N2Africa Annual Report 2019

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N2Africa

Putting nitrogen fixation to work for smallholder farmers in Africa

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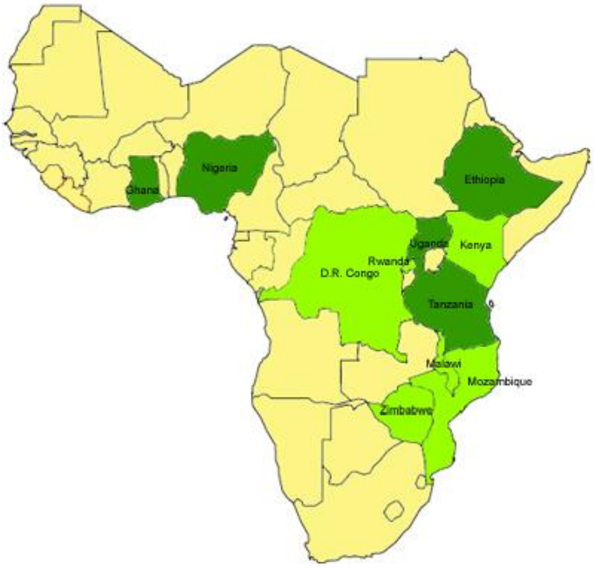
Acronyms and Abbreviations

Acronym	
ABP	Anchor Borrowers Program
AFEX	Africa Exchange Holdings Limited-Nigeria
ASDP	Agriculture Sector Development Program
CBN-ABP	Commercial Bank of Nigeria-Anchor Borrowers Program
CRS	Catholic Relief Services
CV	Community volunteers
GCL	Guavay Company Limited
MoU	Memorandum of Understanding
NIRSAL	Nigeria Incentive-Based Risk-Sharing System for Agricultural Lending
TOSCI	Tanzania Official Seed Certification Institute
QDS	Quality Declared Seeds
RAA	Regional Agricultural advisory
SME	Small and Medium Scale Enterprises
SMS	Short Message Service
SSP	Spraying Service Provider
SSP	Single superphosphate
TIJA	Transforming Industrial through Joint Agriculture Transformation in Tanzania
TSP	Triple Super Phosphate (TSP) Fertilizer
VBAA	Village- based agricultural advisors

1 Introduction to the project

The aim of N2Africa was to contribute to increasing biological nitrogen fixation and productivity of grain legumes among African smallholder farmers which was to contribute to enhancing soil fertility, improving household nutrition and increasing income levels of smallholder farmers.



N2Africa Project Core countries (dark green), Tier 1 countries (light green).

As a vision of success, N2Africa was set to build sustainable, long-term partnerships to enable African smallholder farmers to benefit from symbiotic N2-fixation by grain legumes through effective production technologies including inoculants and fertilizers adapted to local settings. A strong national expertise in grain legume production and N2-fixation research and development was the legacy set by the project. Legume production was to be enhanced in the major legume growing areas in each target country using the local expertise, providing opportunities for the poor and addressing gender disparities.

In Phase II, N2Africa aims to reach 550,000 farmers across all countries. The project was implemented in five core countries (Ghana, Nigeria, Tanzania, Uganda and Ethiopia) and six other countries (DR Congo, Malawi, Rwanda, Mozambique, Kenya and Zimbabwe) as Tier 1 countries. In the case of Nigeria, the project was implemented in two phases and for this reason, Nigeria will be represented as Borno and Nigeria.

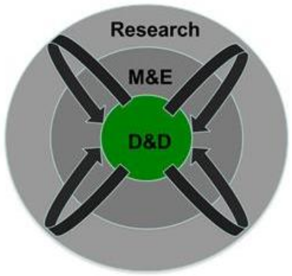


Figure 1. N2Africa's 'Development-to-Research'

N2Africa is a *development-to-research project*. Each year thousands of farmers experiment N2Africa technologies and adapt them to their own needs. This 'development and dissemination', or 'D&D', forms the core of N2Africa (Fig. 1). Extensive 'monitoring and evaluation', or 'M&E', of these small trials allows data to flow into research. N2Africa team then tailor and adapt 'best fit technologies' at the field-scale into a set of locally relevant options and principles.

N2Africa Phase II used the experience gained from Phase I to expand activities to reach many more farmers in Ghana and Nigeria, and extend the project to Ethiopia, Tanzania and Uganda (the five Core Countries). In DRC, Kenya, Rwanda, Malawi, Mozambique and Zimbabwe (Tier 1 Countries), the phase II focused on disseminating outcomes from Phase I at scale, institutionalizing legume expertise within national systems, and shifted activities to other donors through co-funding. The impact assessment was implemented in all five core countries.

2 Highlights of Results: 2014 to 2019

The project Results Framework (RF) guides the project implementation. Results are summarized based on the key results areas. The outcomes of the project include: building strong partnerships with capacity strengthening, awareness/knowledge gained by beneficiaries, access to inputs and output markets by smallholder farmers, participation of women in project key activities and increasing their benefits, tailoring the technologies to local needs of end users and assessing the impact of the project at scale through strategic monitoring and evaluation of results. These key outcomes are to generate five strategic system level impacts including i) increased productivity; ii) increased income; iii) increased nutrition status of women and children iv) improved natural resources systems (use of inputs in sustainable rotations; v) National systems leading emerging legume technologies evidenced and (vi) Gender disparity and empowerment. Below is a summary of results focusing on the key outcomes of the project.

1. PROJECT STRATEGY FOR DELIVERY

• *Public-Private Partnerships as driving strategy for scaling:* Public Private Partnerships have been the driving force for scaling legume technologies within N2Africa. This has ensured the integration of technologies into national and partner's systems. Implementation of project activities were done through 43 partnerships in 2019. Of these partnerships, 67% addressed input markets, and 61% output markets, whereas dissemination and capacity building were covered by 54% and 50% respectively. In addition to the partnerships, other national, regional, and district stakeholder platforms were used to address areas such as coordination and policy issues within legume value chains. A cumulative total of 257 partnerships were established and renewed from 2015 through 2019.

• *Capacity Strengthening to Sustain Delivery:* Capacity building activities focused on both partner staff and value chain actors. A total of 61,401 persons have been trained since 2014 with 36% of the beneficiaries being female. This is a combination of persons trained by training of trainers (such as lead farmers) as well as direct trainings to value chain actors (agro dealers, processors). Training of trainers constitute 15% of the total persons trained with 31% of female participation. In 2019, partner staff conducted almost 100% of these trainings with N2Africa staff providing backstopping where needed. The ToTs also provided technical backstopping in the technology dissemination activities (demonstrations, adaptations, field days, etc.). In addition, the project has supported 103 students at MSc and PhD levels, with 36% female participation, out of which 72 MSc/MPhil and 9 PhD have completed.

2. DELIVERY AND DISSEMINATION OF LEGUME TECHNOLOGIES

Awareness of Proven Technologies: In 2019, a total of 107,306 farmers were reached (45% female) through various dissemination approaches. In all, 677,495 farmers (45% female) have been reached[1] by the end of 2019. This number exceeded the target (555,000 farmers) by 19%. Key among the dissemination approaches were the organization of demonstrations, adaptations (limited), field days, media events, and video shows. The effectiveness of these approaches has been assessed in Ghana in collaboration with Africa Soil Health Consortium (ASHC) and other partners. Findings indicate that a mix of different approaches is important (e.g., demonstration plots, radio programs, comics, and SMS), as some approaches have wider coverage, but less knowledge gained (radio) and others have limited coverage but provide platforms for direct learning (e.g. demonstrations).

• *Last-Mile Delivery Systems, a key for input delivery and access*: Access to inputs has always been a priority as many farmers become familiar with the technologies. At project level, 62% of the 2019

[1]Reach means awareness and knowledge gained through dissemination approaches such as demonstrations, adaptations, field days, radio, video shows, SMS, etc by group of farmers

target for seed was achieved (6,660 t year^{-1}) and about 54% of the target for fertilizer (11,100 t year^{-1}), whereas the inoculant target (56 t year^{-1}) was achieved by over 100%.

The private sector took the lead in inoculant marketing in Ghana (Green-Ef company), Nigeria (Flour Mills Nigeria, Harvest Fields, Intrio Synergy Limited and others), Tanzania (Guavay) and Ethiopia (MBI). These private companies had different approaches and models to the delivery of inoculants in the countries. Intrio Synergy Limited (ISL) in Nigeria tested the implementation of the private Anchor Borrowers Scheme in which soyabean processing company (AFEX) contracted farmers and provided input packages for them. In Tanzania, the Village-Based Agricultural Advisory (VBAA) model was piloted and led by Guavay. Agro dealers and farmer cooperatives also played a critical role in the last mile delivery, especially in Ethiopia.

• *Output Markets as a Driving Force for Adoption of Technologies*: Stimulating access to profitable markets enhances investment in input usage by smallholder farmers. By the end of 2018, a total of 176,910 persons (41% female) were involved in collective marketing, achieving 64% of the target for 2019 (275,000). Soyabean, common beans and bush beans are the legumes commonly sold through collective marketing with soyabean having mostly formal markets with signed agreements. In Tanzania, about 70% of the soyabean produced by farmers under the partnership with CRS was sold to companies such as Soldecom commodities, KEA and Matembwe village companies. Though farmers continue to participate in collective marketing, the bulk of them still face challenges such as low market prices due to the quality, limited storage, non-acceptance of some varieties (especially those with smaller seeds sizes, etc.) and poor road networks causing high transportation costs. In Nigeria, a private Anchor Borrowers Program is being piloted in which farmers are supported to access both input and output markets. In Ghana, key soyabean processing companies such as Vestor oil and Ghana Nuts have been linked to farmers in seven districts. In Ethiopia, the cooperative unions continue their role in collective marketing.

• *Sustaining Private Sector Commitment for Input Delivery*: The rigorous engagement with the private sector since 2016 has led to an improvement in access to inputs especially in inoculants in Ethiopia and Nigeria. Seed companies such as Agriseed and Beula (Tanzania), Heritage (Ghana) and Jirkur (Borno State) have contracted community seed producers trained under the various partnerships across these countries. These engagements have contributed to greater volumes of inputs being distributed and used by farmers and have sustained the interest of some companies in the partnerships. Sustainable access to foundation seed is mostly supported by public institutions (e.g. ARI Uyole in Tanzania, ARARI, EIAR and OARI in Ethiopia).

For inoculant distribution channels, key private sector companies hold the fort for the distribution of the products. Though most inoculant volumes were sold in Nigeria and Ethiopia, it is significant to mention that partners in Tanzania have piloted the VBAA model which proved to be effective in terms of timely delivery, generating trust among farmers and companies.

3. EMPOWERING WOMEN TO INCREASE BENEFITS FROM LEGUME PRODUCTION

• *Female participation in increasing the benefits:* Gender has been mainstreamed at various levels of the project. Starting with identifying gender constraints and integrating specific campaign themes to enhance female participation in project interventions. The project has achieved 31% and 36% female participation in ToT and step-down trainings respectively,45% of total farmers reached (677,495) were female. Over 13,000 women were involved in processing various products and using various legume technologies.

• *Access to Labour-saving Tools as Entry Point to Reduce Drudgery:* Farmers have started using their preferred labour-saving tools after a series of validations to showcase tools and to obtain feedback on them. A total of 48,462 farmers are using threshers and herbicides as major labour-saving tools in 2019, achieving 87% of the project target.

4. ENABLING LEARNING AND ASSESSING IMPACTS AT SCALE

• *Effective Approaches for Continuous Technology Dissemination*: Various approaches have been used across the countries to disseminate technologies. Both implementing partners and farmers provided feedback on the use of such approaches and the feedback is used to improve the approach for subsequent activities. Partners who hitherto used only demonstrations and field days (about 80% of partners), embraced adaptations as key step to tailoring of technologies to the needs of farmers and also included video shows as a means to reach out to more women beneficiaries. Majority of partners also used a combination of approaches (video, trainings, demonstrations, radio programs etc.) in disseminating the technologies as feedback from farmers through surveys indicated the strengths of different approaches. One of the key factors for continuous dissemination of technologies by partners on their own after N2Africa exits will depend on the cost effectiveness of the approaches and to some extent the continuation of the partner initiatives. With this, many different tools have been developed (e.g. videos, leaflets, manuals, etc.) to support partners in the continuous use of the approaches. The link to the N2Africa Report that summarises all of the tools is (https://n2africa.org/sites/default/files/N2Africa%20training%20and%20extension%20materials.pdf).

• *Making Best-Fit Technologies Available for Continuous Dissemination*: The multiple locations of the dissemination trials, combined with farmers' feedback in the evaluation of technologies has contributed to reshaping of the technology packages into more preferred options. The changes made in options and the processes used to obtain such changes are currently being documented to be made available for wider use by partners as the project exits. The project analyzed the farmer technology feedback, to combine this with current best-fit technologies and the learning pathways, and documented sets of best-fit technologies for location-specific options to ensure their availability to partners for continuous dissemination. For instance, in Ethiopia, a list of best-fit practices were tested with public and private partners in the seven PPP clusters being the results of demonstration trials. These will be documented in manuals with the explanations on the approaches and the lessons learnt to reach to a wider range of farming communities.

• *Impact analysis study:* the N2Africa impact analysis study and analysis was conducted in 2018-2019, the set-up and initial results are summarized in Chapter 3.7, showing the levels of awareness of at least one component of the technologies is over 95%, for two and three components are around 67% and 28% respectively, while usage of at least one component is 94% with 61% and 22% using two or three components respectively. On productivity, N2Africa technologies have contributed significantly to increase the productivity of legumes per hectare, the highest impact is in Uganda where adopters increased their legume productivity by 244 kg/ha followed by Tanzania (215 kg/ha), Borno State (109 kg/ha), Nigeria (100 kg per ha), Ethiopia (83.5 kg/ha) and Ghana (50.6 kg/ha), the level of income received from crop sales in Ethiopia increased by $166, in Ghana $21, Borno, $156, Nigeria, $408, Uganda, $313 and Tanzania $178. N2Africa technologies significantly contributed to improve food security among smallholder's legume farmers through diversification of food consumed, adopters increased their HDDS by 0.2 in Ethiopia, Ghana by 0.8, in Borno, 0.2, in Nigeria, 0.7, in Tanzania 0.5 and 0.6 in Uganda. The gender consideration demonstrates that there is no one group which gain more from the project than another. On women's empowerment, women adopters benefitted in most cases equally in terms of income and productivity as their men counterparts (especially in Borno State where this was contrary during the baseline). In addition, women have more access to output market compared to men, N2Africa and its partners contributed to these benefits especially in Borno state where the baseline indicated contrary results. A detailed report on the impact study will be shared once it becomes available.

• *Policy analysis in Tanzania and Ethiopia:* In 2019 project staff and a consultant conducted a policy analysis in Tanzania and Ethiopia, which produced policy briefs which results were presented during stakeholder meetings and further taken up in detailed discussions with the Ministries and other government institutions to improve on current and design new interventions.

• *Contribution analysis:* Across the core countries, contribution analysis (CA) studies were conducted in 2019, merging CA and impact assessment (IA) using logical thinking from the CA for analysing the IA data i.e. from the quantitative data: evidence in the process from activities to impact, structured analysis with meaningful examples and complete overview of actual performance, the report on the results of the CA in relation to the impact study will be shared once finalized.

Keywords

Key milestones, objectives, progress, biological nitrogen fixation, grain legumes, Nigeria, Borno State, Ghana, Tanzania, Ethiopia, Uganda, DR Congo, Kenya, Malawi, Rwanda, Zimbabwe.

3 Status of Project Implementation

This chapter gives an overview of the N2Africa project-Phase-II status and accumulative achievements from 2014 to 2018. The status is based on the Project Monitoring Evaluation and Learning (MEL) surveys and routine data collections covering all project target primary and secondary beneficiaries in the target areas, from which the evaluation survey drew a sample which is further explained in Chapter 5 (Methodology). The MEL and evaluation findings are connected through narrative sections including extrapolating the evaluation samples to the overall farmers reached.

3.1 Public-Private Partnerships as key implementation strategy

Public-Private Partnerships (PPPs) have been the main driving strategy for the implementation of N2Africa Phase II with its four pillars (Capacity Building, Input Supply, Output Markets, and Technology Dissemination) to guide the partnerships' development.

The project in its life span, exceeded its yearly targets for number of PPPs to be established. With a target of 21 and 32 PPPs for 2015 and 2016/17 respectively, the project established 81 and 90 PPPs in these respective years. The project completed its operations with 43 PPPs in 2018 with key private and public partners such as input distributors.

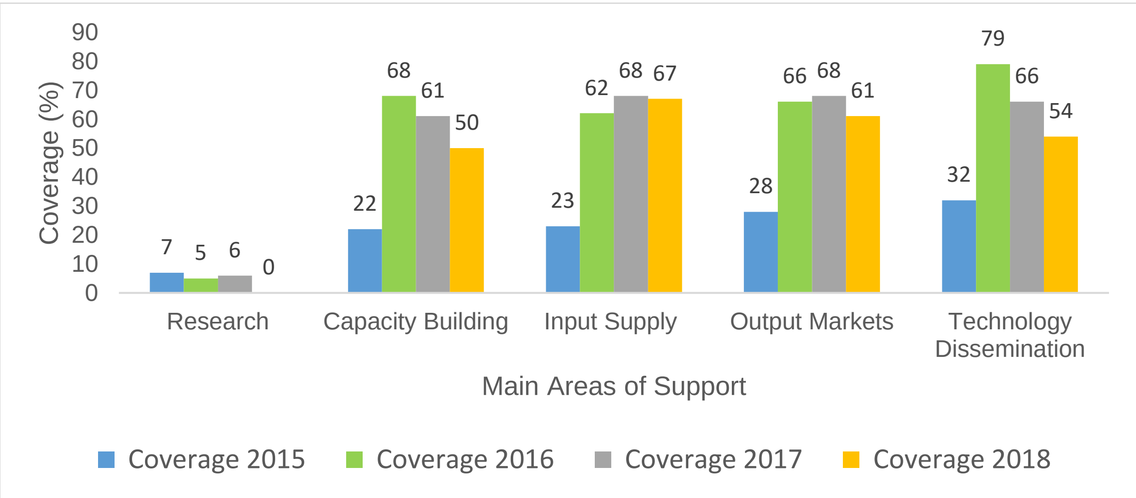


Figure 2. Main areas of support for partnerships in 2015 to 2019

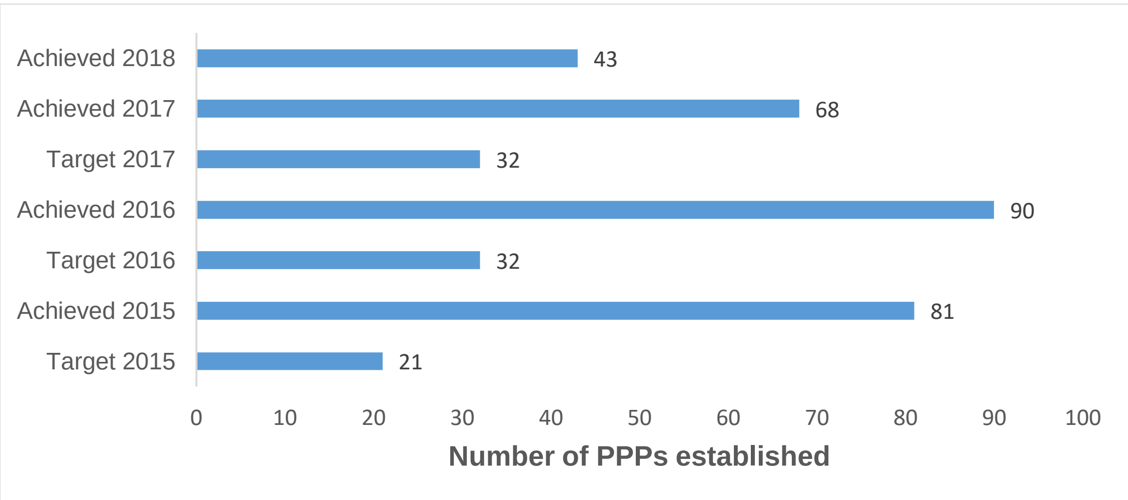


Figure 3. Total number of partnerships (targeted and achieved)

The types of partners include local and international non-governmental organizations, other government institutions, private input suppliers, legume buyers, processors, and development partners (Appendix I). The main types of agreements were the Cooperative-Collaboration agreements (50%), Sub-contract agreements (43%) and sub-contract/cost share agreements (7%). Various dissemination models, e.g. Farmer Training Centres (FTC), Producer collective, Out-grower models and the Input Supplier and Information Management model were used to enhance learning among farmers and to ensure access to input-output markets.

3.2 Capacity development

3.2.1 Non-degree Training

The project has since 2014 engaged in non-degree trainings in the form of training of trainers (ToTs) to build the capacity of implementing partner staff including Extension Agents. This is the core of the non-degree trainings with an objective to equip partner staff with the necessary capacity for step down training. The project has cumulatively trained a total of 9,016 (31% female) persons as ToTs across all countries (including Tier 1 countries). Fig. 4 shows the categories of trainings conducted with most covering Good Agricultural Practices (GAPs) for both grain and seed production and post-harvest handling (81%) whereas the least in number was business entrepreneurship focusing on lead cooperatives/ farmer organisations and youth agripreneurs.

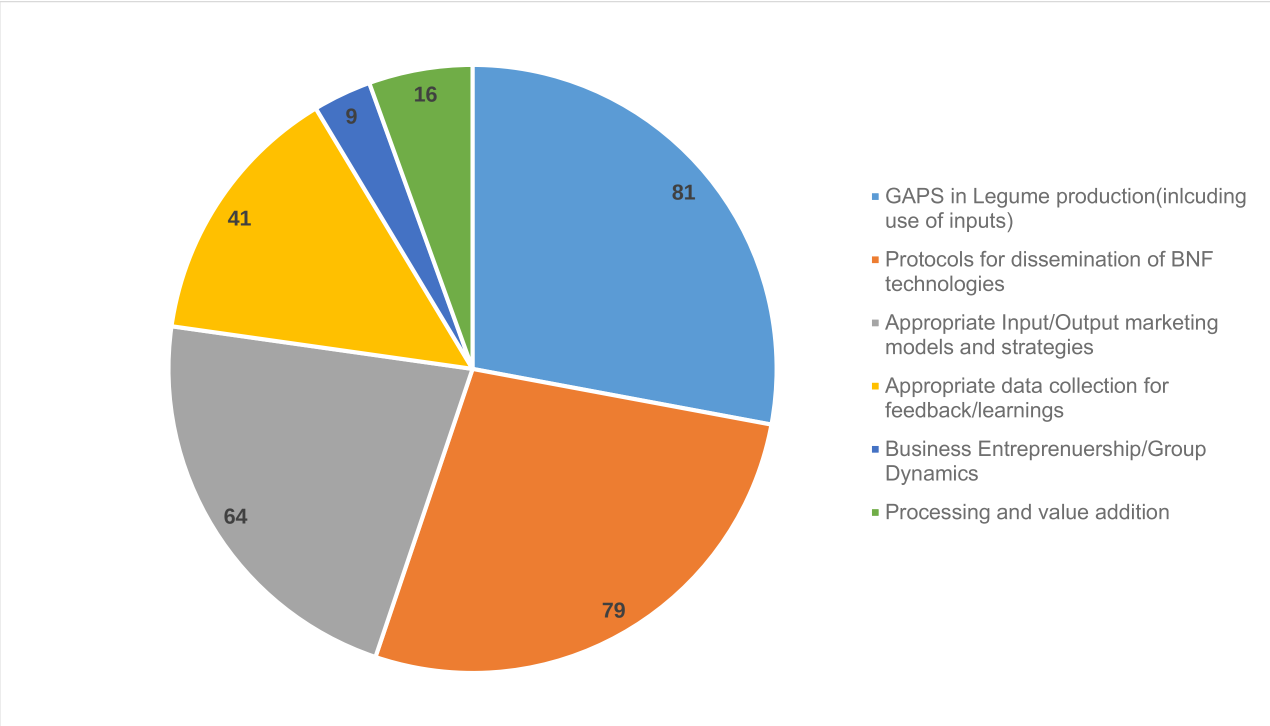


Figure 4. Focus areas covered by Training of Trainers (%)

The large number of participants for GAPs gave the opportunity to create awareness about the legume technologies across the countries. Step-down training (for value chain actors, e.g. farmers, agrodealers/ input retailers, youth agripreneurs in different business ventures) were also conducted, in all resulting in a cumulative total of 61,401 (36% female) step down participants across all countries. To ensure legume seed availability as key constraint identified by legume value chain actors, several trainings were conducted to provide access through training of selected farmers as seed producers. More than 60% of GAPs trainings also covered seed production. The selection of training topics was done in conjunction with partners during planning meetings, after which the curriculum for such trainings was developed.

3.2.2 Degree training

The degree training targets students at different levels (e.g. MSc and PhD) across the countries and mostly within partner institutions in the countries. In total 79 MSc/MPhil students (35% female) and 24 PhD students (42% female) are contributing to research activities in the project. With this, a total of 81 students (72 MSc/MPhil and 9 PhD) have graduated so far. Details on research topics, institutions, and gender of students are presented in Appendix II.

3.3 Farmers reached through various dissemination activities

N2Africa and its partners introduced legume technologies to smallholder farmers whereby a total of 660,198 farmers were reached (41% female) by 2018 (Fig. 5). This figure is the sum of farmers reached through all dissemination approaches, except for the number of farmers reached through media events where in most cases estimates exceeds assumed community population, and hence have been excluded.

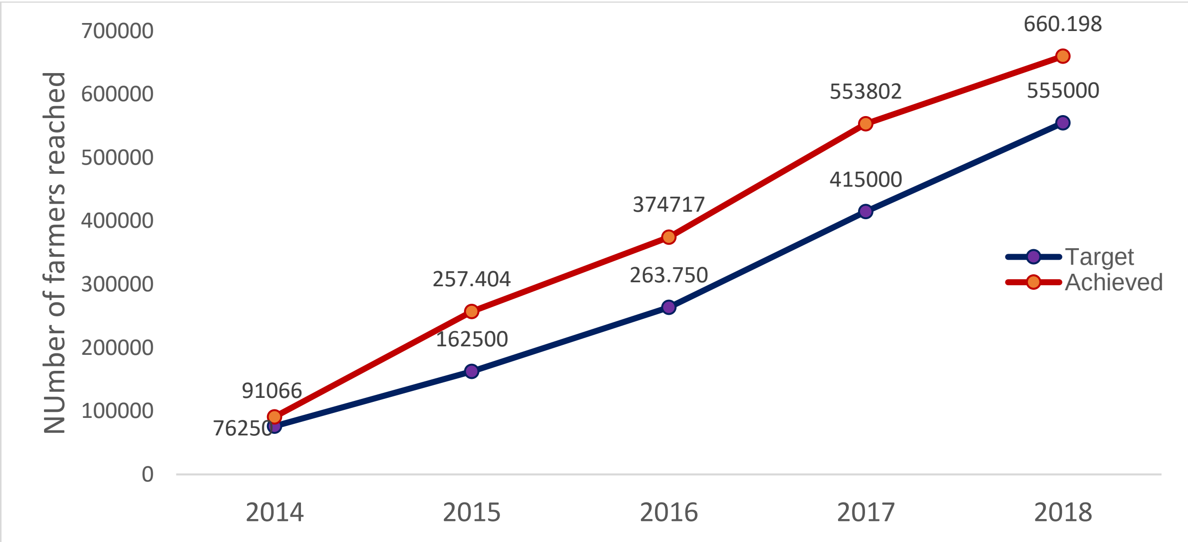


Figure 5. Total number of farmers reached from 2014 to 2018.

Figure 6 indicates achievements at country level between 2017 and 2018. Most farmers were reached through collaborative partnerships with existing partners. The target was achieved through the numerous partnerships and their expansion of operational areas.

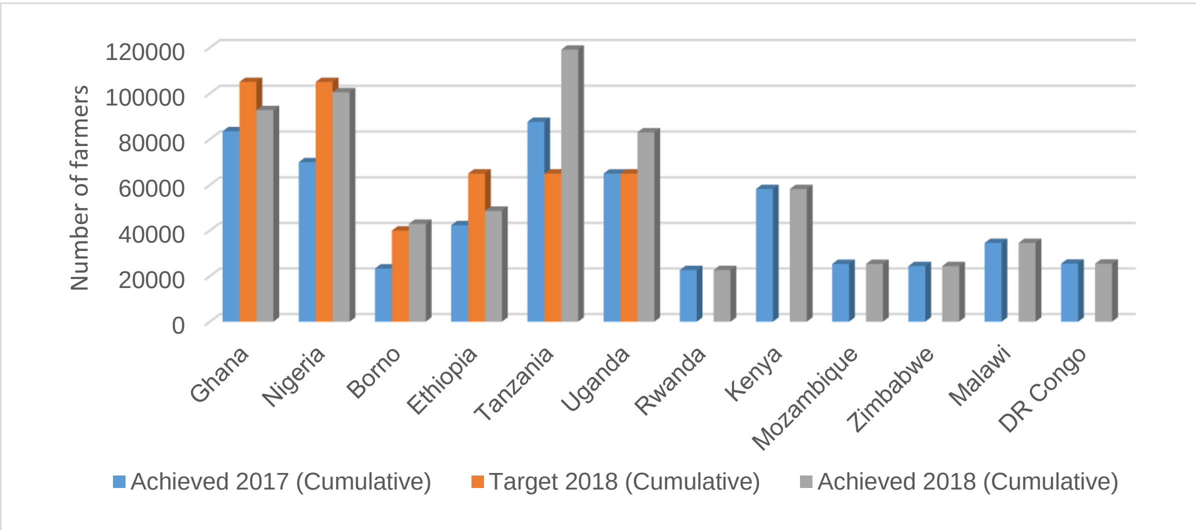


Figure 6. Total number of farmers reached per country (targeted and achieved).

3.4 **Overview of Use of N2Africa technologies**

3.4.1 Availability and Access to legume inputs

To address the challenge of limited access to and use of legume seeds, inoculants, and fertilizers, the countries pursued various strategies. Most national systems (e.g. ARI Uyole in Tanzania, and ARARI, EIAR and OARI in Ethiopia) continue to produce foundation seeds. They make this seed accessible to seed companies for further production of certified seeds.

Seed companies and community-based seed producers are still engaged in producing certified and quality declared seeds. Table 1 shows the quantity of certified and quality declared seeds (QDS) produced by seed companies, farmer groups organized around the local seed business (LSB) model and quantities sold by those involved with N2Africa. It is shown that 52% of the seeds produced are sold either directly by farmer groups in their communities to other farmers or mopped up by seed companies and agro-dealers. Soyabean seeds are relatively much sold (92%) across the N2Africa core countries and the least sold are groundnut (32%).

Table 1. Seed quantities produced and sold by seed companies and farmers in core countries in 2018

Legume Type	Quantity produced (tons)	Quantity Sold (tons)	% Sold (%)
Soyabean	296.2	273.3	92
Groundnut	650.4	214.2	32
Cowpea	440.9	233.4	53
Common Bean	32.0	16.9	53
Total	**1,419.5**	**737.8**	**52**

*Source of data: Project ME&L and Country reports

From the available data, a total of 737.8 t of seeds was sold by seed companies, agro-dealers, Village Promoters and community-based seed producers in 2018 in the project target areas, increasing the cumulative volume of seeds sold by producer groups from 3,399 t to 4,137 t, achieving 62% of the target for the whole project period (6,660 t). In addition, the high percentage of soyabean, cowpea and common bean seeds sold in the target areas indicates the alignment of producer groups needs to the supply by input dealers.

The cumulative volume of inoculants sold (62 t) across the core countries in 2018 exceeded the 2018 target of 56 t by 10% (Fig. 7). The largest proportion of inoculants was sold in Ethiopia (56%) and Nigeria (41%). Various channels were used in the distribution of the inoculants. Though there have been improvements in the volumes of inoculant distributed and used, challenges remain to be resolved. Critical among them is the unwillingness of most agro-input dealers to stock rhizobia inoculants due to the short shelf-life of the products. Also, because of small acreages being cultivated by farmers, volumes per season are small, which also increases the transaction cost for distributers. This results in low profit margins which are unattractive to investors, being also one of the findings in the Wellspring strategy report of March 2019 on the Inoculant Go to Market Strategy for Sub-Saharan Africa.

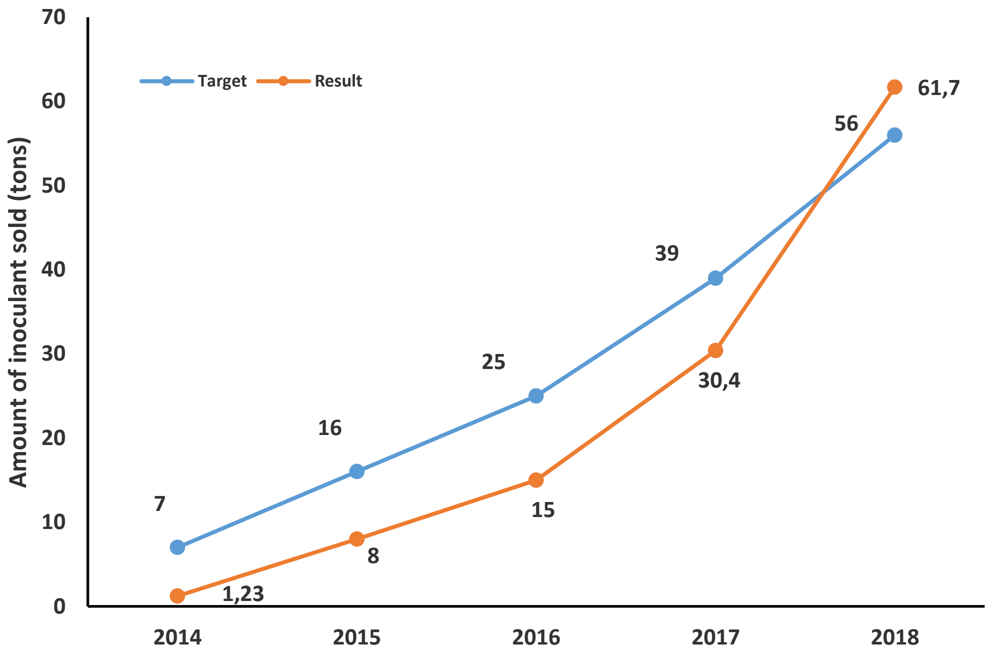


Figure 7. Cumulative amount of inoculants used by N2Africa farmers throughout the project period (targeted and achieved) (t). Data are based on records available from Project MEL system

With the use of fertilizers, 54% of the 2018 target (11,100 t $year^{-1}$) was achieved, with a volume of fertilizer of 6,046 t. These volumes are largely obtained from agro dealers (working in the target areas) in Ghana and Nigeria. In Tanzania, there is a "bulk procurement" policy of fertilizers by companies who win tenders and establish indicative prices for different target areas. The majority of local agro-dealers hesitated to sell fertilizers in 2017-2018, as it was considered not profitable. With this, it was difficult to record fertilizer sales and use in the target areas. Though the overall targets for fertilizer have not been met in 2018, the use of fertilizers from a sample of farmer groups in Borno Nigeria indicates over 590 t $year^{-1}$ in the areas where the project is operational.

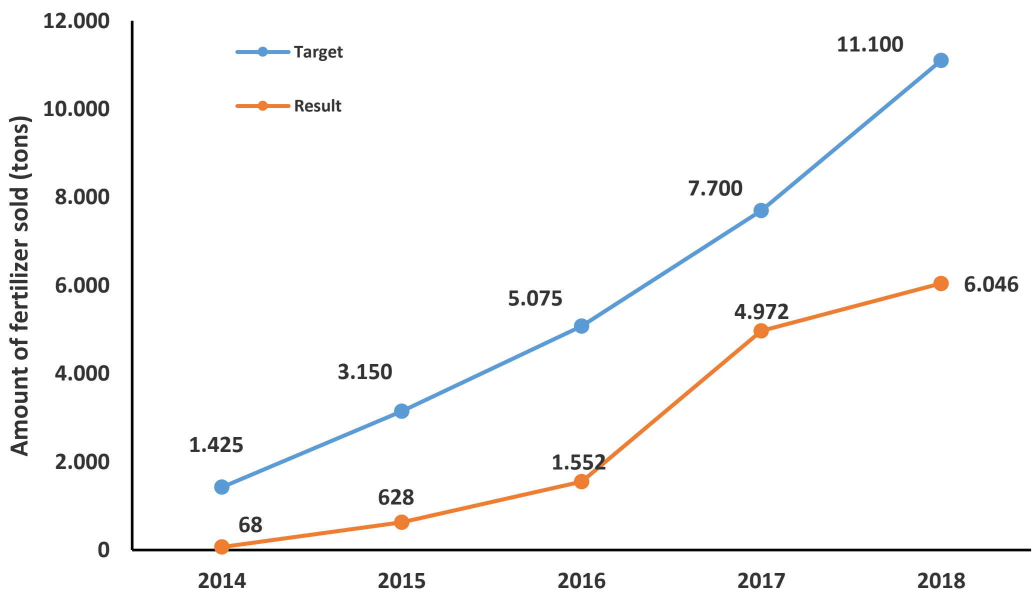


Figure 8. Cumulative amount of fertilizers used by farmers (targeted and achieved) (t), source N2Africa farmer groups

3.4.2 Inoculant production

The project continued to facilitate the availability of inoculants in all countries through PPPs. Table 2. Inoculant distribution channels summarises the status of inoculant supply in each country.

Table 2. Inoculant distribution channels

Country	Mode of availability	Inoculant brand	Main producer /importer
Ghana	Importation	NoduMax	Green-ef
	Local production	Sarifix	Savannah Agricultural Research Institute
Ethiopia	Local production		Menagesha Biotech Industry Plc
Nigeria	Local Production	NoduMax	IITA-BIP
Tanzania	Importation	LegumeFix	IITA/GCL
Uganda*	Local Production	MakFixer	Makerere University
	Importation	LegumeFix	Farm-Ag International

Table 2 shows inoculant production and/or importation in the core countries at varied degrees with either an established distribution channels such as Ethiopia through agro dealers and Cooperative unions, Nigeria through Village Promoters, agro dealers and Anchor Borrower's Program model. Savannah Agricultural Research Institute (SARI) in Ghana produces inoculants under the brand name SariFix while also NoduMax imports are sold, for both cases the company Green-ef is the main distributor of these inoculant brands.

3.5 Output market access and collective marketing

The output market, being a driving force for investment in inputs, has been given substantial attention in the project, in addition to adding value to legume grain and alternative income generation from legumes. A cumulative total of 176,910[2] persons (41% female) have been involved in collective marketing and value addition. Value addition took place at both household and commercial levels. For participation in collective marketing, 64% of the 2018 target has been achieved (Table 3). Major buying outlets include cooperatives, companies with both formal and informal agreements and the open markets. Although some farmers participate in collective marketing, challenges remain. Open markets, still being an important marketing channel, offer low quantities and the market locations usually pose transport challenges to farmers. Low quality grain and high storage costs for bulking remain challenges as well.

Table 3. Number of farmers accessing output market in 2017 and 2018 (targeted and achieved).

Targeted 2017(#)	**Achieved 2017**(#)	**Targeted 2018**(#)	**Achieved 2018**(#)
195,000	149,818	275,000	176,910

3.6 Overall women's participation

Women empowerment starts with participation in project key activities. About 31% of Lead farmers who hosted dissemination trials (e.g. demonstration and adaptation) were female; 36% of the participants for step-down trainings and 35% for ToTs were female. Women again form 41% of total farmers reached.

Gender mainstreaming strategies and interventions were developed using country context and the results of gender studies conducted. Gender specific themes were defined based on the constraints and integrated into the dissemination activities of the different partners. In Borno, for instance,

[2] 2018 data is obtained from the 28 partnerships in which 61% covered output market

communities were sensitized on gender mainstreaming and its importance, taking into consideration the context of North Eastern Nigeria and the need to support women and male and female youth to participate in project activities, especially business entrepreneurship for better living conditions. Messages were used like *"it is time to move on"," leave no one behind",* and *"be a giver not a beggar"*, as an entry point for women's participation in project activities.

3.6.1 Legume processing tools improving nutritional status

Legume processing interventions were supported with the aim of improving the nutritional status of farming communities. Trainings focused on sensitization of farming communities on the nutritional values of the different legumes being grown, and methods of processing of legumes into different products which can be integrated into household diets and taken up as business. With the trainings and other related interventions within the project partnerships, many individuals in farmer groups and communities have taking up legume processing at either household levels or small commercial businesses. The main processed products include groundnut oil, soyabean milk, groundnut and soyabean cakes, African biscuits, etc. In all, a cumulative number of 13,000 women have been involved in processing of various products and using various legume technologies from 2014.

3.6.2 Labour-saving tools

Farmers often grow a limited area of legumes on their farm, as they consider planting, weeding and threshing of legumes to be labour intensive. To reduce labour demand, the project validated planters, herbicides (post and pre-emergence) or threshers across all countries and developed a joint model to enable farmers to access the tools. These models include specific tool service providers (e.g. Youth Spraying Service Providers in Borno), providers of other services such as tractor operators, and nucleus farmers integrating threshing as part of their services to farmers.

A cumulative total of 48,462 farmers (37% female) have used the various labour-saving tools in 2018. Herbicides continue to be the most widely used labour-saving tool (94% in 2018 and 92% in 2017). In Borno, spraying service providers continue to provide access to herbicides for many farmers, and therefore sustain the use of the tool. The target for the number of farmers using labour-saving tools was met by 87%. This indicates that 8% of the farmers reached were using labour-saving tools, against a target of 10%.

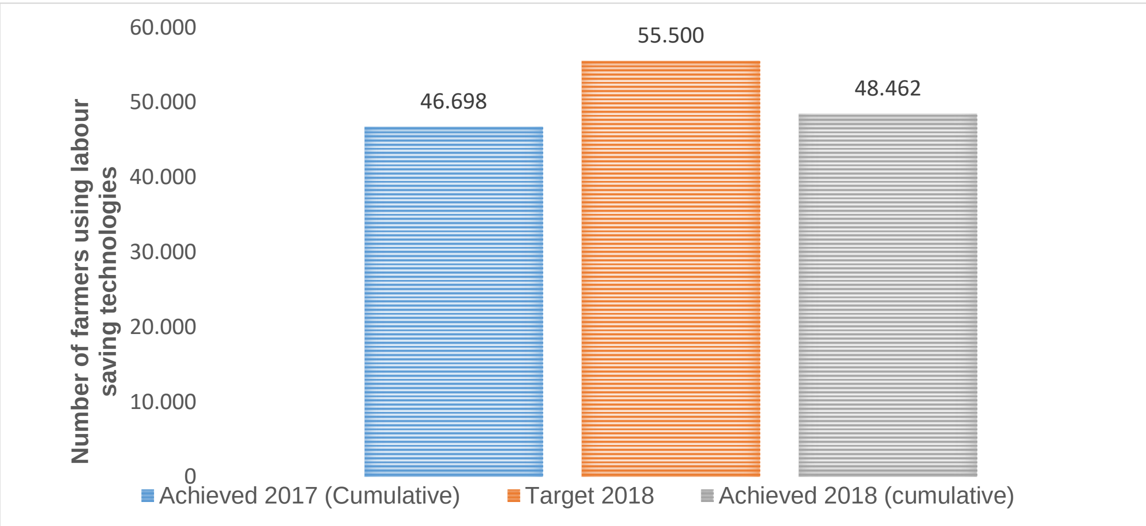


Figure 9. Number of farmers using labour-saving tools in 2018 (targeted and achieved).

With planters, many prototypes have been validated across the countries, but few met the criteria set by farmers and hence few farmers used them. Those who did obtained planters through direct purchases (e.g. Kwara group in Nigeria) or accessed them through service providers (such as nucleus farmers in Ghana). However, most planters did not meet the criteria of farmers and service providers. In Tanzania, all three prototypes of planters did not meet most criteria set by farmers (not breaking seed, ease of handling, efficiency in planting, and possibilities of using them on different types of soils and terrain).

Partners have agreed to modify planters locally by Agromech Limited in Tanzania to further improve their efficiency as recommended by farmers. The Africa RISING-NAFAKA project is keen to further evaluate the new generation of planters once ready. Threshers and reapers were also validated and integrated into nucleus farmers' activities in Ghana and Ethiopia.

3.6.3 Businesses established and led by women

A total of ten businesses were expected to be established and led by women by the end of the project in 2018; all to be established in 2017. This target was exceeded, as a total of 32 businesses (mainly SMEs) were established. These businesses include seed production (QDS and certified seeds), bulking and marketing of grain legumes, processing, and sales of livestock feed using residues. A cumulative total of more than 10,000 women were involved in these businesses.

3.6.4 Status of the Borno Youth Agripreneur (BYAP) interventions in 2018

N2Africa continued its interventions on its Youth component in Borno, focusing though on limited but key interventions such as exit strategies to guarantee continued technical support, input and output markets operations and industrial trainings (internship) for the agripreneurs. A key exit strategy includes the linkage with ENABLE TAAT and the Feed-the-Future Integrated Agriculture Activity (FtF/IA) in north-eastern Nigeria. The ENABLE TAAT program, as a youth component of TAAT, will provide a platform for continued learning and sharing of lessons by the various youth involved.

Empowering women under the BYAP

As a key component of the project to empower women to benefit from the legume value chains, it was key to ensure women participation in the Borno Youth Agripreneur interventions. More than 40% of participants were women, with some establishing businesses along the segments of the value chain. Box I reports on progress of a woman's business among the youth agripreneurs.

The Critical Success Factor of the BYAP

Box I. The Story of Mercy Wakawa: A BYAP Beneficiary

Mercy Wakawa (a youth agripreneur) is the founder and Managing Director of Confianza Global Resources that is processing groundnuts into oil, sludge and cake for livestock feed. Mercy says groundnut processing is a profitable business as a ton of good groundnut grains gives an average of 450 litres of oil and 400 kg of groundnut cake which is a major raw material for animal feed mills. Confianza Global Resources is currently employing four youth (1 permanent and 3 casuals) from the host community. The business has also created downstream livelihood opportunities for many women in sludge processing and marketing in the host community.

Business has been good for Mercy, except for seasonal price fluctuation of raw materials (groundnut grains). The average total cost of processing 1 ton of grain including overheads is US$ 583 while the average total revenue from oil, cake and sludge is US$ 889. All things being equal, the factory can process an average of 3-5 tons of grain per week. Her business was recently evaluated by the Bank of Industry (BOI), Nigeria; and based on performance and prospects was offered a term loan of $ 6,319 to be disbursed towards the acquisition of more equipment for edible oil milling as well as working capital. This gives an indication that Confianza Global Resources is gradually being integrated into the mainstream private sector.

In the words of Saleh the factory technician, ''the establishment of Mercy's company provided a lifeline for me, because I have been rendered jobless for months by my former employer in Kaduna''.

The strong focus on ''youth engagement for profitable agribusiness and sustainable livelihood'' led to the evolution of the starter pack approach under the N2Africa project. Experience has since shown that the provision of a tangible starting grant in cash and kind soon after training is critical to business take-off, while access to finance/bank credit is important to growing the established businesses. Consequent upon the provision of about US$ 2000 per youth agripreneur to kick-start their businesses, the top 30 businesses have been able to operate with an average cost–benefit ratio (CBR) of 1:1.5 in the last 24 months of business activities.

It is important to stress the fact that the provision of start-up grant to young entrepreneurs is a critical success factor. It is in line with the FAO's focal areas for investment in sustainable livelihoods, such as deliberate efforts at increasing access to assets and building resilience and recovery capacities in especially traumatized societies like Borno State, Nigeria. This is equally reflected in the special enterprise infrastructural/equipment support (such as multipurpose grain flour milling machine, groundnut oil processing mill, livestock feed mill and grain threshers) to unique enterprises/entrepreneurs. These approaches combined with appropriate internship opportunities proved to be an effective package of business booster as well as strategic N2Africa legacies.

3.7 **Summary of the N2Africa Impact Evaluation**

3.7.1 Rationale and context of the Evaluation

In N2Africa, project activities in the 11 countries were implemented through partnerships with various types of organizations (research, development, private sector, etc). The project Results Framework (RF) guides the work through the partnerships. The RF identifies five strategic areas of system level impacts i) increased productivity; ii) increased income; iii) increased nutrition status of women and children iv) improved natural resources systems (use of inputs in sustainable rotations); and iv) National systems leading emerging legume technologies evidenced. A set of intermediate outcomes link the impact level indicators to lower level outputs, framing the operational results framework of each objective within the project. Part of the outcomes reflect adoption and uptake by immediate users and beneficiaries such as national systems, dissemination partners and farmers (end users).

3.7.2 Purpose and Objectives of the Evaluation

The N2Africa impact assessment aimed to investigate if and to what extent the project activities benefited the intended recipients most especially smallholders' farmers. In other words, a causality is established between the project's activities and change in potential outcomes and their effect on beneficiaries' well-being, i.e. tracking the impact pathway of the project. It also provides accountability, support to decision-making, and lessons for improving quality and effectiveness of implementation for development outcomes. The assessment focused on specific areas where the implementation was successfully achieved and expected impact to be observed in farmers' outcomes. The specific impact domains and learning areas are outlined below:

- ✓ Change in income earned from increased legume production and use of such additional income
- ✓ Gender inclusion and empowerment: Changes in gender disparities in targeted value chains
- ✓ Benefits/value generated to male and female farmers including health and nutritional benefits specifically change in nutritional aspects of selected women and children benefiting from project interventions (legume-based protein intake).

3.7.3 Methodology

3.7.3.1 The Study Area and Scope

The survey covered key areas where the dissemination started early enough and was satisfactorily done with the Public Private Partnerships (PPPs) in place to ensure availability of the technologies of the project across five countries including Ethiopia, Ghana, Borno (Nigeria), Nigeria, Tanzania and Uganda. Within each operational area, the study covered selected action sites, (local government areas or districts as pertained in the different countries) which usually contained several villages and these villages were selected further to represent both treated and comparison groups. The scope of the study involved both quantitative and qualitative information about households in the project implementation area and their neighbourhood.

In addition, the selection considered areas where we expect a traceable impact from the project (e.g. use of legumes, varieties -soyabean as a new crop, or use of inputs- inoculants, etc.). The selected areas to be assessed for impact were related to the PPPs, which means the household survey can be analyzed on a PPP basis to indicate awareness and knowledge levels, use of technologies, etc. in relation to specific PPPs. These will help to assess the efficiency and effectiveness of dissemination approaches, access to input-output market models, gender, etc. within those PPPs.

3.7.3.2 Sampling strategy, data collection and sample distribution

Sampling strategy
The key actors of focus for the evaluation were smallholder legume farmers in both treated and non-treated areas. The non-treated areas were selected using the stratification criteria used for the treated areas selection (agro ecological potential for legume cultivation, input and out market potential for legume inputs and output markets respectively, socio-economic/ cultural circumstances).

Table 4 below presents the sample distribution of the N2Africa impact evaluation survey in Ethiopia, Ghana, Borno, Nigeria, Tanzania and Uganda together with some major socio-demographics characteristics. In total 3,744 farmers households were interviewed including 49.4% treated and 50.6% non-treated. The total sample is distributed across countries as follow: 744 (19.8%) from Ethiopia, 603 (16.1 %) from Ghana; 599 (16.0%) from Borno, 595 (15.9%) from Nigeria; 609 (16.3%) from Tanzania and 594 (15.9%) from Uganda. Female households head represented about 21% of the total sample.

Data collection
Data were collected in all the five countries using a structured household questionnaire. The household questionnaire covered key indicators in the results framework and entail: demographics; awareness and knowledge; management practices; cost and sources of inputs; crop yield; access to output markets and revenue; communication and information sources, etc.

The survey tool (questionnaire) was programmed using Open Data Kit (ODK) and administered through a face-to-face interview using electronic tablets. Enumerators were selected among universities' graduates who have some years of experience in data collection and the use of tablets. In addition, one of the selections criteria was the knowledge and the use of local language for the survey. At least one training of three days was organized in each country to ensure common understanding of the tool and pretesting the survey tool. All collected data were sent directly to the N2Africa ODK aggregate platform for easy follow up, corrections and accessibility. The centralized data were assessed for its completeness, validity, quality check, etc. Data were analysed using STATA to produce findings regarding the impact indicators and the related outcome indicators against the sample frame for comparison group.

Yield measurements

The study obtained crop yield at farmer main field to ascertain the contributions of the adoption of technologies to yield. Legume grain yield were estimated by farmers while field area was both estimated and physically measured directly for selected farms with the help of farm owner. Field area measurement was done with a Global Positioning System (GPS) using the ***geotrace*** application to physically measure the plot area of the farmers (at least one plot was physically measured for each farmer) except where it was impossible to do so (e.g. there was no field measurement in one community in Ghana due to flooding). In places where harvesting was not yet done before the data collection, the farmer main field yield measurements conducted in relation to adaptation trials were used which can be generalized to the entire study population. In addition, the yield was obtained through farmer recall of his/her current and immediate previous season.

Analysis of the entire data

Analysis of the data for all countries and complete sample size is against 'treated – non-treated' respondents meaning those who received direct support by the project are considered 'Treated' while those who did not (at output level – activities) are non-treated or a control group. In addition, analysis is made against 'adopters and non-adopters', these stem from both the 'treated-non-treated' groups considering that there was a spill-over effect of the N2Africa project as various dissemination models e.g. radio, leaflets and farmer diffusion avoided a scenario of 'isolation' of the treated and non-treated i.e. farmers became aware and adopted technologies during the N2Africa project (a question in the survey), could contribute this to N2Africa and partners but resided in 'non-treated' areas.

In the impact study, adopters are defined as having used at least three N2Africa technologies, improved practices are put as one component, even if more than one practice is used, and inputs (improved variety, P-fertilizer, inoculants) if used, as a separate component each. For example, use of seeds of an improved legume variety. legume fertilizer, spacing, crop rotation, weed management is seen as using 3 components (2 inputs plus practices). The adopters-non-adopters analysis allows assessing the impact of N2Africa technologies across all respondents, the determinants for adoption and the characteristics of the respondents.

Table 4. Sample Distribution

Country	Ethiopia (N=744)				Ghana (N=603)				Borno(N=599)				Nigeria (N=595)			
Parameter	Treated	Non-Treated	Total sample	|T- test|	Treated	Non-Treated	Total sample	|T-test|	Treated	Non-Treated	Total sample	|T-test|	Treated	Non-Treated	Total sample	|T-test|
Sample (%)	384 (51.6)	360 (48.4)	744 (19.8)	0.77	309 (51.2)	294 (48.8)	603 (16.1)	0.05	300 (50.1)	299 (49.1)	599 (16)	0.88	252 (42.4)	343 (57.6)	595 (15.9)	0.27
% of female farmers as main decision makers	8.6	11.1	9.8	1.33	9.7	11.6	10.6	0.54	27.7	22.7	25.2	1.92	4	5.3	4.7	0.53

Country	Tanzania (N=609)				Uganda (N=594)				Over all (N=3744)			
Parameter	Treated	Non-Treated	Total sample	|T-test|	Treated	Non-Treated	Total sample	|T-test|	Treated	Non-Treated	Total sample	|T-test|
Sample (%)	304 (49.9)	305 (50)	609 (16.3)	0.92	299 (50.3)	295 (50)	594 (15.9)	0.36	1848 (49.4)	1896 (50.6)	3744 (100)	1.28
% of female farmers as main decision makers	40.1	31.8	35.9	4.58**	51.8	44.4	48.1	3.28*	23.4	20.5	21.9	4.81**

*Note: *** Significant at 1%; ** Significant at 5% and * Significant at 10%*

3.7.4 Findings

3.7.4.1 **Descriptive Analysis of Households Characteristics**

The preliminary analysis of the impact study on the average households size indicates the households are relatively large within the treated group as the average number of people living under the same roof and eating from the same pot was approximately 8 people with Ghana having the highest number (10) followed by Nigeria (9) while Tanzania has the lowest (4). This can be explained by the different social structure in Northern Ghana and Nigeria compared with the more nuclear family structure in East Africa. Most respondents (85.8%) are married and they are still at their very active age as they are 45 years old on average. There is a significant difference in terms of gender and age of the households' head between treated and untreated while household sizes are largely similar.

In addition to the parameters above, the education level of household's head across the countries shows that most farmers interviewed had a primary level of education with an average of 5.5 years of school attendance. In addition, household head were significantly more educated in the treated groups in Ethiopia, Borno and Nigeria compared to their counterpart in the non-treated group.

The respondents have a relatively high number of years in both farming in general and in legume farming. The average number of years spent on general farming varies between 20 and 29 years while that of legume varies between 12 and 28 years with an average of 16 years. In general, both treated and non-treated groups are experienced and there is no significant difference in the number of years of experience between the two groups.

3.7.4.2 **Awareness and Usage of Legume Technologies**

Summary of technologies considered under the impact evaluation
Technologies considered under the impact study were those disseminated during N2Africa project implementation and these include Improved legume germplasm (bush bean, climbing bean, cowpea, faba bean, chickpea, groundnut and soyabean); inorganic fertilizer and organic amendments (DAP, TSP, SSP, Yara, NPK, manure, etc.); Inoculant (Nodumax, Biofix, LegumeFix, Mark-biofix, Minjingu, etc.) and best agronomic practices (legume rotation with other crops, intercropping of legumes with other crop, weed management, row planting).

3.7.4.3 **Definition and estimation of adoption rate**

The N2Africa Project considers a farm household as an 'adopter' if, for three seasons, it uses at least two of the N2Africa technology components. Components could include new variety (s), additional legume, fertilizer, inoculants, and improved agronomic practices. This definition becomes complex to measure when farmers can adapt and make changes each season also based on availability of inputs. In addition, some technology components can be used once and its effect can be realized in 3 seasons (e.g. improved seed, inoculants) and does not warrant continuous use for three seasons. Moreover, for farmers that were reached in 2016 – 2017 with one (main) season for legumes, three seasons would not apply as 1-2 seasons is more likely. Based on the above challenges, four scenarios were considered to represent the progress toward adopting the various components. These include:

1. The farmer knows at least one component of the N2Africa technology package, has access to it and has used one of the N2Africa package components for at least one season in their legume fields;
2. The farmer knows at least two components of the N2Africa technology package, has access to them and has used two of the N2Africa package components for at least one season in their legume fields;

3. The farmer knows at least three components of the N2Africa technology package, has access to them and has used three of the N2Africa package components for at least one season in their legume fields;
4. The farmer knows at least four components of the N2Africa technology package, has access to them and has used the four N2Africapackage components for at least one season in their legume fields.

Based on those scenarios, Table 5 presents the awareness distribution of N2Africa packaged technologies across the countries. From the analysis, more than 96% of the farmers are aware of one component of the N2Africa technologies, being mainly the agronomic practices. For agronomic practices not to become overruling compared to use of inputs, in Table 5 they are considered as 'one component' if a farmer is aware of at least one improved practice.

With scenario two, Table 5 shows that the level of awareness N2Africa countries ranging from 44% in Nigeria to 80% in Ethiopia while on average it stands at 67% for all countries. After Ethiopia, the next higher level of awareness was recorded in Borno (80%) followed by Ghana (69%), Uganda (67%), Tanzania (54%). This result shows that there is still an awareness/exposure gap of farmers to N2Africa technologies. There was no significant difference in awareness level between the treated and untreated groups mainly due to the high percentages of awareness on practices that in Table 5 are interwoven with the awareness on inputs.

Table 5. Awareness of N2Africa Technologies Across Countries – number of household heads with % in parentheses.

	Ethiopia	Ghana	Borno	Nigeria	Tanzania	Uganda	Total
Sample size	**744**	**603**	**599**	**595**	**609**	**594**	**3744**
Awareness of N2Africa technologies							
At least 1 component	722(98.8)	598(96.2)	595(99.3)	457(91.8)	560(93.7)	529(99.1)	3441(96.6)
At least 2 components	583(79.8)	415(69.1)	476(79.5)	219(43.9)	322(53.9)	358(67.0)	2373(66.6)
At least 3 components	333(45.6)	217(36.1)	156(26.2)	69(13.9)	85(14.2)	131(24.5)	992(27.9)
At least 4 components	274(37.5)	200(33.3)	104(17.4)	51(10.2)	69(11.5)	126(23.4)	824(23.1)

3.7.4.4 Combinations of technologies in use

In total, 10 combinations are considered - Improved legume varieties and Inoculant, Improved legume varieties and Fertilizer, Improved legume varieties and Practices, Fertilizer and Inoculant, Fertilizer and Practices, Inoculant and Practices, Improved legume varieties, Inoculant and practices, Improved legume varieties, Inoculant and Fertilizer, Improved legume varieties, Fertilizer and Practices, Improved legume varieties and Fertilizer, Inoculant and Practices. In each country, farmers have specific preference in combination of N2Africa technologies.

Table 6 shows that in Ethiopia among treated households the combination of improved legume varieties and inoculant has the highest rate of adoption (28.1%) followed by fertilizer and inoculant (16.9%). In Ghana, improved legume varieties and practices have the highest rate of adoption (34.3%) following by Improved legume varieties and inoculant (33.0%). Borno and Nigeria have the same preferences in technologies combinations. It appears that improved legume varieties and inoculant has the highest rate of adoption in these two countries (32.7% and 19.4% respectively) following by the combination of improved legume varieties and practices (26.3% and 9.5% respectively). Tanzania and Uganda have the same preferences. The usage of inoculants in Tanzania is much less than in the other countries as the commercial inoculant supply chain developed late in the project. In total three combinations are more preferred in these countries including: improved legume varieties and fertilizer, improved legume varieties and practices and fertilizer with practices. Overall, two combinations of N2Africa technologies are preferred: improved legume varieties and practices and improved legume varieties and inoculant on average with 25.4% and 23.5% respectively.

Table 6. Percentage of treated and non-treated respondents using combinations of technologies

	Ethiopia			Ghana			Borno		
	Treated	Non treated	Total	Treated	Non treated	Total	Treated	Non treated	Total
Total sample size	384	360	744	309	294	603	300	299	599
Usage of technologies	356	312	668	309	294	603	300	299	599
Improved legume varieties and Inoculant	28.1	14.7	21.9***	33	7.1	20.4***	32.7	9.7	21.2***
Improved legume varieties and Fertilizer	16.3	14.7	15.6	31.7	19.1	25.5***	14.3	7.0	10.7***
Improved legume varieties and Practices	13.8	11.5	12.7	34.3	19.7	27.2***	26.3	12.7	19.5***
Fertilizer and Inoculant	16.9	9.9	13.6***	23.3	3.7	13.8***	6.3	2.3	4,3**
Fertilizer and Practices	9.3	7.7	8.5	30.4	15	22.9***	10.7	4.4	7.5***
Inoculant and Practices	11.8	6.1	9.1**	24.3	3.1	13.9***	15.3	2.3	8.9***
Improved legume varieties, Inoculant and practices	8.7	3.9	6.4**	18.8	3.1	11.1***	13.3	1.7	7.5***
Improved legume varieties, Inoculant and Fertilizer	10.1	6.4	8.4*	18.5	3.4	11.1***	6.3	2.0	4,2***
Improved legume varieties, Fertilizer and Practices	5.3	3.9	4.6	23	10	16.6***	9.3	3.0	6.2***
Improved legume varieties, Fertilizer, Inoculant and Practices	2.8	1.6	2.3	14.2	1.4	8.0***	4.3	0.0	2.2***

	Nigeria			Tanzania			Uganda			Overall		
	Treated	Non treated	Total	Treated	Non treated	Total	Treated	Non treated	Total	Treated	Non treated	Total
Total sample size	252	343	595	304	305	609	299	295	594	1848	1896	3744
Usage of technologies	252	343	595	238	177	415	278	213	491	1733	1638	3371
Improved legume varieties and Inoculant	19.4	2.3	9.6***	2.9	0.0	1.7**	18.7	0.9	11.0***	23.5	6.5	15.3***
Improved legume varieties and Fertilizer	7.1	2.9	4.7**	13.9	5.1	10.1**	28.4	2.4	17.1***	18.9	9.0	14.1***
Improved legume varieties and Practices	9.5	3.2	5.9***	20.6	5.7	14.2***	47.8	23.9	37.5***	25.4	12.5	19.1***
Fertilizer and Inoculant	4.4	2.0	3.0	1.7	0.6	1.3	15.1	0.0	8.6***	12.0	3.5	7.9***
Fertilizer and Practices	4.4	4.4	4.4	13.9	9.6	12.1	28.4	1.4	16.7***	16.3	7.1	11.8***
Inoculant and Practices	6.8	1.2	3.5***	1.3	0.0	0.7	20.5	0.9	12.0***	13.9	2.5	8.3***
Improved legume varieties, Inoculant and practices	4.8	0.3	2.2***	0.8	0.0	0.5	15.5	0.9	9.2***	10.7	1.8	6.4***
Improved legume varieties, Inoculant and Fertilizer	2.8	0.6	1.5**	0.4	0.0	0.2	11.9	0.0	6.7***	8.8	2.3	5.7***
Improved legume varieties, Fertilizer and Practices	1.6	1.8	1.7	10.5	2.8	7.2***	22.3	0.9	13.0***	12.1	3.9	8.1***
Improved legume varieties, Fertilizer, Inoculant and Practices	0.4	0.3	0.3	0.4	0.0	0.2	9.4	0	5.3***	5.5	0.6	3.1***

*Note: *** Significant at 1%; ** Significant at 5% and * Significant at 10%, significant at 1% is indicated in dark green, and at 5% in light green*

3.7.4.5 **Determinants of N2Africa Technologies Adoption**

In the impact study, five categories of determinants are considered, including socio-demographic, socio-economic, financial, physical and social capital related characteristics. Table 7 presents the calculated or estimated parameters of a probit analysis of the major factors that contribute positively or negatively to adoption of N2Africa technologies. It uses the dummy variable that classifies a farmer as an adopter if at least three technology components were used (see Table 6) and a non-adopter if less than three. It examines the relationship between adoption and a set of explanatory variables conditional on the adoption decision (Table 7).

Among the positive factors are age of the household head (the younger the better), year of schooling (the higher the better), household size (the bigger the better), total legume production in the previous year (the higher the better), the level of income received from livestock (the higher the better), amount of credit received from any source (the higher the better), being a member of association or any farmer group, being aware/exposed to the technologies, the number of farmers adopting the technologies in the village (the higher the better), ownership of the land as well as the total land possessed by the household.

The social capital variables (awareness of the technologies, number of adopters of a technology in a village and group membership) seem to have much positive relationship with adoption of the technologies (determine the adoption rates). This is evident in the correlation between awareness and adoption, as almost all farmers who are exposed to the technologies, proceed to use at least once in a season.

On the other hand, the factors that contribute negatively are the level of income received from the selling of other crops (the lower the better) and the long distance to inputs market. As evident in the use of improved seeds from both the adoption analysis and the project status, the availability and accessibility of the various inputs plays a critical role. Farmers have to travel short distances (sometimes not at all) to access seeds, due to the various distribution channels established including community seed producers. However, inoculant sales have mostly been limited due to distances between farmers and the sales points.

Table 7. Probit Model Estimation of Determinants of Adoption of N2Africa Technologies

Variables	(1)	(2)	(3)	(4)	(5)	(6)
	Ethiopia	**Ghana**	**Borno**	**Nigeria**	**Tanzania**	**Uganda**
Socio-demographic characteristics						
Age of household head (years)	-0.01	0.03*	-0.02	0.01	-0.01	-0.03**
Gender of household head female (%)	0.12	-0.08	0.20	0.94	0.16	0.22
Marital status (Married)	0.06	0.33	-0.00	-1.12	-0.10	-0.34
Years of schooling of household head (years)	0.05**	-0.04	0.01	0.03	0.08	-0.01
Household size	-0.06	-0.00	-0.00	0.10	0.00	0.02
Farming experience	-0.02	-0.02	-0.00	-0.06	0.01	0.04**
Average years of Legume experience	0.03***	-0.01	0.02	0.10	-0.01	-0.04**
Socio-economics characteristics						
Total legume production (2018 in kg)	0.00	0.00	0.00	-0.00	0.00	
Total legume production (2017 in kg)	0.00*	0.00**	0.00**	0.00	0.00	0.01
Crop income (USD)	-0.00	-0.00*	-0.00	-0.00	0.00**	0.00**

Variables	(1)	(2)	(3)	(4)	(5)	(6)
	Ethiopia	**Ghana**	**Borno**	**Nigeria**	**Tanzania**	**Uganda**
Livestock income (USD)	0.00	0.00*	0.00	-0.00	-0.00	0.00
Off farm source of income (Yes)	-0.14	0.79*	-0.29	-0.10	-0.46	-0.17
Off-farmer income (USD)	-0.00	-0.00	0.00	0.00	0.00	0.00
Distance to nearest Input Market (Min)	0.00***	0.00	0.00**	0.01**	0.00	0.00**
Household Dietary Diversity Score	0.10*	0.13	0.11	0.21	0.05	0.01
Financial capital						
Access to credit (Yes)	-0.24	-0.29	-0.75	-1.06	4.91	0.65
Amount received per credit source	0.00	0.01	0.00	0.02*	-0.00	-0.00
Social capital						
Number of groups Membership	0.04**	0.02	-0.15	0.13		0.06
Awareness of N2Africa Fertilizer	0.92***	2.92***	2.22***	5.26***	2.24***	0.89
Awareness of N2Africa Improved seed	0.51***	1.02***	0.61**	5.06***	0.93***	0.52
Awareness of N2Africa Inoculation	2.02***	4.39***	3.03***	3.26***		
Awareness of N2Africa Practices	0.67***	2.21***	0.83***	3.20***	1.10***	1.28***
Number of Fertilizer adopters in the village	0.00	0.01	0.06***	0.19**	-0.00	-0.16***
Number of Improved Seed adopters in the village	0.05***	0.04	-0.03	0.03	0.01	0.04***
Number of Inoculant adopters in the village	0.10***	0.34***	0.11		-0.01	0.27***
Physical capital						
Land Ownership status	0.20	0.32	0.65**	2.48**	-0.54	-0.44*
Farm size	0.07	0.01	-0.03	-0.26*	-0.06	0.05
Constant	-4.81***	-10.88***	-5.44***	-16.82***	-5.24***	-0.19
Observations	640	427	500	362	526	585

*** p<0.01 Significant at 1%, ** p<0.05 Significant at 5%, * p<0.1 Significant at 10%

3.7.4.6 **Access to output market**

The study shows empirical evidence of a relationship between percentage of legume sold and whether or not the farmer received price information. It appears that overall, farmers who have received price information sold more than those who received no price information. Specifically, in the treated group, farmers who received price information sold 35.8% of their legume production while those who did not receive price information sold 34.0%.

The same conclusion is observed in the non-treated group on overall. Considering other factors which increase access to market as group membership and access to credit, it appears that in most cases farmers who are members of groups or associations sold more than those who are not members with respective average percentage of legume sold 34.7% and 34.2% in treated group.

The equivalent percentage of quantities sold between farmers who received market information and those who did not could be due to the fact that different models were pursued by different partners to accelerate access to output market. Some partners provided direct linkage between farmers and buyers; some cooperatives offered bulk purchases whilst other partners implemented through nucleus farmers who provided ready market for produce. Farmers who sold their legume through such models did not consider them as having access to market information. In addition, open markets, still serve as important marketing channel (during off seasons) and this may have contributed to the high sales by the non-treated group as well. However, an inverse relationship pertains between access to credit and percentage of legume sold for some countries in the treated area. In addition, the study indicates that on average, adopters participate more in the market than the non-adopters. Consequently, the rate of market participation varies between 17 and 36% for non-adopters against 23 and 39% for adopters.

Table 8. Percentage of legume sold (Individual and collective)

% of legume sold (Individual and collective)						
Counties	Adopters	Non-adopters	Adopters		Non-adopters	
			Female	Male	Female	Male
Ethiopia	23.1**	18.6	27.3**	22.8	14.2	19.2**
Ghana	27.0	27,0	41.1***	25.7	20.3	27.7**
Borno	44.6	45.4	37.7	46.2***	44.4	45.7
Nigeria	49.7*	44.0	53.3	49.7	52.0**	43.7
Tanzania	39.3	36.7	33.3	42.0***	33.7	38.4*
Uganda	38.7	36.0	34.7	42.5***	33.1	38.7*

From Table 8, it can be seen that female adopters sold more of their legume produce than their male counterparts. Though not the case for the non-adopters. The adopters as evident in the determinants of adoption (Table 7), have high social capital (e.g. group membership) which supports and avenue for greater sale of produce. The project and its partners used mostly the producer collective model through which dissemination of the technologies were done and to about 41% female having access to collective marketing and value addition in 2018.

3.7.4.7 Mean Difference in Outcome Variables

The impact in this section is assessed on major outcomes of the project including legume productivity which is defined as the quantity of legume harvested per hectare, level of crop income which is the level of income received from crop sale including legumes and level of Household Dietary Diversity Score (HDDS) which is an indicator of nutritional status of the households. Table 9 shows the difference of the listed outcomes between adopters and non-adopters of N2Africa technologies. The level of outcome is significantly greater among adopters than the non-adopters. The rationale for this analysis i.e. adoption versus treated-untreated was earlier explained in Section 3.7.3.2. 'analysis of the entire data'. Propensity score matching (PSM) and other analyses showed no significant difference on key demographics between adopters and non-adopters making them comparable groups for the analysis presented in Table 9.

Table 9. Mean differences in outcome variables

		Adopter	**Non-adopter**	**|T-test|**	**Treated**	**No-treated**	**|T-test|**
Ethiopia	Legume Yield 2017	846.9	810.8	0.93	790.8	858.5	1.86*
	Crop Income	494.7	380.2	3.45***	454.5	380.2	2.36**
	HDDS	5.2	5.0	0.76	5.0	4.9	1.15
Ghana	Legume Yield 2017	292.4	264.8	1.05	284.4	261.9	0.92

		Adopter	Non-adopter	|T-test|	Treated	No-treated	|T-test|
	Crop Income	333.9	271	2.59***	327.9	250.3	3.49***
	HDDS	5.7	4.9	5.58***	5.3	4.9	2.65***
Borno	Legume Yield 2017	652.5	631.7	0.43	662.1	611.1	1.28
	Crop Income	871.9	648.1	3.49***	680.2	725.7	0.81
	HDDS	5.8	5.6	1.68*	5.7	5.5	2.23**
Nigeria	Legume Yield 2017	726.9	512.9	3.13**	575.0	510.7	1.34
	Crop Income	1275.2	734.5	4.57***	822.1	760.8	0.85
	HDDS	6.0	5.3	2.78***	5.0	5.6	4.29***
Tanzania	Legume Yield 2017	359.6	211.8	3.54***	261.9	181.2	3.18***
	Crop Income	827.8	403	4.43***	539.4	336.4	0.89
	HDDS	5.5	5.0	1.84*	5.6	5.4	1.03
Uganda	Legume Yield 2018	838.7	1119.4	2.28**	1124	983	1.30
	Crop Income	616.6	376.5	3.89***	456.7	370	1.91*
	HDDS	5.7	5.1	3.78***	5.3	5.1	1.72*

Considering legume productivity, N2Africa technologies have contributed significantly to increase the productivity of legume per hectare in the whole five countries. The highest impact is in Uganda where adopters increased their legume productivity by 244.4 kg/ha followed by Tanzania with around 214.8 kg/ha of legume productivity change. In Ethiopia, adopter farmers increased legume productivity by 83.5 kg/ha. In Ghana adopters increased legume productivity by 50.6 kg/ha. Borno State and Nigeria have almost similar results. In Borno, adopters increased legume productivity by 109.1 kg/ha, while in Nigeria the change in productivity was 100.1 kg/ha.

The productivity gains significantly increased the level of income received from crop sales in the whole countries. In Ethiopia, the income received from all crop sales increased by $166, in Ghana it increased by $21.1. While the different in productivity gain between Borno and Nigeria where seems to be similar, there is a big difference in how the technologies impact the income received from crop sale. In Borno, adopter farmers gain $156 while in Nigeria the gain in crop income is around $408.2. Uganda and Tanzania have respectively an income gain of $313.4 and $178.

N2Africa technologies has significantly contributed to improve food security among smallholder's legume farmers through diversification of food consumed. Empirically, adopters increased their HDDS by 0.2 in Ethiopia, Ghana by 0.8, in Borno, 0.2, in Nigeria, 0.7, in Tanzania 0.5 and 0.6 in Uganda. The gender consideration demonstrates that there is no one group which gain more from the project than another.

3.7.4.8 **PPP business models and use of inputs (improved seed, inoculants, P-fertilizer)**

A link between the PPPs and the use of improved seed, inoculants and P-fertilizer was made to assess the extent to which different PPP models had effect on the use of these inputs. Different partners in a PPP worked with different models. In some countries, multiple partners worked in the same district. In that case, a dominant partner/ PPP model was assigned to the district. In other cases, different partners worked in different villages. In that case, multiple models could exist in the same district. Five different models were distinguished in practice: the buyer-driven/ outgrower model, the information linkages model, micro entrepreneur model, nucleus farmer and producer-

collective driven model. In Ghana, Nigeria and Tanzania, different models existed across the country. In Ethiopia and Uganda, only the producer-collective driven model was applied. Ghana, Nigeria and Tanzania had three to four different models (Table 10). Most models occurred across different districts, or districts had multiple models. Only in Tanzania, were models confounded with district.
In Ghana, the use of improved seed was larger among farmers being part of the producer-collective driven model than the information linkages model (Table 10). It should be noted, however, that the interaction with district was significant. Moreover, most farmers being part of the producer-collective model were located in Savelugu northern, versus Bawku and Binduri for the information linkages model. The nucleus farmers model had only four respondents. In Nigeria, the percentage of farmers using improved seed, inoculant and P-fertilizer differed significantly between the PPP models. The producer-collective driven model had the largest percentage of farmers using improved seed and P-fertilizer. The percentage of farmers using inoculant was largest among the farmers in the buyer-driven/ outgrower schemes model. In Tanzania, the use of inputs was the same for farmers being involved in different models.

Table 10. Percentage of farmers using improved seed, inoculant and P-fertilizer per PPP model per country. P-values indicate significant differences between PPP-models within a country

		Improved seed		Inoculant		P-fertilizer	
		Yes	No	Yes	No	Yes	No
Ghana	Information linkages	72	28	0	100	98	2
	Nucleus farmers	100	0	0	100	100	0
	Producer collective	89	11	9	91	100	0
	P-value	< 0.001		ns		ns	
Nigeria	Buyer-driven/ Outgrower schemes	46	54	11	89	69	31
	Micro-entrepreneur	38	62	4	96	86	14
	Producer collective	86	14	9	91	90	10
	P-value	< 0.001		0.01		< 0.001	
Ethiopia	Producer collective	59	41	12	88	92	8
Tanzania	Buyer-driven/ Outgrower schemes	55	45	0	100	70	30
	Producer collective	55	45	0	100	70	30
	P-value	ns		ns		ns	
Uganda	Producer collective	78	22	1	99	26	74

3.8 Tailor and adapt legume technologies to close yield gaps and expand the area of legume production within the farm

3.8.1 Diagnostic, demonstration, and adaptation trials

A total of 18 diagnostic trials were established in 2018 in Ethiopia as continuation of the variety by strain trials for the third season. The repeated trials are to complement the quality of datasets generated in 2016 and 2017 in which extreme variabilities in the performances of the trials across agro-ecologies were observed.

For dissemination of the technologies, a total of 157 demonstration trials were established focusing on disseminating a single technology or a combination of technologies. As part of the process, farmers evaluate these technologies to ascertain their preferred technologies, and to reshape the technology packages to be accessed by farmers. In addition to demonstration trials, 1,569 adaptation trials were established. A selection of these adaptation trials was monitored to assess the performance of the technologies under the heterogeneous farmers' conditions and management. Table 11 gives an overview of the total number of trials established in the Core countries in 2018.

Table 11. Total number of diagnostics, demonstration, and adaptation trials established per country in 2018.

	Diagnostic trials (#)	Demonstration trials (#)	Adaptation trials (#)
Ghana	-	24	-
Nigeria	-	-	-
Borno State	-	80	200
Ethiopia	18	27	1140
Tanzania	-	5	-
Uganda*	-	21	229
Total	**18**	**157**	**1,569**

In Tanzania, five demonstrations of common bean were held. Treatments demonstrated included a control (no amendment); Nitrogen (N) alone at 40 kg/ha; phosphorus (P) at 20 kg/ha; N+P (40 kg N + 20 kg P); inoculant 1 (Legumefix –from Legume Technology UK); inoculant 2 (Rhizoliqbean – from Rizobacter Argentina); inoculant 1+P; and inoculant 2+P. Results from the demonstrations show the importance of inoculants, P fertilizers and their combinations on increasing bean production (Figure 10). The performance of inoculants was similar to the addition of N fertilizer. Beans planted in the demonstrations performed well, unlike previous seasons. This could be attributed to good weather and the selection of demonstration sites with good initial soil fertility and low acidity.

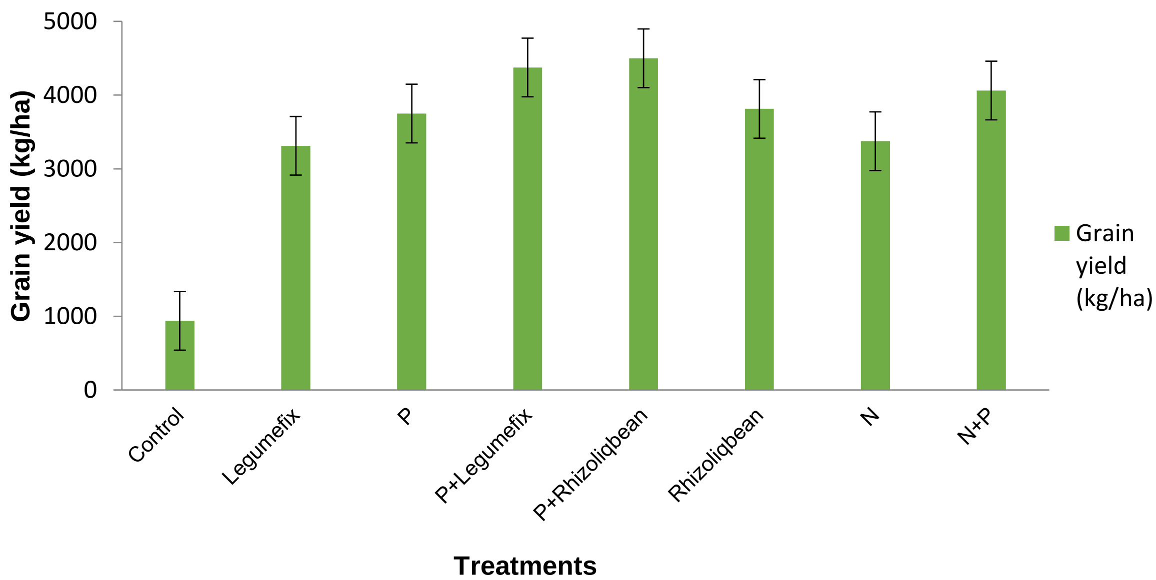


Figure 10. Response of common bean to N and P fertilizer, and rhizobium inoculants as observed in farmers' fields in Lushoto (n = 4)

In Ethiopia, results from on-farm dissemination trials demonstrated that using improved legume seeds with inoculation and phosphorus fertilizer resulted in better grain yields than the national average yield of each legume, albeit with variable responses across agro-ecologies (Figure 11).

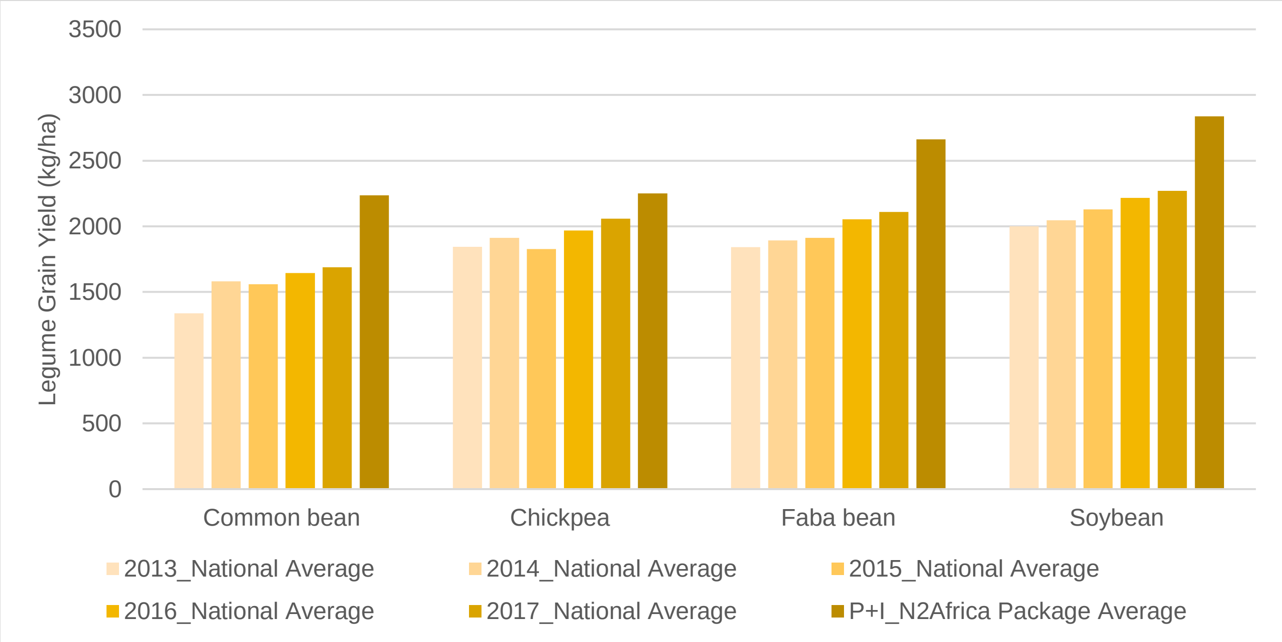


Figure 11. Comparison of mean national yields (2013-2017) of the four targeted legumes with the N2Africa-Ethiopia dissemination trials (2013-2017) across different agro-ecological locations.

3.8.2 Recommendations for best-fit technologies

The combined results of yields and farmers' evaluations of diagnostic, demonstration and adaptation trials over multiple seasons led to the development of best-fit recommendations for the different legumes in the Core countries (Table 12).

Table 12. Best-fit recommendations for legume cultivation based on diagnostic, demonstration and adaptation trials.

Country	Legume	Treatment
Ghana	Cowpea	Varieties Padi-tuya (Upper West Region) or Wang-Kae (Upper East and Northern Regions); New Yara Legume fertilizer
Ghana	Groundnut	Variety Samnut 22; New Yara Legume fertilizer
Ghana	Soyabean	Varieties Afayak (farmer preferred) or Suongpungun in Upper East and Northern Regions, or TGX 1985-10E (early maturing) in Upper East and West Regions; New Yara Legume fertilizer; inoculants
Nigeria	Soyabean	Varieties TGx 1951 - 3F; TGx 1955 – 4F; TGx 1904 – 6F or TGx 1835 – 10E; farm yard manure; SSP fertilizer; inoculants
Nigeria	Groundnut	P+K fertilizer
Ethiopia	Bush bean	P-fertilizer; inoculants
Ethiopia	Chickpea	P-fertilizer; inoculants; 30 kg ha^{-1} of S (northern Ethiopia)
Ethiopia	Soyabean	P-fertilizer; inoculants; 60 kg ha^{-1} of K_2O and 4.6 t ha^{-1} of lime (acidic soils in western Ethiopia)
Tanzania	Bush bean	Variety Lyamungu 90; (N)PK fertilizer; inoculants
Tanzania	Cowpea	Variety Tumaini; P-fertilizer

Tanzania	Groundnut	Variety Pendo; farm yard manure; Minjingu Rock Phosphate (MRP); gypsum; Aflasafe
Uganda	Soyabean	Variety Maksoy 3N; TSP; inoculants
Uganda	Climbing bean	NABE 12C; farmyard manure P-fertilizer

For Ethiopia, the list of best-fit practices that have been tested by N2Africa-Ethiopia with public and private partners in the seven PPP clusters are presented below (Table 13). These best-fit practices are the results of demonstration trials which are deemed proven enough to be scaled out for many more farmers. This information would be documented in manuals with the explanations on the approaches and the lessons learnt in order to reach to a wider range of farming communities.

Table 13. Best-fit recommendations for legume production for the seven PPP cluster woredas in Ethiopia

c	Cluster	Legume	Woreda	Variety	P fertilizer	Inoculant
1	South	Bush bean	Shalla	Nasir	23-46 kg/ha P2O5	HB-429
2	South	Bush bean	Boricha	Nasir, Awassa Dume	23 kg/ha P2O5	HB-429; HB-A-15
3	South	Bush bean	Soddo Zuria	Awassa Dume	50 kg NPS	HB-429
4	South	Bush bean	Halaba	Nasir, Awassa Dume	23-46 kg/ha P2O5	HB-429; HB-A-15
5	South	Chickpea	Damot Gale	Habru, Arerti	23 kg/ha P2O5	CP-29
6	South-East	Faba bean	Goba	Degaga, Dosha	23 kg/ha P2O5	EAL-110
7	South-East	Faba bean	Agarfa	Degaga, Moti	23-46 kg/ha P2O5	EAL-110
8	South-East	Faba bean	Sinana	Degaga, Shallo	23-46 kg/ha P2O5	EAL-110
9	South-East	Chickpea	Ginir	Arerti, Habru	23-46 kg/ha P2O5	CP-29
10	North	Faba bean	Dabat	Wolki, Dosha	23 kg/ha P2O5	FB04, EAL-110
11	North	Faba bean	Debark	Wolki, Dosha	23 kg/ha P2O5	FB04, EAL-110
12	North	Faba bean	Yilmana Densa	Wolki, Moti	23-46 kg/ha P2O5	FB04, EAL-110
13	North	Chickpea	Dembia	Arerti	23-46 kg/ha P2O5	CP-29
14	North	Chickpea	Gonder Zuria	Arerti, Habru	23-46 kg/ha P2O5; 30 kg/ha S	CP-29
15	North	Chickpea	Enemay	Arerti, Habru	23-46 kg/ha P2O5	CP-29
16	North	Soyabean	Alefa	TGX-13-3-2644, Belesa-95	23 kg/ha P2O5	MAR-1495[3]
17	Central	Chickpea	Ada'a	Arerti	23-46 kg/ha P2O5	CP-29
18	Central	Chickpea	Becho	Arerti	23-46 kg/ha P2O5	CP-29
19	Central	Chickpea	Gimbichu	Arerti, Natoli	23-46 kg/ha P2O5	CP-29
20	Jimma	Soyabean	Kersa	Clark-63K	23-46 kg/ha P2O5	MAR-1495
21	Jimma	Soyabean	Tiro Afeta	Clark-63K	23-46 kg/ha P2O5	MAR-1495
22	Pawe	Soyabean	Pawe	Belesa-95, TGX-13-3-2644	23 kg/ha P2O5	MAR-1495
23	Pawe	Soyabean	Jawi	Belesa-95, TGX-13-3-2644	23 kg/ha P2O5	MAR-1495
24	Pawe	Soyabean	Mandura	Belesa-95, TGX-13-3-2644	23 kg/ha P2O5	MAR-1495
25	Pawe	Bush bean	Mandura	Nasir	23-46 kg/ha P2O5	HB-429; HB-A-15

[3] MAR 1495 is the strain USDA 122 from the Marondera, Grassland Research Institute in Zimbabwe

c	Cluster	Legume	Woreda	Variety	P fertilizer	Inoculant
26	Pawe	Bush bean	Dibatie	Nasir	23-46 kg/ha P2O5	HB-429; HB-A-15
27	Chewaka	Soyabean	Bako Tibe	Dhidhessa	23-46 kg/ha P2O5; 60 kg/ha K2O and 4.6 t/ha of lime	MAR-1495
28	Chewaka	Soyabean	Dano	Keta, Dhidhessa	23 kg/ha P2O5	MAR-1495
29	Chewaka	Soyabean	Illu Gelan	Dhidhessa	23-46 kg/ha P2O5	MAR-1495
30	Chewaka	Soyabean	Gobu Sayo	Dhidhessa	23-46 kg/ha P2O5	MAR-1495
31	Chewaka	Soyabean	Wayu Tuka	Dhidhessa	23-46 kg/ha P2O5	MAR-1495
32	Chewaka	Soyabean	Chewaka	Dhidhessa	23 kg/ha P2O5; 60 kg/ha K2O and 4.6 t/ha of lime	MAR-1495
33	Chewaka	Bush bean	Bako Tibe	Nasir, Awassa Dume	23-46 kg/ha P2O5	HB-429; HB-A-15
34	Chewaka	Bush bean	Gobu Sayo	Nasir	23-46 kg/ha P2O5	HB-429; HB-A-15
35	Chewaka	Bush bean	Wayu Tuka	Nasir	23-46 kg/ha P2O5	HB-429; HB-A-15

3.8.3 Effects of management and the environment on nutritional quality of legume grain and on feed value of residues (see Key Milestone 3.5.1)

There is strong evidence that agronomic measures that stimulate nitrogen fixation in grain legumes also significantly increase the size and nutritional quality of the seed. The strongest evidence to date comes from studies in Ethiopia and in Ghana. Belete et al. (2019) reported a 6% increase in seed weight, 2.2% increase in crude protein content and 1.5% increase in digestibility[4] in common bean and 4% increase in seed weight, 9% increase in crude protein content and 6% increase in digestibility in soyabean. Michael Kermah in his forthcoming PhD thesis has evidence of enhanced protein content in fresh cowpea pods. Interestingly, in the study of Belete et al. (2019) significant effects of inoculation and P fertilization on protein content of the legume grain were observed in common bean, cowpea and soyabean but not in chickpea. Both soyabean and common bean are members of the Tribe Phaseoleae of the Leguminosae, and thus transport the products of nitrogen fixation predominantly as ureides (Giller, 2001). Earlier research has indicated a direct link between nitrogen fixation, ureide transport and harvest index in soyabean (Hungria *et al.*, 1989). It is possible that this could explain the strong effects in cowpea, soyabean and common bean and the absence of such effects in chickpea where amides are the main transport product of nitrogen fixation.

Effects of management on the feed value of legume residues for livestock are also clear, with rhizobium inoculants and phosphorus significantly enhancing protein contents and digestibility of grain legume residues (Dejene *et al.*, 2018; Belete *et al.*, 2019). A PhD study on this topic is currently being finalised for Ghana (Daniel Akapo).

Belete, S., Bezabih, M., Abdulkadir, B., Tolera, A., Mekonnen, K. & Wolde-Meskel, E. 2019. Inoculation and phosphorus fertilizer improve food-feed traits of grain legumes in mixed crop-livestock systems of Ethiopia. *Agriculture, Ecosystems and Environment*, **279,** 58-64.

Dejene, M., Dixon, R.M., Duncan, A.J., Wolde-Meskel, E., Walsh, K.B. & McNeill, D. 2018. Variations in seed and post-harvest residue yields and residues quality of common bean (Phaseolus vulgaris L.) as a ruminant feedstuff. *Animal Feed Science and Technology*, **244,** 42-55.

Giller, K.E. 2001. *Nitrogen Fixation in Tropical Cropping Systems*. CAB International, Wallingford.

Hungria, M., Neves, M.C.P. & Dobereiner, J. 1989. Relative efficiency, ureide transport and harvest index in soybeans inoculated with isogenic Hup mutants of *Bradyrhizobium japonicum*. *Biology and Fertility of Soils*, **7,** 325-329.

[4] In vitro organic matter digestibility

3.8.4 Rhizobiology: Country Updates

3.8.4.1 Strain evaluation in Tanzania

In Tanzania, elite rhizobia strains of soyabean and groundnuts were evaluated to come up with strains that could be readily advanced to inoculant production. Strains of common bean and cowpea were supposed to be tested as well, but unfortunately those could not be obtained from the Nodumax factory at Ibadan Nigeria.

The experiments were established at three sites Suluti, Milundikwa and Mbimba in the Southern Highlands of Tanzania. Soyabean strains evaluated included NAK 12, NAK 84, RACA 6, RANI 22 and IRJ 2180A, against a commercial inoculant Legumefix, a commercial strain USDA 110, N at 20 kg/ha and a control (no amendment). Groundnut strains tested included IGB469, NJR 493, NC 92, SBG 234, SNN 336 and SNN 343, against a control and N at 20 kg/ha.

The results in this season showed no significant differences between the evaluated elite rhizobia strains, but there was clear indication of the need for inoculation (Figure 12). The commercial inoculant Legumefix and the commercial strain USDA 110 performed slightly better than the rest of strains.

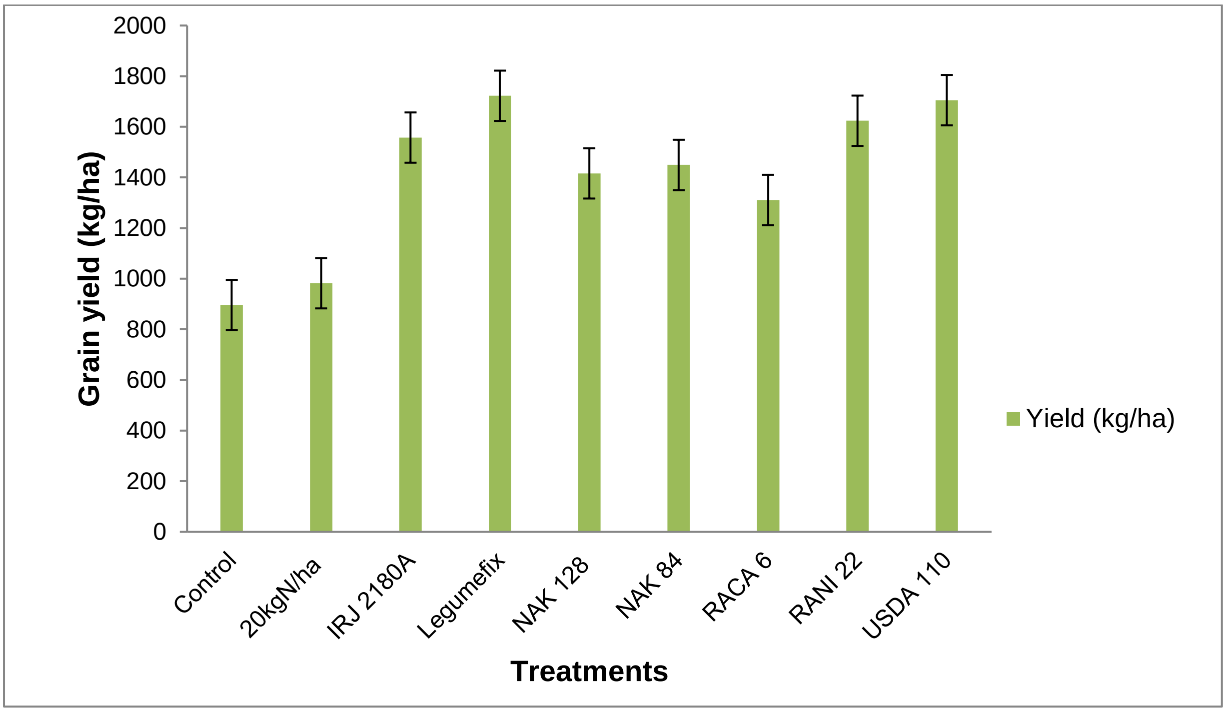


Figure 12. Performance of soyabean elite rhizobia strains in the Southern Highlands of Tanzania (n = 3)

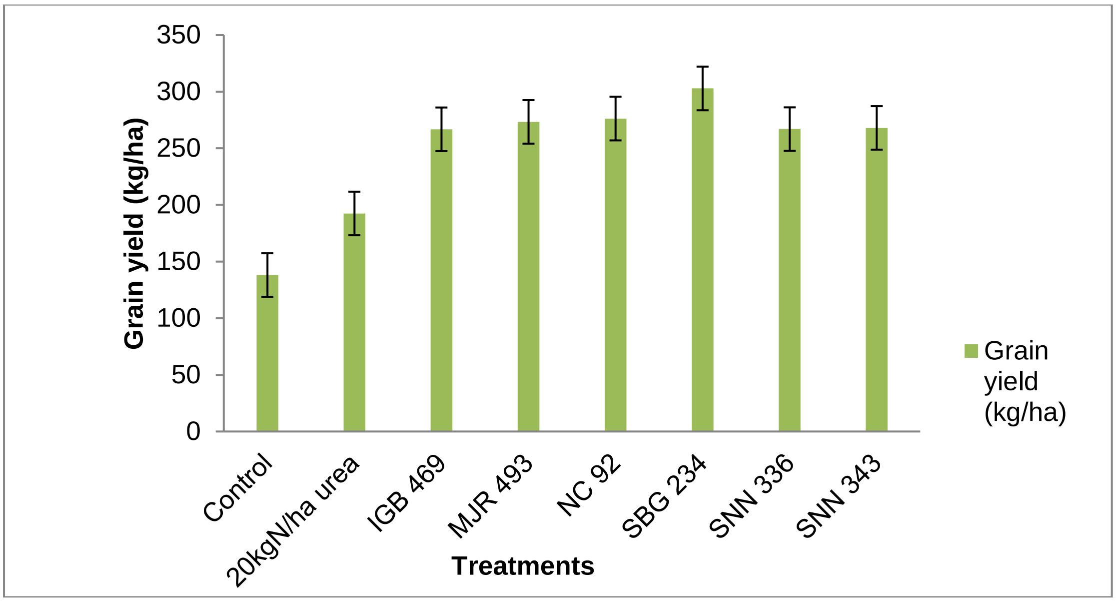


Figure 13. Performance of groundnut elite rhizobia strains in the Southern Highlands of Tanzania (n = 3)

There were no significant differences in yield of groundnut treated with different strains. It is worth noting that results of the performance of both soyabean and groundnut strains are based on final grain yield and not on other parameters like biomass accumulation and nodulation, which are equally important in evaluation of rhizobia strains. Data on other parameters are being compiled by TARI Uyole and a detailed analysis will be done and reported. However, cross-country analysis of strain evaluation trials is required in order to identify a stable strain that consistently gives good response in grain yield and can be advanced as commercial strain for groundnut.

3.8.4.2 **Inoculant quality control in Tanzania**

During the reporting period, quality control of inoculants was conducted by Sokoine University of Agriculture for the newly registered inoculants by Rizobacter (rizoliq soy) and a stock of Legumefix inoculants stored at IITA for Guavay (N2Africa partner). The lab testing results are:

- RizoliqSoy: 8.6 x 10^9 (+/- 19%) colony forming units (CFU) per ml on YMA CR average of seven drop plates.
- Legumefix: 8.4 x 10^9 (+/- 21%) colony forming units (CFU) per ml on YMA CR average of seven drop plates

These results indicate that all inoculants are considered of excellent quality by both TFRA and international standards.

3.8.4.3 **Strain evaluation in Ethiopia**

N2Africa-Ethiopia rhizobiology research activities have been undertaken in collaboration with Hawassa University (HwU), Ethiopian Institute of Agricultural at Holeta (EIAR-Holeta) and MBI. The major focus areas were the collection of new strains across agro-ecologies and the evaluation of candidate strains for their symbiotic effectiveness under greenhouse and field conditions, before embarking into inoculant production with them. Strain collections were generally made in the potential growing corridors of the target grain legumes in Ethiopia. After collection of root nodules, rhizobia were isolated from some of the nodule samples. A total of 12 isolates (3 chickpea, 5 faba bean and 4 soyabean) is ready for field evaluation.

The ongoing variety-by-strain trials have revealed that there are variety-specific interactions with elite rhizobia, and the performance of those rhizobia varies across different agro-ecologies. Overall, the widely disseminated legume varieties show good responses to inoculation with the rhizobial strains under evaluation. Generally, the new elite strains performed better than the commercial strains, and sometimes even better than the treatment with inorganic nitrogen fertilizer (positive control). However, their responses vary across different agro-ecological locations (Figure 14A). The overall results of these investigations will contribute substantially to the effort that N2Africa has made to identify multiple candidate elite rhizobia strains for the commercial production of site- and variety-specific inoculants for closing the yield gaps of the target legumes. For instance, one of the best performing common bean elite strains (HB-A-15) was taken from this trial into the dissemination trials. This elite strain performed competently with the existing commercial strain (HB-429) in the last two cropping seasons. Thus, this strain is recommended for commercial production and further scaling up.

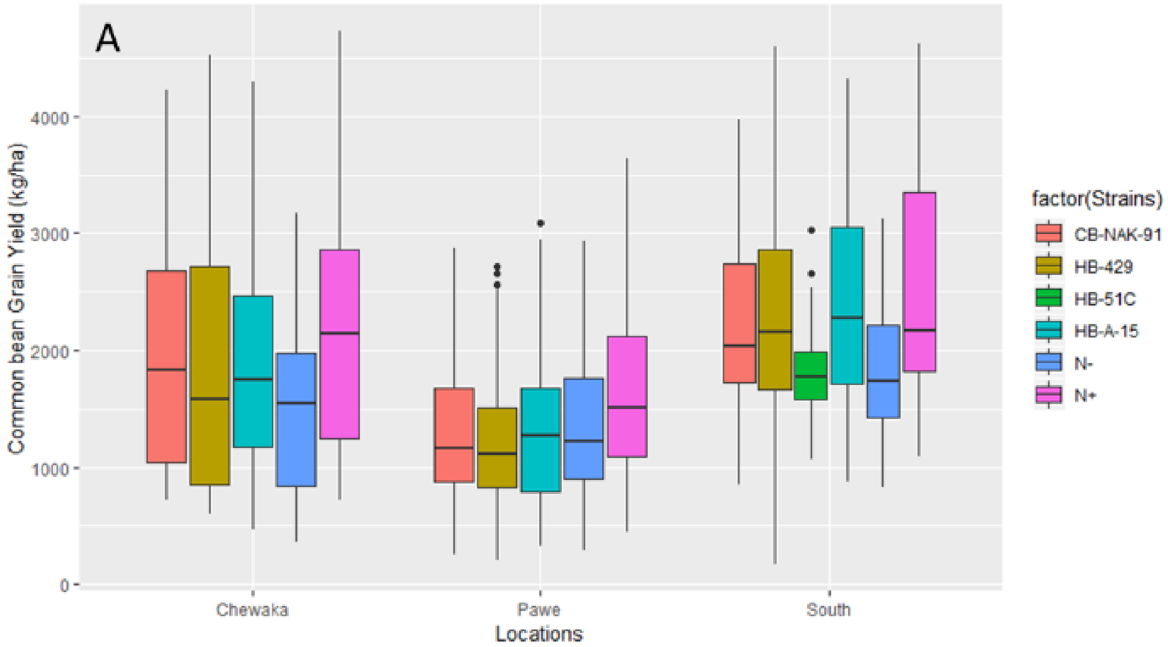


Figure 14. Performances of rhizobial strains at different locations in Ethiopia

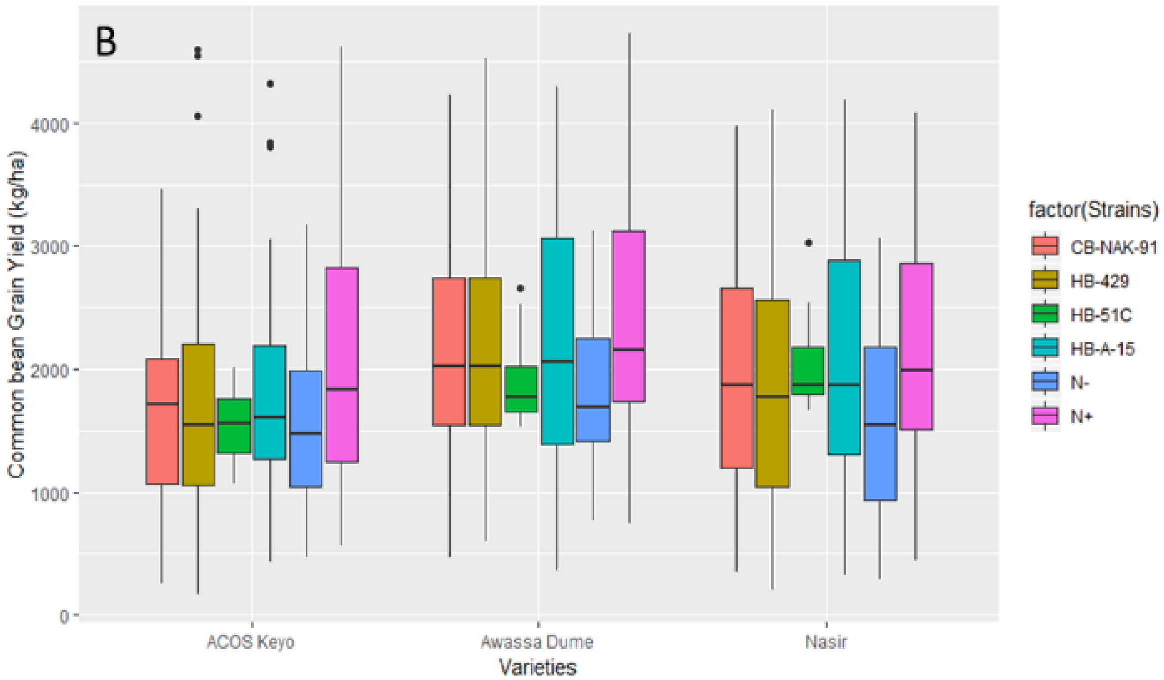


Figure 15. Performances of different varieties of common bean inoculated with different rhizobium strains in 2016-2017 in multiple locations in Ethiopia

3.8.4.4 **Development of Standard Operating Procedure in Ethiopia**

In 2018, N2Africa-Ethiopia was an active player and contributor to the development of the national biofertilizer/ inoculants standard operation procedure (SOP), registration guidelines and working manuals. The development of a national SOP for rhizobiology laboratories was another significant achievement as a result of N2Africa-EIAR-HWU-MBI and COMPRO II collaborations. The Ethiopian Standard Agency published the SOP and referred to it as "ES 3907-1: 2015- Fertilizers-Biofertilizers-Part 1: Rhizobial specification and test method". N2Africa-Ethiopia was also involved in the development of the Ethiopian Biofertilizer Registration Guidelines, but these guidelines are not yet endorsed by the Ministry of Agriculture. The Federal Ministry of Agriculture plans to incorporate the guidelines under the upcoming modified "Fertilizer Law".

In addition to these efforts, a manual entitled "Rhizobial Inoculant Development and Management" was developed in collaboration with EIAR and submitted for publication in the first week of December 2018. The manual will be distributed for public and private laboratories working on rhizobia, including higher learning institutes as reference material. Hopefully, this will support efforts towards capacity development on rhizobiology. The absence of a well set-up functional system, well-equipped public and/or private laboratories and lack of enough experts/ technicians remains to be the main concern to ensure effective quality control of inoculants in the different supply chains, from factory to farm gates.

3.8.4.5 **Key findings from rhizobiology activities in Tanzania and Ghana in Phase II**

A study was commissioned to take stock and analyse the available data collected through project partners during the implementation of rhizobiology activities across the core countries and provide findings and conclusions regarding effectiveness of strains for inoculant production. The initial study analysis however concentrates on Ghana and Tanzania. Nigeria data will be analysed in due course and integrated into the N2Africa final report. On the other hand, Uganda had challenges of drought and the available data from two sites in 2016 is not conclusive. However, this will be followed up in subsequent reporting.

N2Africa Phase I was successful in establishing and testing a massive collection of rhizobia nodulating a range of target legumes including soyabean, groundnut, cowpea, beans and common bean. As a result, several strains of indigenous rhizobia were identified which compare well, and sometimes do better than the recommended ones (including standard commercial strains) used as checks. The use of such high quality rhizobial inoculants can reduce legume yield gaps and maximize profit to small-scale farmers. One of the objectives under Phase II was to investigate if such strains could be readily advanced to inoculant production, and to determine in which areas of sub-Saharan Africa the use of such inoculants can maximize profit to small scale farmers.

The evaluation of strains and the selection of elite strains for common bean, cowpea, groundnut and soyabean was conducted in multi-locational experiments in Ghana and Tanzania. Elite rhizobia evaluated were sourced from different contributors to the N2Africa network, and gathered in a central laboratory at IITA Ibadan.

Table 14. Strains used on selected legumes for multi-location trials in Tanzania and Ghana

Common bean*	Soyabean	Cowpea	Groundnut
Control	USDA 110	BR 3262	IGR 469
USDA 2677	USDA 532C	BR 3267	MJR 43C
CIAT 899	NAK 128	2NAG 53e	NC 92
Ha.Alia	NAK 84	2NAG 9d	SBG 234
RIZOLIQBEAN	RACA 6	2NAG 91a	SNN 336
	RANI 22	CB756	SNN 343
	IRJ 2180A	2NAG 5261	

* Tanzania only

The performance of strains varied across sites in both countries. In Tanzania, common bean inoculation with strains CIAT 899, HaAlia, RIZOLIQBEAN and USDA 2677 resulted in increased grain yields ranging from 184 to 344 kg ha^{-1} relative to the un-inoculated control.

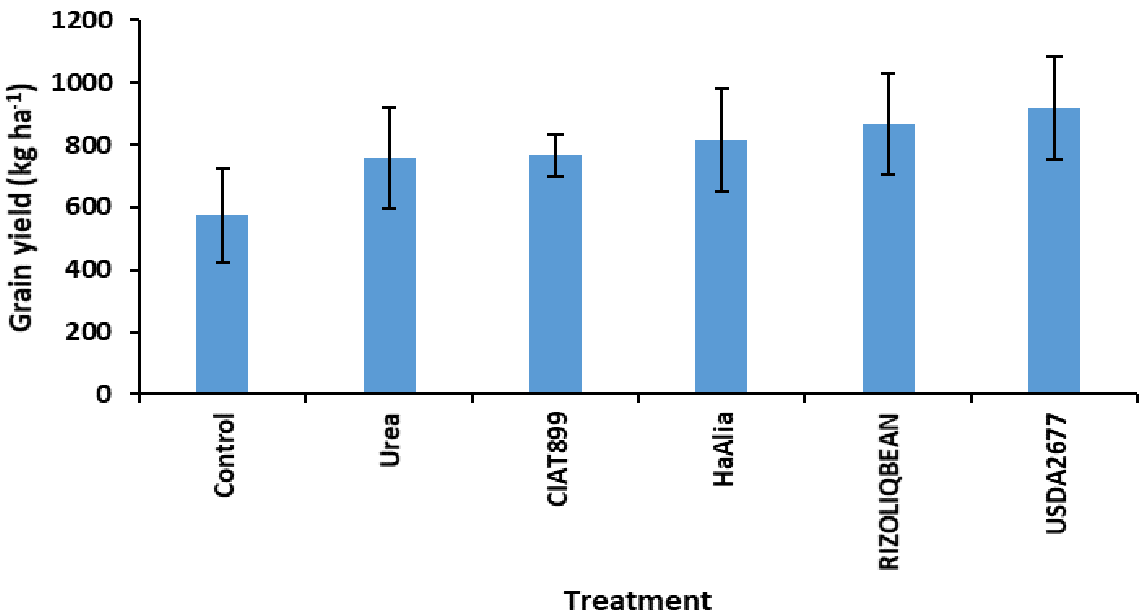


Figure 16. Performances of different varieties of common bean in 2016-2017 in multiple locations in Tanzania

Cowpea responded to inoculation, with grain yield increases of between 4 to 25% for strains CB756 and 2NAG53e, respectively.

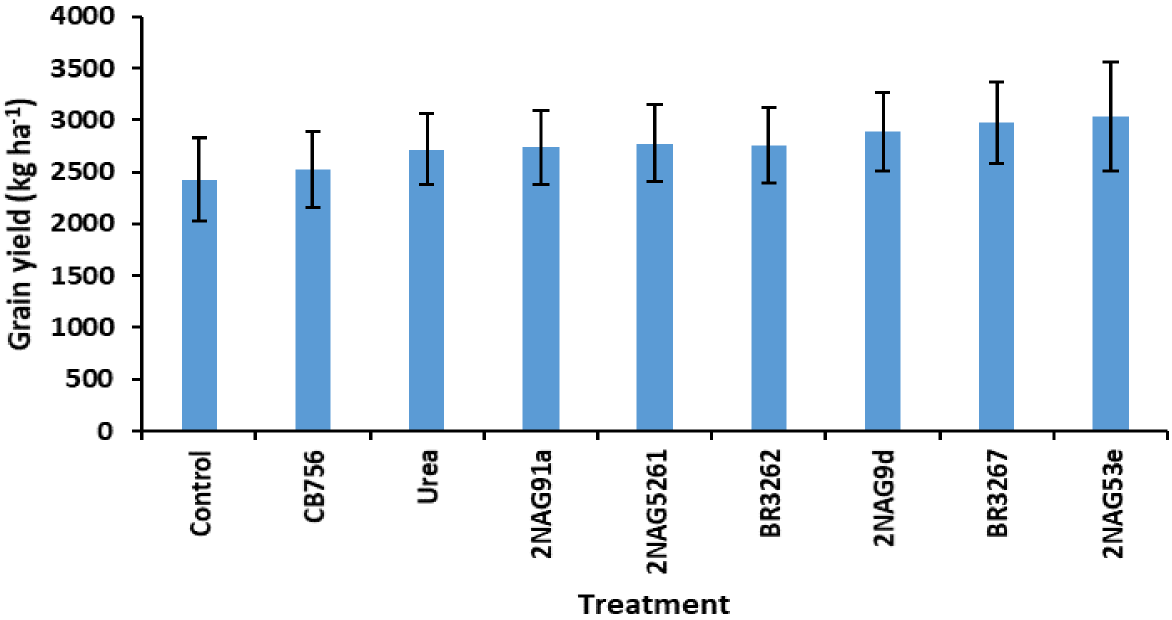


Figure 17. Grain yield of cowpea grown in Tanzania as affected by inoculation with selected elite rhizobia strains. The error bars represent the standard error of the mean.

Groundnut, when inoculated, gave yield increases ranging from 34 to 54% in the 2017 growing season for strains SNN336 and SNN343, respectively. Larger increases were obtained in 2018, ranging from 93 to 119% for strains IGB469, SNN336 and SBG234.

Soyabean responded well to inoculation in the 2017 and 2018 growing seasons. Overall, soyabean responded to inoculation with grain yield increases ranging from 16 to 45% for strains NAK128 and RACA6, respectively in 2017 and 46 to 92% for strains RACA6 and Legumefix in 2018.

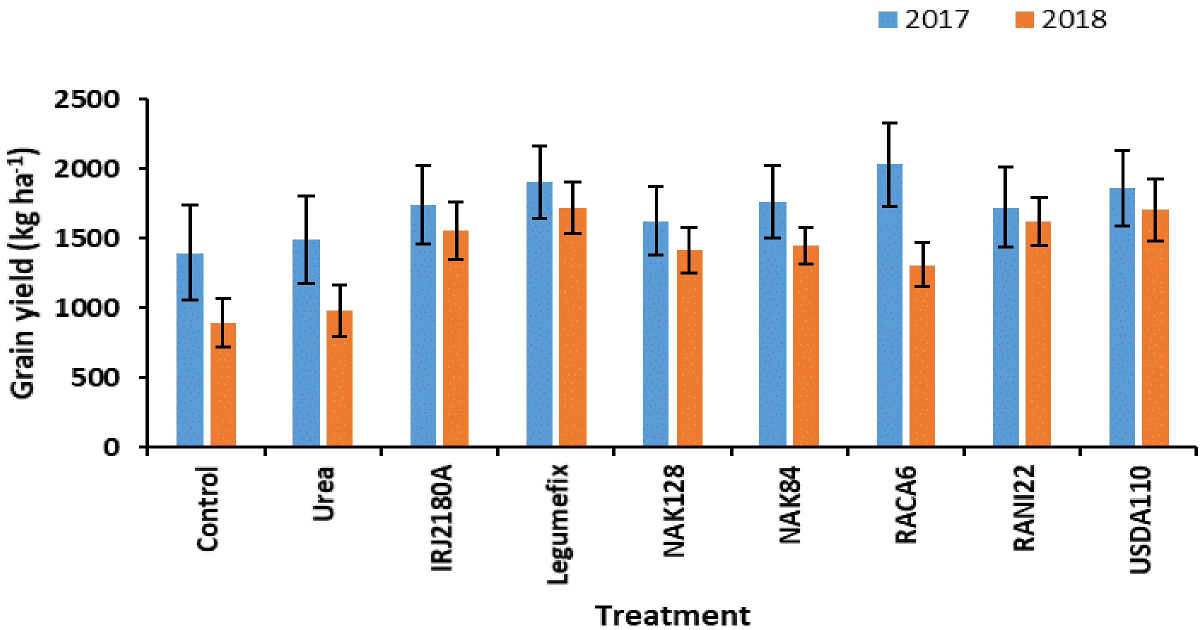


Figure 18. Grain yield of soyabean grown in Tanzania as affected by inoculation with selected elite rhizobia strains during the 2017 and 2018 growing seasons

In Ghana, cowpea did not respond to inoculation in the 2016 growing season. Overall, cowpea inoculation with different elite rhizobia strains showed an increase in grain yields in the 2017 cropping season, with increases ranging from 22 to 51% after inoculation with strains CB756 and BR3262, respectively.

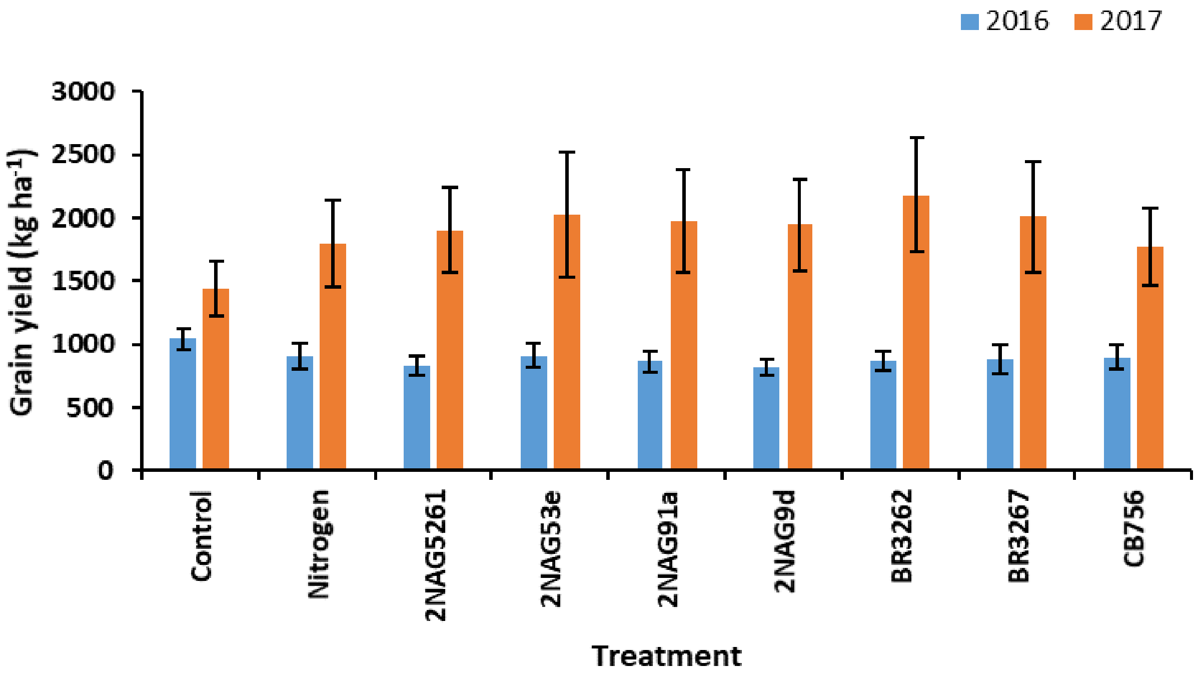


Figure 19. Effect of cowpea inoculation with selected elite rhizobia strains on grain yields in Ghana during the year 2016 and 2017 growing seasons.

The cowpea grain yields in 2017 were significantly ($P \leq 0.05$) higher than in 2016 growing season. The best performing strain in 2017 was BR3262 with a grain yield of about 2200 kg ha^{-1}. In 2016, cowpea did not respond to inoculation (Figure 5). Overall cowpea inoculation with different elite rhizobia strains showed an increase in yield ha^{-1} in 2017 ranging between 1445 to 2183 kg ha^{-1} (Figure 19).

For soyabean, the highest increase in grain yield was observed by inoculation with strain RANI22 in the 2016 and 2017 growing seasons. In the 2016 season the best performing strains were NAK84, RACA6 and RANI22 resulting in grain increases of 36, 37 and 44%, respectively. Higher responses to inoculation were observed in 2017 with grain yields increases of 70, 75 and 81% after inoculation of soyabean with strains USDA532C, IRJ2180A and RANI22, respectively.

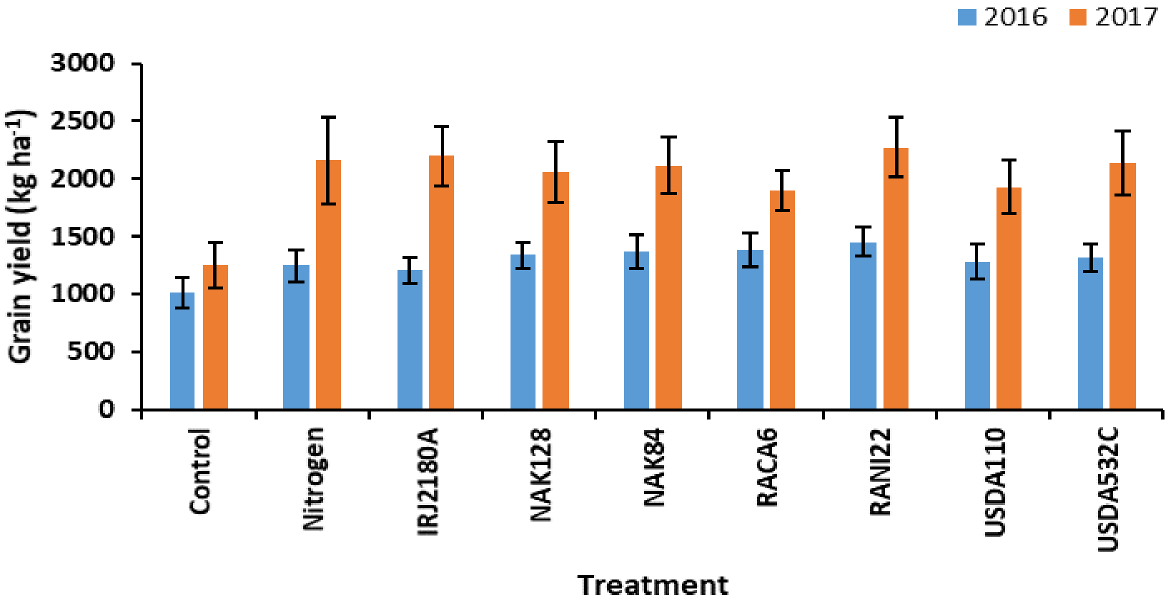


Figure 20. Grain yield of soyabean grown in Ghana as influenced by inoculation with selected elite rhizobia strains during the 2016/2017 growing seasons.

Groundnut was cultivated in two seasons in Ghana: 2016 and 2017. In 2016, only pod yield data was available, while grain yields were available for the 2017 cropping season. Generally, pod yields ranged from 2259 kg to 2917 kg ha^{-1} in 2016. Pod yield increases of between 5 to 15% were observed after inoculation using strains IGB469 and MJR43. Strain SBG234 was the only one that did not result in any increased in pod yield (Figure 21). In 2017, groundnut grain yield increases after inoculation ranging from 8 to 70% with strains SNN343 and IGB469 respectively. Strains MJR493 and IGB469 were the best performing resulting in 65 and 70% increase in grain yield.

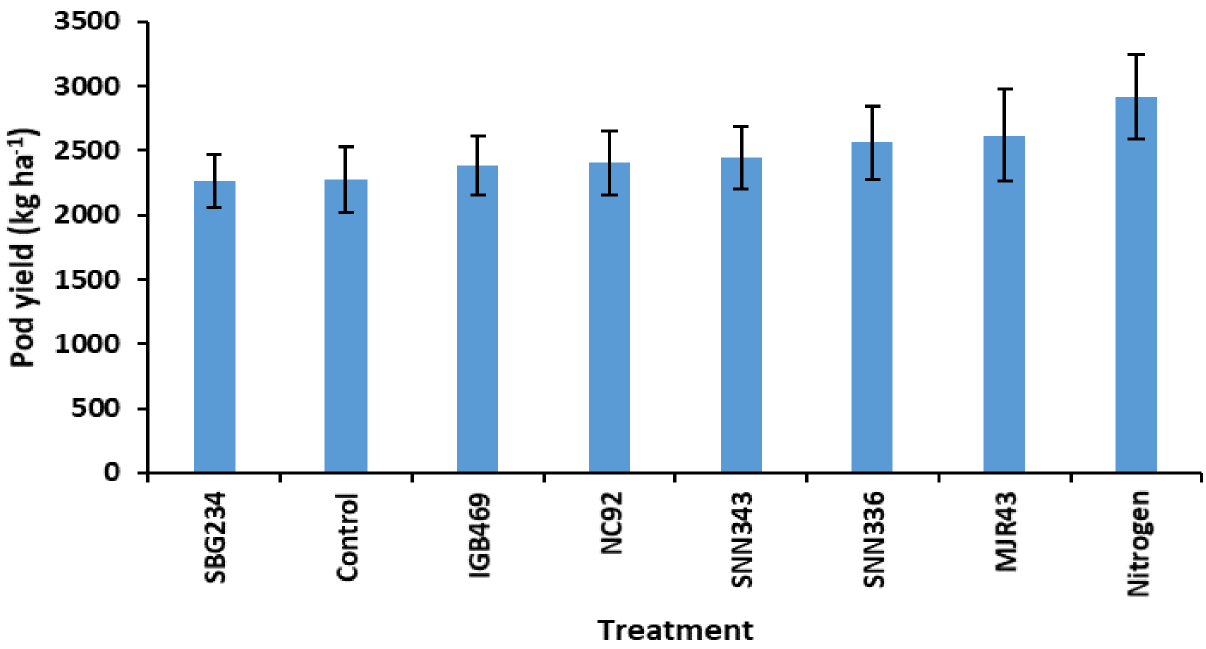


Figure 21. Pod yield of groundnut grown in Ghana as influenced by inoculation with selected elite rhizobia strains in the 2016 cropping season.

In conclusion, soyabean strain RACA6 was promising as it resulted in high grain yields in both Ghana and Tanzania. Strain SBG234 is a promising strain for groundnut based on grain yield increase in Tanzania and pod yield in Ghana. Cowpea did not always respond to inoculation, and in instances where it did there was no common strain that worked well for both countries. In some instances, responses were also site-specific. Considering that in all the trials only one legume genotype was screened, multi-locational variety-by-inoculant-strain trials are required to validate the results and select the best rhizobia and legume-variety combinations suited for different agro-ecologies.

3.9 **Enable learning and assess impacts at scale through strategic M&E**

The project commenced its impact assessment in the last quarter of 2018 and analysis in 2019 to investigate if and to what extent the project activities benefited the intended recipients (farmers) and if these benefits can be attributed to the project activities or contributions by the project can be traced to such benefits. The impact assessment focused on the difference between the observed long-term results with the interventions of the project and the long-term results that would have been without the intervention, and this is assessed at farmer level.

In 2019 project staff and a consultant conducted a policy analysis in Tanzania and Ethiopia, which produced policy briefs which results were presented during stakeholder meetings and further taken up in detailed discussions with the Ministries and other government institutions to improve on current and design new interventions.

In addition to the farmer level impact assessment, a more qualitative approach, contribution analysis (CA), was conducted to ascertain the various contributions by the project and its partners as a means to explain further the quantitative results from the impact assessment. The main areas of focus include improved soyabean varieties in Ghana and inoculants in Ethiopia. Additional areas comprised Ghana, Ethiopia and new areas in Tanzania, Uganda, and Nigeria for the contribution analysis. A range of partners and non-partners of the project were interviewed to find evidence for N2Africa's contribution.

The analysis of the different studies is currently ongoing, and reports will be made available on the N2Africa website.

4 Achievements in relation to project milestones

Table 15. Progress Key Milestones 2019

Milestone	Indicator	Cumulative target at grant end	Target 2019	Achieved 2019 (cumulative)	% achieved against target
Objective 1					
1.3. Partners along the legume input and output value chains cooperate actively towards achieving the overall N2Africa goals.	Number of partnerships developed and active.	32	32	43 partnerships for implementation of project activities Cumulatively 267 partnerships since 2015	Over 100%.
1.4. By Q4 of Year 5, at least 320 partners trained in N2Africa technologies and approaches.	Number of persons trained (gender- disaggregated data) in N2Africa technologies and approaches and number of N2Africa technologies (by type) in which the persons were trained. (	320	320	ToT: 9,016 (31% women) Step down: 61,401 (36% women)	Over 100%
1.4.1. By Q3 of Year 1, an internal and external communication strategy developed	Communication plans	1	1	1	100%
1.5.1. By Q4 of Year 1, country-specific research and dissemination implementation plans formalized, including an exit strategy.	Number of specific research and dissemination plans formalized.	5	5	6	120%
1.7.1. By Q4 of Year 1, a research plan, engaging at least five PhD and 10 MSc candidates, developed.	Project-wide research plans to engage PhD and MSc students developed and number of PhD and MSc students (men/women) engaged.	1	1	1	100%
Objective 2					

Milestone	Indicator	Cumulative target at grant end	Target 2019	Achieved 2019 (cumulative)	% achieved against target
2.2. Dissemination partners attain/surpass the anticipated number of households targeted and continue to engage in legume intensification post-project.	Number of target households (men/women) reached *(outcome level: these farmers continue to engage in legume intensification activities after participating in dissemination activities).*	555,000	555,000	660,198 (45% women)	Over 100%
2.3. Local agro-dealers marketing fertilizers, seeds, and inoculants are aligned with grassroot producer groups and input wholesalers and manufacturers.	*Volume of seeds, fertilizers, and inoculants used per targeted producer group per land area, *Volume of seeds, fertilizers, and inoculants sold by agro-dealers.	6660; 11,100; 56	6660; 11,100; 56	Seeds (4,136.8 t); Fertilizers (6,046.4 t); Inoculants (61.7 t)	Seeds (62%); Fertilizers (54%) Inoculants (100%)
2.3.1. By Q4 of Years 1-4, at least two media events (e.g., radio, newspaper articles, field days, etc.) per country implemented.	Number of media events implemented.	50	50	145	Over 100%
2.4. A pre-set (see Returns-on-Investment calculations) number of households engaged in the collective marketing and value addition of legume grains and value-added products.	Number of households (men/women) engaged in collective marketing, value addition of legumes, and value-added products. Volume of produce sold through collective marketing, volume of value addition products, and types of value added products.	275,000	275,000	176,910 persons with 41% women	64%
2.5.1. By Q4 of Years 1–4, inoculants available through public-private partnerships, through importation and/or local production, the latter facilitated by the inoculant production pilot plant.	Number of inoculant outlets in the target areas, volume of inoculants imported and/or produced in the identified outlets.	5	5	11 Volume imported/produced	Over 100%
Objective 3					
3.2.2. By Q4 of Years 4–5, at least two businesses led by women established per country.	Number of businesses established and led by women & number of women involved in the businesses established.	10	10	32 10,125	Over 100%

Milestone	Indicator	Cumulative target at grant end	Target 2019	Achieved 2019 (cumulative)	% achieved against target
3.3. Better knowledge of and access to household-level legume processing tools improve the nutritional status of women and children in at least two target countries.	Number of women using household-level legume processing technologies	5,000	5,000	13,000	Over 100%
3.4. Women use pre- and postharvest labour-saving tools, resulting in higher net profits from legume production and processing.	Number of women using pre- and postharvest labour-saving tools.	55,500	55,500	48,462	87%
3.5.1. By Q4 of Year 3, relationships between grain nutritional quality and management/environmental conditions quantified.	Number of relationship equations quantified	5	5	Strong evidence for enhanced seed weight, protein content and digestibility of legume grain (see 2019 report)	Completed
Objective 4					
4.1. Recommendations for the intensification of legume production result in at least 50% increase in legume productivity	Percentage change in legume productivity among target households participating in adaptation trials (early adoption instead of adaptation trials) Number of target households (men/women-headed) with 50% increased productivity through adaptation trials	275,000	275,000	365,850	Over 100%
4.1.2. By Q4 of Years 2–4, improved legume production recommendations integrated in the dissemination campaigns	Number of improved legume production recommendations (based on diagnostic trials) integrated in dissemination campaigns	15	15	19	Over 100%

Milestone	Indicator	Cumulative target at grant end	Target 2019	Achieved 2019 (cumulative)	% achieved against target
4.2. Inoculant producers avail improved inoculant formulations for the target legumes resulting in at least 10% increase in legume productivity and BNF	Number of inoculant formulations applied/used by inoculant producers for target legumes in core countries (Productivity will be measured by milestone 4.1)	3	3	3 (soyabean, beans, and groundnut)	100%
4.6.2. By Q4 of Year 5, elite strains used for inoculant production for beans groundnut, and/or cowpea	# new effective and elite rhizobia identified	6	6	920 candidate strains evaluated for chickpea, common bean, faba bean, and soyabean in Ethiopia, climbing bean in Uganda, common bean in Tanzania, and cowpea in Nigeria	In progress
4.8.1. By Q4 of Year 2, standard operating procedures of quality control (storage), product registration, and application of inoculants used by inoculant producers and retailers	Number of inoculant producers and retailers (public private suppliers) using standard operating procedures.	5	5	11	Over 100%
Objective 5					
5.1.1. Throughout the project, a strategic M&E framework provides timely feedback to learning and future planning	Existence of M&E framework that outlines the types of feedback for planning, and provides timely data	1	1	1	100%
5.2. Dissemination partners integrate effective and efficient dissemination approaches for legume technologies in their future development initiatives	Number of dissemination partners integrating effective and efficient dissemination approaches in their programs across target countries (Effectiveness and efficiency of dissemination approaches will be measured by Activity 5.6)	16	16	Over 257 partnerships established in the lifespan of the project had various dissemination approaches (both new and old) integrated	Refer to section 1.2.2 for effectiveness of dissemination approaches

Milestone	Indicator	Cumulative target at grant end	Target 2019	Achieved 2019 (cumulative)	% achieved against target
5.5.1. By Q4 of Year 4, the relative important of G_L, G_R, E, and M understood for specific legumes and production environments and integrated in improved recommendations	Number of quantified relationships integrated in improved recommendations. Best-fit recommendations available to all target legumes in each country	16	8	16	Completed. Best-fit technologies available per country and per location, indicating variety, amounts of P-fertilizer and rhizobia inoculant, GAP practices required, etc. refer to section 1.4.3
5.7.1. By Q4 of Year 4, the sustainability of legume interventions for smallholder farmers evaluated through impact assessment studies	Project-wide impact assessment conducted with available report indicating level of sustainability of project interventions	1	1	1	The impact assessment of the project has been conducted in 2018 across all five core countries

5 Lessons learned

5.1 Ethiopia

- **Bio-fertilizers recognized as important inputs and included in the extension packages:** As the result of the efforts made by N2Africa and local partners in the last five years, the importance of inoculants in the cultivation of legumes is now well recognized, and bio-fertilizer technology has been taken as a major extension package in Jimma PPP cluster. Another encouraging measure was also taken in the South PPP cluster. Boricha woreda the Bureau of Agriculture (BoA) in SNNP region created a position for the "biofertilizer expert" to solely work on the promotion and access of inoculant and legume technologies.

- **The market connections via the N2Africa PPP channel:** Bulking and marketing of grain legumes is done mostly by farmers' cooperative unions, who are linked to exporters and local processors. These linkages provide a consistent market for farmers and buyers such as AKF, Guts Agro, etc., and other emerging potential buyers via cooperative unions.

- **N2Africa's improved legume production technologies continue to spill-over beyond project target locations:** While the use of improved seed, application of inoculants and P fertilizer and good agronomy practices are acknowledged to enhance yield in target legumes at the project locations, the spill-over of soyabean production technology exceed all. Pawe is the N2Africa project action site for soyabean in Benishangul-Gumuz region. Currently, the crop is extended and widely cultivated in the western lowlands of Amhara region (including Jawi, Alefa and Quara woredas) and Humera (North western tip of the country). These areas were known to be important sesame production areas. Driven by increasing local and export demands and available market, it seems sesame is being replaced by soyabean production.

- **Best-fit technology packages specific to different location made possible:** Based on information collected (field days and technology evaluation events; diagnostic, demonstration and adaptation trials etc.), specific recommendations (adapted varieties, inoculants, P fertilizers and agronomic practices) were made to target locations. The changes and their reasons and initiators are listed in tables per crop reported in Thuijsman, E. et al., 2017. (Tailoring and adaptation in N2Africa demonstration trials http://www.n2africa.org/content/tailoring-and-adaptation-n2africa-demonstration-trials).

- **Targeted soil fertility research needs to continue:** On-farm diagnosis/ demonstration/ adaptation trials demonstrated that the inoculant technology works for most of the smallholders. However, there are farms where the technology fails to show expected benefits, thus calling for specific soil fertility research. Strengthening understanding of soil fertility variability and developing legume-targeted fertilizer blends are important tasks to be taken up.

- **Legume residues are important feed resources in smallholder's systems**: In the mixed crop-livestock systems in Ethiopia, legume residues are an important feed resource for livestock during the dry months of the year when green fodder is unavailable. While inoculation enhances feed quality, the conservation, utilization and trade-off between feed and other uses (mulching, soil fertility maintenance) are important research areas for effective utilization of crop residues and intensification of smallholder systems where grain legumes are prominent crops.

5.2 **Borno State, Nigeria**

- Demand uncertainty is a major bottleneck in linking producers with input and output markets.

- Provision of tangible starter pack, soon after training, is critical to business take-off, while access to bank credit is important to growing the business of the youths and can mostly be accessed based on existing business records.

5.3 **Ghana**

- Partnership with the private sector can ensure sustainable supply of legume inputs at the end of project implementation phase. Although N2Africa in 2018 did not facilitate access to inputs including P fertilizers and inoculants, the private partners (YARA, Heritage Seed, GreenEf, etc) were able to make these inputs (P fertilizer, seed, inoculants) available to farmers through their own distribution channels.

- Through advocacy interventions by N2Africa and its partners (particularly MoFA), the government of Ghana has integrated the New YARA legume (NYL) fertilizer into its subsidy program for legumes. This advocacy realized a total of about 2,500 tons of the New YARA legume in 2017 and in 2018, YARA continued to sell the NYL fertilizer at unsubsidized price to farmers. There is therefore the need to encourage partners to engage in partnerships for coordinated results and to ensure sustainability. There is the need to align project interventions with the governments' policies and programs to improve delivery.

- Partnerships involving key value chain stakeholders has improved both awareness and access to inputs by farmers over the past three years. New varieties of legumes developed by the NARS hitherto not known to farmers have been evaluated and different varieties have been identified for the different agro-ecological zones. Certified seeds of these improved varieties have been made available to farmers by the private seed companies. Rhizobium inoculants which was also not known by farmers and many institutions are now available for sale to farmers. Four brands of inoculants have been registered in the country in the last two years by the Plant Protection and Regulatory Services Directorate of the Ministry of Food and Agriculture (PPRSD). These include Nodumax, LegumeFix, Eco-Rhizo Soya and SARFIX.

5.4 **Nigeria**

- End users of inputs such as NoduMax are aware of its efficacy. However, there are still a number of impediments to the ready retailing of such products as NoduMax by last mile retailers. Retailers of crop protection products are used to credit structures which are not available for NoduMax at present. Most retailers require accurate demand quantification from end users to avoid unsold quantities due to the shelf life of the product. The need to have cool storage as communicated to end users is another hindering factor. However, given the continued interest of ISL and other private partners' in promoting NoduMax access at rural level, it remains a critical issue that need to be addressed.

- The usual challenge of inconsistencies in government policies has also manifested itself in the ABP program with far reaching consequences. One of such is the new requirement for farmers land to be contiguous to the tune of 250 ha to be able to participate in the program. Also, even after all requirements are met, significant delays are experienced due to public sector bureaucratic nature and processes which has resulted in our having to receive the funding after the farming season. It therefore underscores the need for development programs/project (like N2Africa) to look for alternative and sustainable mechanisms for leveraging finance for farmers. A possible way might be to create a farming as a business fund from where inputs for farmers can be financed in way that the funds are recovered from sales of farm outputs to off-takers so that the pool of funds are sustainable. In that way farmers can be supported promptly in the bid to migrate them from subsistence to commercial agriculture.

5.5 **Tanzania**

- Village based agricultural advisors (VBAAs) and or community volunteers (CV), if supported, can become an effective conduit to connect farmers and input dealers, thereby achieving an efficient input delivery system. This is because of their closeness and knowledge of farmers in their communities and capability of aggregating input demand at a minimum cost. They are also trusted by farmers, as farmers can easily trace back inputs they sell.

- Improving the availability and affordability of seed will lead to increased seed demand as was observed with high uptake of Quality Declared Seeds produced locally. Different from the general perception that smallholder farmers save their seeds from season to season, they use a mixed bowl of seeds, including seeds they have saved themselves and seeds that they buy from open markets.

- Farmers are ready to use inputs on their legumes only if they have an assured market of the excess produce, which they will attain by using those particular inputs.

- Improved agricultural practices such as spacing, early planting and crop rotation have high potential of uptake by farmers, mainly because of the low costs associated with them.

5.6 **Uganda**

- The ICT- village agent exit strategy is enabling to scaling the reach of farming communities with technologies to areas N2Africa had worked till 2017. This has been possible through information sharing through the platform and village agents and has attracted other development partners and public organisations including the Uganda Microfinance Centre to provide loans to access inputs.

- There is a clear traceability of famers engaged with the platform through the profiles being developed.

- Clear demand forecasts of required inputs is getting more organised and aggregated through the village agents that have direct contacts with farmers and farmer associations.

- Diversification in information services is taking place in the context of farming system and this is interesting more actors and players in the farming system.

- Interface with the village agents is building trust for aggregation of grain for marketing as they are a kind of assurance for follow up to link with markets.

- Village agents are enthusiastic with their work because they have found business opportunities that sustain them such as commissions from sale of aggregated produce from farmers and farmer associations and marketing of inputs from input traders.

6 Opportunities

6.1 Ethiopia

- The Ethiopian Commodity Exchange (ECX) has added soyabean and chickpea to its trading list. Common bean was included since the establishment of the ECX in 2008. Three of the four N2Africa-Ethiopia target legumes (common bean, chickpea and soyabean) are now ECX commodities. This development followed the increasing demand for grain legumes abroad, a huge market that emerged, notably from China and east Asia countries (see Box II).

> Box II. China will start allowing soyabean imports from Ethiopia, customs authorities said September 2018, as the world's top importer seeks to reduce its reliance on supplies of the oilseed from the United States amid a trade row with Washington. Soyabean production in Ethiopia has more than tripled in seven year, from 35,000 metric tons in 2011/12 market year to around 120,000 metric tons in 2018/19 market year, in response to growing local demand for cooking oil, soya-based foods, and livestock feed. Future production is expected to continue its upward climb to respond to rising consumer demand.
>
> *Source: Addis Fortune Newspaper, Published on Nov 03,2018 [Vol 19, No 966]*

- The partnership approach that N2Afrca has established has led to the formation of a consultation platform for the key legume value chain actors including smallholders, and promises to offer a self-sustaining solution. Thus, preservation of the institutional network and the partnership as legume value chain platform ensures smallholders' access to scientific outputs in terms of technologies (NARS), input supplies (seed companies, inoculant manufacturers) and output markets (private processing and export companies) and fosters the development of the legume production sector.

6.2 Ghana

- Since 2017, increased volumes of soyabean grains have been exported into Turkey and this has caused a rapid increase in the price in the local market which if continued will increase the production of soyabean.

- The work of N2Africa and its partners (including MoFA) in the Upper East and Upper West Regions of Ghana served as an opportunity for the implementation of the government's flagship program 'Planting for Food and Jobs' (PFJ). Trained MoFA Staff, including Extension Agents by N2Africa, were used in the implementation of the program activities. To sustain the integration and use of expertise, Agriculture Extension Agents in other districts who were not involved in the implementation of N2Africa need to be trained in N2Africa technologies.

6.3 Nigeria and Borno

- The privately financed Anchor Borrowers Program is ongoing in Kaduna with AFEX Nigeria as a pilot, and with plans to expand to other states including Borno during the 2019 season. This is in addition to ISL's continued engagement with critical driving institutions for the CBN-ABP, especially NIRSAL to ensure readiness of farmers for the program. After securing a contiguous 250 ha in Borno for N2Africa farmers, final approval has been received for 221 farmers in Borno. This serves as opportunity to access both inputs and output markets on a loan basis.

6.4 Tanzania

- Renewed demand for soyabean by feed manufacturers following increased tariffs on imported soyabean grain and cake. Feed millers are now sourcing soyabean locally. It is expected that this will increase the production volumes once again and will have an effect on the entire soyabean value chain.

- Registered seed growers have an opportunity to access loans from the District Community Development office for production, packaging and distribution of legume seed within their localities. The District development offices in addition have responsibilities to supervise and guide all registered groups within the district, build capacities of the groups related to business skills, contract farming and help them to develop business plan. This provides an opportunity for availability of seeds at community levels

- Existence of Transforming Industrial through Joint Agriculture Transformation in Tanzania (TIJA) Consortium by AGRA and launching of TAAT common bean compact, and in future soyabean compacts guarantees continued demand of legume seeds and inoculants.

Existence of the Agriculture Sector Development Programme (ASDP II) which recognized legumes as key crops to diversify and intensify agricultural systems and as one of climate smart agricultural practices

7 Challenges

7.1 Tanzania

- There was a lack of market for soyabean, attributed to the government instituting VAT on animal feeds. This led to an increase in prices of animal feeds which consequently reduced the demand. According to animal feed manufacturers, they could not process soyabean purchased in 2016 as there was no demand for animal feeds. However, the Tanzania government has reversed its decision and slowly soyabean demand is on the increase.

- Late onset of the season and poor rain distribution in central Tanzania leading to low yields of both cowpea and groundnut.

- Labour-saving tools appropriate for smallholder farmers are not readily available in the country and those available require large cost outlays beyond the reach of our target farmers.

- Insufficient amounts of foundation seeds to move with quality demand of certified seeds.

- Contaminated foundation seeds from research institutions leads to ASA and seed companies making loss (logging[5] % of many varieties is estimated at above 20%)

- Inoculants: inoculants are imported, no local production, low profit margin may not attract big investors.

- Low capacity (human resources) of ASA to lend inspection services of expanding fields under seed production

7.2 Ghana

- The key challenge related to sustainability of the dissemination activities is price volatility of soyabean in the local market. The price of the grain is highly unpredictable. Whenever the price rises, processors tend to import soyabean from outside to flood the market thereby forcing the price downward and discouraging local production by farmers. The current price at the time of harvest hovers around GHs140 ($30.43) and GHs160 ($32.65) per 100 kg bag. Huge volumes of soyabean are being shipped to Turkey which has increased the price in the local market. About 3,564 tons of soya has already been purchased in 2018 season by one company for a market in Turkey.

[5] Sorting out right in the field by pulling out plants in the field that are off types.

8 N2Africa Legacy in Tier 1 Countries: Updates from countries

Introduction

Though the project funding for implementation ended in 2017 in the Tier 1 countries (DR Congo, Kenya, Malawi, Mozambique, Rwanda and Zimbabwe), extensive discussions, documentation and implementation of exit strategy activities were conducted in 2017 and others integrated into partners existing frameworks.
This section of the report provides update from four of these countries, focusing on key questions below in understanding the legacy that N2Africa has in these countries.

1. *To what extent is there still a (knowledge) network around legumes and nitrogen fixation active in your country?*
2. *To what extent are private sector and/or NGOs still selling/ using / promoting "N2Africa technologies"? Can farmers readily access seeds, inoculants, legume-specific fertilizers?*
3. *Are there any interesting new developments taking place around legumes and nitrogen fixation?*
4.

Below are country specific updates provided by the Country Coordinators who are still in the networks of the project partners and supports legume activities one way or the other in the respective countries.

8.1 DR Congo

Farmers continue to seek knowledge by engaging in new and existing networks around legumes and nitrogen fixation due to the high demand for soyabeans in the region and especially that there are large soyabean processing plants located in neighbouring countries Rwanda; Uganda (Plant Mont Meru and Mukwano) who serve as main buyers from farmers. There are also some initiatives with the small processing units (soy flour; biscuits; cake); feed for livestock; fish ponds with the soy constitutes a large part. These farmers are supported by existing NGOs and N2Africa partners working in the legume value chains in the country.

With regards to access and use of the technologies, some USAID-funded organizations are working on the soyabean value chain in the region of East DRC supporting some farmers organizations who worked and collaborated with N2Africa and have applied the technologies before. The challenge however, has remained with access to good quality seeds due to the non-functioning seed system; no functional seed companies; no company is in the production of inoculum and public service is not involved in the production of seeds or inoculum. Also access to fertilizer has remained a challenge because of the high price and high cost of importation.

However, some initiatives have started and would like to continue with the achievements of N2Africa in the DRC. These are the CCFBA (Consultative Committee on Nitrogen Biological fixation) with an NGO APD:(Association for the Promotion of Development) working on a project to continue some of the activities of N2Africa with the National Ministry of Agriculture through its specialized service SENAFIC (Service National des Fertilisants et intrants Connexes). The objectives of the initiative are to produce and disseminate organic fertilizers through the outputs of the N2Africa project and the organization has contacted companies that have shown interest already. The Ministry of Agriculture through its specialized service SENAFIC will use the scientific advances of N2Africa in the field of organic fertilizers on the improvement of carrying strains, strategies and approach to extension delivery of organic fertilizers and to be able to duplicate the results of N2Africa in west of DR Congo because the project had operated only in the East to date.

8.2 Kenya

During Phase 2 of N2Africa, the Kenyan team focused upon commercial knowledge pathways with regard to the promotion of BNF technologies. This approach was built upon the availability of legume seeds, inoculants and specially blended fertilizer as input products offered by agro-dealers. Also, the approach of shifting from farmer field days, that requires project support, to customer open houses hosted by local agro-dealers proved successful in terms of more lasting impact. During the N2Africa project, responsibility for agricultural extension services shifted from the national Ministry of Agriculture to the individual counties, and this resulted in lack of organization with regard to their effective participation in N2Africa and other projects. This trend is changing to the better as the farmer associations and agro-dealer networks are now receiving better extension support. Similarly, the processing of legumes has continued at both the cottage industry and agro-industrial scales through the production and distribution of soya milk and flavoured yogurt, instant beverages, blended flours and textured vegetable proteins. Customers recognize these a healthy food products and farmers and marketing mechanisms organized through N2Africa continue to supply raw soyabeans.

Agro-dealers across the former N2Africa West Kenya Action Site continue to market improved soyabean seed (mostly cv Saga from AgriSeed-SeedCo), BIOFIX legume inoculants, and the Sympal fertilizer blend. Most seed, however, tends to be produced through community-based mechanisms relying upon improved varieties (mostly cv Saga) distributed to farmer groups by N2Africa. The distribution of soyabeans tolerant to Asian Rust disease by N2Africa has resulted in lasting impacts. BIOFIX inoculants continue to be produced at the factory built by MEA Fertilizers in Nakuru and distributed to agro-dealers through product representatives. A new, larger 150 g package was added to the BIOFIX product line. Also, a liquid formulation inoculant for soyabean is under development. Inoculant quality control testing continues by the nationally-sanctioned MIRCEN and its laboratory that the N2Africa project helped modernize. In many cases, inoculants continue to be displayed by agro-dealers in small glass-fronted refrigerators that were provided as incentives through N2Africa. Unfortunately, the innovative product return policy for unsold BIOFIX crafted by N2Africa was discontinued, so local agro-dealers now assume full risk for marketing these products. MEA Fertilizers continues to produce the Sympal fertilizer blend in 40-ton batches at its blending facility in Nakuru. This blend has achieved an identity alongside other specialized blends for rice, tea, coffee and other commodities, but MEA as a relatively small Kenyan company is finding it increasingly difficult to compete with multi-national fertilizer importers. One positive spin off is that MEA readily agreed to produce and test market a new fertilizer blend intended for root crops designed by IITA scientists based upon the earlier success of the legume blend formulated by N2Africa.

New developments are worthy of note. 1) TechnoServe has initiated a working group devoted to improving soyabean marketing in Kenya. Their consultants visited several former N2Africa cooperators, including farmer groups, agro-dealers and small-scale processors, in the formulation of their recommendations. Two events were held in 2018 that brought together soyabean producers, input manufacturers, buyers and processors, and N2Africa technologies and partners featured prominently in these discussions. 2) In addition, Technologies for African Agricultural Transformation (TAAT), a Pan-African Program devoted to modernizing agriculture, has included legume inoculants and specialized fertilizer blends within its technology "toolkits". These toolkits assume many forms and the Kenya Quick Win working group leads in translating proven TAAT technologies as combined product offerings through agro-dealer networks. This approach is now being applied as a means to modernize farmer's traditional maize-bean intercropping systems.

8.3 **Malawi**

There is huge networking around legumes and nitrogen fixation in Malawi. Apart from the well-established projects funded by multinational donors (such USAID, GIZ among others), the tobacco industry (being the biggest farming industry in Malawi) started diversifying into legumes and have their farmers access improved legume seed and locally produced inoculant, Nitrofix by AISL (Agro-Input Suppliers Limited).

Newspaper advert on inoculants

The private sector led by Agro-Input Suppliers Limited (AISL) is very actively involved in production and selling huge volumes of soyabean and groundnut seed inoculant.

Some initiatives are promoting the use of inoculants through various medium and one notable initiative by Feed the Future (The US Government's Global Hunger and Food Security Initiative) has been floating adverts in the local newspapers with the caption 'Use INOCULANT! For increased Legumes Production'. See Box 1.

Access to inputs such as seeds and inoculants continue to improve, and farmers can readily access legume seeds through various seed companies and agro-dealer networks spread across the country. The only challenge which some farmers cite is the high cost of the seed.

Composition: New legume fertilizer from MFC Malawi

Access to legume-specific fertilizers is also being made possible through one major local fertilizer company, Malawi Fertilizer Company (MFC) which has started blending and distributing legume-specific fertilizers. See Box 2 for the fertilizer composition. The company joins hands with other partners to disseminate this fertilizer and this season, a total of 191 demonstration plots have been established with Farmers Services Unit (a sister unit to Malawi Fertilizer Company) in the central and southern Malawi, Multi Seeds Company (a private legume seed producing company) in six districts of central region of Malawi and CARD's (Churches Action in Relief and Development) Economic Empowerment Project in Mchinji District.

Other interesting and new developments around legume production in Malawi. Big tobacco buying companies in Malawi are supporting their outgrower farmers to grow legumes (mostly soyabean and groundnuts) as a way of diversifying their agro-enterprise.

8.4 Zimbabwe

The N2Africa project was implemented in Zimbabwe between 2009-2017. The project engaged smallholder farming communities on intensified grain legume integration in their farming systems across eight districts.

SeedCo seed company has continued to produce soyabean and groundnut seed for Zimbabwe and neighbouring countries markets. For soyabean, the model where farmers access seed and rhizobia under 'one roof" has reduced transactional costs. Cowpea has been mostly supported by NGOs in marginal rainfall regions as a climate smart intervention to provide a grain legume crop in drought-prone regions. We worked with the Cluster Agricultural Development Services (CADS) for several years. This NGO has continued to mainstream grain legume production with communities on its HIV/AIDS alleviation and rural nutrition programs.

The government of Zimbabwe's 'command agriculture' program, that had over the past 3 years exclusively supported farmers for maize production, has now extended seed and fertilizer inputs support for soyabean production. This has increased demand for soyabean inoculants, thus tapping into N2Africa investments in Zimbabwe. N2Africa made investments on improving inoculants quality and production capacity at the Soil Productivity Research Lab in Marondera. The equipment included refrigeration facilities, microbiological incubator, an autoclave and a modern laminar flow chamber for aseptic transfer of sterilized materials inoculation of microbes. Technicians that received N2Africa expert training have also contributed to the continued production of high-quality inoculants at the factory.

Appendix I – Overview of active partnerships

Table 16. Active public-private partnerships in 2019.

Country	N2Africa lead partner	Type of organization*	Type of partnership**	Main areas of support***
Ethiopia	Menagesha Biotech Industry PLC (MBI) – AGRA-SSTP	Private Organization	Grant Agreement	Dissemination, Input Supply, Market linkage, Capacity building
Ethiopia/Chewaqa	International Fertilizer Development Centre (IFDC)—2SCALE Project	NGO	Cooperative/Collaboration Agreement	Dissemination, Input Supply, Market linkage, Capacity building
Ethiopia/Chewaqa	Anno Agro Industry Plc.	Private Organization	Subcontract under collaborative agreement	Seed supply
Ethiopia/South East	Bale Green Spice and Development Plc. (BSGD)	Private Organization	Cooperative/Collaboration Agreement	Dissemination, Input Supply, Market linkage, Capacity building
Ethiopia/South East	Bale Green Spice and Development Plc. (BSGD)	Private Organization	Subcontract under collaborative agreement	Capacity building, Input Supply, Market linkages, Dissemination
Ethiopia/Chewaqa and South East	Oromia Agricultural Research Institute (OARI)	Research Institution	Subcontract under collaborative agreement	Dissemination
Ethiopia/Central Shoa	SNV/Agriterra-Cooperatives for Change (C4C)	NGO	Cooperative/Collaboration Agreement	Dissemination, Input Supply, Market linkage, Capacity building
Ethiopia/Pawe	Ethiopian Institute of Agricultural Research (EIAR)–Pawe Agricultural Research Centre	Research Institution	Cooperative/Collaboration Agreement	Dissemination, Input Supply, Market linkage, Capacity building
Ethiopia / Central Shoa and Pawe	Ethiopian Institute of Agricultural Research (EIAR)	Research Institution	Subcontract under collaborative agreement	Dissemination
Ethiopia/Jimma	Facilitator for Change (FC)	NGO	Cooperative/Collaboration Agreement	Dissemination, Input supply, Market linkage, Capacity building
Ethiopia/Jimma	Facilitator for Change (FC)	NGO	Subcontract under collaborative agreement	Dissemination, Input supply, Market linkage, Capacity building
Ethiopia/South	Hawassa University (HwU)	Research Institution	Cooperative/Collaboration Agreement	Dissemination, Input supply, Market linkage, Capacity building
Ethiopia/South	Hawassa University (HwU)	Research Institution	Subcontract under collaborative agreement	Dissemination, Input Supply, Market linkage, Capacity building
Ethiopia/South	Soddo Catholic Secretariat (SCS)	NGO	Subcontract under collaborative agreement	Capacity building, Input supply, Market linkages, Dissemination
Ethiopia/North	Tsehay Multi-Purpose Cooperative Union (Tsehay Union)	Other	Cooperative/Collaboration Agreement	Dissemination, Input Supply, Market linkage, Capacity building
Ethiopia/North	Amhara Region Agricultural Research Institute (ARARI)	Research Institution	Subcontract under collaborative agreement	Capacity building, Input supply, Market linkages, Dissemination

Country	N2Africa lead partner	Type of organization*	Type of partnership**	Main areas of support***
Ghana	Evangelical Presbyterian Development and Relief Agency YENDI (EPDRA-Yendi)	NGO	Subcontract	Capacity building, Input supply, Market linkages, Dissemination
Ghana	Urban Agriculture Network (UrbANET)	NGO	Subcontract	Capacity building, Input supply, Market linkages, dissemination
Ghana	Green-Ef Eco-Business Village Limited (Green-Ef)	Private Organization	Cooperative/Collaboration Agreement	Input supply and ICT information management
Ghana	CABI-IITA: Gender and the Legume Alliance: Integrating multi-media communication approaches and input brokerage (GALA)	NGO	Cooperative/Collaboration Agreement	Dissemination, Input supply, Market linkage, Capacity building
Nigeria	Intrio Synergy Limited (ISL)	Private Organization	Subcontract/Cost share	Dissemination, Input supply, Market linkage, Capacity building
Nigeria (Borno)	The Borno State Agricultural Development Project (BOSADP)	NGO	Subcontract	Dissemination, Seed systems, Market linkages
Nigeria (Borno)	Leventis Foundation	NGO	Subcontract	Capacity building—Spray service providers (SSP_
Nigeria (Borno)	Intrio Synergy Limited (ISL)	Private Organization	Subcontract/Cost share	Dissemination, Input supply, Market linkage, Capacity building
Tanzania	Nelson Mandela Africa Institute of Science and Technology (NM-AIST)	Research Institute	Subcontract	Rhizobiology
Tanzania	Tanzania Fertilizer Regulatory Authorities (TFRA)	Public Organization	Cooperative/Collaboration agreement	Registration of inoculants and provision of import permits (country wide)
Tanzania	Sokoine University of Agriculture (SUA)	Public Organization	Cooperative/ Collaboration agreement	Quality Control of rhizobia inoculants (country wide)
Tanzania	Catholic Relief Services (CRS) – Soya ni Pesa Project	NGO	Cooperative/Collaboration agreement	Dissemination, Input supply, Market linkage, Capacity building
Tanzania	Agriculture Research Institute -Uyole (ARI-UYOLE)	Research Institute	Subcontract	Dissemination, diagnostics
Tanzania	FAIDA MARKET LINK (FAIDA MaLi)	NGO	Subcontract	Market linkage, Capacity building
Tanzania	ARI—SELIAN (ARI—SELIAN)	Research Institute	Subcontract	Dissemination, Diagnostics
Tanzania	Building Rural Incomes Through Enterprise (BRiTEN)	NGO	Subcontract	Dissemination, Input supply, Market linkage, Capacity building
Tanzania	Agriseed Technologies Limited (AgriTech)	Private (seed) organization	Subcontract	Input supply

Country	N2Africa lead partner	Type of organization*	Type of partnership**	Main areas of support***
Tanzania	Guavay Company Limited (GCL)	Private (fertilizer) organization	Subcontract	Input supply
Tanzania	Beula Seed Co. & Consult LTD (BSCC)	Private (seed) organization	Subcontract	Input supply
Tanzania	G2L Company Limited	Private organization	Subcontract	Market linkages
Uganda	National Agricultural Research Laboratories (NARL)	Research Institute	Subcontract	Diagnostics
Uganda	National Crops Resources Research Institute (NaCRRI)	Research Institute	Subcontract	Dissemination
Uganda	Netherlands Development Organization (SNV) - The Uganda Oilseed Subsector Platform (OSSUP)	NGO	Cooperative/Collaboration agreement	Innovation Platform (IP)
Uganda	National Agricultural Research Organization (NARO)	Research Institution	Subcontract	Groundnuts, Diagnostics, Dissemination, Capacity building
Uganda	Agricultural Innovation Systems Brokerage Association Limited (AGINSBA)	Private Organization	Subcontract	ICT-Platform—Dissemination, Input and output market linkages
Uganda	Simlaw Seeds Company Uganda Ltd	Private Organization	Cooperative/ Collaboration agreement	Seed supply
Uganda	Agency for Sustainable Rural Transformation Limited (AFSRT)	Private Organization	Subcontract	Capacity building, Market linkages, Technology dissemination

Appendix II – PhD and MSc student overview

Table 17. Overview of PhD students involved in N2Africa Phase II.

Country	Name	Gender	Research topic
DRC	Bintu Ndusha	F	*Working with the output of Phase I* Started field work April 17
Ethiopia	Ashenafi Hailu Gunnabo	M	Use of crop residues for livestock.
Ethiopia	Mesfin Dejene Ejigu[1]	M	Options for improving the yield and nutritive value of maize and grain legume residues for ruminants in East African farming systems (Partially funded by N2Africa)
Ethiopia	Tamiru Amanu Abete	M	Understanding the role of Public-Private Partnerships in overcoming institutional barriers to technology adoption
Ghana	Daniel Brain Akakpo	M	Use of grain legume residues as livestock feed resource for smallholder farmers in Northern Ghana.
Ghana	Michael Kermah	M	Exploring opportunities for sustainable intensification of grain legumes towards improving crop productivity, food security and livelihoods of smallholder farmers in northern Ghana.
Kenya	George Mwenda	M	Characterization of nitrogen-fixing bacteria from *Phaseolus vulgaris* L. in Kenya
Mozambique	Amaral Machaculeha Chibeba	M	Characterization of rhizobia isolated from soyabean in Mozambique and strategies to maximize the contribution of biological nitrogen fixation.
Nigeria	Aliyu Anchau Abdullahi	M	Exploring the genetic diversity of groundnut-nodulating rhizobia in moist and dry savannas in Nigeria for increased symbiotic nitrogen fixation and productivity.
Nigeria	Comfort Ojo Tinuade	F	Host legume x rhizobium strain interactions in cowpea.
Nigeria	Tolorunse Kehinde Dele	M	Phenotyping and yield stability studies in soyabean (*Glycine max* (L.) Merrill) under rhizobia inoculation in the savanna region of Nigeria
Nigeria	Adediran Olaotan Abimbola	F	Physiological Responses of Cowpea (*Vigna Unguiculata* (L.) Walp) Varieties to Rhizobia Inoculation, Nutrient Management and Sowing Dates in Nigeria Southern Guinea Savannah.
Borno State	Faruk Galadanchi Umar	M	Response of Groundnut Varieties to *Rhizobia* Inoculation in The Sudan And Northern Guinea Savannas of Nigeria.
Borno State	Binta Ali Zongoma	F	Impact Assessment of Improved Cowpea Varieties on Women Farmers in Southern Borno State, Nigeria
Borno State	Jennah Fatima Bebeley	F	Evaluation of the productivity and profitability of high and low input soyabean production systems in northern Nigeria
Rwanda	Edouard Rurangwa	M	Improving nitrogen fixation in common beans and soyabean in Rwanda.
Tanzania	Eliakira Kisetu Nassary	M	Intensification of maize-bean cropping systems in Northern Tanzania.
The Netherlands	Ilse de Jager	F	Agriculture and nutrition linkage in N2Africa.
The Netherlands	Esther Ronner	F	From Targeting to Tailoring - Baskets of options for legume cultivation among African smallholders
The Netherlands	Wytze Marinus[1]	M	Using the NUANCES approach to examine benefits of legumes in farming systems of East Africa

Uganda	Connetie Ayesiga	F	Adoption of grain legume technologies among smallholder farmers in Uganda: Role of ICT market intervention and impact
Zimbabwe	Mazvita Chiduwa	F	Symbiotic performance of soyabean root nodule bacteria (RNB) recovered from Zimbabwe.
Zimbabwe	Tatenda Kainga	F	Rhizobiology
The Netherlands	Eskender Andualem Beza[1]	M	Citizen science and remote sensing for crop yield gap analysis

M= male, F= female
[1] PhD candidate having collaborative research with N2Africa

Table 18. Overview of MSc students involved in N2Africa Phase II.

Country	Name	Gender	Research topic
Ethiopia	Beza Shewangizaw Woldearegay	M	Response of chickpea (*Cicer aritienum* l.) to sulphur and zinc nutrients application and *Rhizobium* inoculation in north western Ethiopia.
Ethiopia	Negash Teshome	M	Influence of potassium fertilization and liming on growth, grain yield, and quality of soyabean (*Glycine max* L. (Merrill) on acidic soil in Gobu Sayo district, western Ethiopia.
Ethiopia	Getahun Negash Takele	M	Symbiotic and phenotypic characteristics of indigenous rhizobia nodulating faba bean (*Vicia faba* L.) growing in some parts of Wello, Northern Ethiopia.
Ethiopia	Tadele Ereso	M	Symbiotic effectiveness of rhizobia from chickpea (*Cicer arietinum* L.) and phenotypic characteristics of faba bean (*Vicia faba* L.) nodulating rhizobia.
Ethiopia	Mesfin Fenta	M	Adoption of improved chickpea technologies in North Gondar zone of Ethiopia: the case of Gondar Zuria district.
Ethiopia	Galmesa Abebe	M	Adoption of improved soyabean varieties: the case of Buno Bedele and east Wollega zones of Oromia region, Ethiopia.
Ethiopia	Dagmawit Getachew	F	Analysis of Preference for Adoption of Legume Technology Packages: the Case of Chickpea and Common bean Producing Smallholder Farmers in Boricha and Damot Gale Districts, Southern Region.
Ethiopia	Yitbarek Tegegne	M	Factors affecting adoption of legume technology and its impact on income of farmers: the case of Sinana and Ginir Woredas of Bale zone.
Ethiopia	Sisay Belete	M	Effects of phosphorus fertilizer and inoculation on yield and nutritive values of grain and haulm of selected grain legumes in mixed crop-livestock production system of Ethiopia.
France	Ugo Verlingue	M	Guiding varietal choice for soyabean in Africa: A comparison of bottom-up and top-down modelling approaches to assess water limited potential yields.
Ghana	Kennedy Ahlija	M	Response of soyabean to rhizobial inoculation and nitrogen management options in the Southern Guinea savannah zone of Ghana.
Ghana	Wuni Mawiya	M	Effect of genotype and plant population on growth, N-fixation and yield of soyabean in Northern Guinea Savanna zone of Ghana.
Ghana	Gifty Kumah	F	Effect of genotype and plant population on growth, nitrogen fixation and yield of soyabean (*Glycine max*. L. Merrill) in Guinea savanna agro-ecological zone of Ghana.
Ghana	Florence Jessicah Kumah	F	Influence of P sources and rhizobium inoculation on growth, nodulation, N & P uptake and yield of three soyabean genotypes in Tanchera soil series of the northern Guinea savannah zone of Ghana.
Ghana	Godfrey Wilson	M	Symbiotic effectiveness and saprophytic competence of selected indigenous rhizobia isolates for groundnut inoculation in northern Ghana.
Ghana	Gregory Mensah	M	Implementation of N2Africa Project in Ghana:Putting Nitrogen Fixation to work for smallholder farmers in Ghana.

Country	Name	Gender	Research topic
Ghana	Kwasi Gyan	M	Farmers' willingness to pay for soyabean production inputs in northern Ghana.
Ghana	Ibrahim Issifu	M	Evaluation of liming, inoculation and phosphorus fertilizer on yield components and yield of soyabean (*Glycine max* (L.)) Merrill in the Guinea savannah of Ghana.
Ghana	Abdul Rahaman Karim	M	Farmers' practices in soyabean (*Glycine max*) storage and their effects on viability and vigour of seeds.
Ghana	Robert Tumyagewor Atawura	M	Adoption of Improved Technologies by Legume Farmers in The Upper West Region of Ghana.
Ghana	Mats Hoppenbrou-wers	M	Usage of agricultural technologies for soyabean and groundnut.
Kenya	Martin Kiagayu Koinange	M	Influence of biochar amendment on the effectiveness of elite Kenyan rhizobia nodulating common bean (*Phaseolus vulgaris* L.).
Kenya	Wycliffe W. Waswa	M	Evaluation of yield potential and management practices affecting soyabean production in western Kenya.
Malawi	Donald Siyeni	M	Effect of rhizobia inoculation and phosphorus fertilizer on nodulation and yield of soyabean (*Glycine max* (L.) Merril) in Dedza, Kasungu and Salima districts of Malawi.
Nigeria	Ngwu Chuwudi Hillary	M	Genotype X Environment Interaction and Stability Analysis for Yield and Its Components In 24 Lines of Soyabean (*Glycine Max*) in Three Agro Ecological Zones of Nigeria.
Nigeria	Muhammed Mustapha Ibrahim	M	Optimization of biological nitrogen fixation and yield of groundnut (*Arachis hypogaea* L.) in a savanna alfisol through fertilizer application and soil amendment.
Nigeria	Musa Muhammed	M	Response of Cowpea Varieties to Rhizobium Inoculant and Phosphorous Fertilizer in Sudan Savanna.
Nigeria	Muhammad Halliru	M	Determinants of Inputs Demand and Adoption of Grain Legumes and Associated Technologies of N2Africa in Kano State, Nigeria.
Nigeria	Andy Okpoho	M	Effects of Tillage, Variety and Starter Nitrogen on Soil Physical Quality, Root Profile, Biological Nitrogen Fixation and Inoculated Soyabean Performance at Minna, Nigeria.
Nigeria	Ekle Angu Sunday	M	Effects of inoculation, chemical fertilizers and manure on nutrient uptake and yield of soyabean in savanna zone of Kano State.
Nigeria	Damilola Samuel Abikoye	M	Assessment of The N2africa Project on Empowering Women Involved in Soyabean (*Glycine Max*).
Nigeria	Joy Ekaette	F	Response of promiscuous soyabean to rhizobial inoculation in combination with organic and mineral fertilizers in some soils of the Nigerian Guinea savanna.
Nigeria	Gambo Umar	M	Response of soyabean to rhizobial inoculation and phosphorus application in Nigerian Savanna.

Country	Name	Gender	Research topic
Nigeria – Borno	Muhammad Nurudeen Isa	M	Characterization and evaluation of indigenous *Rhizobia* of cowpea for biological nitrogen fixation and improved crop yield in the Nigerian savanna.
Nigeria – Borno	Hauwa Mohammed Alkali	F	Analysis of market participation by women soyabean farmers in Hawul Local Government Area of Borno State, Nigeria.
Nigeria – Borno	Maryam Baba Kyari	F	Analysis of cowpea marketing in Biu Local Government area, Borno State, Nigeria.
Nigeria – Borno	Muhammad Sheriff Ali	M	Effect of different single superphosphate (SSP) rates and plant spacing on yield of groundnut in Sudan savanna zone of Borno State, Nigeria.
Nigeria – Borno	Sahbong Lucy Kamsang	F	Gender difference in the adoption and impact of improved soyabean varieties in Southern Borno State, Nigeria.
Tanzania	Yusuph Namkeleja	M	Isolation, authentication and evaluation of symbiotic effectiveness of elite indigenous rhizobia nodulating *Phaseolus vulgaris* L. in Hai District, northern Tanzania.
Tanzania	Fides Temu	F	Dynamics of Common Bean (*Phaseolus Vulgaris L.*) Insect Pests with Altitudes, Cropping Seasons and Cropping Patterns in Hai District Tanzania.
Tanzania[2]	Scolastica Gatty[1]	F	Effectiveness of Alternative Extension Methods in Raising Knowledge, Stimulating Uptake and Increasing Profitability under Different Improved Farming Practices: A Case Study of Common Bean Farmers in Southern Highlands of Tanzania.
Tanzania[2]	Ernesta Gerald Sanga[1]	M	Determinants of adoption of improved common bean technologies among small farmers in Southern Highlands in Tanzania: cost-effectiveness of dissemination approaches.
Tanzania[2]	Nimbona Daphrose[1]	M	Gender Differences in Reception of Information and Its Effects on The Adoption of Improved Soyabean Technologies in Njombe Region-Tanzania.
Tanzania[2]	Amina Mustapha[1]	F	Effectiveness of extension methods for scaling up improved common bean technologies among small-scale farmers in Babati district, Tanzania.
Tanzania[2]	Charles Byalugaba Lugamara[1]	M	Effectiveness of communication channels and smallholder farmers' adoption of improved legume technologies: a case of Morogoro region, Tanzania.
Tanzania	Verena Mitschke	F	Inducing the adoption of good agricultural practices by educating Tanzanian smallholder farmers – what works best and at what costs?
Tanzania	Henry Tamba Nyuma	M	Response of three groundnut (*Arachis hypogaea* L.) genotypes to calcium and phosphatic fertilizers.
Tanzania	Zephania Simon	M	Isolation and characterization of nitrogen fixing rhizobia from previously cultivated and uncultivated soils of northern Tanzania.
The Netherlands	Eva Thuijsman	F	Light and nutrient capture by common bean (*Phaseolus vulgaris* L.) and maize (*Zea mays* L.) in the Northern Highlands of Tanzania.
The Netherlands	Eva Thuijsman	F	Adaptation of improved climbing bean (*Phaseolus vulgaris* L.) technologies in the Ugandan highlands.
The Netherlands	Kohji Nakasaka	M	Evaluating farmers' decision making on choosing technologies and practices in adaptation trials.
The Netherlands	Tijmen Kerstens[1]	M	Findings on: Environmental impact in Dutch arable farming, experimental data on soyabean yield

Country	Name	Gender	Research topic
			potential, the yield gaps of sugarcane and sugar beet, and N2Africa baseline studies.
The Netherlands	Wytze Marinus	M	Opportunities and constraints for climbing bean cultivation by smallholder farmers in the Ugandan highlands. A basket of options?
The Netherlands	Wytze Marinus	M	Cowpea-maize relay cropping. A method for sustainable agricultural intensification in northern Ghana?
The Netherlands	Lisa Piper[1]	F	N2Africa Project Review.
The Netherlands	Laurie van Reemst	F	Understanding drivers behind the implementation and adaptation of improved climbing bean (*Phaseolus Vulgaris* L.) technologies by smallholder farmers in Kapchorwa district, Eastern Uganda.
The Netherlands	Jan Huskens	M	Climbing bean (*Phaseolus vulgaris L.*) cultivation and its diffusion in Kapchorwa District, Uganda.
The Netherlands	Nikolaj Meisner Vendelbo	M	Effect of cropping system design on severity of biotic stresses in common bean (*Phaseolus vulgaris*) and maize (*Zea mays*) in Northern Tanzania.
The Netherlands	Dorien Westerik	F	Simple farm simulation model of smallholder farms in Ghana.
The Netherlands	Mats Hoppenbrou-wers	M	The financial sustainability of concrete technology options for grain legumes: An economic evaluation of input adoption by smallholder farmers in Ghana.
The Netherlands	Susana Prieto Bravo	F	Analysis and revision of the N2Africa focal adaptation survey, a tool for monitoring technology performance and untangling yield variability.
The Netherlands	Suzanne Roelen[1]	F	Exploring the current state of ruminant value chains in northern Ghana, and the role of grain legume residues as a livestock feed resource.
The Netherlands	Dorien Westerik	F	A simple farm simulation model of smallholder farms in Ghana.
The Netherlands	Els van der Spek	F	Soyabeans and nitrogen fixation in Uganda.
The Netherlands	Jua Dai Fleer	M	Soyabeans and nitrogen fixation in Uganda.
The Netherlands	Charlotte Mallet	F	Prediction of bush bean (*Phaseolus vulgaris* L.) yield in northern Tanzania based on spectral analysis of soils.
The Netherlands	Betty Masamba	F	Analysing the performance of N2Africa technologies in on-farm adaptation trials across the different crops and countries.
The Netherlands	Roos Mulder	F	Factors influencing grain legume technology adoption across Sub-Saharan Africa.
The Netherlands	Bouwiene Zwaan	F	Chickpea in Ethiopia
Tanzania / The Netherlands	Hannah Broerse	F	Kukua delivery weather data prediction to smallholder farmers and the extent to which local smallholder farmers are willing to use and pay for weather prediction services.
Tanzania / The Netherlands	Sandra Gonza	F	Kukua delivery weather data prediction to smallholder farmers and the extent to which local smallholder farmers are willing to use and pay for weather prediction services.
Tanzania / The Netherlands	Pepijn Bras	M	Kukua delivery weather data prediction to smallholder farmers and the extent to which local smallholder

Country	Name	Gender	Research topic
			farmers are willing to use and pay for weather prediction services.
Tanzania / The Netherlands	Justin Hoek	M	Kukua delivery weather data prediction to smallholder farmers and the extent to which local smallholder farmers are willing to use and pay for weather prediction services.
Tanzania / The Netherlands	Robin Hooft van Huysduynen	F	Kukua delivery weather data prediction to smallholder farmers and the extent to which local smallholder farmers are willing to use and pay for weather prediction services.
Uganda	Kennedy Mwesigewa	M	Characterizing nutrients limiting soyabean production in central Uganda.
Uganda	Eriya B. Kule	M	Gender based factors influencing farmer participation in marketing of climbing beans (*Phaseolus vulgaris* L.) in Kabale district, south western Uganda.
Uganda	Sridhar Bharathwaj	M	Adoption constraints with climbing beans in Kashambya subcounty, Uganda.
Uganda	Mats Hoppenbrou-wers	M	Challenges and coping strategies in the soyabean market chain in Uganda.
Zimbabwe	Vongai Chekanai	F	Response of common bean (*Phaseolus vulgaris*) to rhizobia inoculation, nitrogen and phosphorus application and residual benefits to maize on smallholder farms in eastern Zimbabwe.

M= male, F=female

[1] Student having collaborative research or internship with N2Africa

Appendix IV – 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 soyabean, common bean, cowpea, and groundnut varieties with proven high BNF potential and sufficient seed availability in target impact zones of N2Africa Project
10. Project launching 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 seeds 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 seeds 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. 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. Launching 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 Launching 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
101. N2Africa Project Kenya Exit Strategy
102. N2Africa Project Malawi Exit Strategy

103. N2Africa Project Mozambique Exit Strategy
104. N2Africa Project Rwanda Exit Strategy
105. N2Africa Project Zimbabwe Exit Strategy
106. N2Africa Annual Report 2017
107. N2Africa review of policies relating to legume intensification in the N2Africa countries
108. Stakeholder Consultations report
109. Dissemination survey Tanzania
110. Climbing bean x highland banana intercropping in the Ugandan highlands
111. N2Africa Annual Report 2018
112. N2Africa Annual Report 2018 Ethiopia
113. N2Africa Annual Report 2018 Ghana
114. N2Africa Annual Report 2018 Nigeria, Borno State
115. N2Africa Annual Report 2018 Tanzania
116. N2Africa Annual Report 2018 Uganda
117. N2Africa training and extension materials
118. Responses to inoculation of Phaseolus beans
119. N2Africa in northern Ghana 2019
120. N2Africa Annual Report 2019

Appendix V – Partners involved in the N2Africa project

A2N

AGINSBA

Bayero University Kano (BUK)

Caritas Rwanda

Diobass

Eglise Presbyterienne Rwanda

Ethiopian Institute of Agricultural Research

Jay Fortunes

Kwame Nkrumah University of science and Technology

MIRCEN
University of Nairobi MIRCEN

Resource Projects-Kenya

Sasakawa Global; 2000

Université Catholique de Bukavu

University of Zimbabwe

Urbanet