Mama farmers' cooperative union. This cooperative union provided the business model for the PPP, the cooperative (or farmer producer) model, through which the target farmers for the PPP interventions were reached. About 15,000 Mama members were targeted over four years (2015-2018).

A cooperative union was the heart of the PPP: the Mama farmers' cooperative union

improve dissemination of legume inputs and provide long-term access for smallholders to legume inputs and output markets. Among those PPPs was the Pawe PPP, a partnership that mainly targeted soyabeans and common beans. The name 'Pawe' was adopted from the name of one of the five districts covered by the PPP interventions and where the PPP coordination is based.

Cooperative union

The PPP consisted of three public parties: the Pawe Agricultural Research Centre (PARC), the District Bureaus of Agriculture

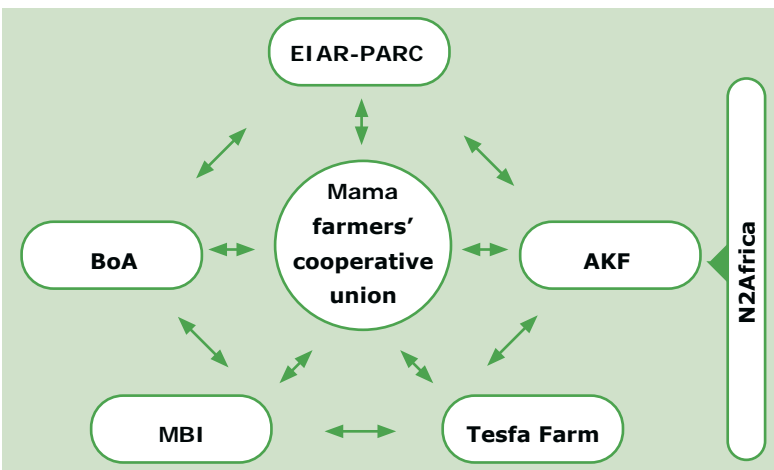
In this partnership, N2Africa took the overall initiative for establishing the partnership to build an effective and efficient supply chain of seed, inoculants and fertilizers and for marketing legume grains. N2Africa also took the role of identifying and advising about which varieties were demanded by the market so that they could be demonstrated to and produced by the target smallholder farmers, developing and providing data protocols for monitoring and evaluation, and providing facilities to support soyabean and common bean technology dissemination activities.

The Pawe PPP was very successful in helping farmers to get access to legume inputs (particularly to soyabean inoculant, which



Farmer Wadim Dikako (third from left) proudly showing his 3 ha soybean seed multiplication to the local N2Africa staff.

PHOTO: ENDALKACHEW WOLDE-MESKEL



was never the case before). Joint promotion of soybean inoculant with improved soybean seed varieties has resulted in increased soybean inoculant demand from smallholder farmers.

Besides the success in creating access to inoculants, the Pawe PPP succeeded in getting access for smallholder farmers to the soybean grain market. N2Africa and PARC played a key role in linking the union with the processing companies. The Mama union played an indispensable role in bulking and delivering high-quality soybean grains to the processing company.

In 2016, the first year of this PPP, a total of 150 tons of soybean grain was sold to AKF, the biggest animal feed processing company in Ethiopia. During the second year, the business relationship between the Mama union and AKF continued and a larger volume of soybean grain compared to 2016 has been sold.

HIGHLIGHTS

- The Pawe PPP was most successful in helping farmers getting access to legume inputs (particularly soybean inoculant, which was never the case before) which made farmers produce a marketable surplus of soybean grain.
- The Pawe PPP was also successful in creating access for smallholders to the soybean grain market.
- In 2016, the first year of this PPP, a total of 150 tons of soybean grain was sold to AKF, the biggest animal feed processing company in Ethiopia.

Bottlenecks

There are some potential challenges that can interfere with the success of the PPP. A high level of government interference in unions’ business decision-making, slow decision-making processes within the unions’ boards of management, limited financial capacity, and the lack of an efficient information system to support input and output marketing could all make the PPP become less effective.

The Legume Alliance



Farmers get agricultural information from a range of sources, varying from radio broadcasts to training courses. But the information given out by different organizations is not always consistent. To improve the quality of information disseminated to farmers, N2Africa was pleased to join the Legume Alliance.

Back in 2015, a group of like-minded organizations came together to explore the idea of forming an alliance to improve the information provided about improved legume techniques for farmers. The idea of this Legume Alliance was to test a new integrated approach to developing and sharing agricultural information. Farmers did not always get their information, for instance about using fertilizer or rhizobium inoculants in legumes, in a clear and consistent way. This made it difficult for new techniques to gain a foothold.

Research showed that information is essential, but not sufficient to bring about long-lasting change

The new approach was based on two hypotheses:

- Targeting smallholding families at multiple entry points, with media that reach both younger and older people, men and women, whether literate or not gives us the best chance of creating a shared understanding across the generations of new agricultural technology;
- Making sure different age cohorts and demographic groups access messages first hand should create a debate in the family leading to higher levels of adoption for the

technologies. It also makes sure that no one person is responsible for remembering how the technology should be applied, thereby making it more likely the technology will be applied correctly.

Bean Champions

The Legume Alliance implemented a first campaign on Maharage Bingwa (Bean Champions) in northern Tanzania in 2015. The Maharage Bingwa campaign assisted the dissemination of technologies and practices for the common bean recommended by the Selian Agricultural Research Institute (SARI) in Tanzania and by N2Africa. Multiple media and distribution channels were used simultaneously, each targeting different members of the farming family, with nuanced messages that meet the information needs of these different members.

Coordinated by the Centre for Agriculture and Bioscience International (CABI), partners of the Alliance took up various roles: Farm Radio International and CABI handled radio broadcasts. Well Told Story: Shujaaz, a youth communications platform, developed two story lines in their comic and social media platform which showed how a young farmer and an agro-dealer were working with improved legume technologies. The CABI-led African Soil Health Consortium (ASHC) worked with the



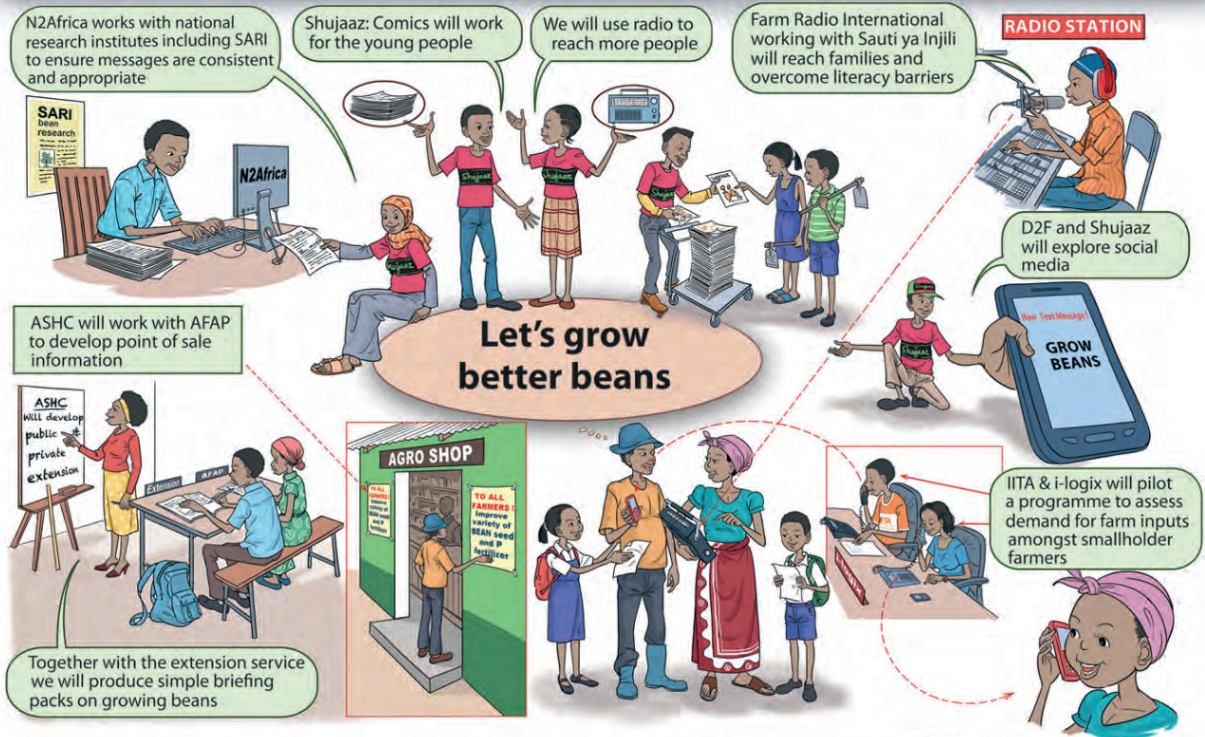
Woman listening to an interactive radio programme on all aspects of legumes.

PHOTO: SIMON SCOTT

African Fertilizer and Agribusiness Partnership (AFAP) to develop point-of-sale information for agro-dealers. The role of N2Africa and SARI was to give technical support and to ensure that the messages given were consistent and based on sound science.

After the campaign, farmers' preferences for various legume technologies were assessed through computer-aided telephone interviews. A key finding of these interviews, conducted among over 2,600 farmers, was that stocks of registered improved seeds were in short supply and the logistical

Bean Thinking: Maharage bingwa Smallholder farming families in Tanzania receive information from the radio, mobile phones, posters, comics, social media and extension explaining the importance of growing improved varieties of common bean using good agricultural practices and fertilizer...



Poster showing the roles of all of the partners in the Bean Champions (Maharage Bingwa) campaign.



Farmers listening and providing feedback on the Farm Radio International campaign in Tanzania.

PHOTO: DHARMESH

challenges of providing bean seed at scale are significant. In a subsequent phase, the Legume Alliance therefore included the Agricultural Seed Agency (ASA), working to bulk up more seed, and AFAP, who would pursue the policy issues associated with matching supply to demand for common bean seed. The research therefore also showed that information is essential, but not sufficient to bring about lasting change. Access to both input and output markets is required to make investments viable.

Another and unexpected outcome of the interviews was the very strong preference among farmers for the yellow common bean variety called Soya Njano. This variety was not part of the technologies being spread because, at the time, the variety was not registered for use in Tanzania. Whilst an informal, unregulated economy was operating at scale to provide farmers with this preferred bean variety, projects like N2Africa must not circumvent the national systems, which meant that the project could not include this popular variety or develop proper agronomic advice for it. However, the conclusions from the interviews created enough pressure on the agricultural research institutes when shared by the Alliance, so that the seed was registered (under the name Selian 13). Now, the seed could be legally produced and sold in Tanzania.

Scaling up

In 2016, the Alliance implemented scaling-up campaigns in northern and southern Tanzania under the umbrella of the Scaling-up Improved Legume Technologies (SILT) project. The multimedia campaigns included various combinations of leaflets, posters, comics, interactive radio, text messages, demonstration plots and farmers' training sessions and they reached 600,000 farming family members. The Alliance impact survey conducted under SILT found that 100,000 farmers increased their use of the techniques promoted, including improved varieties, inputs and good agronomic management practices. Moreover, 85 per cent of the respondents mentioned that they had learned something new about beans or soyabeans after the campaign, largely through demonstration plots that were implemented under N2Africa and its

partners along the value chain.

However, different approaches proved to be useful for different types of messages: mass media like radio can be used for simple messages, e.g. to raise awareness about a new variety or the presence of a pest, but are less suitable for more complex information like the proper use of inoculants or the benefits. Demonstration plots played an important role for such more complex messages.

85 per cent of the respondents mentioned that they had learned something after the campaign

Covering 11 regions and 23 districts

The Legume Alliance built on and linked to communication campaigns sponsored by projects funded by the Bill & Melinda Gates Foundation, USAID, IFAD, UKAid and IDRC. In leveraging these partnerships and projects, the Alliance could benefit from a variety of stakeholder networks, including knowledge, delivery, value chain, and communication and research partners that facilitated and brokered its access to farmers, input suppliers and other stakeholders covering 11 regions and 23 districts in Tanzania.

The Legume Alliance has since expanded to Ghana and Nigeria, taking the same approach while adding new partners and insights. The addition of video to the dissemination campaigns in particular proved to be highly effective in creating awareness and knowledge about soyabean inoculants in Ghana. ◇

HIGHLIGHTS

- **Access to both input and output markets is required to make investments viable. Information is essential, but not sufficient to bring about lasting change.**
- **Mass media such as radio can be used for simple messages, but are less suitable for more complex information. Demonstration plots played an important role for these more complex messages.**



A fertile cooperation with Palladium



Through a partnership with Palladium, who approached N2Africa for cooperation, improved soyabean technologies were disseminated in large parts of Uganda. This helped farmers improve their yields and gain access to output markets at the same time.



Soyabean farmer's group in Lira, Uganda.

PHOTO: KEN GILLER



Soyabean pods.

PHOTO: SHUTTERSTOCK

The Palladium group is a private company working to implement a project in the West Nile region of Uganda. The project, funded by the British Department for International Development (DFID), aimed to transform the economy in northern Uganda through climate-smart agri-business market development. Palladium had identified soyabeans as a promising crop for the region, considering the favourable agro-ecology and the market potential for the crop (both locally and in neighbouring Congo), providing a source of income to help address poverty and improve the livelihoods of smallholders in northern Uganda.

The project initially faced challenges because of low soyabean productivity, attributed to limited agronomic knowledge and

skills among the producers. There was also insufficient access to high-quality inputs (especially seed and inoculants) and limited awareness among smallholders of the opportunity to increase their cash incomes. To address these constraints, the project

The partnership aimed to disseminate soyabean techniques that had been proved to work in other areas

looked for suitable value-chain actors such as input suppliers and output buyers as well as researchers to validate the potential of soyabeans in the area, test and demonstrate the potential of the inputs to increase soyabean productivity, create demand and empower producers by teaching them agronomic skills.

To that end, Palladium Uganda approached N2Africa and entered a partnership with the project in 2017. The partnership aimed to disseminate soyabean technologies that had already been proved to work in other areas to the entire West Nile Region, covering eight districts. The partnership also involved the West Nile Private Sector (WENIPS) development promotion centre, a regional support centre that aims to link private sector value chain actors with farmers. This centre provided the extension staff who were then trained in soyabean production.

Building skills

A combination of demonstrations, farmer try-outs (adaptation trials) and field days was used as a method for building skills and creating demand among the producers. The extension staff worked with farmers and es-

interested in the promising results of the adaptation trials. As the owner of a farm himself, Esia Commercial Farm, he requested WENIPS for training in seed production to alleviate seed shortages in the region. The trained extension staff, with technical support from N2Africa, were able to provide the required help.

Subbe Central Women Farmers' Group

Smallholders in the region embraced the knowledge gained from the N2Africa project. One group that has seen a tremendous improvement in their soyabean production is the Subbe Central Women Farmers' Group (6 men and 24 women) in the Ofua sub-county of the Adjumani district. The group hosted the soyabean demonstration in 2017 and after that their members put the knowledge and skills learned (improved seed and good agronomic practices) from the demonstration into practice. This resulted in improved yields of soyabeans and more income from the crop. The group and the surrounding community have managed to bulk and market over 109 tons of soyabean grain since 2017, with over 133 farmers involved.

In 2017 the soyabean grain was marketed at 1,200 Ugandan shillings per kilogram, while in 2018 the grain was sold at 1,550 Ugandan shillings per kilogram (nearly half a dollar). Correspondingly, members of the group and the communities that bulked together with them earned income that did indeed help improve their household's situation.

Mobilizing farmer groups

Eria Kategaya, a member of the Subbe Central Women Farmers' Group, says that members have seen their soyabean yields double from about 250 or 500 kg per ha to about 750 to 1000 kg per ha on average. "Because of the increased production, we started bulking to improve our market access. So far, we are only using the improved seed and correct spacing and proper weeding because we can't access inoculants and fertilizers."

This outcome will provide an impetus for continued development of the input market chain

established soyabean technology demonstrations at the group level. The inputs demonstrated were various types of inoculants, applied alone or in combination with triple superphosphate (TSP) fertilizer.

Small packets of seed (216 g) with the inoculant of choice, both with and without TSP fertilizers, were given to individual farmers to set up adaptation trials on their own farms comparing the performance against a similar treatment at the group demonstration plot. Following technology evaluations at the end of the season, farmers learned that inoculation increased yields, but combining inoculants with TSP fertilizer returned better yields (averaging 1670 kg per ha). Kinybium, developed by Kinyara Sugar Works Limited in Uganda, was the best performing inoculant in the region.

Promising results

During the first season of 2018 in Adjumani District, the third Deputy Prime Minister of the Republic of Uganda became extremely





Subbe Central Women Farmer's Group members conducting an end-of-season technology evaluation.

PHOTO: IITA

Subbe Central Women Farmers' Group is now also mobilizing farmers' groups in Adjumani and has formed a soyabean growing association called the Golinda Farmers' Association, which will even be obtaining formal registration to make it easier for them to organize production and marketing of soyabean grain.

To meet the growing demand for improved soyabean seed, Esia Commercial Farm started to produce seed from the 2018 season onwards, with continued technical support from WENIPS, with the aim of selling high-quality, affordable soyabean seeds to the farmers. The farm harvested 15 tons of soyabean seed in 2018, which was ready for sale in 2019. There is also ongoing engagement of farmer group leaders in the district to ensure they can access the seed on time

for the first 2019 planting season. This outcome is providing an impetus for continued development of the input market chain to improve access to other inputs such as inoculants and phosphorus fertilizers, as well as increasing the volumes of seed. ◇

HIGHLIGHTS

- **Palladium Uganda approached N2Africa and entered a partnership with the project in 2017.**
- **The partnership disseminated soyabean techniques to the entire West Nile Region, covering eight districts.**
- **Esia Commercial Farm started to produce seed to sell high-quality affordable soyabean seeds to farmers.**
- **The increased soybean production led to bulking of soyabeans to improve market access.**

PERSONAL STORY

A journey from unemployed to successful business owner



Thanks to a training course from N2Africa and IITA, the Nigerian farmer Mercy Haruna Wakawa escaped unemployment. Now she runs a successful agribusiness company.

Mercy Haruna Wakawa, from Borno state, studied Food Science and Technology and graduated from the prestigious University of Maiduguri. She was full of dreams and enthusiasm for a good, steady white-collar working career and livelihood. Unfortunately, her dream of proper employment was dashed and she joined the burgeoning group of unemployed young people in the country.

‘After so many futile efforts seeking proper employment, I joined up, rather reluctantly. Just to be part of anything’

Mercy received an invitation from the International Institute of Tropical Agriculture (IITA), which was a partner with N2Africa providing training courses on agri-business skills for young people in Borno state. “After so many futile efforts seeking a proper job and almost at the point of giving up, I joined up. Rather reluctantly. Just to be

part of anything at that moment.”

It turned out to be three-weeks of mind-changing intensive training that covered topics in agribusiness, entrepreneurship, ICT in agribusiness, fish farming and science-driven agricultural practices.

Starter package from Bill and Melinda Gates

“Despite my initial reluctance, I was counselled and mentored to venture into the post-harvest processing of groundnuts. The business took off in practical terms in January 2016. I was given a starter package by the N2Africa project that is sponsored by Bill & Melinda Gates Foundation. This consisted of processing machines and a working capital of 2.5 million naira, about 7000 dollar.”

It turned out to be a match made in heaven. Today, Mercy Haruna is the founder and managing director of a successful agribusiness company, Confianza Global Resources, which processes groundnuts into oil and cake for livestock feed.



Inspecting a groundnut oil refining unit.

PHOTO: N2AFRICA

Confianza Global Resources employed four young people from the host community. The business also created downstream livelihood opportunities for many women in sludge processing and marketing in the host and neighbouring communities.

‘Creating job opportunities for young people was one of my most satisfying accomplishments’

“My life as an entrepreneur is challenging but also rewarding. Creating job opportunities for young people, providing markets for groundnut farmers, and providing solutions for customers who really want the products of groundnut processing was my most satisfying accomplishment.”

Key players

Over the next ten years, Mercy wants to become one of the key players in groundnut oil production, expand her business and explore the value chains of groundnut enterprises.

“I want to develop the capacity to produce my raw materials directly from my farm, and possibly establish livestock production units that can utilise the groundnut cake from my mills as feed. I’ll then be in a position to employ more young people, not only from the host community but from all over Nigeria and Africa as a whole.”

Her advice to young entrepreneurs is to always believe in their capacity to succeed. “They should not be discouraged by the small things they are doing because they don’t know where these can take them”. ◇



Mercy Haruna Wakawa inspecting her groundnut cake.

PHOTO: N2AFRICA



Groundnut processing turns out to be a profitable business.

PHOTO: NEIL PALMER, CIAT



An agrochemical and fertilizer sales outlet, Kaduna State Country, Nigeria. PHOTO: N2AFRICA

LESSONS LEARNED

Long-lasting PPPs

Every project has its surprising twists and turns and unexpected outcomes as well as the expected ones. What have we learned about public-private partnerships and alliances from ten years of N2Africa?

1 PPPs are key to driving increases in production

Smallholders often struggle to get the inputs of seed, inoculants and fertiliser, and to market their produce. N2Africa played a pivotal role in bringing together all the partners needed for making connections with input and output markets and providing the knowledge to improve their production methods. There are various business models to choose from that need to be matched up to how farmers are organized and to suit local market opportunities.

2 Partnerships can be long-lasting if market access is guaranteed

Availability of a profitable output market seems to be the key incentive in determining farmers' input purchases and legume production. The performance of improved soyabean seeds and the effectiveness of the inoculant then determine the smallholders' productivity. Establishing links between input sellers, farmers and output markets during a project greatly increases the chances of the partnership lasting. A guaranteed output market seems to be the decisive factor.

3 Overcoming misconceptions can lead to great partnerships

NGOs often have a sceptical view of the private sector as they expect companies to be exploitative. Conversely, the private sector is reluctant to work with NGOs as they may be regarded as competing unfairly. However, as it is in the private sector's interest to sell products that their customers want, they are willing to listen carefully to farmers. And NGOs may support the private sector in providing information about these market wishes. Bringing these parties together requires understanding and patience, but eventually helps to establish lasting partnerships.

4 A diversity of dissemination approaches helps farmers understand information

Disseminating information involves a trade-off between the number of people who can be reached, the level of detail of the information that can be spread and the costs. Mass media like radio are useful for getting simple messages across to large audiences, such as raising awareness about a new variety. Such media are less suitable for more complex information such as the proper use and benefits of inoculants. Demonstration plots and adaptation trials in which farmers tested new technologies in their own fields played an important role for these more complex messages.

5 Legume agri-business may offer job opportunities for young people

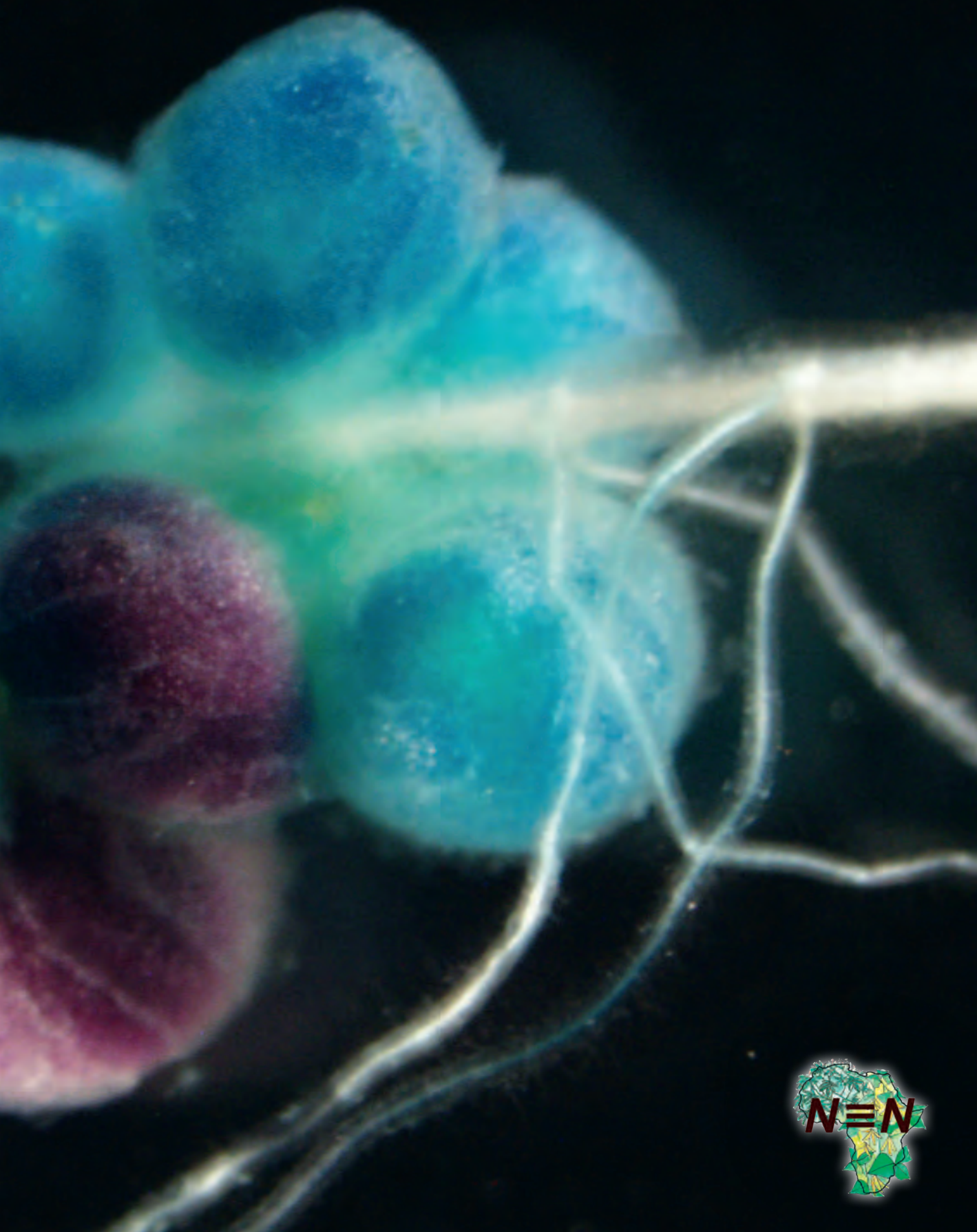
Concerns have been raised about the lack of attractive opportunities for young people in agriculture. The Youth Agripreneurs Programme that was rolled out in Borno State (Nigeria) showed that agribusinesses can provide such opportunities. Even though the entrepreneurs still face common challenges in their business, some may grow to provide job opportunities to others.

Advances in research on rhizobiology and agronomy

A close-up, microscopic view of several spherical rhizobium nodules. The nodules are stained with different colors: some are a vibrant blue, some are a deep magenta, and some are a pale yellowish-white. The background is dark, making the colorful nodules stand out. The nodules appear to be clustered together, with some in sharp focus and others blurred in the background.

Double-stained nodules after inoculation
with CIAT 899-gusA (blue) and NAK
104-pGM1 (magenta).

PHOTO: GEORGE MWENDA



The effects of inoculants and nutrients



At the start of N2Africa, the benefits of phosphorus fertilizer and rhizobium inoculation (on soyabeans in particular) were known. Widespread testing of a range of nutrients for a diversity of legumes confirmed the positive effects of phosphorus and showed that other legumes also benefit from inoculation. The response to other nutrients was less clear-cut.

As part of N2Africa's 'Development to Research' approach, we carried out numerous trials across the N2Africa countries over the past eight years to test the performance of different inputs (inoculants, fertilizers, manure and lime) on farmers' fields. Important questions to be answered with these trials were: what the effects are of phosphorus and inoculant on the yields of the various legumes and



whether there is evidence that potassium or other nutrients are the limiting factors for particular legumes or locations. Answers to these questions would provide a solid foundation for appropriate recommendations to farmers on how to improve their yields.

The trials showed a universally positive response to phosphorus (P). Application of 20 to 30 kg P per ha in fertilizer in-



Demonstration of the effects of rhizobial inoculation on soyabeans in Songea, Tanzania.

PHOTO: KEN GILLER

creased yields in common beans, cowpeas and soyabeans by an average of almost 300 kg per ha. Groundnuts showed a more modest response, but still almost 200 kg per ha.

Potassium (K) is another important element in crop nutrition. For legumes, we only found significant positive effects on common beans in East Africa, with yield increases of about 150 kg per ha. Responses in other regions and in other legumes

Phosphorus and inoculant remain the most reliable inputs for increasing the yield of grain legumes

were not consistent. In specific cases, positive responses to secondary nutrients and micronutrients were observed.

We assessed the effects of inoculants in soyabeans and other legumes separately from the nutrient responses. The positive



Farmers showing their cowpea crops in Wedza, Zimbabwe.

PHOTO: KEN GILLER

effects of inoculants in soyabeans are relatively well-known and the N2Africa trials confirmed this. Inoculation responses varied substantially between countries and years but inoculation resulted on average in a relatively modest increase of 115 kg of additional grain yield per hectare. This increase of about 10 per cent is in line with results from countries in Latin America, where soyabean inoculation is a common practice. Moreover, given the estimated cost of 10 USD per hectare, it is a cost-effective technology. Apart from soyabeans, N2Africa also evaluated inoculation in trials with chickpeas, cowpeas and common beans. In all three



Esther Chinedu, N2Africa's Farm Liaison Officer for Nigeria, unloads rhizobial inoculant boxes.

PHOTO: N2AFRICA

crops, we observed significant yield increases, similar to those achieved for soyabeans. For common beans, results were however somewhat inconsistent, with an overall average response as high as 288 kg per ha in Ethiopia compared with negligible responses in the trials Kenya and Rwanda. This could be due to variability in inoculant quality as much as to the effects of local conditions.

Phosphorus and inoculant remain the most reliable inputs

Finally, there were a number of inputs that were not systematically tested across crops and countries, but were generally



Potassium deficiency in beans in West Usambara, Tanzania.

PHOTO: KEN GILLER

observed to have yield-enhancing effects where used: organic manure, nitrogen fertilizer and liming. Manure gave fairly consistent yield increases for all legumes and countries. Nitrogen fertilizer was tested with common beans in northern Tanzania and gave a positive effect. Liming enhanced grain yields of common beans in southwestern Uganda. Although all three may offer opportunities for increasing yields, they are not always cost-effective options for smallholders, as the costs and the amounts required to boost yields may be high.

Overall, we can conclude that phosphorus and inoculant remain the most reliable inputs and can be generally recommended for increasing grain legume yields. Other

Application of phosphate fertilizer increased legume yields on average by 300 kg per ha

nutrients may also be required, but the yield response and economic benefits still need to be assessed per legume and per location. ◇



Understanding variability in yield



Some N2Africa farmers genuinely benefited from applying inoculants and fertilizer, whereas the other farmers' yields remained the same. The results of our attempts to understand the underlying causes of variation in yields have been disappointing. Predicting the likelihood of success remains difficult.



Soyabean plants grown in problem soils in pots and fed with different nutrient solutions to identify which nutrients are critically deficient. PHOTO: SAMSON FOLI

A key benefit of large-scale projects such as N2Africa is the opportunity to test yield-improving technologies in a large number of farmers' fields. During the project, we monitored farmers who planted a small try-out, consisting of a simple comparison of the best local variety of the grain legume with and without inoculation and phosphorus fertilizer, and with inoculation and P-fertilizer combined, to give four distinct plots in each farmer's field. We collected data from these try-outs on the type of field, the management practices that the farmer used (such as weeding, applying manure, planting in rows or not), as well as a number of household characteristics. The yield of the try-outs was measured by field assistants at the end of the season.

Although the farmers' try-outs in the various countries differed in terms of climate and soils, we observed surprisingly similar patterns in yields and responses to the inputs (inoculant and P-fertilizer). The yields that farmers got without inputs varied widely, and so did the response to the improved practices – often ranging from crop failure to yields close to the genetic potential of the legume at around 4 tons per ha. While some farmers gained real benefits from applying the inputs, others risk investing in inputs while their yields remain the same.

Understanding the variation in crop response is key to being able to predict the likelihood of success of the technology for farmers. N2Africa therefore studied the variation in legume



yields and the response to inputs in order to find out which practices worked best, under which circumstances (climate, soils) and for which types of farmers (poorer or wealthier, men or women, producing for home consumption or for the market).

Little predictive value

The attempts to understand the variation gave disappointing results. For instance, differences in year, farm size, plant establishment, total rainfall and soil pH explained 40–60 per cent of the variation in soyabean yield response to inputs in northern Nigeria. These variables had little predictive value across locations

yield responses to inputs. It is possible that we do not have sufficiently accurate information about the crop management (such as planting densities, sowing dates and weeding) and environmental variables (soil and climate). Collecting more detailed information from larger numbers of try-outs (we had about 200 per country per season) would require an enormous investment in well-trained field staff.

Why farmers may be reluctant

Moreover, it is questionable whether more data would give better predictability for the yields and responses. A variable such as rainfall for the next season is hard to predict and analysing soils from every field is not feasible. The finding that there is wide variation in yields and responses is valuable in itself. It makes clear that all farmers may not benefit to the same extent and it explains why farmers may be reluctant to invest in a certain technology: the risk may simply be too high. Testing a technology on a large number of farmers' fields is therefore certainly a valuable approach for any future project.

The yields that farmers got without inputs varied widely, as did their responses to the improved practices

or seasons, though, which means we cannot predict which farmers would benefit from applying inoculant or P-fertilizer in a new district in the next season.

It is unclear why it is so difficult to predict



Limited climbing bean yields in Uganda, caused by a diversity of variety, environmental and crop management factors. PHOTO: ESTHER RONNER



MSc student Samson Foli conducting 'missing nutrient' experiments in a greenhouse in Kano, Nigeria. PHOTO: KEN GILLER

A better starting point for understanding yield variability may be to study specific factors in detail: what the effect of late planting is on the response to fertilizer, for instance, or whether inoculation still works well in sandy soils. Such factors can be studied in replicated trials on a small number of representative farmers' fields. This information will help develop decision support tools that give recommendations on which practices to apply under which circumstances. ◇

* Source:

This article is based on:

Ronner, E., Franke, A.C., Vanlauwe, B., Dianda, M., Edeh, E., Ukem, B., Bala, A., van Heerwaarden, J. & Giller, K.E. (2016). Understanding variability in soybean yield and response to P-fertilizer and rhizobium inoculants on farmers' fields in northern Nigeria. *Field Crops Research*, 186, 133-145.

Vanlauwe, B., Hungria, M., Kanampiu, F. & Giller, K.E. (2019). The role of legumes in the sustainable intensification of African smallholder agriculture: Lessons learnt and challenges for the future. *Agriculture, Ecosystems & Environment*, 284, 106583.

A LEARNING LOOP ON MISSING NUTRIENTS

Although the overall effects of rhizobial inoculation and phosphorus fertilizer are attractive to farmers, there is no yield response in about 10 per cent of cases in nearly all regions. In northern Nigeria, we suspected that the lack of response to inoculant and phosphorus was due to other nutrients being missing in the exhausted soils. MSc student Samson Foli investigated this by sampling these problem soils and conducting 'missing nutrient' experiments in pots in a greenhouse. His experiments revealed that the soils lacked potassium and some other micronutrients.

We have identified the missing nutrients needed by legumes in several countries. Based on these results, we have collaborated with fertilizer companies to test and develop new legume fertilizer blends that are now on sale on the market in rural areas of Kenya, Ghana and Nigeria.

Read more about these fertilizers on page 88.

To grow beans, you have to own a cow



Common beans are an important staple crop for farmers in East Africa. Most farmers grow bush beans, but in highland areas climbing beans yield much more. However, growing climbing beans also requires more investment by farmers. N2Africa experimented with nutrients and staking materials for supporting the bean plants.

Climbing beans are an interesting crop for smallholders. In contrast to the more commonly grown bush beans, climbing beans grow tall – if supported by stakes – and can yield two to three times as much as bush beans. Especially for farmers with small plots of land, the vertical growth of climbing beans really improves yields. Climbing beans were originally found in

just a few places in the highlands of East Africa. But when improved varieties of climbing bean were introduced in Rwanda in the 1980s, they were rapidly adopted in the highlands of northern Rwanda and spread to neighbouring countries such as Burundi, DRC and Uganda. Climbing beans do particularly well in highland areas over 1600 metres above sea level. Not only is their yield an advantage, but





Hillsides covered with climbing beans in northern Rwanda. PHOTO: KEN GILLER

climbing beans also have more potential for fixing nitrogen. Because the beans grow vertically, they can capture a lot of light for photosynthesis, create a lot more biomass and therefore fix more nitrogen per hectare than bush beans. Moreover, climbing beans keep producing pods throughout the season: as long as the rains continue, the bean keeps growing. A farmer can start harvesting the lower

pods, leave the bean to grow in the field and harvest the upper pods as the season progresses.

Animal manure is needed to get climbing beans to grow well

Growing climbing beans is also associated with a number of challenges. Climbing



Farmer showing climbing beans in a demonstration field.

PHOTO: ESTHER RONNER



Climbing beans growing on tripods in western Kenya. PHOTO: KEN GILLER

beans need reasonably fertile soils, for instance. Because they produce more biomass than bush beans, they also need more nutrients. Or as Marie Therese Nyirankuye, a farmer in Gakenke district, northern Rwanda put it, "To grow beans, you have to own a cow."

Uganda, however, farmers said that staking was a key challenge for cultivating climbing beans. In this area, farmers felt stakes were expensive because they often need to buy them instead of growing them on their own farms.

Esther Ronner, who conducted her PhD research in the N2Africa project, assessed alternative staking materials. "Together with the N2Africa team in Uganda, we tested materials such as strings or ropes made from banana fibre. However, the farmers then said that these methods were indeed cheaper, but they also required a lot of work."

On larger plots of land, such as the farms in eastern Uganda, farmers often still favour bush beans because they require less labour.

She found that poorer farmers grew climbing beans more often, but they used practices such as applying manure or staking every bean plant less often. Planting the beans but compromising on staking or manure application in turn reduces yields. "This shows how important it is not only to grow the right legume in the right environment, but also to be able to apply the right management practices to maximize the benefits from these beans," says Esther. ◇

Compromising on staking or manure application when planting climbing beans reduces yields

The cow can supply manure, which in turn encourages prolific growth of the climbing beans. As owning a cow also requires an investment that not all farmers may be able to afford, N2Africa worked with farmers in DRC to experiment with using manure from guinea pigs and rabbits. Just a teaspoon of this manure placed in the planting hole made a big difference in improving bean yields from poor soils.

Elephant grass or maize stalks

Climbing beans also need to be staked to help them grow. In a country like Rwanda, where most farms are very small, farmers soon realized the advantages of the climbing bean. They prune trees around the field or use elephant grass or maize stalks as stakes. In eastern



Gasilida, an iron-enriched variety, named after the farmer in the picture. PHOTO: KEN GILLER

PERSONAL STORY

Battling to form nodules

Rhizobium inoculants work well for soyabeans, whereas the response in other legumes such as the common bean is erratic. PhD student George Mwenda investigated why and discovered that some introduced strains of rhizobia are capable of displacing large populations of rhizobia already in the soil.

Rhizobium inoculants ensure that there are lots of rhizobia bacteria around the roots that emerge from the germinating seed so that the legumes can form numerous root nodules and fix large amounts of nitrogen. N2Africa researchers tested 'off-the-shelf' rhizobium inoculants with soyabeans in many countries with convincing results.

Rhizobium inoculants work well on the soyabean as it is a specific legume that needs a fairly particular type of rhizobium. Furthermore, soyabeans are often being grown

the common bean, cowpea, chickpea, faba bean and groundnut so this was a key research priority for N2Africa. Nodule formation in these plants generally involves a wide range of bacteria commonly present in the soil. These are often called 'promiscuous' legumes. Introduced rhizobia therefore have to compete against this large population of rhizobia in the soil.

A particular case is the common bean, studied by PhD student George Mwenda. "The common bean is generally seen as being much less able to fix nitrogen than many other grain legumes," says George, who conducted his studies at the Centre for Rhizobium Studies at Murdoch University in Perth, Australia. "One of the reasons we think that the common bean does not fix nitrogen well is that soils contain a lot of bean rhizobia are only weakly able to fix nitrogen."

These rhizobia are referred to as "poorly effective" or "ineffective". When common beans are grown in soil that contains a large population of these ineffective rhizobia, it is difficult for the inoculant strain to compete against them to form nodules.

Need for elite rhizobia

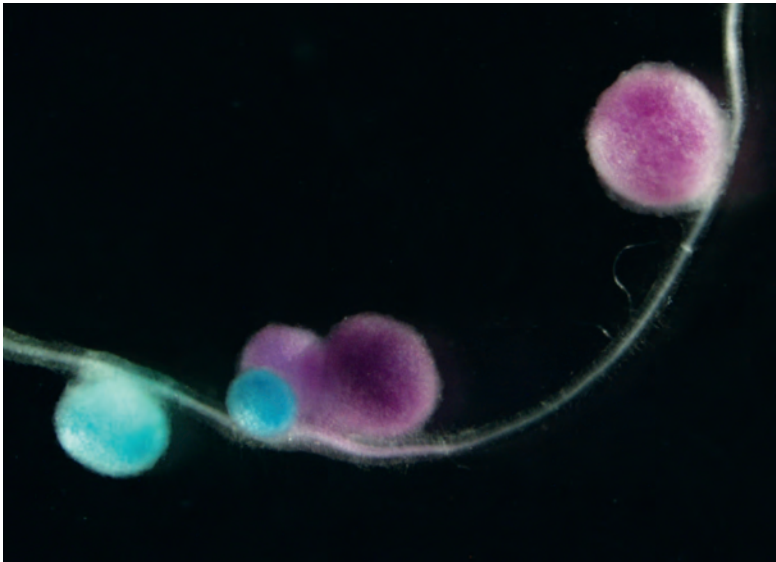
"In my PhD research, I studied this phenomenon for nodulation of the common bean,"

Farmers were soon convinced of the benefits of this magic 'black powder'

for the first time in the farmers' fields and so the soils contain very few rhizobia that can form nodules with soyabeans. This is the perfect situation for the test. Soyabean yields were greatly increased and farmers were soon convinced of the benefits of this magic "black powder", as they called it.

Key research priority

The situation in many other grain legumes is more complex. Much less research has been conducted on rhizobial inoculation of



Double-stained nodules after inoculation. PHOTO: GEORGE MWENDA



Soyabean nodules up close. PHOTO: KEN GILLER



George Mwenda working in his lab on nodule inoculation.

PHOTO: N2AFRICA

says George. "Using techniques from molecular biology, I introduced gene markers into various strains of rhizobia. I marked the standard inoculant strain for common bean with a gene that turned nodules blue when exposed to a specific chemical. Other strains were marked with a gene that led to magenta-coloured nodules being formed. This let us study the competition for nodulation between different strains of rhizobia. The surprising result was that I found some strains were able to displace a large background population of rhizobia entirely!"

Introduced nodule-forming rhizobia have to compete against rhizobia in the soil

Many scientific researchers argue that there is a need for a search for novel strains of rhizobium that are better adapted to local conditions than the strains generally used in commercial inoculants. However, N2Africa's experience indicated the opposite: off-the-shelf inoculants that contained elite strains produced good results in a wide range of soil types.

According to George Mwenda, his results are key to the development of the next generation of rhizobial inoculant strains that will be both highly effective at fixing nitrogen and highly competitive against a large background population of rhizobia. ◇



Women's group growing cowpeas
in Ghana. PHOTO: KEN GILLER

LESSONS LEARNED

The need for inoculation and nutrients

Every project has its surprising twists and turns and unexpected outcomes as well as the expected ones. What have we learned from research on rhizobiology and agronomy from ten years of N2Africa?

1 Phosphorus and inoculant are the most reliable inputs for legumes

Widespread testing of nutrients and inoculants showed that all the target legumes benefited from phosphorus fertilizer but the responses to additional nutrients like potassium were inconsistent. Soyabeans, chickpeas, cowpeas and common beans all benefited from inoculation.

2 A better understanding of yield variability is needed

Try-outs on farmers' fields revealed considerable variation in yields and responses to improved legume technologies. Understanding the key factors behind this variation could lead to better recommendations for farmers. However, despite the wealth of data collected in N2Africa, obtaining a proper understanding proved difficult, as did predicting yields for new farmers in order to improve recommendations. More detailed meteorological or agronomic information or a different experimental setup may improve our understanding of the variability, but more research is needed to achieve this.

3 Management matters most!

Management plays a predominant role in the interaction between legume genotype, rhizobium strain, environment and management, $(G_L \times G_R) \times E \times M$. Management can involve the application of manure, mineral fertilizer or inoculants, or the right plant spacing, timely weeding, and pest and disease control. Ensuring awareness, availability and access to these management practices is key to maximizing the benefits for legumes.

4 Off-the-shelf inoculants are as good as novel strains

Many scientific researchers argue that there is a need to search for novel strains of rhizobia that are better adapted to local conditions than the strains generally used in commercial inoculants. However, N2Africa's experience indicates the opposite: off-the-shelf inoculants that contain elite strains produced good results in a wide range of soil types. Future research needs to focus on novel, effective strains that can compete with rhizobia already present in the soils.

Dissemination of knowledge



N2Africa farmers evaluating varieties in the field, northern Tanzania.

PHOTO: KEN GILLER



‘Farmers believe it when they see it and understand it when they do it’



How can you get farmers to adopt new technologies? Farmer training on aspects such as legume production, inoculant application and output marketing have played a key role in the N2Africa project. The country coordinators for the five core countries share their experiences.

GHANA, SAMUEL ADJEI-NSIAH: **‘We achieved two key milestones’**

“Training women farmers in soyabean recipes enhanced the use of soyabeans in household nutrition and created business opportunities for women. This let us achieve outcomes for two key milestones – business opportunities for women and the development of legume-enriched food baskets for smallholder families.

“The training courses were organized for group leaders who in turn organized training for their members or community members, reaching many people within a relatively short time. This also reduced the amount

of money spent on training. When training women about the added value, for instance, we trained selected women from every community. These women in turn organized step-down training for their community members with technical advice from extension staff. This reduced transportation and other costs related to the training. “It is important to time the training courses well. We organized different types of training based on the cropping calendars. For instance, agronomic training was organized just before the start of the cropping season, while post-harvest training was organized just before crop harvesting. This let the people attending the courses use the skills acquired immediately.”





A farmers' group evaluating soybean crops in Nigeria.

PHOTO: KEN GILLER

NIGERIA, NKEKI KAMAI:

'Farmers were always looking forward to training'

"In Nigeria, I feel that the training courses have been very successful. In fact, farmers were always looking forward to training. That success can be seen in the way farmers accept the technologies N2Africa has been promoting in Nigeria.

"The major challenge in Nigeria is to get government institutions – especially at management levels – involved deeply in project activities for sustainability. N2Africa also had a lot of activities in the Borno region where the issue of political instability and personal insecurity is a big challenge.

"For future projects, I would recommend keeping organizing demonstrations in farmers' fields. This is a key to success. Furthermore, trainers should respect the views of farmers and not make false promises. If farmers are told that improved seed of a certain variety of a crop will be given

Trainers should respect the views of farmers'

to them for demonstrations, then do that. When training farmers, you have to be punctual. Farmers usually have other things to do as well, so respect for time is very important. You also have to allow time for questions and give precise answers."



A farmers' group attending an N2Africa field day evaluating new technologies for production of common beans, Tanzania. PHOTO: KEN GILLER

TANZANIA, FREDERICK BAIJUKYA:
'Farmers become eager to learn about technologies if they're easily available'

"Farmers are diverse in terms of their level of education and their capacity to take up new knowledge. Whereas young farmers with formal primary and/or secondary education are quick learners, old farmers with no formal education are slow learners. So they require repeated contact to understand new knowledge.

"In this case, a Training of Trainers (ToT) approach becomes important, focusing on lead farmers (knowledgeable farmers, trusted by communities and with good public relations skills). The lead farmers continuously provide valuable access to knowledge for farmers in areas too remote for most agricultural extension officers to cover.

"Farmers believe things when they see them, and understand them by doing them. So use a mixture of media (to get them engaged) and let them practice when learning. The larger the number of sources of information (printed materials, demos, radio, TV, etc.) that reach a household or farmer, the more likely they are to understand and implement new technologies."

ETHIOPIA, ENDALKACHEW WOLDE-MESKEL AND TAMIRU AMANU ABETE:

'Model farmers play a pivotal role in informal farmer-to-farmer training'

"In Ethiopia, training of farmers accounted for around 30 per cent of the total number of farmers reached during the project's lifespan, so this was an important component of the project. Although all the training themes might seem equally important in changing the farmers' practices, we learned when working with farmers that training based on real farmers' needs are adopted more readily by the farmers. For example, training courses about the relatively new technology of inoculant application seem to be more effective than the row-planting techniques that are frequently advised.

"The other key lesson in changing farmers' practices via training is that the training approach used matters a lot. Training that took account of the farmers' literacy levels and was related to their life experiences tended to be more effective. Further practical training is more suitable for farmers than classroom training. In Ethiopia, for example, we provided courses at farmer training centres, with demonstrations of a



A demonstration plot in Kapchorwa district, Uganda.

PHOTO: LAURIE VAN REEMST

step-by-step application of the technology. “The training of trainers (ToTs) approach that was used, aiming to reach more farmers, might be somewhat less effective, as the follow-up training may not be delivered as originally planned in terms of timing and content. Instead, long-term engagement with innovative model farmers can be used as a demonstration to the surrounding community. These model farms play an exemplary role and enhance the teaching and learning processes and the adoption of legume technologies by the community. Model farmers are always there in the community and play a pivotal role in informal farmer-to-farmer training.”

UGANDA, PETER EBANYAT, JUSTINE ONYINGE:

‘Local knowledge lies at the heart of improved production systems’

“Farmer training in Uganda took account of the roles that farmers’ groups play in developing agricultural systems and how farmers share knowledge and experience within such groups. Before any training at the start of the planting season, we held planning meetings in host communities with farmers’ group leaders and group members in order to generate ideas for alternative practices

and new technologies. Farmers asked for traditional practices to be included such as broadcast planting, local varieties alongside the improved varieties and nutrient management practices such as manure and

Training related to farmers’ life experiences tended to be more effective

fertilizers. Training farmers through practitioner-led approaches involving demonstrations and adaptations let them make comparisons in which they acquired and adapted new knowledge, skills and technologies to suit the prevailing conditions.

“Our experience is that feedback loops became important for farmers to share their own learning experiences during feedback meetings, technology evaluations and field day events. These learning experiences encouraged other farmers to try out technologies and helped develop technologies that are relevant to farmers. Smallholders’ local knowledge is at the heart of the design of improved production systems. As such, farmers’ learning fosters the exchange and sharing of know-how and experience between farmers.”



A wealth of information materials



N2Africa generated a lot of knowledge about biological nitrogen fixation, agronomic practices and legume processing and marketing. This information was not only published in academic journals, but also translated into easy-to-use information. A legacy of training manuals, leaflets and posters has been left behind for other projects or organizations working with legumes.

During the first phase of N2Africa, farmers were trained using the lead farmer and satellite farmer model. Lead farmers trained directly by project staff then trained a number of satellite farmers in turn. Training guidelines for lead farmers were encapsulated in the booklet *Biological Nitrogen Fixation (BNF) and Grain Legume Enterprise: Guidelines for N2Africa Master (or Lead) Farmers**. This booklet focused on biological nitrogen fixation, inoculation, setting up an on-farm experiment, good agronomic practices for legume cultivation, post-harvest handling and marketing of legumes. Three different versions (in English) of this booklet were developed, one each for East and Central Africa (EAC), Southern Africa and West Africa.

Since then, many additional materials have been developed covering a wide range of topics, e.g. related to rhizobium strain isolation and characterization, processing legumes and adding value to them, or simplified instructions on applying rhizobial inoculants. Most of these materials have been adapted for the relevant context in the various N2Africa countries or translated into local languages.

Determining the lessons learned

Over the past five years, a great deal of attention was paid to extracting the lessons learned from the first phase and presenting this information in easy-to-use leaflets and posters for farmers and other people communicating agricultural advice to farmers (extension officers, NGO field staff). A





Macklean Mafubza gets to read an N2Africa publication from the IITA stand in Malawi.
 PHOTO: LLOYD PHIPHIRA

N=N Putting nitrogen fixation to work for smallholder farmers in Africa

Biological Nitrogen Fixation and Grain Legume Enterprise: Guidelines for N2Africa Master Farmers

CIAT-TSBF and FORMAT 2010

Better soybean

through good agricultural practices

N=N For farmers in Tanzania

Twongere umasururo wa Soya dukoresha inyongeramusaruro ya Rizobiyumu











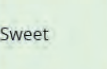





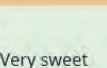

Soya ni igitanga kiri na umyanya w'ibinyamisiye. Zikangaye ku byutaka vyambiri (protein) n'izavuta.

Soya ni ibindi binyamisiye (ik'ibanyinda). Ite ibanyohotzi bwo guturura mu gukoresha umuho wo mukuru wa azote itanyuye mu dukoko "bacteria" twitwizobiyumu "Rizobia" twibara mu gupfere "Nodules" twa ku mizi ya Soya.

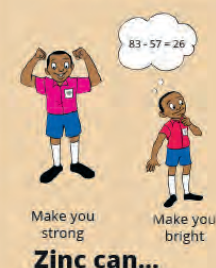
Uko Rizobiyumu ikoreshewa

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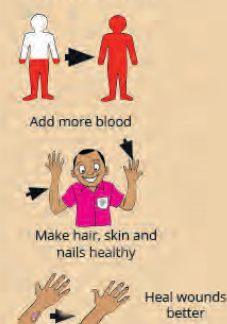
N2Africa training materials for farmers.

1. Bean Varieties	Attributes			Distinctive Features		
	Yield (kg/ha)	Maturity (days)	Suited Altitude	Seed Colour	Taste	Grain shape
NAROBEAN 4C	 2500-3700	 82-88	 Mid- high	 Red mottled	 Sweet	 Medium seeded (Oval shaped)
NAROBEAN 5C	 2500-3300	 88-96	 Mid- high	 Dirty yellow	 Sweet	 Medium seeded (kidney shaped)
NABE 12C	 2500 - 3500	 89-110	 Mid- high	 Cream with purple speckles	 Very sweet	 Medium seeded (oval shaped)

2. These varieties beans are high



Iron can...



major partner in this development was the African Soil Health Consortium (ASHC). A joint effort was made to ensure that the information presented was consistent and in line with information provided by other projects. A general booklet on Biological Nitrogen Fixation was complemented with country-specific information on good agronomic practices for the various legumes. A complete overview of all the materials

Most of the materials have been adjusted to the relevant context in the different N2Africa countries

developed during the project shows the wealth of information that was created and provides easy access to the material for other projects or organizations working with legumes.

The overview of all training materials is available at www.n2africa.org. This overview includes a brief description of the various training materials developed, followed by the available information sorted by topic:

- Biological nitrogen fixation and grain legume enterprise



- Technical training and protocols
- Rhizobium inoculation
- Agricultural management practices for legumes
- Post-harvest handling, processing and marketing of legumes

*Source: Woome, P.L. (2010), *Biological Nitrogen Fixation and Grain Legume Enterprise: Guidelines for N2Africa Master Farmers*. Tropical Soil Biology and Fertility Institute of the International Centre for Tropical Agriculture, Nairobi, 17 pp.

**of climbing
in Zinc and Iron**



Prevent diarrhoea

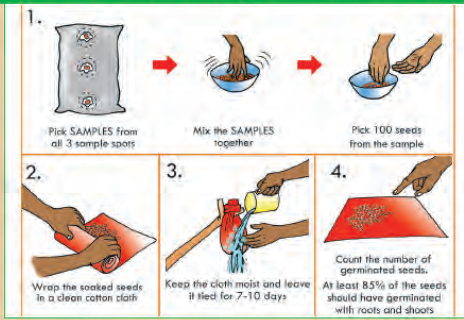


Help you focus better

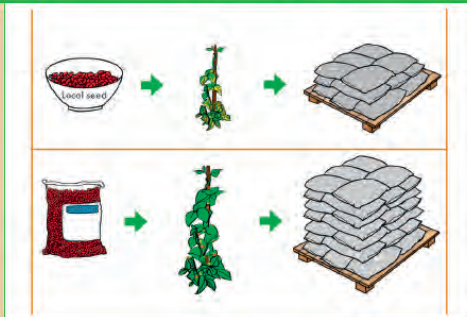


Add more energy

3. How to conduct a germination test

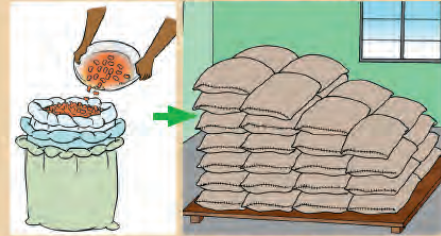


The Importance of Using Good Quality Bean Seeds



4. Seed Storage

Seeds become less healthy over time. Dried seed should be stored in airtight containers without exposure to light or moisture. It is best to plant seeds within one year.



Common airtight storage containers include silos (made of plastic or metal) and hermetic storage bags. Airtight containers prevent moisture, pests and air from damaging grain.

Illustrated and designed by
MANGO TREE
communicate design educate



Participants training more farmers in various villages in Zimbabwe.

PHOTO: ISAAC CHABATA

N2AFRICA'S RECOMMENDATION TOOL

In addition to the wealth of knowledge collected in leaf-lets, booklets and posters, the knowledge and experience of N2Africa is also accessible through a simple online tool. Anyone interested in appropriate legume production information for a given region can access the tool to find summaries of varieties, inputs and agronomic practices that have been successfully tested by N2Africa.

A map shows the technology trial sites across the African continent, covering various agro-ecological zones. One click on a legume or a location on the map directly generates a prompt with technologies tested in similar agro-ecologies. Zooming in on a region gives a location-specific overview of appropriate legume technologies.

The tool also provides specific details such as varietal characteristics, fertilizer compositions, inoculant rates, application procedures and plant and row spacing advice. Selected technologies are automatically placed on a printable summary sheet for easy reference and distribution.

Find the tool at www.n2africa.org.

A take-home flyer about climbing bean varieties.

PERSONAL STORY

‘Everybody was looking for this new variety’



Lead farmers formed an essential part of the dissemination of N2Africa’s knowledge. They benefited from the new technologies themselves and were also responsible for sharing their experiences with their fellow farmers.

Nyirandama Marie lives in Rubanga, Kamonyi District, not far from the Rwandan capital Kigali. She started working with N2Africa in February 2010.

“I began with a demonstration plot of common beans and cassava. N2Africa gave me mineral fertilizer and improved seeds. That first season, I planted about two kilos of beans and harvested thirty-two.”

It is a superior variety in terms of cooking time, taste and colour

Nyirandama sold part of her yield to COCOF, a Rwandan non-governmental local women’s organization, to disseminate to other farmers. She also sold 15 kilograms to her neighbours.

Becoming a lead farmer

The next year, Nyirandama became a lead farmer and helped other N2Africa farmers

with new technologies. She herself also profited from the new practices, she says.

“I planted fifteen kilos using modern technologies and harvested two hundred and fifty. I became popular in the area because of the new variety of common bean that I grew. Everybody was looking for this new variety, so I continued growing it. We grow it during three seasons per year; on average we harvest two hundred kilos a season, sometimes three.”

She sells her beans for about half a dollar per kilogram.

Home consumption

Nyirandama keeps around 100 kg of the beans for home consumption. “It is a superior variety in terms of cooking time, taste and colour. So besides good food, we have a good market as well, both for the seed and for the grain.”

Nyirandama’s family also makes a profit from growing cassava and – more recently – soyabeans and vegetables. Last year,



N2Africa lead farmer Nyirandama Marie.

PHOTO: N2AFRICA

she was able to build a new house from the money she made from the legumes.

Legume platform

After working with N2Africa, some of Nyirandama's fellow lead farmers were inspired to keep the interventions going after the project ended.

For example, the former lead farmers in Kamonyi District decided to set up a legume platform. The group is called Karibanya and it has a mandate to promote legume cultivation and marketing. They also provide technical knowledge about legume crops



Legume platform members in Kamonyi District.

PHOTO: KANTENGWA SPECIOSE



Rwandan landscape. PHOTO: KEN GILLER

(soybeans and common beans) to other farmers who seek advice from them. The platform has forty members.

Another farmer who was inspired by the project is Gashirabake Celestin from Buge-sera district. He was a lead farmer in the first phase and is now running a one-stop shop where he sells agricultural inputs such as fertilizers and seeds. In addition, he provides technical advice to farmers who buy from his shop. To help farmers, he has written information leaflets to distribute. He became an official agro-dealer and sells his products at subsidized prices. ◇



A policy workshop in Tanzania.
PHOTO: KEN GILLER

LESSONS LEARNED

Training and inspiration

Every project has its surprising twists and turns and unexpected outcomes as well as the expected ones. What have we learned about knowledge dissemination from ten years of N2Africa?

1 Tailor-made training is crucial

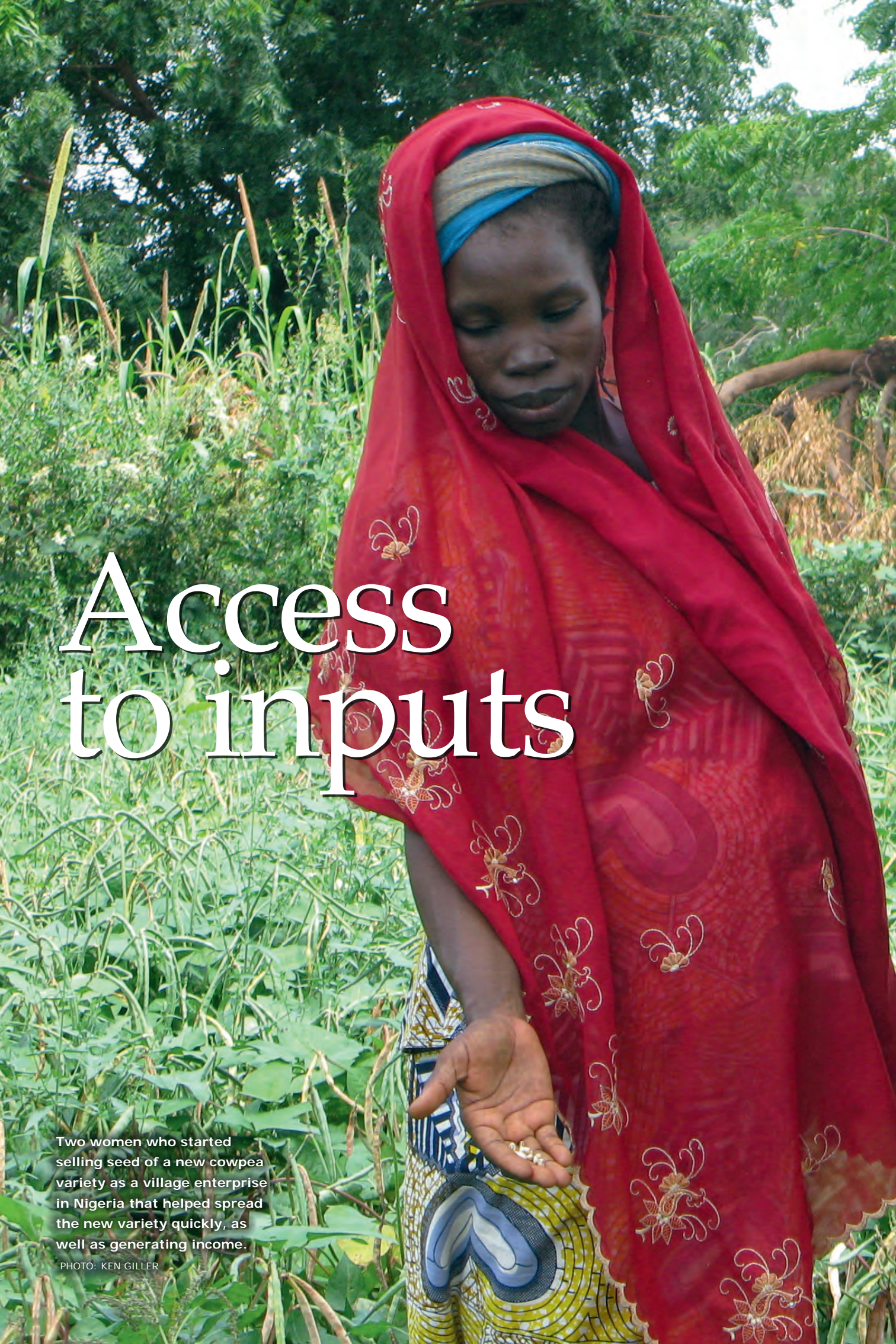
The target audiences of training courses are often diverse. Young farmers with formal education may learn quickly, but older farmers with no formal education are slower and so they require repeated contact with a lead farmer who is known in the community and who can keep sharing his knowledge with farmers. Training courses also need to be country-specific. Whereas the Training of Trainers (ToT) approach worked well in Tanzania in reaching large numbers of farmers, in Ethiopia it was felt that this model compromised the timing and content of the training. Instead, long-term engagement with innovative 'model' farmers was the key approach for demonstrating technologies to the community.

2 Ensure consistency in the information provided to farmers

Farmers are often exposed to many projects and receive information from a variety of sources. Sometimes these messages are contrasting: do legumes need fertilizer or not? Do beans benefit from inoculation or not? Together with the African Soil Health Consortium, N2Africa produced leaflets and posters with up-to-date, consistent and easy-to-understand information about legume cultivation, as well as broadcasting radio programmes through Farm Radio International. Involvement of the key national partner organizations (national research institutes and NGOs) ensured that the messages were consistent and the materials were embraced for wider use.

3 Training inspires farmers to take up roles in knowledge and input provision

Most farmers who participate in training use the knowledge gained to increase legume yields on their own farms. Farmers taking part in N2Africa training courses also regularly reported that they took up different roles after their engagement in the project. They realized the importance of continued access to knowledge and to the inputs they had become familiar with during the training. Some started multiplying seed to sell to the community; others opened small agro-input shops and also provided information for farmers buying those inputs. These initiatives help farmers to access these services, even in remote areas.



Access to inputs

Two women who started selling seed of a new cowpea variety as a village enterprise in Nigeria that helped spread the new variety quickly, as well as generating income.

PHOTO: KEN GILLER





Field days as a platform for co-learning in Zimbabwe.

PHOTO: N2AFRICA



N2Africa's branded legume products marketed by N2Africa farmers in Zimbabwe. PHOTO: N2AFRICA

High-quality seed: diffusion at the grass roots level

N2Africa's efforts to disseminate improved legume technologies created demand for legume inputs, including improved seed varieties. Access to affordable and good quality seeds at the grass roots level is a challenge, however.



In the first phase of N2Africa, the project applied a model in which farmers received a small starter pack of seed and were asked to repay double the amount of seed they received, in order to make dissemination to other farmers possible. The dissemination of seed was therefore largely led by the project and relatively little effort was put in establishing links with agro-dealers or other official channels.

Despite the lack of formal access to seed for the improved legume varieties, farmers often shared the seed that they had received with other farmers after harvest. During the first phase of the project, we conducted a study in Ghana, Kenya, Malawi and Zimbabwe in which we explored the diffusion of seed given to farmers involved N2Africa's demonstration trials. It turned out that more than 90 per cent of participating farmers who were given a starter pack of 1-5 kg of legume seed had shared it, on average with four other farmers.

The farmers who received this seed from the original farmers shared it further less frequently, although we could trace up to four "generations" of farmers sharing it in



Open market sales in Kenya.

PHOTO: LOUISE SPERLING CRS



some cases. From this study, we estimated that in addition to the 250 thousand farmers who participated directly in the N2Africa demonstration trials in the project's first phase, another 1.4 million farmers may have received seed of a new legume crop or variety as it diffused from one farmer to the next.

Improving access to high-quality seed

In the second phase of N2Africa, more emphasis was put on improving access to high-quality seed in rural communities by supporting local seed business groups or individuals interested in seed multipli-

More than 90 per cent of participating farmers who were given a seed starter pack shared that seed

cation. In Uganda, for example, N2Africa partnered World Vision and the Integrated Seed Systems Development project (led by Wageningen University & Research) to start building up the capacity of selected farmers' groups to become local seed business groups (LSB).

Bridging the gap

The groups received training to improve their skills in producing and marketing quality declared seeds (QDS) and in institutional development to become a business. The LSB groups are bridging the gap that existed in the grain legume seed sector: commercial seed companies are less interested in promoting grain legume seeds, as farmers can re-use improved seed varieties for a number of years. This makes it less viable for seed companies to multiply and distribute the seeds, in contrast to seeds of hybrid maize for instance, which have to be purchased every season.

The chair of one of the LSB groups involved, Francis Odyek from Bedijo, has said that demand for soyabean seeds especially is growing steadily. In 2017, the forecast demand was for up to 6 tons of soyabean seed, although only about 4 tons materialized. In 2018, the group grew about 10 tons.

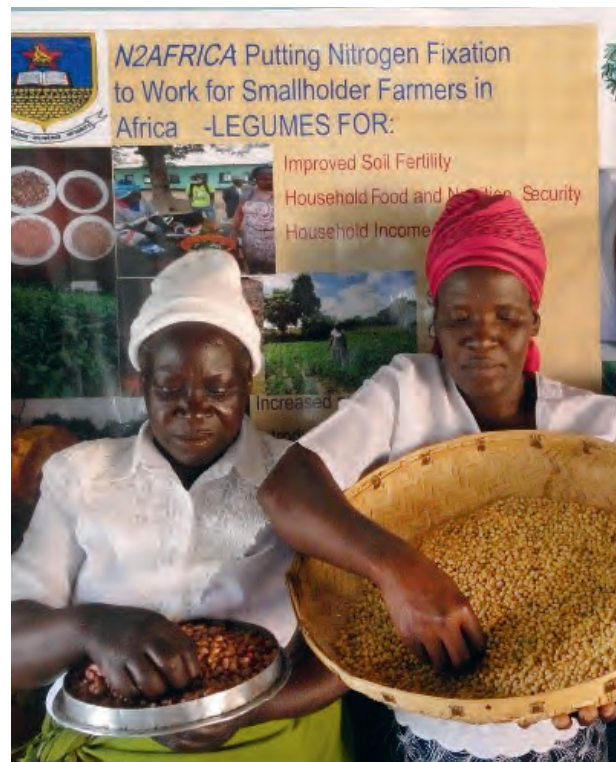
Quality control

Despite the absence of formal structures, the LSB groups worked as partners with various key stakeholders such as the ministry of Agriculture, Animal Industry and Fisheries (MAAIF) and Makerere University



Discussing poor seed germination in Uganda.

PHOTO: N2AFRICA





HIGHLIGHTS

- More than 90 per cent of participating farmers in Ghana, Kenya, Malawi and Zimbabwe who were given a starter pack of 1-5 kg of legume seed shared it, on average with four other farmers.
- Local seed business groups can bridge the gap in the legume seed sector: commercial seed companies are less interested in promoting grain legume seeds, as farmers can re-use improved seed varieties for a number of years.



Farmers showing the grain they produced to make more valuable products.

PHOTO: N2AFRICA

in Kampala. MAAIF's certification service ensured that farmers buying the seed could be sure of the quality. The groups were also registered with the Northern Uganda Local Seed Business Association (NULS-BA), an umbrella group that coordinates the activities of LSBs in northern Uganda. The association supported the group to ensure quality controls were put in place. They also followed up on links to sources of foundation seed and markets for the seed

within and outside the regions.

The key challenges remaining for the business include the lack of capital for procuring enough foundation seed, extreme weather conditions like drought, and the lack of proper demand estimation systems. Work is being done on the last of these through the cooperation with M-Omulimisa, an ICT platform offering market intelligence services [see page 92].



Inoculants: a boost in awareness and availability



People have long been aware of the benefits of biological nitrogen fixation by grain legumes, but the use of rhizobial inoculants by smallholder farmers in sub-Saharan Africa was extremely limited. Thanks to the efforts of N2Africa and partners, rhizobial inoculants are now available in all countries where N2Africa has been active.



Almost two decades ago, professor Ken Giller* concluded that grain legumes that could nodulate and fix nitrogen without inoculation were the best options for smallholder farmers, due to the perceived problems of delivering rhizobial inoculants. At that time, this conclusion was reached largely because inoculants were not available in the great majority of countries in sub-Saharan Africa. Production was mainly at national research laboratories, and only on a small scale and primarily for research purposes. However, the increasing numbers

the whole landscape of awareness and deployment of nitrogen fixation by grain legumes in sub-Saharan Africa has changed. Rhizobial inoculants are now registered and marketed in all the countries where N2Africa has been active, with several inoculant companies actively exploring ways of expanding their markets in Africa. Despite increased availability of inoculants in all the countries that N2Africa worked in, some challenges remain. Shortcomings in manufacturing, distribution and storage of inoculant products may undermine quality standards and reduce farmers' confidence in inoculant technologies. Furthermore, rhizobia are living organisms that require careful handling. N2Africa has made efforts to train distributors, extension workers and farmers to handle the inoculant products properly. Matching supply to demand at the right time is critical too. Farmers typically wait until planting time to place their inoculant orders, whereas inoculant companies cannot supply the product at such short notice. Agro-dealers and inoculant companies are reluctant to stockpile inoculants close to the market in anticipation of demand because of the limited

Production of inoculants was mainly at national research laboratories and only on a small scale

of reports of benefits of inoculation in Africa, mainly generated through the N2Africa project, have increased commercial interest in supplying inoculants.

Since the start of N2Africa's activities in 2009,



Demonstration of best practices with the Tikolore soyabean variety in Dedza District, Malawi. PHOTO: KEN GILLER

shelf life. Companies run the risk of being left with unsold packs that cannot be reused the following season. Better coordination of demand from farmers' groups could solve this issue, as well as improved just-in-time logistics and production planning by the inoculant producers.

ETHIOPIA

In Ethiopia, inoculants were previously only produced by the National Soil Testing Centre (NSTC), a public-sector institute with limited capacity and no clear mandate to scale up production on a commercial footing. A new private enterprise, Menagesha Biotech Industry plc (MBI), was established in 2012 to produce and market rhizobium inoculant products in Ethiopia, but as a start-up company it struggled to secure finance and its capacity was very small.

During its first two operational years (2013 and 2014), MBI managed to produce a total of 100,000 packets of inoculant without making a profit. Developing a market for its products was a struggle as it lacked effective distribu-

tion channels. N2Africa offered essential technical support to MBI for preparing a business plan and submitting a successful application to the Alliance for a Green Revolution in Africa (AGRA) under its Scaling Seeds and Technologies Partnership (SSTP).

With this support, MBI secured a grant to purchase manufacturing equipment and expand its capacity to produce chickpea inoculant. The AGRA grant also financed the multiplication and delivery of improved chickpea varieties and fertilizers to 90,000 growers in the major chickpea areas of Ethiopia, alongside training for farmers and other stakeholders in the chickpea value chain.

Shortcomings in the quality of inoculant products may reduce farmers' confidence

N2Africa acted as the chair of the AGRA-MBI project's steering committee and provided direct support for MBI's marketing effort. Thanks to N2Africa, the company's production,



Inoculants to promote nitrogen fixation, to be mixed with seeds. PHOTOS: N2AFRICA

distribution and sale of inoculants increased substantially. The fledgling company's journey to becoming a stable and profitable business had been made easier and quicker, reducing the years of struggle that they would have been facing on their own.

MALAWI

In Malawi, the government's Department of Agriculture Research Services (DARS) was responsible for inoculant production. Inoculants were mostly produced for research and only a few hundred sachets were being sold to farmers. The institution was unable to scale its production to meet the inoculant demand cre-

outlets by 2017. N2Africa provided technical support, trained two technicians at the IITA laboratory in Ibadan, Nigeria and facilitated the acquisition of elite rhizobium strains. AISL constructed a permanent laboratory that will be fully equipped with the requisite equipment for producing inoculants. The expected production capacity at the new facility is 1 million sachets per year.

In addition to soyabean inoculant, the company started developing inoculants for groundnuts and beans together with the DARS. AISL invested in the distribution chain by procuring 15 solar-powered coolers for proper storage of the Nitrofix distributed at 15 of its outlets. Plans are underway to install coolers in the remaining outlets. Ultimately, AISL plans to grow and meet domestic demand through improvements in the laboratory's production capacity and a larger number of outlets over the next 3 years. It will also seize opportunities to export its products to neighbouring Zambia, Mozambique, and Zimbabwe.

NIGERIA

In Nigeria, inoculant production was set up under the IITA Business Incubation Platform (BIP), with (technical and financial) support from N2Africa. The factory started operating in 2015, increasing its production from 3 tons at the time – mainly supplied to IITA projects – to 6.6 tons in 2016 and 11.6 tons in 2017.

Rhizobia are living organisms that require careful handling

ated through N2Africa. This was the situation until 2015, when Agro-Input Suppliers Limited (AISL) stepped in to scale up and commercialize the production and distribution of an inoculant branded as Nitrofix. DARS granted them marketing authority.

Since the initial production of 20,000 sachets from a temporary laboratory facility at 10 retail outlets in 2015, AISL managed to increase production to 250,000 sachets at 25 retail



Prof. David Oyo, a soyabean breeder who profited from the production of Nodumax.

PHOTOS:
FREDERICK SCHREURS

Marketing and dissemination efforts for Nodumax were intensified in 2018. Through the Public Private Partnership with N2Africa and other partners, campaigns including radio, posters, flyers and videos were developed to reach all major soyabean growing areas in Nigeria 2018. Similar campaigns were implemented in Gha-

na, where the company sees important opportunities for expanding its sales. To achieve this, BIP's Nigerian and Ghanaian distributors will aim to establish designated Nodumax sales depots complementing their agro-dealer networks as retail outlets. ◇

HIGHLIGHTS

- **Rhizobial inoculants are now registered and marketed in all the countries where N2Africa has been active, with several inoculant companies actively exploring ways of expanding their markets in Africa.**
- **Matching supply to demand at the right time is critical for inoculants. Because of the limited shelf life, agro-input dealers are reluctant to stockpile inoculants close to the market.**

** Source: K.E. Giller, Nitrogen Fixation in Tropical Cropping Systems (2nd ed.), CAB International, Wallingford (2001).*

Fertilizers: a higher yield with the perfect blend



Legumes benefit from the application of phosphorus and other nutrients. However, there were no fertilizers that contain the optimum nutrient blend specifically for legumes. N2Africa helped to formulate legume-specific fertilizer blends in Ghana and Kenya which improved legume yields.

Grain legume growth and production are often limited by a lack of available phosphorus (P) in the soil. Legumes therefore need it to be added, for instance through the application of mineral fertilizer. While inoculants are relatively inexpensive (about USD 10 per ha), phosphate fertilizer tends to be four to five times more costly. The risk for farmers of investing in fertilizer is therefore relatively high.

cium too. And while legumes generally don't need nitrogen (N) to be added because they can fix it from the air, the most commonly available fertilizer blends that contain phosphorus are nitrogen-phosphorus-potassium (NPK) and diammonium phosphate (DAP), both of which do contain N. Making chemical fertilizers containing nitrogen takes a lot of energy, so there would be an environmental benefit in omitting it where it is not needed.

While inoculants are relatively inexpensive, phosphate fertilizer tends to be four to five times more costly

Moreover, some fields fail to respond to the fertilizer being applied, which makes the investment for farmers even more risky. In some cases this may be because other nutrients are the limiting factor: even though enough phosphorus is supplied, the legume may still not grow well because there is e.g. insufficient potassium or cal-

Only when specifically requested

Legume-specific fertilizer blends were therefore not readily available in most of the countries where N2Africa operated. And even when appropriate fertilizers without nitrogen were available, such as single or triple superphosphate (SSP or TSP), they could often only be obtained on specific request.

In some countries, N2Africa focused on improving the access to existing fertilizers (e.g. TSP and SSP in Uganda and Nigeria, Minjingu in Tanzania), because these fertilizers were considered effective enough in



Legume-specific fertilizers help improve legume yields.

PHOTO: SHUTTERSTOCK

increasing legume yields. In other countries, emphasis was placed on formulating and disseminating legume-specific fertilizers because trials showed that additional nutrients would be required to improve legume yields. In Kenya and Ghana, N2Africa sought cooperation with commercial parties that were interested in blending these fertilizers.

GHANA: COLLABORATION WITH YARA

In 2015, the N2Africa team in Ghana approached YARA, a fertilizer company, with the request to provide TSP fertilizer for field trials and demonstrations. The initial contact evolved into advanced collaboration evaluating new fertilizer blends for legumes.

“No specific nutrition solution for legumes was available at the time, and YARA therefore decided to develop one,” says Mahama Abdul-Rahaman, YARA’s Marketing Manager. “We also realized that we needed other actors like N2Africa who could work on promoting and disseminating this fertilizer.”

The new YARA legume fertilizer (containing a nitrogen starter, calcium, magnesium and boron in addition to phosphorus and potassium) resulted in about 100 per cent increase in grain yield of soyabeans compared with soyabeans without any fertilizer. The average

Soyabeans were one of the crops in this programme. The team used the opportunity to lobby and to recommend the new legume fertilizer blend to the technical committee for use in improving production of soyabeans. The product was accepted for inclusion in the fertilizer subsidy programme that was to be used for legume production in Ghana by the new government. In May 2017, MoFA signed a contract with YARA Ghana to supply about 33,000 bags (1,650 tons) of the YARA legume fertilizer to farmers under the ‘Planting for Food and Jobs’ programme. All the soyabean farmers participating in the planting were supplied with the YARA legume fertilizer for their fields.

Awareness

The partnership improved farmers’ access to legume fertilizers in northern Ghana. An important lesson learned was that joint on-farm trials with input suppliers like YARA created awareness of the need, demand and market for legume fertilizers.

As a next step, the packaging of fertilizers in smaller quantities (e.g. 25 kg instead of 50 kg) is envisaged, to meet the needs of farmers who cannot afford the 50 kg bags. An improved system of quantification and accuracy of input demand information would also help suppliers meet the demand from farmers.

KENYA: COLLABORATION WITH MEA LIMITED

In Kenya, the legume fertilizer blend Sympal was developed. Sympal contains no mineral nitrogen, but offers a balanced supply of phosphorus, potassium, calcium, magnesium, sulphur and zinc. The blend was formulated by N2Africa and prototypes were packaged by MEA Limited, an input distribution company based in Nairobi. Sympal is available in bags of 2, 10 and 50 kg bags to facilitate use on smaller plots of land.

Small packages of Sympal were tested in agronomic trials and distributed to farmers to try out on their own fields. Trial results

The new legume fertilizer gave about a 100 per cent increase in soyabean grain yields

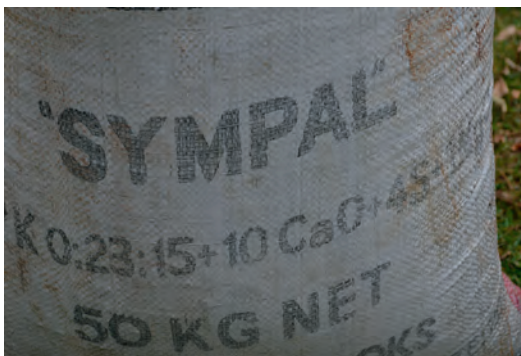
yield difference between TSP and the new YARA blend was about 270 kg per ha.

A public-private partnership was set up between N2Africa, YARA, the Ministry of Food and Agriculture (MoFA) and other partners. Through this PPP, the N2Africa team was requested to provide advice to the technical committee under Ghana’s new agricultural programme ‘Planting for Food and Jobs’.



Left: legumes with fertilizers applied.
Right: crops with no fertilizer applied.

PHOTO: FREDDY BAIJUKYA



The legume fertilizer blend Sympal gave stronger and more consistent improvements in yield of soyabeans. Right: Mahama Abdul-Rahaman, Marketing Manager at YARA.

PHOTO: N2AFRICA, SAMUEL ADJEI-NSIAH

showed that Sympal gave stronger and more consistent improvements in yields of soyabeans than a fertilizer blend (Minjingu) containing phosphorus and calcium. The blend was refined after the on-farm testing and MEA then started to produce the final product at its blending facility in Nakuru.

Appreciation of Sympal extended well beyond the N2Africa network, as over 128 tons of this

product were blended and marketed by MEA in the first phase of N2Africa.

Sympal is very effective when applied to inoculated pea as well, but less so with beans. As a result, MEA formulated and markets a sister product "P Mabau" that combines Sympal with 10 per cent mineral nitrogen, as beans do often benefit from a small dose of nitrogen to kick-start growth. ◇

HIGHLIGHTS

- Through partnering with companies N2Africa improved farmers' access to existing fertilizers.
- N2Africa led to better formulation and dissemination of legume-specific fertilizers.
- N2Africa cooperated with commercial parties who produced the new legume-specific fertilizer blends and marketed them.



N2Africa and M-Omulimisa developed a mobile-phone platform for information exchange between farmers, extension officers, input dealers, banks and insurance companies. PHOTO: M-OMULIMISA

Running a farm with a mobile phone



Like many countries in sub-Saharan Africa, Uganda’s agricultural sector is plagued by a host of challenges. However, the rapid growth of mobile technology can offer a solution. N2Africa entered a partnership with an ICT company, to pilot a mobile extension platform that lets Ugandan farmers use a mobile app to manage their agricultural affairs.

Farmers in Uganda have limited access to affordable credit and it is difficult for them to get good quality seeds and fertilizer. Moreover, they lack access to information with only a few extension officers having to provide information to large numbers of farmers. The rapid growth of information and communication technology presents an opportunity

for solving several of these challenges in one go.

A virtual forum between a farmer and an extension officer

N2Africa entered a partnership with M-Omulimisa, an ICT company, to pilot a web-based mobile phone platform that provides a virtual forum between a farmer and



an extension officer. This made it possible to provide knowledge and agricultural information to farmers as well facilitate access to inputs, outputs and other related services to farmers on a large scale.

The mobile-enabled Village Agent model that was piloted uses farmer networks, partnerships and a network of village agents to provide a bundle of agriculture-related services including facilitating access to input and output markets. In this model, the ICT platform (M-Omulimisa) plays a facilitating role, providing brokerage services by bringing various actors together so that they can collaborate and do business. These actors include suppliers, buyers, insurance companies and credit institutions to give farmers access to business development services that will let them improve their productivity and incomes.

These partnerships have allowed improved seed, fertilizer and agricultural insurance to be delivered through micro-loans from the Microfinance Support Centre (MSC). These services are complemented by mobile-based extension services and output marketing through partner purchasers.

36 village agents and 8000 members

In the pilot, the network of 36 village agents worked with over 200 farmers' groups with a combined membership of

over 8000 spread across 10 districts of northern Uganda. Working with these large numbers results in economies of scale and allows M-Omulimisa to negotiate favourable prices with the suppliers. In addition, M-Omulimisa receives a commission from the suppliers on the products sold and shares a percentage of this commission with the village agents for the services they offer such as aggregating input demands and providing extension advisory services to farmers.

The mobile phone platform uses farmer networks, partnerships and a network of village agents to provide agriculture-related services

How do M-Omulimisa's bundled products work? The foundation is a network of village agents, each with a smartphone that helps define profiles for the farmers, as well as recording the agro-input requirements of the farmers profiled. The profiling (e.g. asking each farmer about the types of crops grown, in which season, the inputs used, membership of a farmers' group and their level of organization) helps to aggregate the demand for input supplies for each group, and to predict the demand for the next season.

Aggregation helps M-Omulimisa negotiate better prices for inputs.

PHOTO: NEIL PALMER, CIAT



A group assessment meeting in Pader, northern Uganda to collect information about the inputs needed. PHOTO: N2AFRICA

Each village agent submits the agro-input requirements of their farmers' groups to M-Omulimisa via a mobile phone platform. At M-Omulimisa, this demand is aggregated and constitutes the basis for placing orders to certified agricultural suppliers. The

higher-quality resources. After the farmers receive an invoice from the agricultural supplies dealer stating the total price for the bundled inputs, the group completes an application to MSC for financing of that amount of money.

These arrangements both reduce the amounts to be borrowed and let farmers get high-quality input

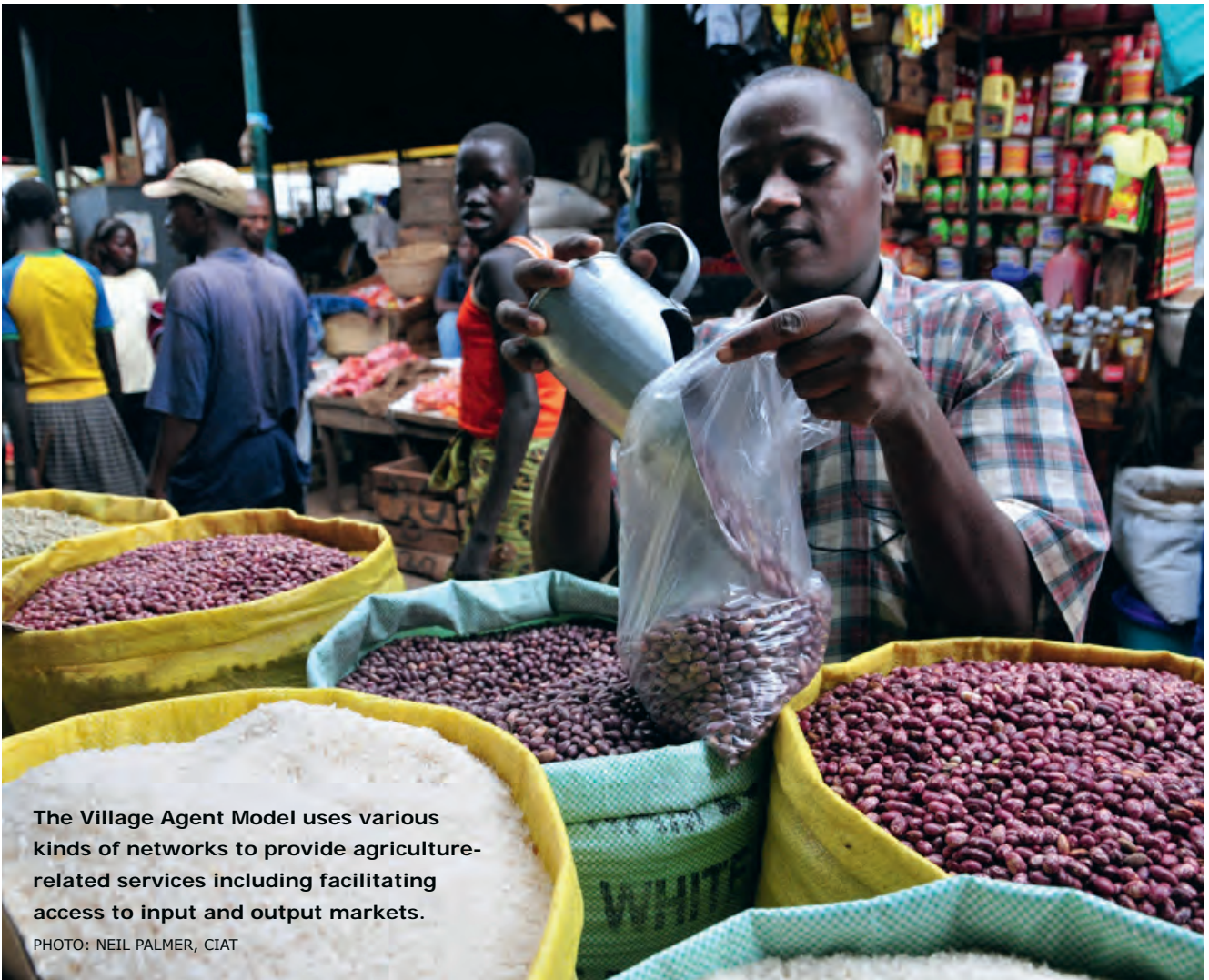
aggregation helps M-Omulimisa to negotiate better prices and after-sales service packages such as free transportation of the materials to the nearest points where the village agents can then distribute them to the beneficiary farmers.

These arrangements not only reduce the amounts to be borrowed by the farmers to get the seed, thereby helping address the liquidity issues, but also let farmers obtain

Critically needed agricultural services

Thanks to the use of the mobile platform, a strategic partnership has been established with various actors in the agriculture ecosystem. This has let M-Omulimisa develop and deliver bundled input loan products that consist of critically needed agricultural services. These bundled products include improved seed, fertilizer, agricultural insurance and post-harvest handling equipment such as tarpaulins and storage bags provided through affordable credit from the Microfinance Support Centre (MSC).

Through the bundled products, M-Omulimisa has distributed USD 30 thousand worth of inputs to 14 groups comprising 590



The Village Agent Model uses various kinds of networks to provide agriculture-related services including facilitating access to input and output markets.

PHOTO: NEIL PALMER, CIAT

farmers. Currently, assessments of farmer groups are being conducted for loans in the first season of 2020. It is expected that M-Omulimisa will work with at least 100 groups and disburse resources worth USD 135 thousand. Agreements have also been made with MSC to add extra products in the bundles in the coming season such as tractor hire services and mobile phones.

Challenges and issues

Of course, there are various challenges that need to be addressed. There are issues with late delivery of inputs due to delayed processing of loans by the Microfinance Support Centre. Setting up a special desk to handle agricultural loans and giving preferential treatment to files from farmers' groups supported by M-Omulimisa should mitigate this next season.

Other problems are the difficulty farmers have completing loan applications and farmers' groups failing to pass assessments

due to poor record-keeping. A refresher training course was held to improve the ability of agents in completing loan application forms; they will then assist their groups. Similarly, a five-day workshop was held for farmers by MSC on financial literacy and business development. ◇

HIGHLIGHTS

- The advent of ICT, especially mobile technology, and its rapid spread in Uganda can – if well leveraged – bring about major jumps forward in access, efficiency and effectiveness.
- Thanks to the use of the mobile platform, a strategic partnership has been established with various actors in the agriculture ecosystem that has allowed M-Omulimisa to develop and deliver bundled input loan products consisting of critically needed agricultural services.

PERSONAL STORY

‘With the seed business, I built a new house’



Maria Brigida Miguel Noé developed from a farmer in a remote province in Mozambique into an innovative seed supplier. With help from N2Africa, the emerging entrepreneur is now the ‘missing link’ in the input supply chain.

In Mozambique, the smallholder farming sector is relatively underdeveloped and a lot of farmers live in sparsely populated rural areas, which makes it a challenge to get farm supplies. Furthermore, there is insufficient business interest to support conventional brick-and-mortar agricultural retailers. N2Africa was therefore happy to assist individuals who were interested in supplying materials for their communities.

Maria Brigida launched an innovative and farmer-friendly model to supply seed to farmers in her village

N2Africa initiated a collaboration with the Chigwirizano farmers’ association. As one of the members, Maria Brigida Miguel Noé from the remote area of Angónia District hosted N2Africa demonstration plots for soyabean production. The practices demonstrated included improved varieties, optimum plant spacing, seed inoculation and fertilizer application. The demonstration plots proved that using inoculated seed and

optimum plant density could let farmers double their yields.

The start of a seed production business

With the new knowledge from the demonstrations, Maria and her associates started cultivating soyabeans on a large scale, as a cash crop. However, as demand grew they could not get enough certified, high-quality seed. This challenge was the first chapter in Maria’s success story, as she vowed to start a seed production business.

“I was inspired to set up this business primarily to improve my life by selling seeds, but also to help colleagues in the association,” says Maria Brigida. “Seeing the growing demand for soyabean seeds, I decided to become the main seed provider in the village, by growing other crops such as groundnuts and maize too.”

Help farmers access high-quality seeds

Assisted by N2Africa, she was able to get some soyabean varieties to multiply on 3 ha out of her 5 ha of land. She launched an innovative and farmer-friendly model to help farmers in the village obtain high-quality soyabean seeds. She made soyabean



Maria Brigida Miguel, an innovative seed supplier in Mozambique.

PHOTO: WILSON LEONARDO



Mozambican landscape with high-quality soybeans in foreground.

PHOTO: KEN GILLER

seeds available to farmers. Each beneficiary farmer paid back three times the amount of soyabean seed they had received as grain they harvested. Maria then sold the grain to middlemen or larger traders such as Cargill. In the first cropping season, she received 25 kg of soyabeans from N2Africa. In subsequent seasons, she bought the seed directly from agro-dealers at Ulongue, the main village in the district, or in neighbouring villages in Malawi.

Confident of a better future

Maria continues to reap the rewards of her hard work and is confident of a better future.

“With the seed business, I built a new house. I requested 30 hectares of additional land from the government, which I was granted. When you visit me next season,

‘When you visit me next season, you’ll be surprised to see the vehicle I intend to buy’

you’ll be surprised to see the vehicle I intend to buy to facilitate my business, as it is costly to rent a car to transport produce.” ◇



Inoculated soyabeans with phosphorus fertilizer in front of the farmers - uninoculated behind. PHOTO: KEN GILLER

LESSONS LEARNED

Matching supply and demand

Every project has surprising twists and turns and unexpected outcomes as well as the expected ones. What have we learned from ten years of N2Africa about access to inputs?

1 Local seed business groups bridge a gap in the grain legume seed sector

Commercial seed companies are less interested in promoting legume seeds, as farmers can reuse improved seed varieties. This makes it less commercially viable for seed companies to multiply and distribute the seeds. Farmers therefore often rely on the use of grain as seed and it becomes difficult to make new legume varieties available on a larger scale. N2Africa assisted groups or individuals who were interested in producing seed for new or existing legume varieties and trained them in producing high-quality seeds. This let local seed businesses ensure that high-quality seed was available at the grass roots level.

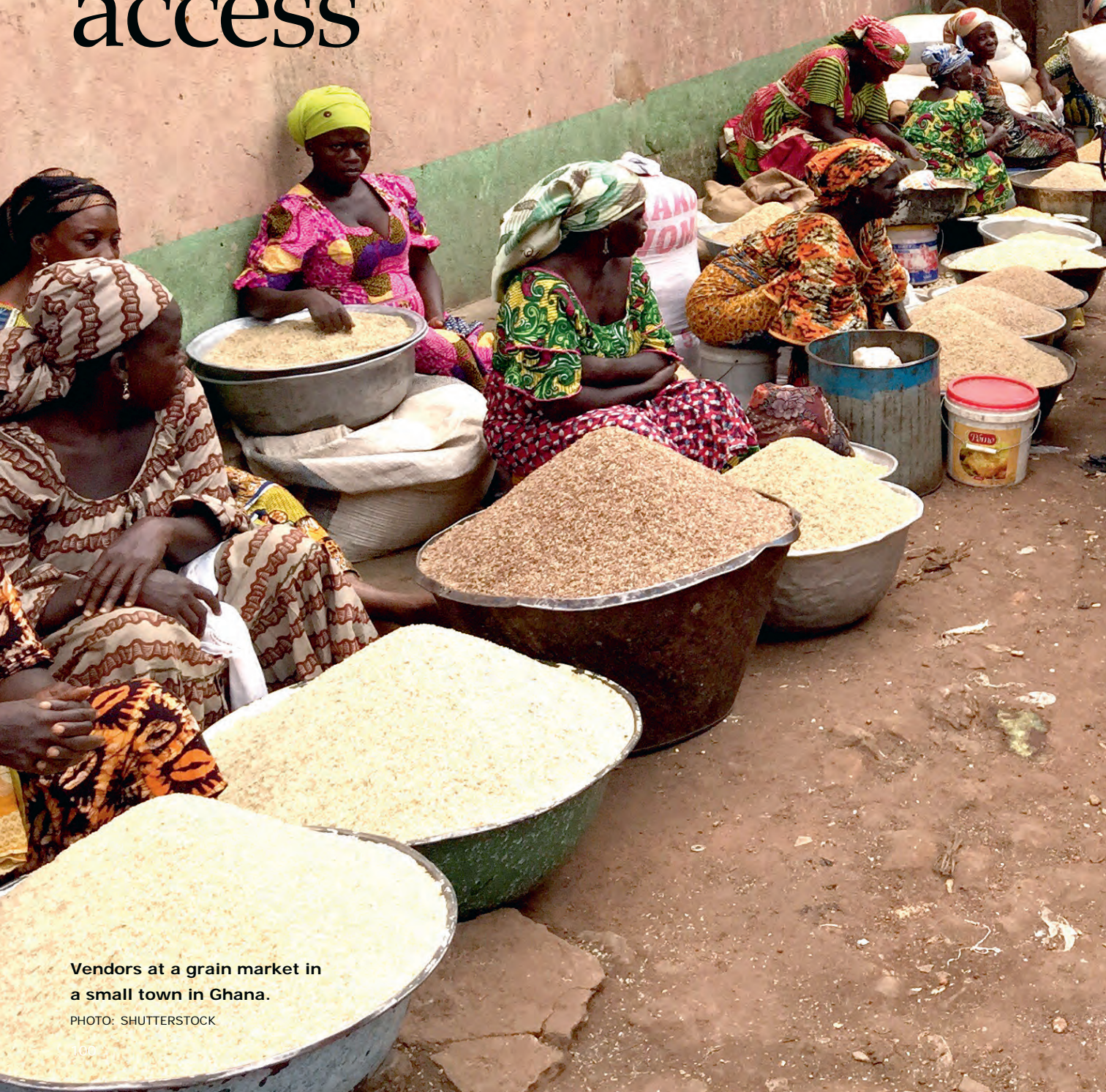
2 Just-in-time delivery remains a key challenge in the inoculant supply chain

Although inoculants can now be purchased in most countries where N2Africa was active, some challenges remain. The lack of cooled supply chains and the fact that many inoculants contain bacteria other than rhizobia means that contaminants rapidly outgrow the rhizobial populations present in the packages. The shelf life of contaminated inoculants is often only a few weeks, which makes agro-dealers and inoculant companies reluctant to keep large stocks, whereas farmers typically wait until planting time to place their orders and inoculant companies cannot supply the products at short notice. Communicating farmers' resource requirements well ahead of the season – e.g. through a farmers' cooperative, a village-based agent who collects farmers' requests or an online platform – would reduce the risks and increase suppliers' interest in the legume value chain.

3 Web-based mobile platforms might help estimate supply and demand better

Farmers often have difficulties pre-financing their agricultural resources. At the same time, suppliers have difficulty estimating the demand from these farmers. N2Africa entered a partnership with M-Omulimisa in Uganda, an ICT company, to bring together various actors through a virtual platform. The partnership let M-Omulimisa deliver bundled products including improved seed, fertilizer, agricultural insurance and post-harvest handling equipment, provided through affordable credit from a microfinance institution. A network of village agents helped aggregate the demand for supplies from farmers' groups. The mobile platform is still in a pilot stage but – if it is successful – it is hoped that more services can be included and that expansion to other parts of the country will be possible.

Output market access



Vendors at a grain market in
a small town in Ghana.

PHOTO: SHUTTERSTOCK





Challenges for soyabean farmers



Soyabeans are an important crop for smallholders in Ghana. Since 2015, the prices smallholders are paid for soyabeans have declined due to a fall in the world market price and massive imports of cheap soyabeans, as well as frequent breakdowns at the processing mills.



Smallholders in northern Ghana want to produce soybean cake for animal feed. Unfortunately they face lots of challenges.

PHOTO: DANIEL AKAKPO

Soyabeans have become an important crop in northern Ghana over the past decade and is grown mainly by smallholders. Soyabeans are an important source of edible oil and high-quality protein for both humans and livestock. The residues after the oil has been extracted are an excellent source of high-quality feed for the poultry and fish (aquaculture) industries, where the product is in high demand.

The good price paid for soyabean grain between 2005 and 2012 encouraged smallholders to increase production. The area under production in northern Ghana rose

from 44,545 ha in 2004* to 85,938 ha in 2011**. However, the market for soyabeans and products produced locally has been de-

In 2018, some 90,000 tons of soyabeans were imported by Ghana, almost all as soya cake for animal feed

clining rapidly since 2015 due to imports of cheap soyabean cake into the country from Argentina, the USA, Belgium, the Netherlands and Paraguay.



Bags of unsold soyabean grains in a farmer's store room in Yendi, Ghana. PHOTO: ERIC DOE



Poultry farmers prefer imported soyabean cake to the locally processed product because they have a lower oil content

In 2018, some 90,000 tons of soyabeans and soyabean products were imported by Ghana, almost all as soya cake for animal feed^{***}. This has forced some of the local processing factories to close, eliminating the

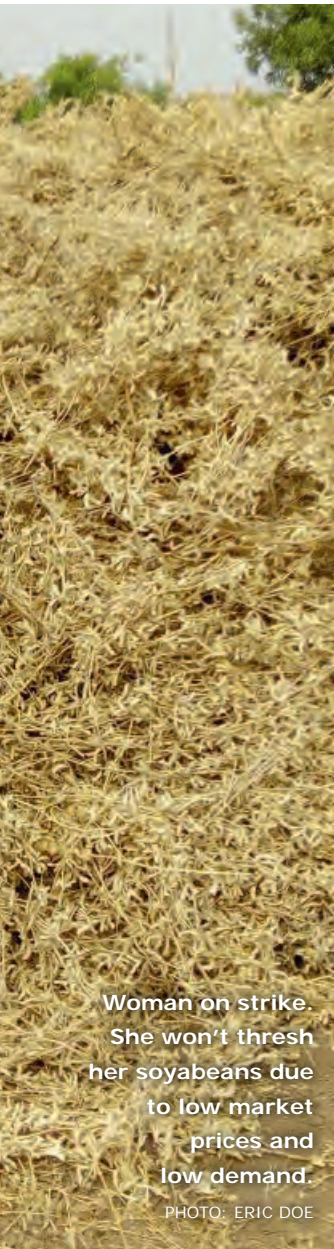
market for the farmers' produce, which hit its lowest price since 2015 of USD 250 per ton (compared with the world market price of almost USD 375 per ton).

According to the poultry farmers who purchase the bulk of the soyabean cake

processed in the country, they prefer imported soyabean cake to the locally processed product because of the high oil content of the latter which is not good for preparing poultry feed. Nine of the top ten processing mills in the country use a mechanical method to extract the oil, leaving a substantial amount of oil in the cake which reduces its quality as feed.

A number of challenges

Besides the lack of a market for locally processed soyabean cake, N2Africa found that the processing mills faced a number of other challenges. These included frequent breakdowns of their machines due to the poor quality grain supplied by farmers (grain mixed with stones), frequent power



Woman on strike. She won't thresh her soybeans due to low market prices and low demand.

PHOTO: ERIC DOE



Soyabean cake for animal feed.

PHOTO: SHUTTERSTOCK



Soyabean technology dissemination activities in Yendi.

PHOTO: N2AFRICA

cuts and the high cost of energy (which almost led to the industry collapsing between 2015 and 2016), high taxes and lack of funding.

N2Africa intervened by training leaders of farmers' organizations in post-harvest handling and processing to improve the quality of the grain. Maintaining the soyabean value chain in Ghana requires further policy interventions to address the numerous challenges faced by the local processors who purchase the bulk of the grain produced by the smallholders. ◇

* Source: Ministry of Food & Agriculture, 2005.

** Source: Ministry of Food & Agriculture, 2012.

*** Source: Ministry of Trade & Industry, 2018.

HIGHLIGHTS

- Challenges include the lack of a market for locally processed soyabean cake and frequent breakdowns of the milling machinery due to the poor quality of the grain supplied by farmers (grain mixed with stones).
- N2Africa intervened by training leaders of farmers' organizations in post-harvest handling and processing to improve the quality of the grain.
- There is a massive opportunity to expand smallholder soyabean production to meet the burgeoning demand for poultry feed and fish food in Ghana.
- This requires policy support and active interventions to overcome the transaction costs in the supply chain to improve quality of production and ensure a better price for farmers.

Every legume its own approach



In Zimbabwe, farmers now have better connections to the markets for selling their legumes, thanks to N2Africa. But not every legume is the same. Each crop is used and traded in a different way. Responding to the wishes and needs of farmers is therefore essential when rolling out new technologies.



One of N2Africa's overall aims was to drive a value chain approach for the various legumes, linking farmers to markets. Value-chain approaches work well with more commercial crops – such as vegetables – but had not been tried much with grain legumes and are now delivering successes in many countries, in

Common beans generally grow well under maize on good soils and produce more grain than when grown as sole crops on outfields

particular with soybeans. However, after discussions with farmers' groups during the early phases of N2Africa in Zimbabwe, it turned out that there are different markets for different types of legumes.

A value chain approach was in fact appropriate for soybeans, with the main problem

being one of consolidating the grain harvest into loads for transport to markets – a market coordination issue. For groundnuts, the challenges were similar in terms of consolidating the produce. But unlike soybeans, which are only consumed in small quantities at the household level, people know what to do with cowpeas and groundnuts. They eat them a lot and groundnuts are also processed into peanut butter for sale at local markets.

Common bean issues

The situation was different again for common beans. Some farmers were growing large fields of common beans, targeting a local market of residential mission school kitchens. Others complained of problems of keeping seed from one season to the next – not because of post-harvest pests – but because the beans are so popular that they get eaten! So there is generally little surplus, and what there



There are various markets for different types of legumes in Zimbabwe. PHOTO: KEN GILLER

is can readily be sold through local markets. The other major issue for farmers growing beans is that they do not perform well in the coarse granite sandy soil that predominates in most of the smallholder (communal) farming areas. Common beans only grow well in the 'infields' – the fields close to the homestead that are treated regularly with cattle manure.

But these fields are where maize, the main self-sufficiency food crop, is grown. The farmers have the perfect solution – simply planting common beans as an intercrop without reducing the density of maize planting. Common beans generally grow well under maize and tend to produce more grain than when grown as sole crops on poorer fields.

Markets for cowpeas

A particularly striking issue was the markets for cowpeas. Essentially, cowpeas are grown



Intercropped groundnuts and maize.

PHOTO: KEN GILLER



Groundnuts ready for sending to the market in Mudzi, Zimbabwe.

PHOTO: ISAAC CHABATA

by most farmers for their own consumption (both the grain and the leaves) and it is liked but not the most popular legume. In contrast with common beans, cowpeas grow well on

Other than trade in seed of cowpea by a few companies, cowpeas are not sold much on open markets

the coarse sandy outfields in Zimbabwe, as long as a little phosphorus is applied. The varieties offered by N2Africa were very popular with farmers and there was considerable demand for them locally. But apart from trade in cowpea seeds by a few companies, cowpeas

are not sold much on open markets, either locally or through the central grain markets in Harare.

So the cowpea is an important food security legume for poorer and wealthier farmers alike because it grows well in their less fertile fields, and one where simply introducing the new varieties and ensuring they are spread through local women's groups can have an important impact at the household level, as both the leaves and the grain are consumed.

Quality time with farmers

So where does this leave us? Not with a problem but with an opportunity! We need



Seed packets and peanut butter made by an N2Africa farmers' group at a market in Murewa.

PHOTO: KEN GILLER

to use differentiated models for the various legumes – a value chain approach for soya-beans, a mixed model for various varieties of groundnut, and various local niche models for common beans and cowpeas.

This provides another example of the importance of spending quality time on discussions with farmers. Many seem to think that all the good ideas come from farmers – and that may often be true – but interactions between farmers, development agents and researchers also leads to innovation. Recognising the different aims and objectives of the farmers is key to designing approaches for rolling out these technologies in new areas. ◇

HIGHLIGHTS

- A value chain approach linking farmers to markets works well for soyabeans but a mixed model is needed for various varieties of groundnut and various local niche models for common beans and cowpeas.
- Cowpeas are an important food security legume for poorer and wealthier farmers alike, and one where introducing new varieties and ensuring they are spread through local women's groups can have an important impact at the household level.
- Interactions between farmers, development agents and researchers leads to innovation.

PERSONAL STORY

‘The yields of soyabeans I get are extraordinary’



Claudine Mukakayonde is a farmer. Before meeting N2Africa, she had no development plan for her crops. Her business is now growing so fast she can barely satisfy the demand from her customers.

Claudine Mukakayonde is a soyabean producer from Mareba in Bugesera District, Rwanda. The 47-year-old married mother of six is one of the partners of the N2Africa project that introduced new farming technologies to increase yields of soyabeans.

“Before meeting N2Africa, I had no development agenda,” she says. “I intercropped beans, soyabeans, maize and cassava in no particular order. As a result, my soyabean production was meagre, although I enjoyed growing the crop because I knew that feeding my children soyabeans would mean they’d be healthy.”

‘On a plot where I previously produced thirty kilos, the production went up to two hundred and seventy. That’s extraordinary’

When the N2Africa project started in 2010, Claudine was selected as one of its first partners.

“I was already growing soyabeans and was a committed farmer.”

The project introduced Claudine to technologies that maximized yields in the fields

through intercropping and rotation of key staples, such as maize and cassava. Appropriate inputs such as organic matter, inoculant and fertilizers were used as well, and improved high yielding varieties were introduced.

“These technologies increased the yields and made me realize that soyabeans produce as much as common beans, or more,” says Claudine. She then intensified her soyabean production.

“On a plot of an eighth of a hectare where I previously produced thirty kilos, the production went up to two hundred and seventy. That’s extraordinary.”

“The project helped compare profitability of the various legumes – soyabeans, beans and groundnuts. The comparison showed that soyabeans gave the best yields and can be used in lots of different ways,” says Claudine. “My farming skills for soyabean production have now improved. I was picked to help spread the new technologies for soyabeans and common beans.”

Find a market

The increased soyabean production posed a challenge for the farmers in finding a market.

“Soyabeans were only used in the homes to make porridge, or boiled to make sauce



Claudine with her son. PHOTO: N2AFRICA

or sprinkle over food," she says. "We had to find a market for soyabeans or teach the community how to process soya into other products that were much more consumable and more marketable."

The N2Africa project took up this challenge and taught the community how to process soyabeans.

"In 2013, I was part of a group of twenty-six women who were taught various ways of processing to add value to soyabeans. That's where my dreams of a better life started, because I saw that the value of the



Claudine using the machine to pound soyabeans.

PHOTO: N2AFRICA

'Soyabeans were only used to make porridge, or boiled to make sauce or sprinkle over food. We had to find a market'

thirty kilos of processed soyabeans I had at home was worth more than a hundred kilos of beans, which are usually only boiled for food. No other processing is possible for beans."



Soyabeans inoculated with P-fertilizer and manure in Bugesera District. PHOTO: EDOUARD RURANGWA

During this training, Claudine learned how to make tofu, soyamilk, dumplings, soya 'tea' and other products. After the training, she started processing her soyabeans using local materials such as a mortar and pestle (isekuru and umuhini) into milk, tofu and the popular doughnut balls for sale.

"The customers were enjoying my products. So I moved my business from a remote centre – Nyamigina – to a place closer to my customers, Ruhuha-Rango," she says. "And I made the most of the existing infrastructure, including electricity. My business grew and soon I couldn't satisfy the demand from my customers. Once again, the N2Africa project helped me by granting me an electric machine to pound the soyabeans." ◇



Children cleaning beans in a village in Gisenyi district, northern Rwanda.

PHOTO: KEN GILLER

LESSONS LEARNED

Tailored approaches

Every project has its surprising twists and turns and unexpected outcomes as well as the expected ones. What have we learned about output market access from ten years of N2Africa?

1 Improving production should go hand in hand with output market access


In Ghana, the number of farmers growing soyabeans increased. However, the national market collapsed after 2015 because oil mills complained about the varieties grown by Ghanaian farmers (with high oil content), poor-quality grain being delivered by farmers and cheap imports of soyabeans. When there is no market, farmers are easily discouraged from growing a certain crop. N2Africa therefore trained farmers to improve the quality of grain and to grow varieties preferred by the market. Market requirements should be taken as a starting point for production and post-harvest handling.

2 Different legumes require different types of marketing models

Value chain approaches generally work well with commercial crops. Legumes like soyabeans and certain varieties of groundnut are often produced for processors, which makes it interesting to explore value chain models for purchasing produce and providing inputs. However, legumes such as common beans or cowpeas have more important roles as food for the household, with any surplus being sold on local markets. This calls for locally tailored approaches to production on the farm as well as ensuring that legumes have the colour, cooking qualities and taste demanded by local markets.

3 Interactions between farmers, development agents and researchers lead to innovation

Many people seem to think that all the good ideas come from the farmers – and that may often be true – but interactions between farmers, development agents and researchers also leads to innovation. It is important to recognise the various aims and objectives of farmers and to understand where the biggest concerns or opportunities are. Nevertheless, not all farmers may be able to imagine what is possible beyond what they have seen in their own region. Interactions between multiple stakeholders allow ideas to be evaluated from multiple perspectives and can eventually bring about the best ideas for innovation.



Empowering women to increase benefits from legume production





A nutrition boost thanks to soyabeans



More than a quarter of young children aged under five in northern Ghana are undernourished. N2Africa taught women in this region how to use soyabeans to prepare more nutritious meals.



Women in Ghana preparing legumes for their families.

PHOTO: ILSE DE JAGER

Improving household income and nutrition using grain legumes is paramount in addressing nutrition problems in northern Ghana. A report by the Ghana Demographic Health Survey indicated that more than a quarter of children under five years of age in the Upper West Region were undernourished. This included severe acute malnutrition and high levels of anaemia.

Soyabeans are a source of protein, vitamin B and micronutrients and can be used to fortify cereal-based diets. However, soyabeans need to be processed before they are edible. Improved knowledge and skills for processing soyabeans were therefore cru-

cial. N2Africa set out to develop legume-enriched food baskets for smallholder families to improve their nutrition, choosing three action sites for the N2Africa project in

N2Africa set out to develop legume-enriched food baskets for smallholder families

northern Ghana that had the most malnourished populations in the country.

To achieve this, women from households within the project area were taught how to

process legume grains and get more value from them. Women In Agriculture Development (WIAD) from the Regional Department of Agriculture in the action areas facilitated the two-day training course. The women being trained were caterers in the school meals programme for primary schools and owners of local restaurants. They were taught how to prepare and add value to soyabeans for both domestic and public consumption.

The trainees were caterers in the school meals programme involving primary schools and owners of local restaurants

Jato Passé, a leader of a farmer-based organization in Bienye, was one of the trainees. She learned how to improve nutrition and food security in the home using soyabeans and cowpeas. She observed that members of the Bienye community benefited immensely from the programme.

“N2Africa taught us how to process soyabeans into various traditional dishes like tubanee,” Jato Passé recalls. “We were also shown how to combine soyabeans with corn dough in baking.”

A turning point

Modesta Gamba had been selling the popular staple foods banku and fufu for over twenty years in Jang, Upper West Region. In 2015, she was one of the women in her community who were given the training. The mother of five says that the training was a turning point for her business, as adding soyabeans to her meals increased the number of customers.

Modesta doubles up as a caterer who cooks for 75 to 80 pupils within her community, under the Government of Ghana’s school meals programme, where she readily applies the knowledge she acquired.

“I mix two kilos of soyabeans powder with four kilos of maize floor to prepare corn dough,” says Modesta. “I then mix this with one kilo of cassava dough to prepare banku.”

They also learned to mix soyabean flour with groundnut powder when preparing the paste used in groundnut soup. Modesta says



Food made of soyabeans in the school meals in northern Ghana.

PHOTOS: ERIC DOE



Passing knowledge between farmers.

PHOTO: N2AFRICA



Children helping the women cook by fetching water from the water pump.
PHOTO: ILSE DE JAGER



HIGHLIGHTS

- Legume-enriched food baskets for smallholder families were developed to improve their nutrition.
- Women from households within the project areas were taught how to add value to legume grains and how to process them.
- Local women said the innovations led to business growth and improved taste of their food products.

the innovations in her food have earned her referrals and helped grow her business.

Soyabean cakes and kebabs

In Bawku, located in Ghana's Upper East Region, Zulaiha Musa has learned from fellow farmers how to prepare soyabean cakes and kebabs for sale. This initiative enlightened her on the many uses of soyabeans.

"I was taught how nutritious soyabeans are and the many ways I can add value to them," Zulaiha Musa explains. "I also use the residue to feed my livestock. Nothing goes to waste."

The learning continues, as the women who benefited from the training gave a step-down training course for other women in the communities the following year. ◇



Harvesting nutrition



Families in Ghana are benefiting from better soya yields thanks to N2Africa. But that does not automatically mean that this nutritious legume will be added to their own meals. A great deal depends on the availability, affordability and desirability of other foods, discovered PhD student Ilse de Jager.

Assibi lives in Pishigu, a small rural village in the north of Ghana. She is married to Hassan and lives together with his other two wives and their children. She never finished school and spends most of her time farming. At the moment, she is pregnant with her second child.

Her first child, Talata, has just turned two. Talata was mostly given maize porridge and breast milk during the first two years of her life. She did not therefore receive all the nutrients she needed and by her second birthday she was too small for her age: she is chronically malnourished. This will have a major impact on her life: a higher risk of disease, of impaired intellectual development and of being less economically productive.

Saving for a motorbike

Assibi participated in the N2Africa project for two years in a row and achieved increased soyabean yields. She sold most of the produce at the local market for a good price. She used half of the income to buy

other food including maize at the market and saved some for other pressing needs such as healthcare for Talata. The other half she gave to Hassan, which he is saving to buy a motorbike. She tried preparing some dishes with soyabeans but did not like the taste and did not give it to Talata or the other children at her house because she is afraid of potential digestive problems when giving it to small children.

Within the N2Africa project, we carried out several studies in Ghana and Kenya to solve the question of how Assibi, her children and other household members could best achieve a nutritious diet from increased cultivation of legumes.

Consume or sell?

These studies showed that there are various ways in which farmers deal with higher yields from agriculture. We focused on two of them: where the extra harvest yield is used for their own consumption, and where the extra harvest is sold at the market so that there is money for other food.

Women
pounding *fufu*
at the market.

PHOTO: ILSE DE JAGER



Measuring how tall the children are to see if they are suffering from malnourishment.

PHOTO: ILSE DE JAGER

For Assabi, the price she can get for soya-beans is relatively high, which is why she chooses not to use the surplus harvest for her own consumption, but to sell it. She buys other food from the money she earns.

Food environment

Our study results suggest that whether N2Africa will achieve dietary improvements for Assibi and her household members or not

food, where a wide variety of local dishes already include the food being promoted and where the targeted food is relatively new and seen as a food crop rather than a cash crop.

The power of women

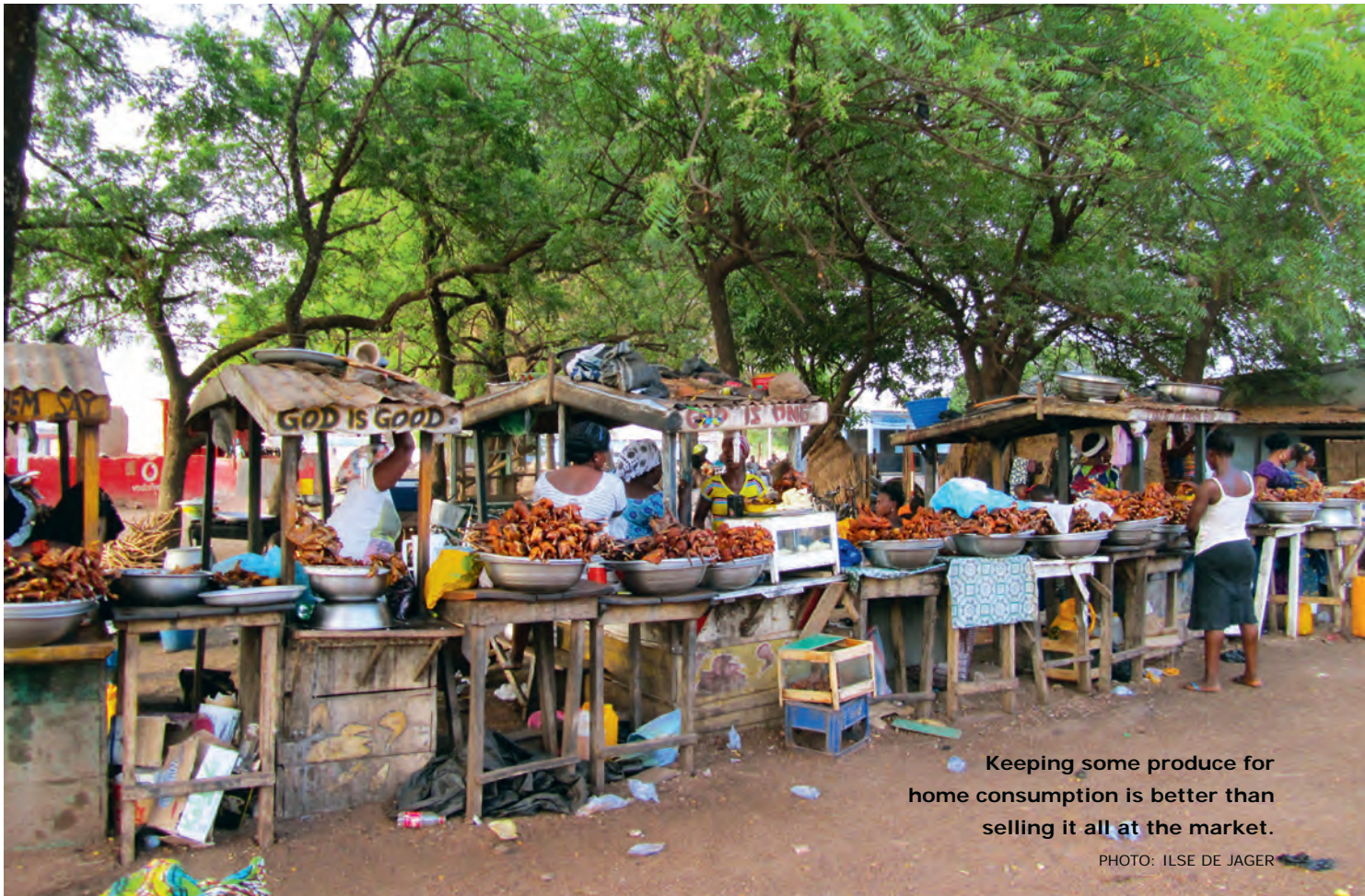
In addition, women play a key role in improving children's dietary diversity. Greater decision-making power for women and more control over resources such as increased legume production and income from the sale of legume produce may help channel nutritious foods within households (which will benefit the children) and to more agricultural income being spent on nutritious foods and healthcare for the family, particularly children. Female N2Africa participants did indeed state frequently that the extra grain legume production was used for the family's own consumption.

How can Assibi best create a nutritious diet from increased cultivation of legumes?

depends on the characteristics of the 'food environment': the availability, affordability, convenience and desirability of various foods, affecting the food choices made by Assibi and her other household members and therefore the quality of their diet.

We found that N2Africa has greater potential for improving children's dietary variation through production for direct consumption in contexts where farmers attribute positive characteristics to the targeted nutritious

food. If there is a strong market available for the food being promoted, it is likely that farmers will prefer to sell it instead of keeping it for their own consumption. Literature shows that whether this income gets used for improving children's nutrition is unpredictable



Keeping some produce for home consumption is better than selling it all at the market.

PHOTO: ILSE DE JAGER

or less than expected, such as in the case of Assibi's husband Hassan who is saving part of the income for a motorbike. Thorough understanding of the food environment and activities such as communication about behavioural changes in nutrition and women's empowerment are needed too if the most benefit is to be gained in terms of nutritious diets for Assibi and her household members from the increased cultivation of legumes.

Micronutrient intake

When a project like N2Africa is successful in increasing or adding legumes to the diet of Ghanaian children like Talata, we found that the main contribution is in terms of micronutrient intake, such as iron and folate. Eating extra beans on top of normal food intake is not (as is often stated) needed for protein. Furthermore, we found that investigating the gaps in food availability and food needs for nutritious diets at the whole diet level (no diet consists of a single food) provides useful insights that allow better coordination and integration of nutrition across agricultural interventions and investments. ◇



Different kinds of legumes.

PHOTO: ILSE DE JAGER

HIGHLIGHTS

N2Africa has more potential to improve children's dietary diversity through the production for direct consumption in a context where

- farmers attribute positive characteristics to the targeted nutritious food.
- a wide variety of local dishes already include the food being promoted.
- the targeted food is relatively new and seen as a food crop rather than a cash crop.
- women are involved.

PERSONAL STORY

'Agriculture has become a genuine business enterprise for women'



Cultivating legumes was previously seen as a lowly trade for unschooled people in DRC. But thanks to new technologies that N2Africa introduced, it has become a profitable enterprise. Women in particular are profiting from this development. Two women tell us how N2Africa changed their lives.

Appoline Mapendo, a mother of 13 children, lives in DRC's remote Cibinda area near the Kahuzi-Biega National Park. Her village is a very long way from civilization and the roads are inaccessible. "That meant we were unable to access new techniques, so our farming practices were relatively archaic." She is one of the farmers who have benefited greatly from N2Africa's techniques. "The N2Africa project introduced me to new improved

beans are the most important crops in my village," she explains, "and that's why we are very interested in them. Four hundred kilos of beans, one ton of cassava and one ton of maize were harvested from less than a hectare. I made a profit of five hundred US dollars from the cassava harvested. I used this money to buy a cow and four goats. Recently, the cow gave me a calf."

Reaping the benefits

Farming was previously considered a lowly trade for unschooled people but has now become a profitable enterprise. Take Josephine Nabandi M'Mironyi from Kajeje, a town neighbouring Kahuzi area, near the Kahuzi-Biega National Park. Married with 11 children, Josephine has a high school diploma (Diplôme d'Etat) in mathematics and physics.

She applied various new technologies learned from the N2Africa project and grew bio-fortified climbing beans and soybeans that were processed into various soya products. She used inoculant, which is referred to as 'atmospheric fertilizer' by the farmers, to

'Agriculture lets me meet my needs and has transformed my life'

farming techniques such as planting the crops in lines, correct spacing and inter-cropping the beans with other staple foods such as cassava and maize," she says. These practices can increase bean yields by up to 20 per cent*.

Mapendao now considers herself an expert in these practices. "Cassava, maize and



Appoline Mapendo (on the right) in a soyabean field.

PHOTO: N2AFRICA



Josephine Nabandi M'Mironyi telling her story in a radio studio.

PHOTO: N2AFRICA



Landscape near Bukavu, DRC. PHOTO: KEN GILLER

boost her soyabean production. She also intercropped her climbing beans with maize and the stalks then supported the climbing beans after the maize was harvested. "Currently, I have a two-hectare farm where I grow soya, climbing beans and maize," she says confidently. "I harvest a ton of beans and seven to eight hundred kilos of soya-beans per season. In addition to the

'The N2Africa project introduced us to new and improved farming techniques such as planting our crops in lines'

agricultural practices introduced by N2Africa, we've also learned how to store our produce and sell it when prices in the market are good. Agriculture has become a genuine business enterprise that lets me meet my needs and has transformed my life."

Healthcare, clothing and school fees

"I'm now able to meet my own seed stock needs for the following season," says Josephine. "I've improved and enriched the diet and the nutritional status of my family. I can also afford key family needs like healthcare, clothing and school fees for children all the way from primary school to university. I used to live in a hut made out of mud and wattle. Now I have a modern house, in addition to buying a plot in town (Bukavu). My children who are studying at the University will no longer face challenges with rents." ◇

• Source: Pypers et al. 2011. *Field Crop Res.* 120: 76-85.



Women involved in N2Africa use the extra grain legume production more often for their own family's consumption than men. PHOTO: ILSE DE JAGER

LESSONS LEARNED

Involving women is key

Every project has surprising twists and turns and unexpected outcomes as well as the expected ones. What have we learned about empowering women from ten years of N2Africa?

1 Involving women increases the chances of positive nutritional outcomes

N2Africa worked with both male and female farmers in training courses on improved legume production. We found that when women were involved in the cultivation of legumes and also have decision-making power and control over the increased legume produce and income from sales, it is more likely that the legumes will be used as nutritious food within the household or that more agricultural income is spent on nutritious food.

Indeed, female N2Africa participants stated frequently that the extra grain legume production was used for their family's own consumption. When agricultural projects have the specific aim of improving households' nutrition, involving women is key.

2 Legumes provide good business opportunities for women

N2Africa trained women to process legumes into various products. This often involved fortifying traditional dishes that were already well-known to the community. For women who were already engaged in selling snacks or preparing meals for restaurants, the fortified products provided a unique selling point that increased their customer base. This increased the income they gained from legume products.

3 Increased legume yields do not always lead to more nutritious diets

Agricultural projects like N2Africa often implicitly make the assumption that increased yields of the crop they are promoting will lead to increased consumption of that crop. But when there is a strong market for the promoted crop, farmers may prefer to sell it instead of keeping it for home consumption. Whether this income will be used for improving their own and their children's nutrition is then unpredictable. Research in N2Africa found that additional activities such as communication about behavioural changes in nutrition and women's empowerment are needed if the most benefit is to be gained in terms of nutritious diets from the increased legume yields.

N2Africa partners

N2Africa worked with many partners across eleven countries. The core organizations that led N2Africa were Wageningen University and Research, the International Institute for Tropical Agriculture, the International Livestock Research Institute, and the Alliance for a Green Revolution in Africa.

N2Africa has worked with various NGOs in combination with national government services and private sector companies. These organizations work on themes such as combating poverty, rural development, entrepreneurship in the agricultural sector and agricultural innovation.





**Hillsides covered
with climbing beans
in northern Rwanda.**

PHOTO: KEN GILLER

ACKNOWLEDGEMENTS

'The Story of N2Africa' is a magazine filled with inspiring stories about ten years of research by the project *N2Africa: Putting nitrogen fixation to work for smallholder farmers in Africa*.

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'The Story of N2Africa' has been produced by Communication Services WUR

<https://doi.org/10.18174/527074>

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**Inoculated soyabean,
northern Nigeria**

PHOTO: KEN GILLER

