# N2AFRICA:
# DELIVERING BIOLOGICAL NITROGEN FIXATION(BNF) TECHNOLOGIES TO AFRICAN ALL-SCALE FARER FOR ENANCING SOIL FERTILITY AND LEGUME PRODUCTION

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# ABSTRACT

There is increasing interest in application of microbial inoculants to crops for acquisition of nutrients and improved nutrient-use efficiency. This would be of great importance to the resource-poor smallholder farmers in sub-Saharan Africa (SSA), who experience low cereal and legumes yields resulting from subsistence farming practices, soil fertility and unfavourable biotic and environmental factors. Grain legumes offer several nutritional, economic and environmental advantages over other crops, as result of symbiotic Biological Nitrogen Fixation (BNF). N2Africa aims at "putting nitrogen fixation to work for smallholder farmers in Africa". Phase 1 of the program focused on increasing grain legume production and its symbiotic $N_2$-fixation for four major grain legumes (common bean, cowpea, groundnut and soybean) in eight countries (DR-Congo, Ghana, Kenya, Malawi, Mozambique, Nigeria, Rwanda and Zimbabwe). The program involved strategic research in legume agronomy and BNF technology dissemination targeting 225,000 poor households over four years. Project partners included international research centers, universities, international NGOs, national research and extension organizations, farmer associations, private sector input producers and grain legume buyers. To ensure rhizobia inoculants were available to farmers in the collaborating countries, N2Africa's aimed to stimulate commercialization of inoculants production in East, South and West Africa within four years in those countries (Kenya and Zimbabwe) producing rhizobia inoculants while encouraging laboratories to explore new inoculants' production techniques and quality control procedures (Malawi and Rwanda). In 2006, MEA Fertilizer Company acquired rights in the production, marketing and distribution of the legume inoculant with a trading name, BIOFIX® from the University of Nairobi. The University of Nairobi, MIRCEN Laboratory ensures research for new elite strains and quality production of BIOFIX® that is sent out to farmers in Eastern and Southern Africa, and plans are underway to start production in Nigeria in 2015. The new product has seen the revolution of soybean production in Kenya leading to an increase of soybean production from 600Kg/ha to 1200Kg/ha with sales of the rhizobia inoculants rising from 1.5t/yr to over 30t/yr in within seven years. Partnership with N2 Africa scientists has assisted in commercialization, as well as development of a legume blend, Sympal (,NPK- 0:26:10) fertilizer which has further enhanced yields to a record 2500kg/ha. As such, farmers have started seeing the benefits of growing soybean in Kenya and the number has since increased. Under fertilized conditions (Sympal 0-23-16+ at 222 kg $ha^{-1}$), climbing bean cv. Tamu and soybean (SB 19) responded to inoculation with BIOFIX® during the 2013 long-rains with yields increasing by +286 and +530 kg $ha^{-1}$, respectively. Recommended practice (BIOFIX inoculant and Sympal fertilizer) resulted in economic returns of 4.2:1 for bean and 3.1:1 for soybean as well as improved nodulation. To date, improved grain legume and inoculation technologies were introduced to 37,464 Kenyan households with an adoption ratio of approximately 70%, average household benefits of $350 per year (KSh. 30,117), and increased symbiotic N-fixation of 46 kg $ha^{-1}$ $season^{-1}$.
Africa is a probable home to genetically diverse root-nodulating bacteria that present opportunities for discovery of highly effective strains of inoculants. and bio-prospecting for elite strains of rhizobia capable of effectively nodulating "promiscuous" and "specific" soybean and common beans in the eight participating countries have collected 1434 isolates from 20 genera in 14 different ecological zones, 85% belonging to the tribe Phaseoleae from Kenya, Democratic Republic of Congo (DRC) and Rwanda. These isolates were tested against industry standard inoculants for bean (CIAT 899) and soybean (USDA 110) and six of the isolates have consistently outperformed the standard commercial strains and they soon to be released for commercial inoculants production in the near future to the collaborating inoculant production industry(s) such like MEA Fertilizer Company. National Biofertilizer Act that are based on the International standards are applied in all QC assessments and N2Africa plans to assist producers to meet and monitor thresholds in both local and imported bio-inoculants in all project countries. Through these efforts, N2Africa BNF technologies and grain legume enterprises have improved farm nitrogen balances, home nutrition and household incomes to 335,000 household in the 8 countries during the 4 years of implementation. Visit the program's website at www.n2africa.org.

**KEY WORDS**
BNF, N2Africa, Rhizobia inoculants, Sympal fertilizer, smallholder farmer,

# CONTRIBUTION OF BIOLOGICAL NITROGEN FIXATION TO FOOD SECURITY IN SMALLHOLDER CROPPING SYSTEMS IN AFRICA:The N2Africa story

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## Content

- **Background on N depletion and BNF**
- **BNF as a focus of N supply**
- **BNF outreach in Kenya**
- **The N2Africa Project**
- **Achievements**

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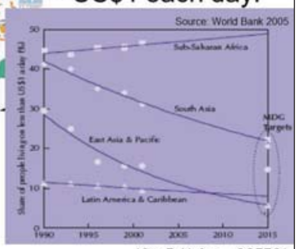
**Reducing poverty and food insecurity remains the main challenge for Sub-Saharan Africa**


About 180 million Africans live on < US$1 each day!




*Livelihoods are mainly based on extensive exploitation of natural resources: principally small-scale farming*

After P. Mafumo, SOFECA

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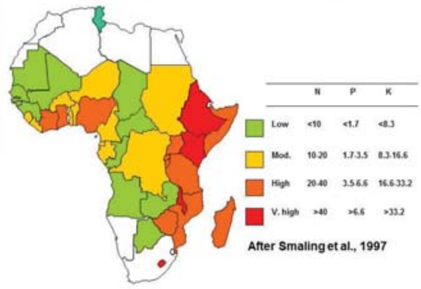
**Soil fertility depletion in smallholder farms is the fundamental bio-physical root cause of declining per capita food production in Africa, and soil fertility replenishment should be considered as an investment in natural resource capital (Sanchez et al. 1997)**

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## BNF as a focus of N supply

- **Limited additional returns to improved crop varieties without improvement in soil fertility**
- **Several long-awaited disease-resistant legume varieties have become recently available.**
- **BNF can mitigate continuous nutrient depletion in smallholder cropping**
- **Smallholder seed systems, fertilizer delivery and inoculant production are important components of emerging agricultural value chains**

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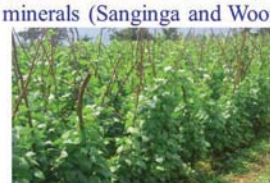
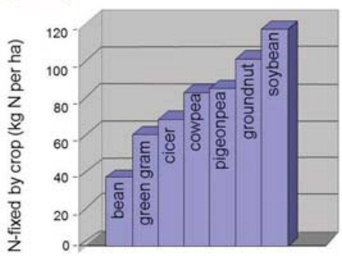
The nutrient supply strategy **"N from the air and others from the bag"** offers flexible adjustment to local conditions and opportunity for optimizing the use of locally available organic resources and agro-minerals (Sanginga and Woomer ,2009)






Nitrogen fixation by tropical grain legumes (Giller , 2001)

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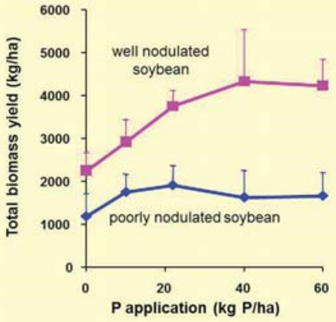
## P requirement by symbiotic legumes


Numerous trials across Africa confirm that P is the second most limiting nutrient to crop production

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## A stepwise approach to soybean promotion in Nigeria


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## BENEFIT OF BNF IN SOYABEAN SYSTEM IN NIGERIA

Adoption of soybean rotation permitted maize farmers to greatly reduce the nitrogen fertilizer inputs to maize!

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## Agronomic contribution

| | *Samsoy 2* | *Tgx* 1448 |
|---|---|---|
| Total N | 137 | 182 |
| N fixed | 44 | 103 |
| N balance | – 8 | 30 |
| Yield | 1,314 | 2,458 |

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## There is huge potential for expanded soyabean production in Kenya

- Currently 80% or 65,000 t /yr is imported
- Demand over 150,000t /yr in 2010
- Potential demand for industrial use and livestock feed is another 300,000 - 487,500 tons/yr
- Promising cash crop for income and dietary diversification

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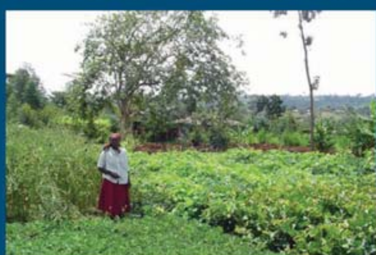
## Grain legume technologies promoted West Kenya



Soyabean production in west Kenya requires that accompanying technologies also be developed

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## THE N2AFRICA ROJECT(2010-2013):www.N2Africa.org

**This project objectives:**

- link the protein and nitrogen needs of poor African farmers directly to massive atmospheric N reserves and provide them with new income-generating crop production enterprises
- advance renewable soil fertility management
- promote adoption of profitable accompanying farm technologies and value-adding enterprises.
- deliver legumes and BNF technologies to farmers throughout sub-Saharan Africa

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## N2Africa Project Goals

- N2-fixation inputs increased from 35 kg N per hectare to over 90 kg per hectare
- total amounts of N per farm increased from 8 to 30 kg N per year on 225,000 farms
- 15,250 tons of N per year from biological N fixation worth 28 million USD
- increase grain legume yields by an estimated 123,000 tons, worth $50 million

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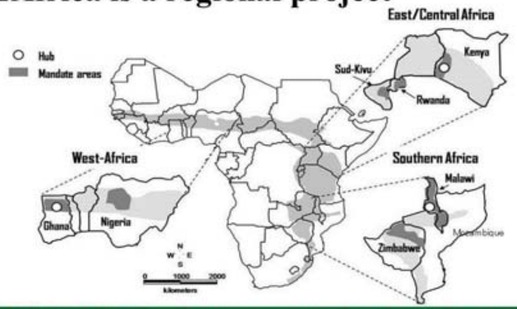
## N2Africa is a regional project




**The N2fixAfrica Project operates in three impact zones and mandate areas, and eight target countries through its three sub-regional hubs**

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## A conceptual model applied advance research for increasing BNF among smallholder African farmers

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

Where,

$G_L$ = legume genotype
$G_R$ = rhizobial strain
$E$ = environment
$M$ = management

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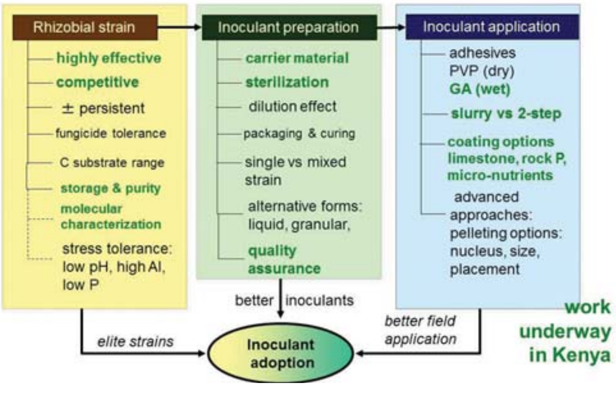
## N2Africa Goal: Improving legume inoculants

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### Assess the need-to-inoculate

Kenya, on-farm, farmer installed and managed

| Season | Long rains 2011 | Short rains 2011-2012 | Long rains 2012 |
|---|---|---|---|
| Soybean variety | SB19 | Samba | Saga |
| | ---------- soybean yield (kg ha$^{-1}$) ---------- | | |
| Not inoculated | 970 | 634 | 845 |
| Inoculated | 1310 | 1059 | 1117 |
| Response (%) | 35% | 67% | 32% |

| season | Soybean variety | nodule number | crown nodulation | red interior |
|---|---|---|---|---|
| | | no plant$^{-1}$ | ---------- % ------------ | |
| 2011 long rains | SB 19 | +5 | +26% | +14% |
| 2011-2012 short rains | SC Samba | +10 | +31% | +43% |
| 2012 long rains | SC Saga | +13 | +35% | +32% |
| mean | | +9.3 | +31% | +30% |

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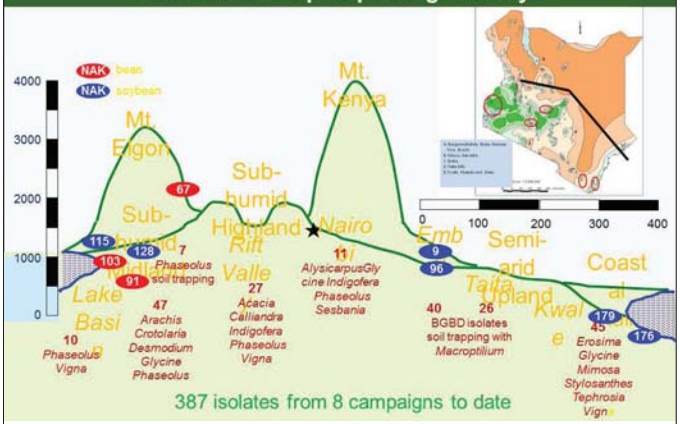
## Rhizobium Bio-prospecting in Kenya

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Bio-prospecting photos (clockwise): coastal Kenya (top left), bio-prospecting team in DRC, *Erythrina* sampling strategies in Rwanda, mixed farming in DRC, RAB experiments in Rwanda, carefully sampling drainage ditch in Rwanda, helpful farmer in DRC (left).

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## Establish and characterize a rhizobium germplasm bank

- 17 descriptors (columns)
- Template distributed to all country leaders
- Cooperators enter their isolates
- Currently 1437 entries (rows) and 350 pending
- Curation strategy required

| country | designation | isolates | host genera | habitat | screened |
|---|---|---|---|---|---|
| | | ------ number ------ | | ------------ % ------------ | |
| DR Congo | NAC | 115 | 16 | 57% natural | 40% |
| Kenya | NAK | 387 | 20 | 54% natural | 85% |
| Rwanda | NAR | 308 | 12 | 91% cultivated | 42% |

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## Identify elite strains (Kenyan example)

| | |
|---|---|
| Bio-prospecting and isolation | ***208 isolates*** |
| Authentication and preliminary screening | ***186 isolates*** |
| Effectiveness testing under greenhouse conditions | ***100 isolates*** |
| Competitive abilities in potted soil | ***24 isolates*** |
| Field testing | ***16 isolates*** |

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| isolate | GH step 1 | GH step 2 with soil | | Field test 2012 long rains | |
|---|---|---|---|---|---|
| Effectiveness Index | sterile media SB24 | Promiscuous SB19 | specific Safari | Bungoma SB19 | Nyabeda SB19 |
| NAK96 | 1.24 | 0.96 | 1.18 | 0.50 | 0.93 |
| NAK115 | **1.09** | **1.03** | **0.97** | **0.74** | **1.16** |
| NAK128 | **1.06** | **1.01** | **1.34** | **0.81** | **1.20** |
| NAK9 | 1.06 | 0.88 | 1.32 | 0.40 | 1.07 |
| USDA110 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |

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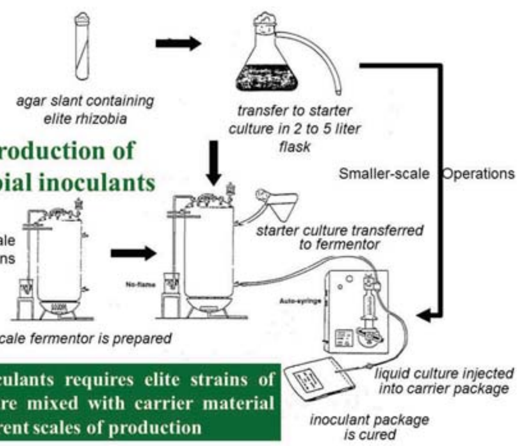
**The production of rhizobial inoculants**




**Producing inoculants requires elite strains of rhizobia that are mixed with carrier material using two different scales of production**

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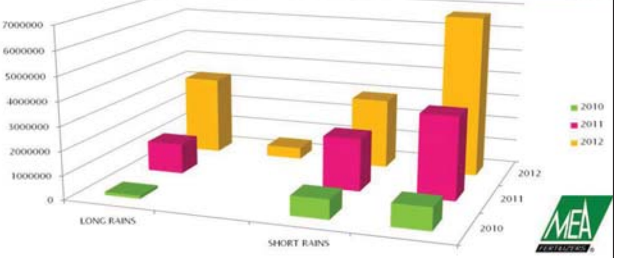
***N2Africa services contributes to rapid growth in Kenya's inoculant industry:***

- Strain selection and preservation
- Carrier sterilization and curing process
- Quality assurance procedures
- Agro-dealer awareness
- Grassroots demonstrations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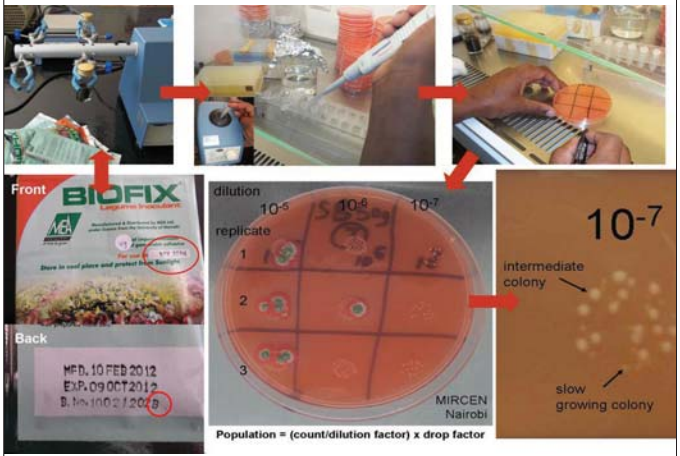


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## Inoculant quality assessment issues

- Industry standards under discussion (>$10^9$ rhizobia <$10^6$ contaminants per gram)
- Procedures in place based on drop plating of $10^{-5}$ to $10^{-7}$ on CR YMA, target sample of 0.2 to 0.4 %, QA utility available
- MPNs preferred but too seldom utilized, GH MPN is imprecise
- Two basic QA strategies needed, one for producers (continuous QA), another for importers (episodic QA)
- Rapid assessment required to intercept inferior inoculants from shelves (rather than improvement through hindsight)

| BIOFIX for ... | Batch number | rhizobia (± SEM) | contaminants (± SEM) |
|---|---|---|---|
| | | x $10^9$ g | x $10^6$ g |
| bean | 030812-28 | 1.3 ± 0.1 | 1.0 ± 0.4 |
| soybean | 130812-23 | 4.3 ± 0.9 | 2.0 ± 0.5 |

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## Ingredient for success: Steady improvement of agronomic practice based upon economic analysis

| soybean management | grain yield | total cost | net return | benefit: cost |
|---|---|---|---|---|
| | - kg $ha^{-1}$ - | --- $ $ha^{-1}$ --- | | ratio |
| SC Saga no BIOFIX | 845 ± 21 | 285 | 246 | 1.86 |
| SC Saga + BIOFIX | 1117 ± 33 | 310 | 391 | 2.26 |
| SB19 + BIOFIX | 1053 ± 33 | 299 | 363 | 2.21 |
| SB19 + BIOFIX + Zn | 1162 ± 37 | 299 | 430 | 2.44 |


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## "Extra ingredient" for success: Addition of 0.1% zinc to Sympal fertilizer blend improves nodulation


| Season | Short rains 2011-2012 | Long rains 2012 |
|---|---|---|
| Variety | SB19 (+I) | SB19 (+I) |
| | nodule number $plant^{-1}$ | |
| Sympal | 23 ± 0.4 | 21 ± 0.5 |
| Sympal +Zn | 27 ± 0.5 | 26 ± 0.4 |


*Available in 2, 10 and 50 kg bags for about $0.86 per kg*

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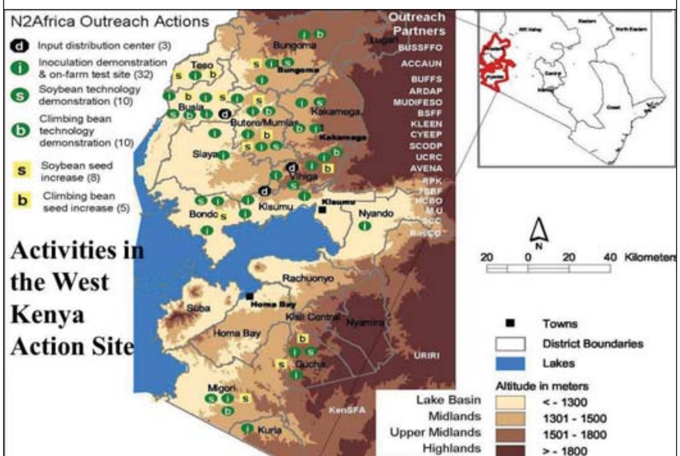


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## Master Farmer Training in BNF

- Develop practical understanding in the management of nitrogen, legumes, rhizobia and biological nitrogen fixation
- Gain skills in rhizobial inoculant handling and application
- Improve abilities to design, install and interpret response to inoculant tests in farmers' fields
- Strengthen skills in working with farmers and their organizations to promote grain legume enterprise

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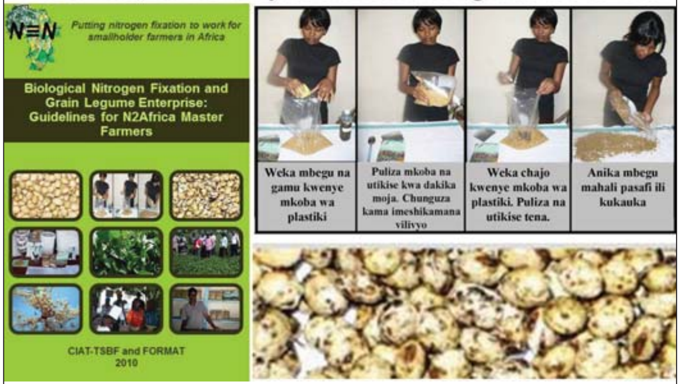
## N2Africa includes comprehensive capacity building at the farmer, community, **technical and graduate levels**

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## Farmer Field Days

Field days are a means to spread important messages to the whole rural community. They have a strong social component. A single field day can target many client groups


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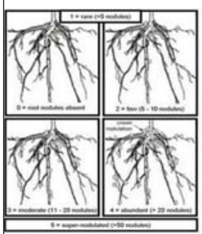
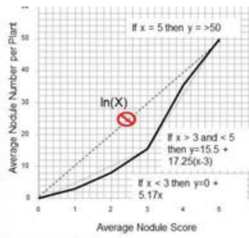


Nodule Assessment




Master Farmer assessed soybean nodulation characteristics in west Kenya in response to applied rhizobial inoculant and blended fertilizer during the 2011 long-rains (±SD).

| Management | nodule number | crown nodulation | red interior |
|---|---|---|---|
| | (no. per plant) | ------- frequency -------- | |
| No inoculant w/SSP | 9 ± 4 | 0.08 ± 0.20 | 0.70 ± 0.33 |
| Inoculated w/SSP | 14 ± 6 | 0.34 ± 0.38 | 0.86 ± 0.28 |
| Inoculated w/PKS+ | 23 ± 14 | 0.51 ± 0.42 | 0.84 ± 0.31 |

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# OUTCOMES

Putting nitrogen fixation to work for smallholder farmers in Africa

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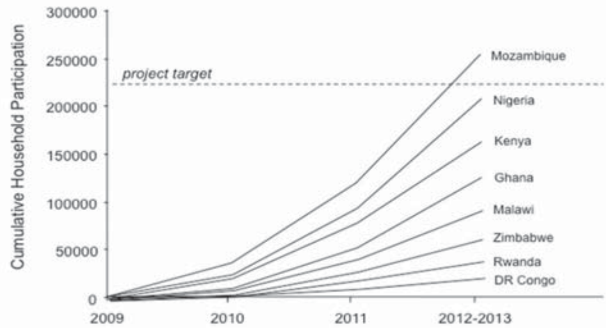
## Number of farmers reached through outreach activity

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**Outreach actions of the N2Africa project in eight countries over four years.**

| Outcomes | Total # |
|---|---|
| Lead Farmers trained | 3021 |
| Postgraduate trained | 58* |
| Farm households facilitated | 252,347 |
| Improved varieties distributed(tons) | 754 |
| Inoculant packs distributed | 142,711 |
| Test fertilizers distributed( tons) | 451 |
| Satellite households reached | 31,299 |

*8 PhDs(*3 Wageningen and 5 Murdoch,Australia*)

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**Chair Tobita:** Let us introduce the third speaker, Professor Nancy Karanja, from Kenya. She is now working for the University of Nairobi and she is also consultant with the International Institute for Tropical Agriculture and International Potato Center. Her expertise is in the area of Soil Science and Ecology and urban agriculture. She has worked at Kenyan Agriculture Research Institute and Kenya Forest Research Institute in Nairobi. Her presentation title is "Contribution of BNF to Food Security in African Smallholder Cropping Systems." Dr. Karanja, floor is yours.

**Dr. Nancy Karanja:** Thank you very much. Good afternoon. Before I give my talk, I would like to thank the management of JIRCAS and to mention Dr. Tobita for inviting me, for affording me, and making me come and visit Japan. It is a dream for many people to come and visit the land of vehicles. So, I am very happy to have made a chance, been able to visit the country in my lifetime.

I am going to talk about the "Contribution of Biological Nitrogen Fixation to Food Security in Smallholder Cropping Systems in Africa." I'll tell a story of one of the large grant or largest project that has been going on for the last 5 years in Africa. The N2Africa Story funded by Bill & Melinda Gates. I am presenting a task or a project implemented by very many people, very many institutions from eight countries in Africa; and therefore, as you see the two names, these are not the ones who did the work. There are many more, including thousands of farmers.

A summary of my presentation is I'll give a background, particularly with respect to N depletion and Biological Nitrogen Fixation. I'll focus more on to BNF and its N supply in the farming systems in Africa. I'll highlight very little of BNF outreach in Kenya and possibly Nigeria. I'll go straight to The N2Africa Project; and finally, give a few achievements that have been made in the last 4 years.

I think Andre Bationo has highlighted this slide about the poverty and insecurity which is a big challenge in Africa. The number of hungry Africans, I think in fact the first speaker talked about 200 million. They could be more. And the reason was also given that principally our livelihoods are based on exploitation of natural resources and that is what Andre referred to as nutrient mining; and therefore, we do use very minimum input in agricultural systems.

I think you've also seen this one and I don't like to highlight something here about good practices, good husbandry in Africa. These are two farms neighboring each other in Western Kenya. What you find is this farmer is actually using right seed, using right inputs, planting at the right time, and the neighbor actually didn't do it. We can actually see one will harvest and the other will have nothing. Basically this is common feature in all the farming systems, not only in what we call high-potential rain with enough rainfall, the dryland areas in Africa is a common trend.

Why BNF or why biological nitrogen fixation? The fact remains that we have said there are lot of efforts going in to improve the varieties without thinking of how they'll be grown or managed. We also do have disease-free or disease-clean seeds that that have been developed right now, again the problem is soil. I think, as I go on in my presentation, you'll find that exploiting nitrogen fixation, because the atmosphere is 80% nitrogen, may actually be one of the solutions towards enhancing food security in Africa.

It is very clear there, a statement given by Sanginga and Woomer that the nutrients – that "Nitrogen from the air and others from the bag" can actually address the issue, not only of soil fertility but of something else that has been raised about organic carbon. Basically there are few you can see the systems that we use in producing legumes in Africa. They could be model crops. They could be multiple cropping. But I think…

This slide actually shows that quite a number of tropical legumes do actually fix substantial amounts of nitrogen and soybean of course is key, and I think there was a question on soybean which is getting a lot of interest in Africa. While we think about nitrogen, I think it's very important to remember we are thinking of a crop that is a legume, that is forming an association with the bacterium in the soil and this crop will not only require nitrogen, it will require other elements. Basically P is the second most important nutrients; and therefore, you find that where a crop is grown without too nodulated you'll not actually achieve the optimum yield or you'll not perform; therefore, we have to think of other nutrients outside the nitrogen.

Here again I think it was mentioned by Andre about the older very intensive work on improvement of soybeans by IITA in the 70s up to 90s and basically they came up with what we call promiscuous soybean. Those are the ones that are able to form nodules without inoculation, exploiting the fauna and the microbial populations in African soils. Basically I'll mention it later in my talk because this is what we have comeback to and I think it was the question that came, why is soybean picking up in Africa.

As a result of that intensive work that was done by IITA in the 70s, we can see actually the benefits adoption of soybean rotated with cereals. Basically there was benefit and this was due to actually you can see that where a good variety of soybean that was nodulated. There was benefit in terms of the nitrogen left in the soil and indeed there was an increase in yield. We can see that after you use a good fixing crop, that either nodulates with the indigenous populations or inoculate you basically do gain in terms of nitrogen and hence yield. So, it's possible in Africa to actually increase yield exploiting sometimes the nature given processes like nitrogen fixation.

I'll go straight to talk about the N2Africa Project, which is a Bill & Melinda Gates project funded, so that started in 2010, ended in 2013, but of course it's still going on. There is a phase 2 that is going on and more countries are involved. If you wish to know more, you just visit the website given out there. The main objectives were to link protein and nitrogen needs of poor African farmers directly to N reserves in the atmosphere, to advance renewable soil fertility management and they have therefore link to integrated soil fertility management that Andre has talked about, promote adoption of profitable accompanying farm technologies and value-addition enterprises, and then deliver the technologies to the farmers.

The goals, as you can see, they're real big. N-fixation inputs to be increased by actually making sure that we use like at least 35 kilograms per hectare and so we use 8. Total amount of nitrogen per farm to be increased and then the yields or the amount of nitrogen that we use should also go up; and therefore, we save some money in terms of USD 20 million. Then increase yields so that actually maybe; one, we reduce imports; and two, we enhance nutrition; and therefore, leading to also savings in terms of foreign exchange.

The countries involved in this project that I am talking about were eight. Then in West Africa, it was Ghana, Nigeria. In Central East and Central Africa, it was Kenya, Rwanda; and DRC, the eastern part of DR Congo; and then Zambia, Malawi, Mozambique and Zambia. The hubs I've shown there. The hub for West Africa was in Ghana, East and Central Africa was in Kenya, and the other one was in Malawi.

The conceptual model for this project was basically attempted to address the issues that may actually bring about increased nitrogen fixation; and therefore, we thought about the germplasm, GL, the rhizobium, the environment and the management. It is linked to other big projects on legume improvement, the GLT-1 and 2; therefore, the project did not work very much on improvement of varieties. But in my talk, I'll actually emphasize more only on rhizobium.

To get to talk about inoculants and let me just mention that the technology is not new in Africa. Just like Andre said, we can't explain why things don't takeoff in Africa. I am coming from an institution where we have talked and actually developed the technology for 30 years in the University of Nairobi, more than 30 years, only 5% of Kenyans use rhizobium inoculants; and therefore, to achieve this or improving legumes through inoculants, we must have strains, we must produce inoculants, we must deliver it, we must teach the farmers how to use the technology.

The one thing that we have to do is can we prove to the farmers that indeed it is necessary to inoculate. Note also that we are going through the soybean again because the two major crops for this project were soybean and the bean. Indeed, we were able to prove to the farmers that it does.

The next thing was do we have rhizobium inoculants. Yes indeed, but what we have is what we are using for commercial production of inoculants for the few industries that are there are important or exotic strains and we wanted to identify our own stains from different soil.

What is presented here for Kenya was done in all the eight countries.

We have actually developed now a database and currently we have more than 2000 entries or 2000 strains, the descriptors are given. Out of that because when you get them from the soil you have to screen and get the right ones that are working; one, we have been engaged in screening the best and getting to know the best; and as of now, most countries have at least one or two elite what the project calls elite strains that are actually ready for dissemination to the industry or private sector for inoculant production.

These are the stages that we go through to identify the right ones.

For instance, for example, in Kenya, you can see we have two strains that we are calling NAK115, NAK128, not yet given names because we have to do molecular work on them, which are actually outperforming USDA, if you see USDA that is an international strain that has been used for many years, coming from the US.

Once we get that, we link the elite strains are supposed to go to the industry so there is public-private partnership. In Kenya, we already have an industry that is producing inoculants. And what is left to the researcher is to keep the elite strains and maybe to actually keep close to the quality control.

Indeed, we have found that public-private partnership works. If you look at this slide from we started, if you look at the year, then the amount produced by 2010, the inoculant, the green bars, we were producing inoculants at the University of Nairobi. When we went to public partnership and went to this institute called MEA, they've been able actually to produce. I think they are standing at almost 100 tons. They have been able to get out of Kenya. They are distributing inoculants now to Southern Africa and very soon, in fact by next year, they are moving to produce inoculants in Nigeria and their discussions in Zambia Mount Makulu to also go there and go commercial.

I say it for biological products quality is very key and here we are involved as in terms of the MoU that we have signed with this private sector, we keep the elite strains, we replenish them when they – because the bacteria tends to change and become inactive, we go and renew. We are also supposed to keep as an external accredited lab to keep the quality control, not only for MEA but for quite a number of other inoculants that are coming out of the country.

The challenges here for all the African countries is that; one, the quality control is a big issue; number 2, quality control for also what we are importing and this is an area that needs to be highly addressed.

We also have a database. Basically if I may mention on the quality of the product, as it has been going on since it was brought, from there I can actually show that we have been able actually to improve the quality of soybean from about less than a ton we are now aiming at 2 tons. And there are quite a number of farmers in many countries in Africa, particularly Nigeria, where we are very proud. They've moved to over a million hectares under soybean and the yields are very high.

I said that to get good yield, we must address fertilizers. I think Andre also mentioned we have a problem; one, across the board rate of application, there is nothing about specificity based on the crop.

But here in N2Africa, we are able to come up with a fertilizer appropriate for inoculation to go with inoculation and legumes.

Dissemination I said is very key.

You can see the intensity in Western Kenya in involvement of farmers, involvement of agro-dealers.

I think or allow me just to go to the final to the conclusions and achievements of the project.

After 4 years, I think you saw the goals or what was aimed at. There are lead farmers that have been trained. Lead farmers are the ones who I used to penetrate and get to the farmers. We've trained postgraduates, 50 masters, 8 Ph.Ds. that are ongoing and expected to finish next year. We have or the project has actually been able to cover more than 257 about 300,000 farm households multiplied by 4 or 5, the number of people reached. Varieties have been distributed. Inoculants have gone very far now in Africa. There are very many places in the households you hear people talk about it. Fertilizer I have said we have identified the good one and the satellite households reached; in fact, you can see how many they are.

I think with these few remarks, I wish to say thank you very much for your attention.

**Chair Tobita:** Thank you very much, Dr. Karanja, for your excellent speech with very, very informative pictures and figures. Thank you very much. From your presentation, we have realized that PNF is very, very important to mitigate the nutrient depletion in smallholders. Time is not so much, but we'd like to have some comments and questions from the participants. So if anybody? Okay, please. Tsujimoto-san.

**Dr. Yasuhiro Tsujimoto:** My name is Tsujimoto from JIRCAS. My question is perhaps not directly related to your presentation, but as you mentioned soybean is promising in terms of nitrogen fixation for the soil management in Africa. But I would like to hear if you have any opinion about the perspective of like soybean market consumption in the continent for the future.

**Dr. Nancy Karanja:** I don't think it's in the future. It's already in place. Kenya alone, we import 80% of the soybean that we require. Basically right now it stands at around 100,000 tons. But when it's properly assessed, including food aid because we are host to a lot of refugees, the industry, particularly for feed, we need like 300,000. In Nigeria, I have said already, it's a million hectares, it cannot be for nothing. There has to be a way that we are using it. And part of the project was actually to teach farmers, it was not just production. I talked about rhizobium only. There're other groups that we are talking about legumes utilization, processing and all that. Basically soybean on in household is now catching up because they know of its multipurpose benefit, food, feed, soil.

**Chair Tobita:** It's okay? One more short question or short comment, please. So, I'd like to have one confirmation to you. Your good strain of rhizobium is indigenous in the soil, so why not coming from outside, is there some reason?

**Dr. Nancy Karanja:** Yeah, there is a reason because we are still growing. Most of the acreage is covered. Particularly in East and Southern Africa, we are still growing what we call specific varieties that do not nodulate with African rhizo – the bad rhizobium species. Therefore, those we still use the rhizobium and all that. However, from the research that we are doing because I have some students who have actually been screening, we are now starting to identify that we do have indigenous strains that actually still works very well with like the NAK120 that is working very well even with the specific varieties. But basically with respect to the promiscuous varieties, we are quite okay with hybrid rhizobium in our soils.

**Chair Tobita:** Okay, thank you very much. Thank you, Dr. Karanja.