Tailoring and adaptation in N2Africa demonstration trials

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N2Africa

Putting nitrogen fixation to work for smallholder farmers in Africa

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1 Introduction

One of N2Africa's objectives is to "tailor and adapt legume technologies to close yield gaps and expand the area of legume production within the farm" (Objective 4). Sub-objectives are to develop variety * inoculant * nutrient management recommendations for the target legumes and areas (Objective 4.1), and to develop best-fit recommendations (Objective 5.5). Each season, in diagnostic and demonstration trials, the effectiveness of varieties, inputs and management practices has been assessed, leading to the development of such recommendations. In other words: technologies were tailored and adapted to make them more suitable for specific legumes, areas or groups of farmers. To report on these objectives, we would like to capture the "learning pathways" that have led to changes in the design of demonstration trials and the development of best-fit recommendations.

This report provides an overview of changes that have occurred on trials in terms of variety selection, input choice and other practices. These changes and their reasons and initiators are listed in tables per crop for five core countries: Ghana, Nigeria, Ethiopia, Tanzania and Uganda. The report only comprises the changes that have occurred, not the full overview of technologies that are being tested and demonstrated by N2Africa.

Information about the learning pathways were collected via an ODK survey with country coordinators and field research officers Samuel Adjei-Nsiah and Arnold Sylvester Amppiah (Ghana), Endalkachew Wolde-Meskel and Birhan Abdulkadir (Ethiopia), Bassey Ukem (Nigeria), Abubakar Mohammed (Nigeria), Sheu Muhammad Dandago (Nigeria), Abubakari Mzanda (Tanzania) and Anthony Epel (Uganda). They described the changes that had occurred in demonstration trials since the beginning of N2Africa Phase II in 2014, and the stakeholders who initiated the actions.

2 Actions of change in demonstration trials

2.1 Overall changes

Across the various crops in demonstration trials in Ghana, Ethiopia, Nigeria and Tanzania, there were 64 variety changes, 13 changes in fertilizer type, and 5 changes in inoculant type, as shown in Table 1. There were alterations in practices (in terms of input rates, plant densities and intercropping) in 16 cases and there were few changes with regard to the control of pests and fungi. Some of the changes were implemented for more than one of the crops available in demonstration trials, and these were counted separately. If the same change occurred at multiple locations, it was counted as one action of change. Table 2 provides some insight into the number of changes that have occurred per crop across the different countries, distinguishing bush beans and climbing beans as different types of legumes.

Table 1. Sum of changes in demonstration trials in Ghana (three legume types), Ethiopia (four legume types), Nigeria (three legume types), Tanzania (five legumes) and Uganda (five legume types), since 2015 until and including 2017. Changes that were implemented not by choice are denoted between parentheses. Changes were counted per action and per crop, not per location within a country. Add.: added; Repl.: replicated; Disc.: discarded.., Cl.: climbing, Gr.: ground.

Country	Variety			Fertilizer type			Inoculant type			Biocontrol		
	Add.	*Repl.*	*Disc.*	*Add.*	*Repl.*	*Disc.*	*Add.*	*Repl.*	*Disc.*	*Add.*	*Repl.*	*Disc.*
Ghana	3	1	2	0	2	0	0	1	0	0	0	0
Nigeria	0	6	3	0	3	0	0	0	0	0	0	0
Ethiopia	4	1	0	0	(4)	0	1	(1)	0	0	0	0
Tanzania	4	0	4	0	1	2	1	0	0	1	0	0
Uganda	26	5	5	1	0	0	1	0	0	0	0	0
Total	37	13	14	1	6(+4)	2	3	1(+1)	0	1	0	0

Country	Insecticide			Herbicide			Practice				
	Add.	*Repl.*	*Disc.*	*Add.*	*Repl.*	*Disc.*	*Input rate*	*Input combi*	*Inter crop*	*Plant density*	*Staking*
Ghana	0	0	0	0	0	0	0	0	0	0	0
Nigeria	0	0	0	0	0	0	0	0	0	3	0
Ethiopia	0	0	0	0	0	0	4	0	0	0	0
Tanzania	0	1	0	0	0	0	0	0	1	0	0
Uganda	0	0	0	6	0	0	0	3	0	0	4
Total	0	1	0	6	0	0	4	3	1	3	4

Table 2. Sum of changes in demonstration trials in Ghana (three legume types), Ethiopia (four legumes), Nigeria (three legume types), Tanzania (five legume types) and Uganda (five legume types), since 2015 until and including 2017. Changes that were implemented not by choice are denoted between parentheses. Changes were counted per action and per crop, not per location within a country. Add.: added; Repl.: replicated; Disc.: discarded., Cl.: climbing, Gr.: ground.

Legume	Variety			Fertilizer type			Inoculant type			Biocontrol		
	Add.	*Repl.*	*Disc*	*Add.*	*Repl.*	*Disc.*	*Add.*	*Repl.*	*Disc.*	*Add.*	*Repl.*	*Disc.*
Bush bean	11	1	1	0	(1)	2	1	0	0	0	0	0
Chickpea	1	0	0	0	(1)	0	0	0	0	0	0	0
Cl. bean	9	0	5	0	0	0	0	0	0	0	0	0
Cowpea	3	1	3	0	2	0	0	0	0	0	0	0
Fababean	0	0	0	0	(1)	0	1	(1)	0	0	0	0
Gr.nut	7	6	2	0	1	0	0	0	0	1	0	0
Soyabean	6	5	3	1	3 (+1)	0	1	1	0	0	0	0
Total	37	13	14	1	6 (+4)	2	3	1 (+1)	0	1	0	0

Legume	Insecticide			Herbicide			Practice				
	Add.	*Repl.*	*Disc.*	*Add.*	*Repl.*	*Disc.*	*Input rate*	*Input combi*	*Inter crop*	*Plant density*	*Staking*
Bush bean	0	0	0	2	0	0	1	0	1	0	0
Chickpea	0	0	0	0	0	0	1	0	0	0	0
Cl. Bean	0	0	0	2	0	0	0	1	0	0	4
Cowpea	0	1	0	0	0	0	0	0	0	1	0
Fababean	0	0	0	0	0	0	1	0	0	0	0
Gr.nut	0	0	0	0	0	0	0	1	0	1	0
Soyabean	0	0	0	2	0	0	1	1	0	1	0
Total	0	1	0	6	0	0	4	3	1	3	4

In most cases changes were the result of the performance of varieties and technologies on the 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 diagnostic trials, adaptation trials and in a few cases partners who had developed a new variety, fertilizer blend or inoculant.

2.2 Varieties

A replacement of a variety or an input could be interpreted as a combination of two practices: discarding and adding. These actions were distinguished because not every discarded variety was replaced at that same moment or location (hence, not replaced right away). For all crops, common reasons for discarding varieties were poor yields which were often the result of increasingly irregular rainfall patterns in recent years. Therefore, introduced varieties were in most cases selected based on their drought tolerance, with early-maturing varieties replacing late-maturing varieties, and better yield. In some cases, the new varieties had been tested first on diagnostic trials and had shown (relatively) high yields. In other cases the varieties were directly introduced on the demonstration trials, in response to the feedback from farmers or in cooperation with seed developers. For groundnut, bush bean, climbing bean, chick pea, faba bean and soyabean high yields were the most important criterion for variety changes, but for groundnut, there was also a clear selection towards varieties with a high oil content and with a good taste, to accommodate market demand.

In 2015A in Nigeria, groundnut variety Samnut 22 was replaced by Samnut 23 and Samnut 24 at some locations, whereas the reverse happened at other locations in Nigeria. The first action was based on a preference for early-maturing varieties with a large oil content for good marketability initiated by extension staff. The reverse action at other locations was also based on marketability, as evaluated by farmers and supported by local extension staff and the country coordinator. This is a good example of local best fits.

In Lushoto in Tanzania, climbing beans were dropped as a crop altogether in N2Africa demonstration trials because their resource requirements were larger than for bushy varieties. Besides, climbing beans were found to compete with vegetables for land and farmers did not seem to be interested. Farmers tended to grow climbing varieties in the valleys and not in the upland fields.

The introduction of new varieties in Uganda was very often based on the requirements expressed by farmers. They wanted to be able to choose from multiple newly-released varieties and compare them in terms of yield and marketability. Iron-enriched climbing bean variety Nyiramuhondo was specifically introduced for women, who are often prone to iron deficiencies. Women and men had different preferences for varieties: women were more often in favour of local varieties with a good taste to use for home consumption, whereas men had a preference for highly marketable varieties. Groundnut tasting sessions were organized in Uganda to select marketable varieties based on taste and oil content, and the preferred varieties were then grown in the demonstration trials.

2.3 Inputs

2.3.1 Inoculants

Legumefix was added to bush beans in demonstration trials in Lushoto and Moshi in Tanzania, in 2017A because results elsewhere (Ethiopia, Rwanda) indicated a response to inoculation in common bean. The inoculant was cheaper than NPK fertilizers, enabling poor farmers to at least purchase inoculants if not also fertilizers. Besides, there was an interest from N2Africa and farmers to see the combined effects of inoculants and fertilizer on the legume yields.

In Ghana, Legumefix had been replaced in 2015 by NoduMax for inoculating soyabean. NoduMax contains elite *Bradyrhizobium* on a peat-based carrier. The replacement occurred to support upcoming production and development of NoduMax in Nigeria, which is being supported by IITA, N2Africa, the Business Incubation Platform (BIP) in West Africa.

For faba bean production in demonstration trials in Ethiopia, inoculant strain FB-04 was replaced by EAL-110 in some regions in 2016A, in spite of a preference for FB-04. FB-04 had been tested and verified on diagnostic trials to be suitable for faba bean production in northern Ethiopia, but inoculant producers no longer provided the product as of 2016. EAL-110 had already been used in demonstration trials before 2015. It was not very effective at that time, so having to return to the use of EAL-110 was

undesirable. In some other regions, the FB-04 strain was multiplied so FB-04 was used there for inoculation (see Appendix II).

In Uganda, Makbiofix had been used from the beginning, and Legumefix was introduced in 2014B to provide farmers with multiple options.

2.3.2 Fertilizers

In Ghana, TSP was replaced in 2017 by the New Yara Blend for fertilizing cowpea and soyabean. The New Yara Blend contains not only phosphorus, but also nitrogen, calcium, sulphur and boron, constituting a mix that can boost production and nitrogen fixation in legumes.

In Ethiopia, the government incentivized the use of NPS instead of DAP, so this change on the demonstration trials in 2016A was completely based on the government's fertilizer supply and not on N2Africa's own strategies. DAP was completely unavailable, so a preferred input could not be used. Before the fertilizer replacement, DAP rates had been increased (from 25 kg to 50 kg/ha) on all crops because research on the diagnostic trials had shown better yield responses to higher DAP rates. NPS was later applied at those same high rates (see Appendix II).

NPK fertilizer was replaced by SSP in Nigeria in 2015A, for cowpea, groundnut and soyabean. Legume yields were higher with SSP, a phosphate fertilizer which also contains some calcium and sulphur.

In Mvomero in Tanzania, TSP fertilizer was replaced by DAP for soyabean in 2016A, despite a preference for TSP. TSP was poorly available there at that time. Earlier, in 2015A, in Lushoto and Moshi in Tanzania, the use of Sympal fertilizer and farmyard manure had been excluded from the demonstration trials. Sympal is a legume-specific fertilizer, but its availability was limited in Tanzania and its effects on yield were similar to more widely available fertilizers in demonstration and diagnostic trials. The use of farmyard manure was very common for farmers, so it was not necessary to demonstrate that input to them anymore.

In Uganda, inputs such as TSP, manure and inoculants were originally applied separately. Combined application of two inputs was tested on some diagnostic and demonstration trials and the yield returns of bush beans, climbing beans and soyabeans were larger than when only one input was applied. Consequently, the practices of combined application of TSP and gypsum (groundnut, 2014A), TSP and manure (climbing beans, 2014B), or TSP and inoculant (soyabean, 2015B) were applied on other trials.

2.4 Practices

Planting practices did not change since the beginning of N2Africa Phase II in demonstration trials in Ghana. In Nigeria, plant densities were increased in 2015A for all legumes and this was also based on yield results from diagnostic trials. In Tanzania in 2016B, bush beans were intercropped with maize instead of sole-cropped because farmers requested to optimize the intercropping practices that they were used to.

Various practices for staking of climbing beans were introduced in Kapchorwa in Uganda, 2014A. The length of stakes was increased to allow the beans to grow taller, and the methods of string staking and tripods were introduced. Tripod stakes are a lot steadier than single stakes which tend to fall when it is windy. However, when stake scarcity is a problem, farmers may want to apply string staking: a few supporting poles are required and the beans grow along strings. Initially the strings that were demonstrated were banana fibres, but these tended to break easily. They were therefore replaced by sisal strings, although they are more expensive than banana fibres. Farmers could choose the method that fitted their requirements in terms of labour intensity and costs.

Insecticide and biocontrol inputs were only changed in some regions in Tanzania, on cowpea and on groundnut, respectively. The insecticide replacement was more broad-spectrum, and the introduced biocontrol reduced the levels of aflatoxins on groundnut and thereby improved the quality and marketability of the product.

Herbicide Beans Clean was introduced in 2015B for the production of bush beans, climbing beans and soyabeans in Uganda, to reduce labour intensity of weeding. Manual weeding was usually done by women and by replacing hand hoeing with herbicide application, women could spend less time on weeding. Some weeds persisted after the application of Beans Clean, so a stronger, broad-spectrum glyphosate herbicide was introduced in 2017A to use in combination with or instead of Beans Clean.

3 Next steps

Challenges are found in the selection of varieties that are more tolerant to changing and irregular weather conditions, while still being high-yielding and marketable. The availability and accessibility of legume-specific inputs such as FB-04, TSP, DAP vs NPS were repeatedly a problem, stressing the importance of networking with partners and of lobbying with policy makers. It is also an incentive for the further development and production of legume-specific fertilizer blends together with partners.

The action initiator was the stakeholder who made the request for a change. In many cases, the initiator was a bit hard to pinpoint because changes were usually discussed on multiple levels before their execution. For example a country coordinator gets his information from extension staff who collect data on trials and from evaluations with farmers from various regions, but she/he is also a key figure in the network who receives information from partners such as fertilizer companies or inoculant producers. When farmers make a suggestion and provide feedback, this is discussed during annual planning meetings of the staff and is then implemented on the subsequent trials. Decision-making processes could be more transparent if the steps along feedback-loops are monitored more closely in the future.

Feedback from farmers was very often the basis of changes. Evaluations with farmers are clearly necessary to steer practices towards best-fits within a regional context with its specific weather and market conditions.

A next step is to provide a grand overview of all practices that are being tested and demonstrated, along with reasons as to why they have remained on the trials and were not discarded or replaced.

APPENDIX: Changes in demonstration trials

APPENDIX I - Ghana

Location	Year	Action	Reason	Action initiator
Cowpea				
Binduri, Nadowli, Savelugu, Wa West, Yendi	2017	**Variety Songotra was replaced by Wang-Kae and Kirkhouse** on all trials.	It was found in agronomy and demonstration trials Songotra was easily infected by disease, and the other varieties were not.	Extension staff, farmers, country coordinator.
Binduri, Nadowli, Savelugu, Wa West, Yendi, Chereponi	2017	**TSP fertilizer was replaced by the New Yara Blend**, a fertilizer for legumes, containing P, N, Ca, S and Bo.	Collaborative on-farm trials with fertilizer company Yara revealed that legume yields responded more strongly to the New Yara Blend than to other P fertilizers.	Country coordinator.
Binduri, Nadowli, Savelugu, Wa West, Yendi	2015	**Variety Zayura was removed** from trials.	The variety germinated very poorly. Farmers suggested to discard the variety.	Farmers.
Groundnut				
Binduri, Nadowli, Savelugu, Wa West, Yendi	2017	**Variety Yenyawoso was added**.	It was a newly-released variety and it was added to compare it with the other improved varieties which were already grown on the trials.	Country coordinator.
Soyabean				
Binduri, Nadowli, Savelugu, Wa West, Yendi	2017	**Variety TGX-1835 – 10E was added.**	It is a high yielding, short-season/ early-maturing variety. Diagnostic and demonstration trials and evaluations with farmers showed high yields with limited rainfall for this variety.	Extension staff, farmers, country coordinator.
Binduri, Nadowli, Savelugu, Wa West, Yendi	2017	**TSP fertilizer was replaced by the New Yara Blend**, a P fertilizer for legumes.	Diagnostic trials revealed that legume yields responded more strongly to the New Yara Blend than to other P fertilizers.	Country coordinator.
Binduri, Nadowli, Savelugu, Wa West, Yendi	2016	**Variety Jenguma was removed** from trials.	Jenguma is a late-maturing variety. It was evident from diagnostic and demonstration trials and from evaluations with farmers that the yield potential could not be realised with only a short period of rainfall.	Farmers.

Location	Year	Action	Reason	Action initiator
Soyabean (continuation of previous page)				
Binduri, Nadowli, Savelugu, Wa West, Yendi, Chereponi	2015	The inoculant **Legumefix was replaced by NoduMax.**	To favour IITA's own product.	Country coordinator.

APPENDIX II - Ethiopia

Location	Season	Action	Reason	Action initiator
		Cowpea		
Boricha, Damot, Gale Halaba, Soddo	2017A	**Variety Awassa Dume was introduced.**	Diagnostic trials had shown that it has a good yield potential in various agro-ecological zones	Extension staff, farmers, country coordinator.
Whole country	2016A	**DAP fertilizer was nationally replaced by NPS** (with N, P and S) at the same rate.	Fertilizer supply was controlled by the government.	Government.
Ada'a, Becho, Boricha, Damot, Gale Halaba, Soddo	2015A	**Variety ACOS RED was introduced**.	Based on market research, to improve the marketability of beans (for export). The variety had been evaluated by farmers, extension staff and researchers. The bean size was attractive but yields were relatively low!	Market, ACOS, country coordinator
Ada'a, Becho, Boricha, Damot, Gale Halaba, Soddo	2015A	**DAP fertilizer rate increased from 25 kg/ha to 50 kg/ha**.	Diagnostic trials revealed that higher DAP rates lead to higher yields. Soil chemical analyses showed lower availability of P in most trial sites in 2013 & 2014.	Extension staff, country coordinator, farmers.
		Chickpea		
Whole country	2016A	**DAP fertilizer was nationally replaced by NPS** (with N, P and S) at the same rate.	Fertilizer supply was controlled by the government.	Government.
Ada'a, Becho, Boricha, Damot, Gale Halaba, Soddo	2015A	**DAP fertilizer rate increased from 25 kg/ha to 50 kg/ha**.	Diagnostic trials revealed that higher DAP rates lead to higher yields. Soil chemical analyses showed lower availability of N and P in most trial sites in 2013 & 2014.	Extension staff, country coordinator, farmers.
Ada'a, Becho, Boricha, Damot, Gale Halaba, Soddo	2015A	**Variety ACOS DUBIE was introduced.**	Based on market research, to improve the marketability of beans (for export). The variety had been evaluated by farmers, extension staff and researchers. The pea size was attractive but yields were relatively low!	Market, ACOS, country coordinator

Location	Season	Action	Reason	Action initiator
Faba bean				
Dabat-Debark Gonder Zuria	2016A	**Preferred strain FB-04 was replaced by EAL-110 for inoculation**.	FB-04 was tested in Dabat-Debark in 2015 and verified as best for northern Ethiopia, but could not be accessed from inoculant producers. Therefore, the nationally used faba bean strain EAL-110 was used in the trials. Poor responses to EAL-110 alone were found, but medium to high responses when applied together with DAP.	Country coordinator, regional research partner, extension staff.
Whole country	2016A	**DAP fertilizer was nationally replaced by NPS** (with N, P and S) at the same rate.	Fertilizer supply was controlled by the government.	Government.
Ada'a, Becho, Boricha, Damot, Gale Halaba, Soddo	2015A	**DAP fertilizer rate increased from 25 kg/ha to 50 kg/ha**.	Diagnostic trials revealed that higher DAP rates lead to higher yields. Soil chemical analyses showed lower availability of N and P in most trial sites in 2013 & 2014.	Extension staff, regional research partner, country coordinator, farmers.
Agarfa, Dabat-Debark, Farta, Goba, Sinana, Yilmana, Densa	2015A	**Inoculant FB-04 was added**.	The previous inoculant EAL-110 showed poor performance districts in the North. FB-04 was introduced at demonstration and adaptation trials and better responses were obtained.	Extension staff, regional research partner, country coordinator.
Soyabean				
Jawi Pawe	2016A	**Variety Belessa-95 was replaced by Nova and Gishama.**	Belessa-95 germinated poorly and took too long to mature in demonstration and adaptation trials. Nova and Gishama are short-duration.	Extension staff.
Whole country	2016A	**DAP fertilizer was nationally replaced by NPS** (with N, P and S) at the same rate.	Fertilizer supply was controlled by the government.	Government.
Ada'a, Becho, Boricha, Damot, Gale Halaba, Soddo	2015A	**DAP fertilizer rate increased from 25 kg/ha to 50 kg/ha**.	Diagnostic trials revealed that higher DAP rates lead to higher yields. Soil chemical analyses showed lower availability of N and P in most trial sites in 2013 & 2014.	Extension staff, country coordinator, farmers.

APPENDIX III - Nigeria

Location	Season	Action	Reason	Action initiator
Cowpea				
Ajingi, Bagwai, Chikun, Gabasawa, Gaya, Gezawa, Giwa, Gwarzo, Igabi, Ikara, Kabo, Kajuru, Kauru Lapai, Lere, Makarfi, Mariga, Mokwa, Paikoro, Rafi, Shanono, Shiroro, Soba, Tofa, Warawa, Zaria	2015A	**Varieties IT89KD-288 and IT90K-277-2 were discarded**.	They were too easily infested by Striga in diagnostic, demonstration and adaptation trials.	Extension staff.
Ajingi, Bagwai, Chikun, Gabasawa, Gaya, Gezawa, Giwa, Gwarzo, Igabi, Ikara, Kabo, Kajuru, Kauru Lapai, Lere, Makarfi, Mariga, Mokwa, Paikoro, Rafi, Shanono, Shiroro, Soba, Tofa, Warawa, Zaria	2015A	**NPK fertilizer was replaced by SSP fertilizer.**	The trials demonstrated that legume production benefits a lot from SSP fertilizer. NPK was no longer required.	Extension staff, farmers, country coordinator.
Ajingi, Bagwai, Chikun, Gabasawa, Gaya, Gezawa, Giwa, Gwarzo, Igabi, Ikara, Kabo, Kajuru, Kauru Lapai, Lere, Makarfi, Mariga, Mokwa, Paikoro, Rafi, Shanono, Shiroro, Soba, Tofa, Warawa, Zaria	2015A	**Planting densities were increased** by reducing within- and between-row plant spacing.	A reduced planting density led to yield improvements on diagnostic and demonstration trials. This practice was endorsed by farmers in evaluations.	Farmers, extension staff, country coordinator.
Groundnut				
Ajingi, Bagwai, Chikun, Gabasawa, Gaya, Gezawa, Giwa, Gwarzo, Igabi, Ikara, Kabo, Kajuru, Kauru Lapai, Lere, Makarfi, Mariga, Mokwa, Paikoro, Rafi, Shanono, Shiroro, Soba, Tofa, Warawa, Zaria	2015A	**Variety Samnut 21 and Samnut 22 were replaced by Samnut 23 and Samnut 24**.	The late-maturing varieties were replaced by early-maturing varieties with a larger oil content.	Extension staff.
Bayu, Biu, Hawul, Kwaya, Kusar	2015A	**Variety Samnut 23 and 24 were replaced by Samnut 22.**	Based on farmers' feedback about poor marketability of the discarded varieties.	Farmers, extension staff, country coordinator.
Ajingi, Bagwai, Chikun, Gabasawa, Gaya, Gezawa, Giwa, Gwarzo, Igabi, Ikara, Kabo, Kajuru, Kauru Lapai, Lere, Makarfi, Mariga, Mokwa, Paikoro, Rafi, Shanono, Shiroro, Soba, Tofa, Warawa, Zaria	2015A	**NPK fertilizer was replaced by SSP fertilizer.**	The trials demonstrated that legume production benefits a lot from SSP fertilizer. NPK was no longer required.	Extension staff, farmers, country coordinator.

Location	Season	Action	Reason	Action initiator
Groundnut (continuation of previous page)				
Ajingi, Bagwai, Chikun, Gabasawa, Gaya, Gezawa, Giwa, Gwarzo, Igabi, Ikara, Kabo, Kajuru, Kauru Lapai, Lere, Makarfi, Mariga, Mokwa, Paikoro, Rafi, Shanono, Shiroro, Soba, Tofa, Warawa, Zaria	2015A	**Planting densities were increased** by reducing within- and between-row plant spacing.	A reduced planting density led to yield improvements on diagnostic and demonstration trials. This practice was endorsed by farmers in evaluations.	Farmers, extension staff, country coordinator.
Soyabean				
Ajingi, Bagwai, Chikun, Gabasawa, Gaya, Gezawa, Giwa, Gwarzo, Igabi, Ikara, Kabo, Kajuru, Kauru Lapai, Lere, Makarfi, Mariga, Mokwa, Paikoro, Rafi, Shanono, Shiroro, Soba, Tofa, Warawa, Zaria	2015A	**Varieties TGX1448-2E and TGX1904-6F were replaced by TGX1951-3F and TGX1835-10E.**	To try out more recently released varieties that were early-maturing and high-yielding	Extension staff.
Bayu, Biu, Hawul, Kwaya, Kusar	2015A	**Variety TGX 1448-2E was replaced by TGX 1951-4F.**	To replace a late-maturing by an early-maturing variety.	Farmers, extension staff, country coordinator.
Ajingi, Bagwai, Chikun, Gabasawa, Gaya, Gezawa, Giwa, Gwarzo, Igabi, Ikara, Kabo, Kajuru, Kauru Lapai, Lere, Makarfi, Mariga, Mokwa, Paikoro, Rafi, Shanono, Shiroro, Soba, Tofa, Warawa, Zaria	2015A	**NPK fertilizer was replaced by SSP fertilizer.**	The trials demonstrated that legume production benefits a lot from SSP fertilizer. NPK was no longer required. Farmers preferred to produce soyabean using inoculant and SSP.	Extension staff, farmers, country coordinator.
Ajingi, Bagwai, Chikun, Gabasawa, Gaya, Gezawa, Giwa, Gwarzo, Igabi, Ikara, Kabo, Kajuru, Kauru Lapai, Lere, Makarfi, Mariga, Mokwa, Paikoro, Rafi, Shanono, Shiroro, Soba, Tofa, Warawa, Zaria	2015A	**Planting densities were increased** by reducing within- and between-row plant spacing.	A reduced planting density led to yield improvements on diagnostic and demonstration trials. This practice was endorsed by farmers in evaluations.	Farmers, extension staff, country coordinator.

APPENDIX IV - Tanzania

Location	Season	Action	Reason	Action initiator
		Bush bean		
Lushoto, Moshi	2017A	**Inoculant Legumefix was added** to the demonstration trials.	First only NPK and PK fertilizers were used, and there is an interest in the combined effects of inoculants and P fertilizers. The costs of the inoculant are low compared to the fertilizer input, enabling poor farmers to at least purchase inoculants if not also fertilizers.	Extension staff, bean research program in Tanzania, country coordinator.
Bumbuli, Kilosa, Korogwe, Lushoto, Machame, Moshi, Rombo	2016B	**Beans were intercropped with maize instead of sole cropped.**	To maximize production on of both beans as well as maize. Farmers demanded the inclusion of maize-legume intercrops in the trials because they learned that appropriate combinations may improve the yields of maize and achieve production of both crops in their small holdings.	Farmers, extension staff.
Lushoto, Moshi	2016A	**Variety Jesca was added** to the demonstration trials.	It is a high-yielding variety that is also tolerant to weather disparities and drought. Previously grown varieties were highly affected by limited rainfall.	Extension staff, country coordinator, farmers.
Lushoto, Moshi	2015A	**Sympal fertilizer and farmyard manure were no longer used on trials**.	The availability of Sympal was limited in Tanzania, and its effects on yield were unpromising in demonstration and diagnostic trials. The use of farmyard manure was so common for farmers that there was no need to demonstrate it anymore.	Extension staff, farmers, country coordinator.
Lushoto, Moshi	2015A	**Variety Njano Uyole was added**.	It was presented in demonstration trials next to Lyamungu 90. During technology evaluations Lyamungu 90 was observed to be susceptible to diseases and farmers ranked it low in marketability, so farmers, extension staff and bean traders requested to include other better varieties. Njano Uyole was included as an alternative to a non-registered variety, Soya Njano, with similar qualities.	Extension staff, farmers.

Location	Season	Action	Reason	Action initiator
		Climbing bean		
Lushoto	2016A	**Varieties Selian 06, Cheupe and MAC 44 were discarded.**	They require very fertile soil, have higher water consumption than bush beans and because they compete for land with the vegetables grown in Lushoto. Only bushy varieties remained on the trails.	Extension staff, farmers, country coordinator.
		Cowpea		
Gairo, Kilosa, Mvomero	2017A	**The insecticide Alphadom (targeting only aphids) was replaced by Karate**.	Results from 2016 showed that cowpea was affected by pest insects despite spraying Alphadom. Karate is a broad-spectrum insecticide effective against a range of pest insects affecting cowpea.	Extension staff, farmers.
Kongwa, Dodoma	2017A	**Variety Raha 1 and Vuli R1 were added.**	To allow farmers to choose from a wider range of varieties in demonstration trials, based on their own selection criteria. The varieties are all high-yielding and tolerant to drought. They also taste well when cooked. Vuli R1 is resistant to *Alectra* weeds.	Country coordinator, extension staff, farmers.
		Groundnut		
Kongwa	2016A	**Variety Mnanje was discarded.**	Only variety Pendo remained. On the demonstration and adaptation trials, Pendo yielded better and was more resistant to rosette disease. Pendo was also evaluated as being more marketable than Mnanje.	Country coordinator, farmers.
Kongwa	2016A	**Biocontrol Aflasafe was added.**	Aflasafe minimizes the level of aflatoxins on groundnut, thereby improving the quality and safety of the product and its marketability.	Country coordinator, farmers.
		Soyabean		
Mvomero	2016A	**TSP fertilizer was replaced by DAP.**	TSP was poorly available in Tanzania.	Extension staff, farmers.

APPENDIX V - Uganda

Location	Season	Action	Reason	Action initiator
		Bush bean		
Kole, Lira, Oyam	2017A	**Varieties NATO Bean 4 and NATO Bean 15 were added**.	Farmers wanted to be able to choose from a range of demonstrated varieties, so newly released varieties were added. NATO Bean 4 and 15 yield well, are tolerant to dry weather, have a good taste and are marketable.	Extension staff, farmers.
Apac, Bugiri, Bukedea, Kabale, Kanungu, Kapchorwa, Kisoro, Kole, Kumi, Lira, Oyam	2017A	**A broad-spectrum glyphosate herbicide was introduced.**	To get rid of difficult weeds prior to planting beans. Farmers and extension staff observed in demonstration and adaptation trials that certain weeds like *Commelina benghalensis* and *Elymus repens* persisted after the application of herbicide Beans Clean, so a stronger herbicide like glyphosate was required.	Farmers, extension staff, country coordinator.
Gulu	2016B	**Variety NATO bean 1 replaced 'yellow beans'.**	NATO bean 1 was recently released by a national research organisation and because it had promising attributes in terms of yield and marketability (taste). Farmers had requested the inclusion of new varieties on the demonstration trials.	Extension staff, farmers, country coordinator.
Kibaale, Rakai	2016A	**Variety RWR 2154 was added.**	It was drought-tolerant and marketable with its nice colour, taste and high iron content. Farmers saw in demonstration trials that RWR 2154 was more tolerant to drought compared to local varieties Nambale and Kasidi.	Farmers, extension staff.
Kibaale, Rakai	2016A	**Variety Roba 1 was discarded.**	Farmers evaluated the yields as very poor.	Farmers, extension staff.
Apac, Bugiri, Bukedea, Gulu, Kabale, Kanungu, Kapchorwa, Kisoro, Kole, Kumi, Oyam	2015B	**Herbicide Beans Clean was introduced to replace the practice of weeding by hand hoe.**	To save labour and money spent on labour. Sometimes there was not enough labour available to do all weeding by hand. Manual weeding was mainly done by women, and the use of herbicides could enable them to use their time for other activities.	Country coordinator, market.

Location	Season	Action	Reason	Action initiator
Bush bean (continuation of previous page)				
Kibaale, Rakai	2015A	**Improved varieties Roba 1 and RWR 2245, and local varieties Nambale and Kasidi were added** to demonstration trials.	These regions were not suitable for growing climbing beans, so a larger variation of bush bean varieties was shown to give farmers various options to choose from, based on yield, marketability, taste or other reasons. Farmers had very different opinions about local and improved varieties, so both types were included. RWR 2245 was preferred by male farmers because of its yields, and by female farmers because it is biofortified. Women also had a preference for local varieties Nambale and Kasidi.	Extension staff, farmers, country coordinator, market.
Climbing bean				
Apac, Bugiri, Bukedea, Kabale, Kanungu, Kapchorwa, Kisoro, Kole, Kumi, Lira, Oyam	2017A	**A broad-spectrum glyphosate herbicide was introduced.**	To get rid of difficult weeds prior to planting beans. Farmers and extension staff observed in demonstration and adaptation trials that certain weeds like *Commelina benghalensis* and *Elymus repens* persisted after the application of herbicide Bean Clean, so a stronger herbicide like glyphosate was required.	Farmers, extension staff, country coordinator.
Apac, Bugiri, Bukedea, Gulu, Kabale, Kanungu, Kapchorwa, Kisoro, Kole, Kumi, Oyam	2015B	**Herbicide Beans Clean was introduced to replace the practice of weeding by hand hoe.**	To save labour and money spent on labour. Sometimes there was not enough labour available to do all weeding by hand. Manual weeding was mainly done by women, and the use of herbicides could enable them to use their time for other activities.	Country coordinator, market.
Kabale, Kanungu, Kisoro	2015A	**Varieties Kabwerese, Katuna, Nyiramuhondo and a 'flat, white variety' were added** in demonstration and adaptation trials.	Katuna and Kabwesere were popular local varieties, giving relatively secure yields. Nyiramuhondo was added because it was biofortified with iron, which was of interest for women. N2Africa had specifically looked for iron-enriched varieties and found some from the Harvest Plus project. The flat, white variety was suggested by the Jay Fortune company for export.	Extension staff, farmers, country coordinator, market.
Kabale, Kanungu, Kisoro, Kapchorwa	2015A	**Variety Nabe 26C was discarded.**	It yielded poorly in demonstration and adaptation trials as a result of susceptibility to diseases and pests.	Extension staff, farmers, country coordinator.

Location	Season	Action	Reason	Action initiator
Climbing bean (continuation of previous page)				
Kapchorwa	2015A	**Varieties Nyiramuhondo and a 'flat, white variety' were added** in demonstration and adaptation trials.	Nyiramuhondo was introduced because it was biofortified with iron, which was of interest for women. N2Africa had specifically looked for iron-enriched varieties and found some from the Harvest Plus project. The flat, white variety had a high market demand abroad and was already linked to buyer company Jay Fortune.	Extension staff, farmers, country coordinator, market.
Kabale, Kanungu, Kapchorwa	2014B	**Improved variety Nabe 12C and local variety Attawa were added** to the demonstration trials.	Nabe 12C had yielded well on diagnostic trials and there was a market demand for its qualities in terms of sweetness and cooking time. Men had a preference for Nabe 12C based on its marketability. Attawa was considered as resistant to drought and was preferred by women for home consumption.	Extension staff, farmers, country coordinator, market.
Kabale, Kanungu, Kapchorwa	2014B	**The practice of combining TSP and manure as fertilizer inputs was introduced.**	The combined effects on yield were much larger than when only TSP or manure was added, on diagnostic, demonstration and adaptation trials. No such effects on yield were found with inoculant application.	Extension staff, farmers, country coordinator.
Kabale, Kanungu, Kapchorwa	2014B	**The banana fibres that were used for string staking and for tripod staking were replaced by sisal strings.**	The sisal strings are stronger than the banana fibres. Farmers appreciated the tripods and string staking methods, but they expressed a need for stronger string material.	Extension staff, farmers.
Kapchorwa	2014A	**The staking method of setting tripods was introduced**	Tripods provide steady support for beans in windy weather conditions.	Extension staff, country coordinator.
Kapchorwa	2014A	**String staking was introduced**.	Growing beans along strings that are attached to a few strong poles reduces the total number of stakes required, to overcome the problem of stake scarcity and to reduce expenses on stakes. However, the banana fibres break easily	Extension staff, country coordinator.
Kapchorwa	2014A	**The length of the stakes used for single staking was increased.**	To allow the beans to grow taller and yield better.	Extension staff, country coordinator.

Location	Season	Action	Reason	Action initiator
Climbing bean (continuation of previous page)				
Kapchorwa	2014A	**Variety Nabe 10C was added** to the demonstration trials.	To compare it to Nabe 26C which was already being demonstrated. Nabe 26C was low-yielding and susceptible to diseases. However Nabe 26C was expected to yield relatively reasonable under dry circumstances.	Extension staff, country coordinator.
Groundnut				
Kibuku, Pallisa	2015A	**Variety Serenut 6 was replaced by Serenut 11T.**	Farmers had expressed a need for new, red, high-yielding varieties. They tasted a few varieties and appreciated Serenut 11T for home consumption. Serenut 11T had a higher oil content and a better yield potential than Serenut 6.	Farmers, extension staff, country coordinator, market.
Kibuku, Pallisa	2015A	**Varieties Kabonge Red and Serenut 14R were added.**	Their high oil content improves their marketability.	Farmers, extension staff, country coordinator, market.
Apac, Kole, Oyam	2015A	**Variety Serenut 14R was added.**	There was a high market demand for red varieties like this one.	Farmers, extension staff, country coordinator, market.
Apac, Kole, Oyam, Bugiri	2015A	**Variety Serenut 6 was replaced by Serenut 11T.**	Serenut 6 was low-yielding and very susceptible to groundnut rosette disease whereas Serenut 11T was high-yielding, with a high oil content. Farmers requested a red varieties because of a high market demand for those. Serenut 11T was appreciated most in a tasting test and was therefore considered suitable for the market as well as home consumption.	Farmers, extension staff, country coordinator, market.
Bugiri	2015A	**Variety Red Beauty was introduced.**	There was a buyer ready to export the fresh pods. Farmers wanted to grow varieties that were highly marketable.	Extension staff, farmers, market.
Apac, Kibuku, Oyam,Pallisa	2014A	**TSP and gypsum were applied together.**	Groundnut yields responded well to the application of TSP or gypsum compared to plots without inputs in demonstration and adaptation trials and the combination increased yields even further.	Extension staff, farmers.

Location	Season	Action	Reason	Action initiator
Groundnut (continuation of previous page)				
Apac, Kibuku, Oyam,Pallisa	2014A	**Varieties Serenut 5 and Serenut 6 were added.**	These varieties are tolerant to diseases, pests and drought. Farmers already knew these varieties and evaluated them as being high-yielding and good for food security, although weak in terms of marketability. Farmers who cannot afford pesticides can rely on these varieties. Women expressed their appreciation for the taste.	Extension staff, farmers, country coordinator.
Soyabean				
Apac, Bugiri, Bukedea, Kabale, Kanungu, Kapchorwa, Kisoro, Kole, Kumi, Lira, Oyam	2017A	**A broad-spectrum glyphosate herbicide was introduced.**	To get rid of difficult weeds prior to planting beans. Farmers and extension staff observed in demonstration and adaptation trials that certain weeds like *Commelina benghalensis* and *Elymus repens* persisted after the application of herbicide Bean Clean, so a stronger herbicide like glyphosate was required	Farmers, extension staff, country coordinator.
Apac, Bugiri, Gulu, Kole, Kumi, Oyam	2016A	**Variety Maksoy 4N was discarded.**	It geminated poorly in demonstration and adaptation trials, especially when planted during heavy rains.	Extension staff, farmers.
Apac, Bugiri, Bukedea, Gulu, Kabale, Kanungu, Kapchorwa, Kisoro, Kole, Kumi, Oyam	2015B	**Herbicide Beans Clean was introduced to replace the practice of weeding by hand hoe.**	To save labour and money spent on labour. Sometimes there was not enough labour available to do all weeding by hand. Manual weeding was mainly done by women, and the use of herbicides could enable them to use their time for other activities.	Country coordinator, market.
Apac, Kole, Oyam	2015A	**The combined application of inoculant and TSP was recommended as a practice.**	The combined effects on yield were larger than the separate effects of TSP and of inoculants, as shown on the diagnostic, demonstration and adaptation trials.	Extension staff, country coordinator, farmers.
Apac, Kole, Oyam	2015A	**Newly-released varieties Maksoy 2N, 4N and 5N were introduced.**	To give farmers multiple options of marketable varieties to choose from, after their request for new varieties.	Extension staff, country coordinator, farmers, market.

Location	Season	Action	Reason	Action initiator
Soyabean (continuation of previous page)				
Bugiri, Kibuku, Pallisa	2015A	**The combined application of inoculant and TSP was introduced as a practice.**	This had shown promising effects on yields in the Northern region in season 2014B. Northern farmers attributed yield increases to these inputs	Extension staff, country coordinator, farmers.
Bugiri, Kibuku, Pallisa	2015A	**Variety Maksoy 2N was replaced by Maksoy 3N, 4N and 5N**.	Maksoy 3N, 4N and 5N were more recently released than Maksoy 2N. Farmers had seen the good effects of inoculants Makbiofix and Legumefix on Maksoy 2N, and they expressed during evaluations that they expected even better yields for newer varieties that were similar to Maksoy 2N. Besides, the new varieties had high oil contents.	Extension staff, farmers, country coordinator, market.
Apac, Kole, Oyam	2014B	**Inoculant Legumefix was introduced.**	To compare its efficacy with that of Makbiofix, which was already being used and had resulted in increased yields in demonstration trials.	Country coordinator.
Apac, Kole, Oyam	2014B	**Fertilizer TSP was introduced.**	Research had shown that it could improve yields.	Country coordinator.
Apac, Kole, Oyam	2014B	**Variety Maksoy 1 Now was discarded.**	The variety had a low yield potential, as was evident on the demonstration and adaptation trials. Its seeds were small, which reduced marketability.	Extension staff, farmers, market.

List of project reports

1. N2Africa Steering Committee Terms of Reference
2. Policy on advanced training grants
3. Rhizobia Strain Isolation and Characterisation Protocol
4. Detailed country-by-country access plan for P and other agro-minerals
5. Workshop Report: Training of Master Trainers on Legume and Inoculant Technologies (Kisumu Hotel, Kisumu, Kenya-24-28 May 2010)
6. Plans for interaction with the Tropical Legumes II project (TLII) and for seed increase on a country-by-country basis
7. Implementation Plan for collaboration between N2Africa and the Soil Health and Market Access Programs of the Alliance for a Green Revolution in Africa (AGRA) plan
8. General approaches and country specific dissemination plans
9. Selected soyabeans, common beans, cowpeas and groundnuts varieties with proven high BNF potential and sufficient seed availability in target impact zones of N2Africa Project
10. Project launch and workshop report
11. Advancing technical skills in rhizobiology: training report
12. Characterisation of the impact zones and mandate areas in the N2Africa project
13. Production and use of rhizobial inoculants in Africa
18. Adaptive research in N2Africa impact zones: Principles, guidelines and implemented research campaigns
19. Quality assurance (QA) protocols based on African capacities and international existing standards developed
20. Collection and maintenance of elite rhizobial strains
21. MSc and PhD status report
22. Production of seed for local distribution by farming communities engaged in the project
23. A report documenting the involvement of women in at least 50% of all farmer-related activities
24. Participatory development of indicators for monitoring and evaluating progress with project activities and their impact
25. Suitable multi-purpose forage and tree legumes for intensive smallholder meat and dairy industries in East and Central Africa N2Africa mandate areas
26. A revised manual for rhizobium methods and standard protocols available on the project website
27. Update on Inoculant production by cooperating laboratories
28. Legume Seed Acquired for Dissemination in the Project Impact Zones
29. Advanced technical skills in rhizobiology: East and Central African, West African and South African Hub
30. Memoranda of Understanding are formalized with key partners along the legume value chains in the impact zones
31. Existing rhizobiology laboratories upgraded
32. N2Africa Baseline report
33. N2Africa Annual country reports 2011

34. Facilitating large-scale dissemination of Biological Nitrogen Fixation
35. Dissemination tools produced
36. Linking legume farmers to markets
37. The role of AGRA and other partners in the project defined and co-funding/financing options for scale-up of inoculum (banks, AGRA, industry) identified
38. Progress Towards Achieving the Vision of Success of N2Africa
39. Quantifying the impact of the N2Africa project on Biological Nitrogen Fixation
40. Training agro-dealers in accessing, managing and distributing information on inoculant use
41. Opportunities for N2Africa in Ethiopia
42. N2Africa Project Progress Report Month 30
43. Review & Planning meeting Zimbabwe
44. Howard G. Buffett Foundation – N2Africa June 2012 Interim Report
45. Number of Extension Events Organized per Season per Country
46. N2Africa narrative reports Month 30
47. Background information on agronomy, farming systems and ongoing projects on grain legumes in Uganda
48. Opportunities for N2Africa in Tanzania
49. Background information on agronomy, farming systems and ongoing projects on grain legumes in Ethiopia
50. Special Events on the Role of Legumes in Household Nutrition and Value-Added Processing
51. Value chain analyses of grain legumes in N2Africa: Kenya, Rwanda, eastern DRC, Ghana, Nigeria, Mozambique, Malawi and Zimbabwe
52. Background information on agronomy, farming systems and ongoing projects on grain legumes in Tanzania
53. Nutritional benefits of legume consumption at household level in rural sub-Saharan Africa: Literature study
54. N2Africa Project Progress Report Month 42
55. Market Analysis of Inoculant Production and Use
56. Identified soyabean, common bean, cowpea and groundnut varieties with high Biological Nitrogen Fixation potential identified in N2Africa impact zones
57. A N2Africa universal logo representing inoculant quality assurance
58. M&E Workstream report
59. Improving legume inoculants and developing strategic alliances for their advancement
60. Rhizobium collection, testing and the identification of candidate elite strains
61. Evaluation of the progress made towards achieving the Vision of Success in N2Africa
62. Policy recommendation related to inoculant regulation and cross border trade
63. Satellite sites and activities in the impact zones of the N2Africa project
64. Linking communities to legume processing initiatives
65. Special events on the role of legumes in household nutrition and value-added processing
66. Media Events in the N2Africa project

67. Launch N2Africa Phase II – Report Uganda
68. Review of conditioning factors and constraints to legume adoption and their management in Phase II of N2Africa
69. Report on the milestones in the Supplementary N2Africa grant
70. N2Africa Phase II Launch in Tanzania
71. N2Africa Phase II 6 months report
72. Involvement of women in at least 50% of all farmer related activities
73. N2Africa Final Report of the First Phase: 2009-2013
74. Managing factors that affect the adoption of grain legumes in Uganda in the N2Africa project
75. Managing factors that affect the adoption of grain legumes in Ethiopia in the N2Africa project
76. Managing factors that affect the adoption of grain legumes in Tanzania in the N2Africa project
77. N2Africa Action Areas in Ethiopia, Ghana, Nigeria, Tanzania and Uganda in 2014
78. N2Africa Annual Report Phase II Year 1
79. N2Africa: Taking Stock and Moving Forward. Workshop report
80. N2Africa Kenya Country Report 2015
81. N2Africa Annual Report 2015
82. Value Chain Analysis of Grain Legumes in Borno State, Nigeria
83. Baseline report Borno State
84. N2Africa Annual Report 2015 DR Congo
85. N2Africa Annual Report 2015 Rwanda
86. N2Africa Annual Report 2015 Malawi
87. Contract Sprayer in Borno State, Nigeria
88. N2Africa Baseline Report II Ethiopia, Tanzania, Uganda, version 2.1
89. N2Africa rhizobial isolates in Kenya
90. N2Africa Early Impact Survey, Rwanda
91. N2Africa Early Impact Survey, Ghana
92. Tracing seed diffusion from introduced legume seeds through N2Africa demonstration trials and seed-input packages
93. The role of legumes in sustainable intensification – priority areas for research in northern Ghana
94. The role of legumes in sustainable intensification – priority areas for research in western Kenya
95. N2Africa Early Impact Survey, Phase I
96. Legumes in sustainable intensification – case study report PROIntensAfrica
97. N2Africa Annual Report 2016
98. OSSOM Launch and Planning Meeting for the west Kenya Long Rains 2017
99. Tailoring and adaptation in N2Africa demonstration trials
100. N2Africa Project DR Congo Exit Strategy

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